RESEARCH AND DEVELOPMENT YEARBOOK 2019

RESEARCH AND DEVELOPMENT YEARBOOK 2019. STERF. SCANDINAVIAN TURFGRASS AND ENVIRONMENT RESEARCH FOUNDATION

STERF YEARBOOK 2019

Demand for research and results was not intense when STERF was formed twenty years ago. Stakeholders instead referred to the large competence base in turfgrass science that was built up at universities, particularly in North America. Fortunately, this did not stop the Scandinavian golf federations from investing in research for a sustainable future.

One reason for not relying on research from North American universities was the fact that Scandinavia has unique climate conditions, light, temperature etc., that require alternative turf management strategies. In addition, the challenges for the golf sector were becoming more pronounced. Climate change had started to affect water conditions, diseases and biodiversity, just to mention a few parameters. The use of chemicals was strongly challenged by the public and authorities and a ban on use of pesticides was initiated in many countries. The golf sector also faced economic restrictions due to the recession and the rising costs of input resources such as fertilisers, growth stimulants etc.

Now, two decades later, it is clear that the initiative to form STERF was a very wise decision. Today STERF has earned a position as one of the best recognised centres of excellence in turfgrass- and environment-related science. STERF is also considered a role model for countries all over the world and we are frequently consulted by different stakeholders on how to build a research and development organisation for turfgrass science. Our advice is to consider regional conditions, characteristics and limitations and to:

- Set up a focused and motivated management and project team.
- Formulate a solid problem description for the region and explore different solutions.
- Identify research needs in the long and short term and ensure rapid delivery of applied results. Ensure also that scientists deliver ready-to-use results.
- Develop a financial system that engages golf clubs/golfers, the industry, public sources and research bodies.
- Create networks between the sector and scientists, and make knowledge transfer the mantra.

These are the STERF factors for success. We look forward to co-operating with the new research nodes that we hope will result from the R&A/FEGGA initiative and other actions.

The new STERF projects presented in this yearbook show that co-operation really is a factor for success, with our many partners finding solutions for a sustainable future together.

I wish you interesting reading!

Bruno Hedlund
STERF Chairman

IMPORTANT EVENTS IN 2019

IPM CONTACT MEETING BETWEEN STERF AND NORDIC AUTHORITIES

In May 2015, STERF invited authorities in the five Nordic countries to a contact meeting regarding Integrated Pest Management (IPM) and implementation of EU Pesticide Directive on golf courses. The follow-up meeting on 6 March 2019 was long overdue and was attended by one representative from the authorities in each of the countries Finland, Sweden, Denmark and Norway, one or two representatives for the Greenkeepers' Associations in those countries, the STERF board and Tatsiana Espevig as invited scientist.

One of the topics in the discussion was the definition of pesticides and how to handle biostimulants, additives and other 'borderline' products which claim to have an effect on plant health. In Sweden in particular, where golf courses must apply to municipal authorities for permission to use specific products, there is a need for more information and more uniform practice. It was decided that the Golf Federations and Greenkeepers' Associations would compile a list of borderline products to be handed over to the authorities, to get a decision on which products are/are not covered by the pesticide legislation. It was also agreed to continue with regular contact meetings between STERF and the authorities.

Participants at the seminar 'Sustainability and environmental risks of pesticide use', Oslo, 7 March 2019. Photo: John Olav Oldertrøen, NIBIO.

INTERNATIONAL SEMINAR - LEACHING AND SURFACE RUNOFF OF PESTICIDES

About 80 greenkeepers, scientists, advisors and representatives from national authorities and the pesticide industry in 10 countries attended STERF's pesticide seminar *'Sustainability and environmental risks of pesticide use on golf courses'* in Oslo on 7 March, organised in collaboration with NIBIO. The background was the project '*Risks for surface runoff and leaching of fungicides from golf greens varying in rootzone composition and amount of thatch*', which came to an end in 2019. Apart from presenting results from the STERF project, the seminar included presentations from the Danish project 'PEST-GOLF: Estimating pesticide leaching to groundwater from greens and fairways' and the German project 'GREEN WATER: Decision support models for pesticide use on golf courses'. On the groundwater issue, a case study of Halmstad GC, Sweden, highlighted a trial at the Swedish Supreme Environmental Court in which simulations using the pesticide leaching model 'MACRO' had resulted in permission for the golf course to apply fungicides on their greens, even within a water protection area. Updates were also given from the environmental authorities in Denmark, Sweden,

Finland and Norway on pesticide legislation relevant to golf courses. Finally, the Netherlands golf federation gave a status report on 'Green Deal', the ambition to maintain all Dutch sportsfields without pesticides by 2020.

NIBIO INTERNATIONAL TURFGRASS FIELD DAY

NIBIO Field Day is a biennial event, usually held by the NIBIO Turfgrass Research Group in odd-numbered years. The 2019 event, which was held at Landvik, Norway, on 18-19 June, had around 50 attendees, 10 of whom were from countries outside Scandinavia. According to tradition, the event started with an evening BBQ and social activities in the garden at Landvik. This was followed by lectures and a field walk on the following day. This year's two main topics were 'Turfgrass nutrition and the need for soil analyses,' revolving around the STERF project 'SUSPHOS', and 'New turfgrass in the Nordic countries', revolving around the STERF project 'Risk assessment, management and control of dollar spot'. Apart from NIBIO's own scientists, the invited speakers were Doug Soldat from University of Wisconsin, USA; Karin Normann from Nyholt ApS, Denmark; and Pål Melbye from the Norwegian Golf Federation.

Board members of International Turfgrass Society 2019 at Furesø golf course. Photo: STERF

SHAPING THE FUTURE OF INTERNATIONAL TURFGRASS SOCIETY (ITS)

A total of 24 ITS officers and national directors from 16 countries participated in the ITS Mid-Term Board Meeting in Copenhagen, arranged by STERF. The theme of the meeting was 'Shaping the future of ITS'. The meeting started with a one-day workshop with the keywords Communicating - Attracting – Expanding. Based on the ITS survey carried out during 2017-2018, the following important items were discussed: How to increase number of ITS members and number of ITRC 2021 participants; Activities between the ITS conferences; Improved communication; Future strategies for ITS publications; and Input to the ITRC 2021 programme. On day two, board members was treated to an all-day bus tour visiting the ITRC 2021 conference venue at Copenhagen University, including a tour in the university park, Frederiksborg castle garden, Furesø golf course and Brøndby stadium. The tour ended at DLF, where the day concluded with a fantastic BBQ dinner hosted by DLF.

CALL FOR PROPOSALS AND NEW PROJECTS

In its call for proposals in 2019, STERF decided to prioritise research and development within the four international thematic areas, according to the R&D programmes within each area: 'Integrated Pest Management', 'Sustainable water management', 'Winter stress management' and 'Multifunctional golf facilities and ecosystem services'. All STERF´s projects and activities should also directly support fulfil¬ment of eight of the 17 UN Sustainable Development Goals (SDGs) set out in Agenda 2030. STERF's activities have relevance to eight of these SDG categories:

- Sustainable use of natural resources and chemicals (SDGs 6, 11, 12, 14, 15).
- Ecosystem services and enhanced biodiversity (SDGs 14,15).
- Adapting to a changing climate and

minimising factors affecting climate change (SDG 13).
- Sustainable cities and communities (SDG 11).
- Healthy lives and well-being for people of all ages (SDG 3).
- Partnership for sustainable development and for new regulations (SDG 17).

STERF received 16 interesting and relevant project proposals within the four thematic areas. The total amount applied for from STERF was SEK 18 000 000, the suggested amount of matched funding was SEK 17 000 000 and the total amount sought for new projects was SEK 35 000 000. The advisory committee and its subgroups have done very good and important work in evaluating the proposals. The subgroup coordinators, Nilla Nilsdotter-Linde and Asbjörn Nyholt, were especially important for the evaluation process. In December 2019, the STERF board decided to prioritise five new projects for funding. See page 30.

Evaluators representing four SCANGREEN and three SCANTURF test sites gathered for a workshop at Landvik on 4 September 2019. Photo: Ove Hetland.

STERF's SCANGREEN programme operates in close collaboration with the SCANTURF programme on variety testing at fairway mowing height and in trials with football-type wear. On 4 September 2019, all evaluators in both programmes were gathered for a one-day course on visual assessment of turfgrass plots. The purpose for the meeting was to achieve a common understanding of turfgrass characters and to harmonise evaluations at the four SCANGREEN and three SCANTURF test sites across the Nordic countries.

FOURTH SCANGREEN TEST ROUND COMPLETED

Testing of turfgrass species and varieties for golf course putting greens has been one of STERF's core activities since 2003, i.e. almost since the foundation was established. The final observations in the fourth SCANGREEN test round were made in November 2018 and new variety lists were published at www.sterf.org and www.scanturf.org in 2019. A new feature in this round was the testing not only of pure varieties, but also of turfgrass mixtures and seed blends of particular interest for the Nordic countries. This extension of the project was initiated by Scandinavian greenkeepers, and the special articles presented at www.sterf.org may well have opened up new discussions about optimal seed mixtures for Nordic golf greens. Although the two programmes have different funding sources,

EUROPEAN TURFGRASS RESEARCH WORKSHOP

On 24 October, The R&A and FEGGA arranged a workshop to explore the possibilities of initiating some new nodes for turfgrass research. The event gathered some 30 representatives from golf federations, greenkeeper organisations and research institutes,

to discuss future structure, collaboration and funding of turfgrass research in Europe.

The R&A presented the Golf Course 2030 initiative, which now has programmes and actions for Great Britain, Ireland and Scandinavia. The current situation in central and southern Europe was also covered.

STERF presented the steps behind the formation of the foundation and factors for success. Two teams were formed, one for central Europe and one for southern Europe, to work on a 'Golf Course 2030' document for each region and to explore the possibilities of forming some kind of research initiative for the regions.

NEW ARTICLES AND FACT SHEETS

Articles on a broad variety of subjects have been published on the STERF website. For instance:

- Turfgrass species and varieties for Scandinavian putting greens.
- Summary of the SCANGREEN trials 2015-2018.
- Experiences with plastic protective covers of greens 2018-2019.
- Could we mix red fescue and creeping bent on Scandinavian greens?
- Avoid surface runoff of fungicides from golf greens.
- Societal benefits of multifunctional golf facilities.

And a fact sheet in the 'Winter Diseases' series entitled 'Biotic winter damage'.

HANDBOOK: OUTDOOR TEACHING

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. This inspirational handbook (in Swedish) describes experiences, ideas and practical activities that can be used in the everyday outdoor teaching at golf courses. The handbook is based on results from the project, "*Go outdoors and use the golf area in a pedagogical way – creativity, learning and health in the unlimited classroom*". The project was carried out at Motala Golf Club in collaboration with Motala Smedsby school, Sweden.

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 this vision, STERF focuses on:

- 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 sustainable use of natural resources and contributing to functioning ecosystems and providing recreation areas that are open to the public and to outdoor activities.

- 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. Activities within the focus

areas must contribute to the fulfilment of eight of the 17 Sustainable Development Goals (SDGs) set in the UN Agenda 2030.

- 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 collaborations 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 at: www.sterf.org

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

STERF´s activities shall contribute to the fulfilment of eight of the 17 SDGs set out in Agenda 2030. STERF has divided these into six categories:

1. Sustainable use of natural resources and chemicals (SDGs 6, 11, 12, 14, 15).
2. Ecosystem services and enhanced biodiversity (SDGs 14,15).
3. Adapting to a changing climate and minimising factors affecting climate change (SDG 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 categories and goals are closely related to the golf and turfgrass industry´s everyday challenges and to STERF's programmes, projects and dissemination efforts.

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 production of biological diversity, the conservation of natural and cultural envi¬ronments and the retention and expansion of ecosystem services, and to improving the conditions for good quality of life and health, e.g. through providing a broa¬der active outdoor life, experiences of nature and better climate adaptation in the everyday landscape.

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 details 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.

The challenges for the future of the turfgrass sector are many and diverse. Climate change impacts are exceeding the worst expectations. Strong restrictions on the use of chemicals and fertilisers and increasing pressure on natural resources (notably water, energy and land) are expected. Loss of ecosystem services and biodiversity in urban landscapes is accelerating. All this calls for more research and innovation for a sustainable future.

The United Nations' Sustainable Development Goals (SDGs) set out in Agenda 2030 will constitute the conference programme framework. We have identified eight SDGs related to the turfgrass industry: 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 13 (Climate action), SDG 14 (Life below water), SDG 15 (Life on land) and SDG 17 (Partnership for the goals).

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 turf¬grass managers and top industry delegates. This will give us the best opportunities to improve and extend important international interdisciplinary collaborations, which is the only viable strategy to overcome the current challenges and create a sustain¬able future. Already more than 250 titles and abstracts for oral and poster presentations have been submitted.

A new event at the 2021 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.

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

Please join us in 2021 for the latest cutting-edge research in the turfgrass industry and stay to enjoy all that the Copenhagen area has to offer!

Up-to-date information about ITRC 2021 can be found on www.itrc2021.org.

GOLF COURSE 2030 SCANDINAVIA

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 (SDG 17), where all stakeholders make efforts to cooperate and align their resources and efforts using United Nation's 2030 Agenda for Sustainable Development with its 17 Sustai-nable Development Goals (SDGs) as a steering document.

Golf Course 2030 was established by The Royal & Ancient (R&A) in 2018 to address the challenges posed by climate change, resource constraints and regulations on golf course conditioning and playability, and to provide best practice in sustainability to those working in golf course management.

As part of The R&A Golf Course 2030 initiative, Golf Course 2030 Scandinavia was created during 2019. This collaboration between STERF and The R&A considers ready-to-use research to be an important tool in helping to prevent negative impacts on the planet and recognises that new knowledge is neces¬sary to change the mind-set and attitudes of people world¬wide. The objective is to secure optimal golf course condition and playability for current and future generations by addressing challenges from, and exploiting opportunities presented by, the changing climate (SDG 13), resource constraints (SDGs 4, 6, 7, 11, 12 and 15) and regulations (SDGs 6 and 12). The activities must also contribute to enhancing and restoring biodiversity (SDGs 14 and 15) and to increasing the multi-functional capacity of golf courses and urban green spaces (SDGs 3, 11, 14 and 15).

Seven organisations, including STERF, will receive grant awards from The R&A for the next four years to run sustainability projects and develop solutions that can be shared with golf course managers, greenkeepers and organisations involved in the maintenance and conditioning of golf facilities around the world.

Information about The R&A initiative Golf Course 2030 can be found at: https://www.randa.org/en/sustainability/golfcourse2030

Information about Golf Course 2030 Scandinavia can be found at: www.sterf.org

SCANGREEN: TURFGRASS SPECIES, VARIETIES, SEED BLENDS AND MIXTURES FOR INTEGRATED PEST MANAGEMENT OF SCANDINAVIAN PUTTING GREENS, 2015-2018

PROJECT PERIOD: JANUARY 2015 – APRIL 2019

FUNDING (kSEK)

	2015	2016	2017	2018	2019	Total
STERF	481	560	563	352	217	2173
Other	243	142	80	80	126	671
Total	**724**	**702**	**643**	**432**	**343**	**2844**

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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 tradtional 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 in turfgrass breeding for northern environments.

TALKS AT CONFERENCES MEETINGS, SEMINARS, FIELD DAYS, ETC IN 2019

31 Jan.: Norwegian Greenkeeper Association Seminar 'Det gresselige året 2018', Trondheim, Norway. Presentation: 'Arter og sorter'. T.S. Aamlid.
14 Feb.: Norwegian Greenkeeper Association Seminar 'Det gresselige året 2018', Stavanger, Norway. Presentation: 'Arter og sorter'. T.S. Aamlid.
15 Feb.: Norwegian Greenkeeper Association Seminar 'Det gresselige året 2018', Bergen, Norway. Presentation: 'Arter og sorter'. T.S. Aamlid.
20 April: Norwegian Greenkeeper Association Seminar 'Det gresselige året 2018', Landvik, Norway. Presentation: 'Arter og sorter'. T.S. Aamlid.
19 June: NIBIO International Turfgrass Field Day. Presentation: 'Ongoing and recently finished research projects'. T.S. Aamlid.

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2020

Thirty-four pure varieties and nine seed blends/mixtures were evaluated on USGA greens at NIBIO Apelsvoll and Reykjavik GC in the northern zone, and NIBIO Landvik and Sydsjælland GC in the southern climate zone of Scandinavia. The trials were cut to 3-5 mm 3 times per wk and managed according to good greenkeeping practice. Plots were evaluated monthly and species, varieties within species and seed blends/mixtures were ranked, first for decreasing turf quality, second for increasing winter damage and third for increasing susceptibility to diseases.

The evaluation showed that the following varieties, in the order listed, can be added to STERF's list of recommended varieties for greens:

	Northern zone	**Southern zone**
Festuca rubra ssp. *commutata* Control variety: Musica	Humboldt, Barchip	None
Festuca rubra ssp. *litoralis* Control variety: Cezanne	None	None
Agrostis capillaris Control variety: Jorvik	Heritage	Rhinegold, Heritage
Agrostis stolonifera Control variety: Independence	Luminary, Riptide, Ignite	Flagstick, Luminary, Riptide, Pure Distinction
Lolium perenne Control variety: Chardin	Clementine	Clementine
Poa trivialis Control variety: Dark Horse	Sabrena 1	Qasar, Sabrena 1

Other findings in the project were as follows:

- *Poa annua* spp. *reptans* 'Two Put' was tested, but not recommended.
- *Poa pratensis* tolerated cuttng to 5 mm but produced coarse putting surfaces. It is not an alternative for greens except at northern sites with extreme winter conditions.
- Evaluation of seed blends of *F.rubra* ssp. *commutata* 'Musica' and *F.rubra* ssp. *litoralis* 'Cezanne' showed that the optimal seed weight ratio of the two subspecies for fescue greens is 75/25 in the northern zone and 50/50 in the southern zone.
- Evaluation of *L.perenne, P.trivialis* and *P.annua* ('Two Put') as nurse grasses to speed up (re)establishment of *A.stolonifera* after winter-kill resulted in a recommendation of *P.trivialis* + *A. stolonifera* in the northern zone. Use of *P.annua* 'Two Put' as a nurse grass was not recommended in either zone. Use of *L.perenne* should also be avoided except in the most winter-tough areas where there is no doubt that it wil die during winter.
- Evaluation of mixtures of *F.rubra* with *A.stolonifera* or *A.canina* in comparison with the more traditional mixture of *F.rubra* and *A.capillaris* showed *F.rubra* + *A.stolonifera* to have certain advantages, such as less disease, less *Poa annua* invasion and less height growth. This mixture warrants further investigation on Nordic golf courses.

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

SCANGREEN: TURFGRASS SPECIES AND VARIETIES FOR INTEGRATED PEST MANAGEMENT OF SCANDINAVIAN PUTTING GREENS, 2019-2022

PROJECT PERIOD: 2019 - 2022

FUNDING (kSEK)

	2019	2020	2021	2022	Total
STERF	500	500	500	500[1]	2000
Variety entrance fees	153	0	0	153	306
Other sources	0	0	0	44	44
TOTAL	653	500	500	697	2350

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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Michelle DaCosta, University of Massachusetts, USA.
Eric Watkins, University of Minnesota, USA.
Karin Juul Hesselsøe, Trygve S. Aamlid, Tatsiana Espevig, Trond Petterson, Wendy Waalen, Jan Tangsveen, NIBIO, Norway

PROJECT OBJECTIVES

- To screen in the field and clarify which varieties of *Agrostis, Festuca, Poa* and *Lolium* are most winter-hardy, most stress-tolerant and most disease-resistant on putting greens at four experimental sites representing the two major climate zones in the Nordic countries.
- 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 into turfgrass breeding for northern environments.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2019

19 June: NIBIO Int. Turfgrass Field Day. 'Ongoing and recently finished research projects'. T.S. Aamlid.
21 Aug.: Visit by high-school students from Grimstad to SCANGREEN trial at Landvik.
22 Aug.: Visit by students from Norwegian University of Life Science (NMBU) to SCANGREEN trial at Landvik.
4 Sept.: Meeting (workshop) for evaluators in SCANGREEN/SCANTURF (and GEVES) turfgrass variety trials at NIBIO Landvik.
17 Sept.: Field day for Icelandic greenkeepers in SCANGREEN trial at Reykjavik GC.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2020

Testing of new varieties is key to improving turfgrass quality. Breeders are focusing on disease resistance and tolerance to abiotic stresses. STERF programmes for IPM and 'Winter Stress Management' recommend variety evaluation as one of STERF's most important tasks. Since 2003, STERF has tested species and varieties under realistic green conditions. Results are updated annually at www.scanturf.org and www.sterf.org. SCANGREEN 2019-2022 is being carried out at NIBIO Apelsvoll Norway (62°N) and Reykjavik GC Iceland (64°N) in the northern zone, and NIBIO Landvik Norway (58°N) and Sydsjælland GC Denmark (56°N) in the southern zone. There are similar trials in Massachusetts and Minnesota, USA.

Ongoing trials are testing 30 new varieties and 24 controls representing 8 species. Seed mixtures are also included, as they showed good results in the southern zone in the previous SCANGREEN test round (2015-2018). They are thus included at NIBIO Landvik, Sydsjælland GC and in the American trials. In this test round, seed mixtures of 85% *Festuca rubra* + 15% *Agrostis stolonifera*, 85% *Festuca rubra* + 15% *Agrostis capillaris* and 85%

Field day at the SCANGREEN trial in Iceland on 17 September 2019. Photo: Bjarni Hannesson.

Festuca rubra + 7.5% *Agrostis stolonifera* + 7.5% *Agrostis capillaris* will be studied. The SCANGREEN trials were seeded 18 June (NIBIO Apelsvoll), 1-2 July (NIBIO Landvik), 6-10 July (Reykjavik), 15 August (Sydsjælland), 1 September (Minnesota) and 18 September (Massachusetts). Each trial has a three-replicate split-plot design, with species on main plots and varieties on subplots. The sowing rate was 0.7, 3.0, 1.5 and 4.0 kg 100 m^{-2} for *Agrostis, Festuca, Poa* and *Lolium*, respectively. Establishment was very uniform at Apelsvoll, Korpa and Landvik, except for one variety of *Festuca rubra* which was resown with new seeds at all sites. For unknown reasons, creeping bentgrass established very slowly at Sydsjælland. The American trials were late-sown but established well and fast. All trials were assessed monthly for visual turf quality and other quality parameters. The first ranking of varieties will be presented in 2020 after one year of assessment.

Preliminary results from 2019 showed that *Poa pratensis* established more slowly than other species in both climate zones. At assessments in October, *Agrostis canina* and *A. capillaris* had more disease symptoms (*Microdochium nivale*) than the other species. At the latest disease assessment at NIBIO Apelsvoll on 1 November, all varieties of *Festuca rubra* also showed microdochium symptoms.

SCANGREEN trial at Troll Turfgrass Research Facility, University of Massachusetts. Photo taken 5 October, 2019, approximately 2.5 weeks after sowing. Photo: Michelle DaCosta

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	1986
Other sources	149	177	177	173	676
TOTAL	674	728	629	631	2662

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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Tore Krogstad, Norwegian University of Life Sciences (NMBU)
Micah Woods, Asian Turfgrass Center, Bangkok, Thailand
Yajun Chen, Northeast Agricultural University, Harbin, China
Kim Sintorn, Swedish Golf Federation
Niels Dokkuma, Netherlands Golf Federation
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:

- 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 (WP1).
- 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 (WP2).
- Document effects on turfgrass quality and fertiliser costs of switching from conventional SLAN-based fertilisation to MLSN- or SPF-based fertilisation on golf courses representing a range of climate zones, soil types and turfgrass species (WP3).

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2019

25 March: Project and reference group meeting, Skype.
19 June: Field day at NIBIO Landvik. Powerpoint presentation: 'Sustainable P nutrition of turf – the SUSPHOS project'. Anne F. Øgaard and Trygve Aamlid.
18 Nov.: Conference held by the GVD in Hamburg 18 of November. Lecture: 'Fertilisation on northern golf courses: Challenges, concepts and recent achievements'. Trygve Aamlid.
25-26 Nov.: Seminars held by the Swedish Golf Association in Bärseback and Gothenburg. Lecture: 'Sustainable phosphorus nutrition of turf – the SUSPHOS project'. Karin Juul Hesselsøe.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2020

Phosphorus has large environmental impacts and is the plant nutrient of which global reserves are most limited.

- WP1 focuses on turfgrass grow-in; i.e. the developmental phase that is usually considered to require most P, especially at low soil temperature. In spring 2017 and 2018,

WP2 at the Ås phytotrone in spring 2019. Photo: Anne F. Øgaard.

turfgrass coverage, clipping yield, root development and P uptake at constant nitrogen (N), but increasing P rate, 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 the Ås phytotrone at 7, 12 and 17 °C. While control cylinders without P fell significantly behind, development of turfgrass coverage after seeding did not respond to a fertiliser P/N ratio > 0.12 (STERF recommendation for established turf) at any temperature. There was no indication that more P is required for root than for shoot growth; in fact, root/top ratio decreased with increasing P rate.

- WP2 investigates the effect of increasing temperature on green-up and early spring growth of established turf. Two time-replicates were conducted in the Ås phytotron in spring 2017 and spring 2019 (Photo 1). For this, 12 cm deep cylinders were taken shortly after snowmelt/soil thaw from a 4-6 year old creeping bentgrass green (pH: 5.6; Mehlich 3: 34 mg P/kg) and transferred to the phytotron at 7, 12 and 17 °C. The pots were fertilised with increasing P as either granular or foliar fertiliser (same amount of P) during the first 5 weeks. Colour/green-up and clipping yield showed a strong effect of temperature, but a small effect of increasing P rate. These results indicate that low soil temperature cannot be compensated for by increasing P inputs. The lack of visual effect of P in this experiment was in agreement with MLSN, as the initial Mehlich(3) P-level was 34 mg P/kg soil (the MLSN-guideline is 18). Foliar P input showed no advantage over granular P input at any temperature.

Soil sampling in WP3 at Jingshan Lake Golf Club, Beijing, China.

- WP3 field trials were started in China, Netherlands, Sweden and Norway in 2017 and supplemented with a new trial in Germany in 2018. The trials compare three different P fertilisation concepts: MLSN, SLAN (old American standard) and Scandinavian Precision Fertilisation (SPF). The results for turfgrass quality 2017-2019 showed few significant effects, but tendencies for more moss without P fertiliser at Princenbosch in the Netherlands, more Poa annua with increasing P rate in Falkenberg, Sweden, and slightly deeper roots without P in Dütetal, Germany.

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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Jo Anne Crouch, Mycology & Nematology Genetic Diversity and Biology Lab, US Department of Agriculture, USA
Kate Entwistle, The Turf Disease Centre, UK
Roskilde GC and **Helsingør GC,** Denmark, **Vallda GC** and **Kävlinge GC,** Sweden, **Drammen GC,** Norway

PROJECT OBJECTIVES

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

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2019

6 March: Gardermoen (Norway). Contact meeting between STERF and the national authorities about pesticide legislation and IPM on golf courses and other turfgrass areas, and new pests and diseases in the Nordic countries related to climate change. Tatsiana Espevig.
28 March: Landvik (Norway), Anleggsseminar/ERFA-treff NGF, GAF og NGA. Risiko for myntflekk i Norge. Tatsiana Espevig.
19 June: Landvik (Norway), NIBIO International Field Day 2019. Cultural control of dollar spot. Karin Normann.
New diseases in Scandinavia with emphasis on dollar spot. Tatsiana Espevig.
11 Sept.: St.-Petersburg (Russia), IV All-Russian Plant Protection Congress, 'Прикатывание и азотное удобрение как приемы интегрированной защиты от долларовой пятнистости и розовой снежной плесени на гольф гринах в Скандинавии' (in Russian). Marina Usoltseva.
14 Nov.: Slettestrand (Denmark), Uge 46, DGA´s årsmøde 2019. Kend din fjende, Svampesygdommen dollar spot. Karin Normann.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2020

Dollar spot (DS) damage in Scandinavia varies, but can give 70-80% dead turf on greens and fairways. This project aims to reduce spread of DS in the Nordic countries and develop non-chemical control measures, in three work packages:

WP1. In summer 2017, on golf greens with red fescue (Vallda GC) and foregreens with red fescue, colonial bentgrass and annual bluegrass (Roskilde GC), rolling 2 times/wk reduced DS by 61% and 37% and rolling 4 times/wk reduced DS by 95% and 54%, respectively. In 2018 (very dry summer), DS did not develop on these greens. At Kävlinge GC, N had no effect in 2017 on a creeping bentgrass golf green. In 2018, increasing annual N from 150

Photo 1. *Kristine Sundsdal doing assesments under in vitro screening of turfgrass species and cultivars for resistance to dollar spot isolates of different origin at Landvik, 20 March 2019. Photo: T. Espevig.*

Photo 2. *Marina Usoltseva presenting results from WP1 on rolling and nitrogen fertilizer as methods of integrated management of dollar spot on golf greens in Scandinavia at IV All-Russian Plant Protection Congress St. Petersburg, Russia, 11 September 2019. Photo: T. Espevig.*

to 240 kg ha^{-1} reduced DS by 24% (from 100 to 76 infection centres/m^2), but increased microdochium patch incidence to 30% in March 2019 (14% on plots which received 150 kg N ha^{-1}). Thus, no firm conclusions can be drawn about using high N rates to fight dollar spot on golf greens with microdochium patch in winter.

WP2. In autumn 2017, all Scandinavian isolates of *Clarireedia* spp. had optimal temperature for growth (OGT) of 24°C, while USA isolates had 16°C and 24°C as OGT. 0°C and 40°C reduced growth of all isolates by ~100%. After 3 wk at 40°C, all isolates died. After 3 wk at 0°C, growth of Scandinavian isolates and British isolates was reduced by 7-36% and 23-38%, respectively, with no reduction in USA and Norwegian isolates. This indicates potential of some isolates for winter survival.

WP3. In spring 2018 and 2019, 20 common turfgrass species and cultivars were tested for resistance to 10 different isolates from Norway, Denmark, Sweden, UK and USA in the lab at NIBIO Landvik (Photo 1). The most aggressive isolates to date are one *Clariredia* sp. from UK and two from USA (*C. jacksonii* and *C. monteithiana*). The weakest isolate is *C. jacksonii* from Norway. *C. jacksonii* isolates from USA appear more aggressive than those from Sweden and Norway. However, based on the data, we cannot conclude that aggressiveness in *Clarireedia* spp. is species-specific, as that of *C. jacksonii* isolates varied between turfgrass species and varieties (cultivars of perennial ryegrass and slender creeping red fescue were generally most resistant).

There was great variation among cultivars of chewings fescue, colonial bentgrass and creeping bentgrass. On average for the five Nordic DS isolates, velvet bentgrass and Kentucky bluegrass had significantly higher resistance than creeping bentgrass and annual bluegrass.

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

PROJECT PERIOD: MAY 2016 - DECEMBER 2019

FUNDING (kSEK)

	2016	2017	2018	2019	TOTAL
STERF	303	294	161		758
Other sources	518	422	259	94	1292
TOTAL	821	716	421	94	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 2019

7 March : NIBIO/STERF seminar 'Sustainable pesticide use' Oslo Airport Gardermoen. Presentation: 'Risks for surface runoff and leaching of fungicides from golf greens varying in rootzone composition and amount of thatch'. T.S. Aamlid, M. Almvik.
19 June: NIBIO International Turfgrass Field Day, Landvik. Presentation: 'Take home messages from the STERF project 'Risks for surface runoff and leaching of fungicides from golf greens varying in rootzone composition and amount of thatch". S. Aamlid, M. Almvik.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2020

According to IPM principles, pesticides should be used only when other measures do not provide sufficient control of the harmful organism. One situation where adequate control is difficult is when golf courses are infected with Microdochium nivale. In such cases, it is important to use efficient fungicides with few environmental impacts.
This project focused on leaching and surface runoff of fungicides and their metabolites from greens after application in late autumn. A field trial was conducted during winter 2016-17 and 2017-18 at Landvik, Norway. The plots had 5% slope and a turf cover of creeping bentgrass. The trial had four blocks and two factors, each with two levels:

Factor 1: Organic amendment in the sand-based (USGA) rootzone:	Factor 2: Turf age / thatch thickness
1.Sphagnum peat, loss on ignition 1.2 % OM, pH 5.5	A. Green seeded in May 2016
2.Garden compost, loss on ignition 1.0 % OM, pH 6.5	B. Green established in May 2016 using sand-based sod, (25 mm thatch)

In both years, Delaro (prothioconazole+trifloxystrobin) and Signum (boscalid+ pyraclostrobin) were sprayed in late October and Medallion (fludioxonil) in early November.

Applications were followed by collection of leachate and runoff until snowmelt/soil thaw around 1 April.

During winter 2016-17, the mostly unfrozen greens had high infiltration rates: 91% of 601 mm precipitation from the first fungicide application to the last sampling was collected as drainage water and only 3 % as runoff. Winter 2017-18 had 948 mm precipitation, and freeze/thaw cycles on frozen greens resulted in ice cover. In this case, 55 and 33 % of precipitation was collected as drainage water and surface runoff, respectively.

Fungicide detections in drainage water were mostly very low; the Norwegian Environmental Risk Level (ERL) was exceeded slightly only for prothioconazole-desthio. In contrast, the ERL for many fungicides and/or their metabolites was exceeded up to 1000 times in surface water, notably in 2017-18. The highest concentrations were found during the first week after spraying and after snowmelt/soil thaw. Because of the thatch layer, concentrations in runoff were usually higher, but concentrations in drainage lower, on sodded than on seeded greens.

The project highlights the importance of keeping wide buffer zones to open water and avoiding surface runoff by maintaining high infiltration rates. This was communicated to more than 70 industry representatives at the project's final international seminar in Oslo on 7 March 2019.

Collection of surface water from frozen turf. Photo: Trygve S. Aamlid.

FROM DENSE SWARDS TO BIODIVERSE ROUGHS

PROJECT PERIOD: JUNE 2017 - DECEMBER 2020

FUNDING (kSEK)

	2017	2018	2019	2020	TOTAL
STERF	175	200	200	200	775
Other sources	122	152	89	0	363
TOTAL	297	352	289	200	1138

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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Ellen Svalheim and **Eveliina Kalloniemi,** NIBIO Department of Landscape and Biodiversity

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;

- Study specific effects of sward cutting frequency, biomass removal and soil carbon addition on rough productivity and establishment of seeded target species.
- Critically test the use of the hemiparasitic plant Rhinanthus minor (yellow rattle) as a method to diversify roughs.
- Assess whether cutting combined with temporal nitrogen immobilisation by incorporating carbon sources in soil improves establishment of seeded species relative to cutting only.
- Quantify the effects of diversification measures on pollinator visiting rates and composition of the pollinator community, and relate these to the provision of resources for pollinators.
- Evaluate whether management treatments have filtering effects on sown species depending on their specific germination and establishment traits.
- Explore the effect of management regimes on the playability of roughs.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2019

6 May: Nordic pollinator workshop held by 'La Humla Suse', Vikersund, Norway. Presentation of project: 'From dense wards to biodiverse roughs'. Trygve Aamlid.
20 June: Norsk Blomsterengdag/Norwegian Flowering Meadow Day, Grimstad, Norway.
- Presentation of projects on diversification of grassland. Hans M. Hanslin, Trygve Aamlid.
- Preliminary results on vegetation development. Harald Bratli, Ellen Svalheim.
- Preliminary results pollinator occurrence. Geir Knudsen, Eivind Krey Nitter.
- Demonstration of field plots of the project 'Fra grasmark til blomstereng' at NIBIO Landvik. Ellen Svalheim.

12 Aug.: Arendalsuka, Arendal, Norway. Lecture: 'Fra plen til blomstereng'. Trygve Aamlid.
20 Sept.: STIKK Pollinator Conference, Bergen, Norway. Invited presentation: 'Species-rich meadows are important for pollinators'. Trygve Aamlid.
3 Oct.: Seminar on urban ecology, Naturvernforbundet Stavanger, Norway. Invited presentation: 'How can urban green infrastructure contribute to ecological integrity and climate adaptation?'. Hans Martin Hanslin.
5 Nov.: Combined project meeting and reference group meeting 'From dense swards to biodiverse roughs/Fra grasmark til blomstereng'. A total of seven presentations.
7 Nov.: Naturviterforum 2019, Oslo, Norway and web. Invited presentation: 'Nature based solutions and urban biodiversity'. Hans Martin Hanslin.
14 Nov.: SWECO forum, Stavanger, Norway. Invited presentation: 'How can urban green infrastructure contribute to ecological integrity and climate adaptation?'. Hans Martin Hanslin.
19 Nov.: NIBIO Landscape Seminar, Lillestrøm, Norway. Invited presentation: 'The restoration of species-rich meadows'. Trygve Aamlid.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2020

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 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 parallell with six similar plots in agricultural and urban settings in 2017. Six treatment combinations were started 2017 and August 2018 where 18 wildflower species (10 at Sigtuna, 21 at Herning) common in mesic to dry grasslands were seeded. 2018 experimental plots were also established at Munich GC with a similar design.

Baseline data on vegetation, pollinators and soil characteristics were collected during 2017 and 2018. A reasonable range of bumblebee and solidary bee species was recorded at the experimental locations, with few individuals and few differences between plots within location, but some differences between locations and considerable variation between years. 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.

A review of results after the 2019 season showed that two cuts a year, especially with hay removal, reduced grass biomass at some, but not all, locations. Sawdust addition to bind nitrogen and seeding of the hemiparasitic plant *Rhinanthus minor* have so far had no major effect on grass biomass. Differences between locations are considerable, however, and the reasons for these differences need to be investigated. The establishment of *Rhinanthus* varied between locations.

Seeded species established during autumn and spring, with only small differences in establishment between treatments. At Oslo GK, the number of species and the increase in the number of species are still at the lower of the range observed at other urban grassland and agricultural sites. The grass cover at Oslo GK is still dense and likely to be the cause of this. Results were better in the drier parts of the plot. Establishment of seeded species at Sigtuna was low, perhaps due to high soil fertility. Few of the seeded species flowered in the first year, so treatments have so far had no impact on pollinator occurrence. We expect pollinator responses to treatments to differ from 2020 onwards.

Hay removal, Oslo GC, 5 September 2019. Photo: Albert Holmgeirsson.

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 by interviews and open questions in a phenomenographical study over time 2017-2019

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2019

March: Motala Golf Club, Golfbanans multifunktionella användning med skolan som målgrupp.
-'Resultat från projektets avslutade lärarintervjuer kring uppfattningar av undervisning och lärande i utomhusmiljön, pedagogisk markanvändning på en golfarena'. Anders Szczepanski.
- 'Smedsbyskolans erfarenheter från utomhuspedagogisk kompetensutveckling/ undervisningsupplägg, bild/filmdokumentation (STERF) samt internationell spridning utifrån projektet'. Teachers who participated in the project at Smedsby skola.
- 'Exempel på utomhusundervisningsupplägg i anslutning till golfanläggningens lärmiljöer utifrån den utomhuspedagogiska ryggsäckens innehåll'. Britta Brügge, Anders Szczepanski.
Febr.-April: Swedish Golf Federation events at 23 sites. Swedish local municipalities and golf clubs. Presentation: 'Golf course as an outdoor classroom'. Johan Kannerberg.
April: Swedish sport federation, Stockholm. Presentation: 'Multifunctional sport facilities'. Johan Kannerberg.
Aug.: Jönköping University National Conference in Outdoor Education and Ecosystem duties. Presentation of the project. Anders Szczepanski.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2020

This project is part of the STERF programme 'Multifunctional use of golf facilities and ecosystem services' focusing the golf course as a pedagogic tool. Golf courses could improve teaching by offering a variety of green surfaces for teaching outdoors.

One pilot school with 15 teachers has been part of the outdoor education intervention and training at the golf area in Motala, Sweden. The outdoor course has developed learning tools and implemented knowledge and skills connected to the Swedish curriculum in subjects like geography, languages, mathematics, technology, ecology and biology in the golf area. The activity and reflection have been documented by teachers in a school blog. The primary school in Motala is using teaching material from the outdoor course.

As a teacher and researcher, AS has made a first study on teachers' experience in the area of outdoor education with open questions. The teachers say that they can see the advantage of the outdoor learning situation to support indoor learning in the classroom. However, it takes time for some teachers and the pupils to understand that the outdoor environment is an outdoor learning environment. The phenomenographical study with interviews was

followed up by research questions after the outdoor education intervention course finished in June 2018.

The pedagogic model and rucksack that we have developed, with items like magnifiers, some security equipment and hand-out material for outdoor learning in water, forest and other places close to the golf area, is available today as a project outcome. The golf club contributed knowledge about the golf area on occasions when school classes visited with their teachers in autumn 2019, covering many subjects in the Swedish curriculum (Lgr11).

There is also a video production released by STERF in both a Swedish and UK version. The learning activities are recorded together with teachers when we meet for reflection about the outdoor didactic questions: Where, when, what, how and why.

The teaching material is also linked to two key books on the subject that we have written: 'Utomhuspedagogik som kunskapskälla – närmiljö blir lärmiljö', Studentlitteratur, Lund (2007 anthology) and 'Friluftlivets Pedagogik – En miljö och utomhus pedagogik för kunskap, känsla och livskvalitet', Liber Läromdel (4:e upplagan).

Outdoor teaching at Motala GC. Photo: Maria Strandberg

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

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PROJECT OBJECTIVES

- The main idea in this project is invite the starling (*Sturnus vulgaris*) to settle on golf courses. It preys upon larvae of insects such as cranefly on lawns and fields. Thus it may help the greenkeeper by performing biological control to remove larvae from the golf course.
- This pilot project aims to study which parts of the golf course and surrounding habitat are most used by foraging adult starlings during the breeding period.
- High-precision GPS-loggers will be fitted to around five starlings, to learn which habitat they prefer and at what distances from the nest site they forage.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2019

- The project was presented in the field to a large group of local nature enthusiast and golf players on a guided bird trip 'Birds at golf courses' by the greenkeeper, the project leader and a group of volunteers from DOF Storstrøm.
- The fieldwork attracted the interest of many golf players and resulted in many fruitful discussions about wildlife at the golf course.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2020

The project "Invite the starling to help the greenkeeper" was initiated as a collaborative work between Sydsjællands Golfklub, Dansk Golf Union and DOF (Dansk Ornitologisk Forening)-Birdlife Denmark in 2018. We prepared and erected ~100 nest boxes, and placed them all over the golf course. All were numbered and georeferenced via the Turfgrass app. We recorded all breeding birds and ringed juvenile starlings and found that 45 successful clutches in 2019 produced on average 5.0 nestlings per clutch. This proves that the golf course provides conditions that are sufficient for the starling to produce successful clutches, with an estimated more than 100 kg prey removed from the grass.

We found marked differences between the number of foraging starling in different parts of the golf course and its surroundings where they foraged during the season. They foraged mainly on the fairway and often also in the semi-rough (there is no rough on this golf course), but rarely on the greens.

In 2019, Sydsjællands Golf Club hosted a successful guided bird trip "Birds at golf courses" for local people on one evening in May. This was led by ornithologists from the local branch of DOF-Birdlife Denmark (DOF Storstrøm). Besides birdwatching, the event gave the opportunity for interaction between members of the two organisations, to talk about the new initiatives at the golf course.

In order to study invertebrates in the turf layer, an additional project was included: "What do starlings eat at the golf course?" To see what the starlings preyed upon, samples of the turf were extracted in transects from the green to the semi-rough. A large number of different invertebrates were found, but only earthworms and cranefly larvae were present in sufficient biomass to be of importance for starlings.

The number of prey items decreased during the breeding season, but the items present increased in size at the same time, so the biomass for starlings increased. The number of earthworms per m2 of the fairway was more than twice that in the semi-rough, with none in the greens. The number of larvae was lower than expected in 2019. Despite no comparable data, the problem with larvae was assessed to have been reduced significantly due to the help from the starlings.

CARBON PAR: ESTIMATING CARBON STATUS OF LAND USED BY ICELANDIC GOLF COURSES AND MEASURING CARBON SEQUESTRATION AND SOIL CONSERVATION POTENTIAL OF TURFGRASS ON GOLF FAIRWAYS AND MOWN ROUGHS

PROJECT PERIOD: JANUARY 2020 - DECEMBER 2022

FUNDING (kSEK)

	2020	2021	2022	Total
STERF	300	300	300	900
Other sources	270	240	240	750
TOTAL	570	540	540	1650

PRINCIPAL INVESTIGATOR / CONTACT PERSON
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CO-APPLICANTS
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Bjarni Hannesson, Kristján Rögnvaldsson, Eureka Golf.

PROJECT SUMMARY
Golf course development in some cases includes wetland drainage or use of pre-existing wetlands. Carbon dioxide losses from golf courses on organic soils can thus be high, while courses on mineral soil can store carbon (C). Research indicates that mown grass can store more C than unmown and that more frequent mowing, made possible with robots, can store even more. The C status of land used by Icelandic golf courses will be measured to set a benchmark and thus facilitate future improvement of golf courses in the area.

Recommendations for similar tests elsewhere in Scandinavia will be provided. Carbon sequestration and soil conservation potential of turfgrass on golf fairways and mown roughs will also be measured at a trial area in Thorlákshöfn, Iceland, mown by electric robots using wind and solar energy. Results should indicate the value of golf fairways and mown roughs as a re-vegetation and carbon sequestration method in combating climate change.

PROJECT OBJECTIVES
The project aims to answer the following research questions:
a) What is the CO_2 loss and carbon storage from land use of cultivated and managed areas on Icelandic golf courses, in total and by facility?
b) Can the estimation process be streamlined beyond the project description? If yes, how?
c) What is required in terms of funding, time and other resources to produce similar estimates for other Scandinavian countries?
d) Are there marked trends revealing or suggesting how golf facilities can, in general, easily improve their C status through land use, without negatively influencing the playing experience? If yes, what are they?
e) How much carbon can golf fairways and roughs store annually, by species and species composition, in Thorlákssкógar in Thorlákshöfn, an area deemed in need of stabilisation/ re-vegetation by the Soil Conservation Service of Iceland (SCSI), when mown at least daily with electric robotic mowers powered by wind and solar energy?
f) What is the financial cost and loss or gain in CO_2 for each area unit of land re-vegetated in Thorlákssкógar, by species and species composition, through the establishment and management of golf fairways and mown roughs using said methods?
g) What is the financial cost and area required for each ton of sequestered C at Thorlákssкógar using the methods described in item (f)?
h) What is the actual result in terms of stored C and re-vegetation compared with simulated results of efforts that SCSI would otherwise have provided in the same area?

Sigló Golf Course in Siglufjörður, North Iceland. The course is partially set in an old gravel quarry (where all the water is in the middle of the picture). Photo: Edwin Roald.

ICE-BREAKER: REDUCING THE AGRONOMIC AND ECONOMIC IMPACT OF ICE DAMAGE ON GOLF COURSES AND OTHER GRASSLANDS

PROJECT PERIOD: JANUARY 2020 - DECEMBER 2023

FUNDING (kSEK)

	2020	2021	2022	2023	Total
STERF	314	549	397	379	1639
Other sources	675	1135	1135	675	3620
Research Council of Norway	920	1674	1465	785	4844
Total	1909	3358	2997	1839	10103

PRINCIPAL INVESTIGATOR / CONTACT PERSON
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CO-APPLICANTS
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Carl Johan Lönnberg, Swedish Golf Federation.
Michelle DaCosta, University of Massachusetts.
Eric Watkins, University of Minnesota.

PROJECT SUMMARY
Winter damage due to ice encasement (IE), melt water and subsequent problems with re-establishment is a recurring problem on Nordic golf courses. This project will prepare turfgrass managers for unstable winters through improved strategies for winter management and re-establishment in spring. The project consists of six work packages: (WP1) Development of a laboratory method to screen turfgrass varieties for Lethal Duration of IE for 50% of plants (LDIE50). (WP2&WP3) Field trials in which wireless temperature and CO_2/O_2 sensors and/or impermeable plastic sheets are installed before ice formation, and snow and ice are removed at various times during winter. (WP4) Laboratory and field trials focusing on the risk of formation of reactive oxygen species (ROS) after ice melt/removal. (WP5) Field and laboratory trials focusing on identification and eradication of toxic substances formed under ice. (WP6) Field trials testing bentgrass cultivars, seed treatments and sowing machines for faster re-establishment after winter kill.

PROJECT OBJECTIVES
Primary objective - Better understanding and improved strategies to prevent and repair damage caused by prolonged ice cover and meltwater on golf courses and other grasslands.

Secondary objectives
a) Develop an efficient laboratory method for screening grass cultivars and breeding lines, including a first evaluation of 30 new and/or commonly used cultivars of creeping bentgrass (*Agrostis stolonifera*), red fescue (*Festuca rubra*), colonial bentgrass (*A. capillaris*) and velvet bentgrass (*A. canina*) for LDIE50.

b) Develop technology to predict ice damage and a decision-support system for when to remove the ice on golf greens by using wireless sensors to monitor temperature and O_2/CO_2 concentrations under ice.
c) Determine whether an impermeable plastic barrier between grass and ice, with aeration pipes under the plastic, can protect grasslands from damage from long-lasting ice encasement and meltwater.
d) Elucidate whether snow and ice removal from greens at different times during winter can reduce ice and water damage.
e) Analyse to the extent to which impaired photosynthesis due to the formation of ROS upon re-exposure to aerobic conditions after ice melt or ice removal contributes to ice damage, and whether such damage can be alleviated using shade cloths.
f) Identify toxic metabolites in the thatch/mat of young and old greens of various species and determine to what extent these inhibitors delay germination and/or seedling growth when reseeding golf greens after ice encasement.
g) Compare, in large-scale trials, various sowing machines/methods and explore the advantage of using primed seed of slowly or quickly germinating creeping bentgrass cultivars when reseeding greens that have been killed by ice encasement.

Photo: Agnar Kvalbein

IMPROVE NATURE AROUND GOLF COURSES FOR MORE BIRDS

PROJECT PERIOD: JANUARY 2020 - DECEMBER 2022

FUNDING (kSEK)

	2020	2021	2022	Total
STERF	284	262	262	808
DOF	601	601	600	1802
Other sources	128	128	128	384
TOTAL	1013	991	990	2994

PRINCIPAL INVESTIGATOR / CONTACT PERSON

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PROJECT SUMMARY

Which birds occur around Danish and Scandinavian golf courses and how do we improve their living conditions through involving golfers and birdwatchers? A close collaboration between DOF/BirdLife Denmark, DGU and the other Scandinavian golf associations has been forged to investigate this, and thousands of volunteers and members are spearheading implementation of the activities around the golf clubs. The main activities are bird monitoring, producing a ready-to-use guide with bird-friendly management initiatives targeting greenkeepers, networking between golfers and birdwatchers through guided birdwatching trips, presentations and setting up nest boxes. The effect of these initiatives will be monitored by DOF/BirdLife Denmark.

PROJECT OBJECTIVES

a) Gather sufficient data to find out what bird species, and how many individuals, are found on the Danish and Southern Swedish golf courses, with the focus on species breeding and feeding there.
b) Improve the living conditions for birds and the overall nature value on and around golf courses, without compromising the main aim of playing golf in the areas.
c) Inspire golfers in the Nordic countries to show more interest in birds and nature, and make birdwatchers in the Nordic countries more aware that golf courses have the potential to be a new arena for birdwatching, resulting in closer collaboration and more overlapping interests between these two groups of stakeholders.

A small bog at Hørsholm Golf Course north of Copenhagen. Photo: Thomas Vikstrøm

INTEGRATED MANAGEMENT OF IMPORTANT TURFGRASS DISEASES AND INSECT PESTS ON EUROPEAN GOLF COURSES

PROJECT PERIOD: FEBRUARY 2020 - JULY 2023

FUNDING (kSEK)

	2020	2021	2022	2023	Total
STERF	386	322	288	178	1 174
The R&A	386	322	288	178	1 174
Other sources	698	698	582	110	2088
Total	1470	1342	1158	466	4436

PRINCIPAL INVESTIGATOR / CONTACT PERSON
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Christian Spring, STRI - Sports Turf Research Institute, UK
Martin Nilsson, Københavns Golf Club, Denmark
Wolfgang Prämaßing, University of Applied Sciences Osnabrück, Germany
Axel Städler, Golf Course Osnabrueck, Germany
Karin Normann, Asbjørn Nyholt ApS, Denmark
Marina Usoltseva, Botaniska Analysgruppen, Sweden
Kate Entwistle, The Turf Disease Centre, UK
Carlos Guerrero, University of Algarve, Portugal
Tatiana Gagkaeva, VIZR - All-Russian institute of plant protection, Russia
Yuri Lebedin, XEMA, Finland
Ingeborg Menzler Hokkanen, University of Eastern Finland

PROJECT SUMMARY
Integrated Pest Management (IPM) refers to the integration of all available techniques for control of diseases, harmful insects and weeds that discourage the development of pest populations and keep the use of pesticides to levels that are economically justified and environmentally sustainable (FAO, 2016). This project is a concerted effort by researchers, greenkeepers and suppliers representing alternative products and technology in the Nordic countries, Germany, Netherlands and UK to investigate cultural practices and new technologies and to manage important diseases namely microdochium patch and dollar spot with no or strongly reduced pesticide inputs.

PROJECT OBJECTIVES
The overall objective of the project is to investigate cultural practices and new technologies for prevention and control of the two most important turfgrass diseases on golf course putting greens and insect pests on golf courses with a minimum use of pesticides.
Thus, the objectives of the project are:

1. To investigate the effect of cultural approaches such as rolling (microdochium patch only), UV-C radiation and alternative products against microdochium patch and dollar spot (WP1 and WP2);

An outbreak of an uncommon disease on Kentucky bluegrass at Landvik in the late summer 2018. Photo: Tatsiana Espevig.

2. To identify the fungal species causing dollar spot in Northern and Central Europe and investigate immonoassay for identification of *Clarireedia* spp. and *Microdochium nivale* in plant tissue and *Clarireedia* spp. in commercial seeds (WP2);
3. To compile a review of the management and potential innovation options of monitoring, warning and control of chafer grubs and leatherjackets on golf courses (WP4);
4. To provide technology transfer to the golf course industry, to disseminate the results from the project trough popular and scientific publications, videos and fact sheets. To participate in international seminars and meetings, which will provide exchange of knowledge and experience among scientists, superintendents, industry, turfgrass agronomists and consultants.

Screening in vials of resistance of different turfgrass species to dollar spot isolates of different origin, spring 2019. Photo: Tatsiana Espevig.

ROBO-GOLF: ROBOTIC MOWERS FOR BETTER TURF QUALITY, REDUCED FERTILISER COST AND LESS USE OF FOSSIL ENERGY ON GOLF COURSE FAIRWAYS AND SEMI-ROUGHS

PROJECT PERIOD: JANUARY 2020 - JULY 2023
FUNDING (kSEK)

	2020	2021	2022	2023	Total
STERF	351	326	336	160	1173
Husqvarna	937	376	386	304	2003
Other sources	81	83	86	0	250
TOTAL	1369	785	808	464	3426

PRINCIPAL INVESTIGATOR / CONTACT PERSON
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PROJECT SUMMARY
Robotic mowers can contribute to more sustainable use of resources on golf courses. This project will generate and disseminate knowledge about implications for turf quality, fertilizer requirements, labor, energy use, CO_2-emissions and players' satisfaction of switching to robotic mowers on roughs and fairways. WP1 will study the impact of robotic mowers on tiller density, leaf texture, cleanness of cut, diseases, weeds (incl. *Poa annua*), divot recovery and soil compaction in four commonly used grass species. WP2 will quantify fertilizer savings on fairways maintained with robot mowers vs. manual triplex mowers with or without return of clippings. WP3 will be implemented on one golf course in each of the five Nordic countries and evaluate changes in turf quality, labor and energy use, CO_2-emissions and players' and greenkeepers' satisfaction after switching from manual to robotic mowers. The project is a collaboration with Husqvarna AB which will provide free mowers and a grant of 1307 kSEK over 4 years.

PROJECT OBJECTIVES
The overall objective is to generate and disseminate knowledge about implications for turfgrass quality, fertiliser requirement, weed encroachment, susceptibility to various diseases, labour and energy use, CO_2 emissions, soil compaction and player and greenkeeper satisfaction of switching from conventional manual mowers to robotic mowers on fairways and semi-roughs with grass species typical for Nordic golf courses. Specific objectives are:
a) To study the impact of robotic mowers on tiller density, leaf texture, cleanness of cut, diseases, weeds (incl. *Poa annua*), divot recovery and soil compaction in four commonly used grass species (WP1).
b) To quantify fertiliser savings on fairways maintained with robot mowers vs. manual triplex mowers, with or without return of clippings (WP2).
c) To implement a trial on one golf course in each of the five Nordic countries to evaluate changes in turf quality, labour and energy use, CO_2 emissions and player and greenkeeper satisfaction after switching from manual to robotic mowers (WP3).

COMPLETED PROJECTS

The projects listed below were funded by STERF during the period 1999-2019. 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)

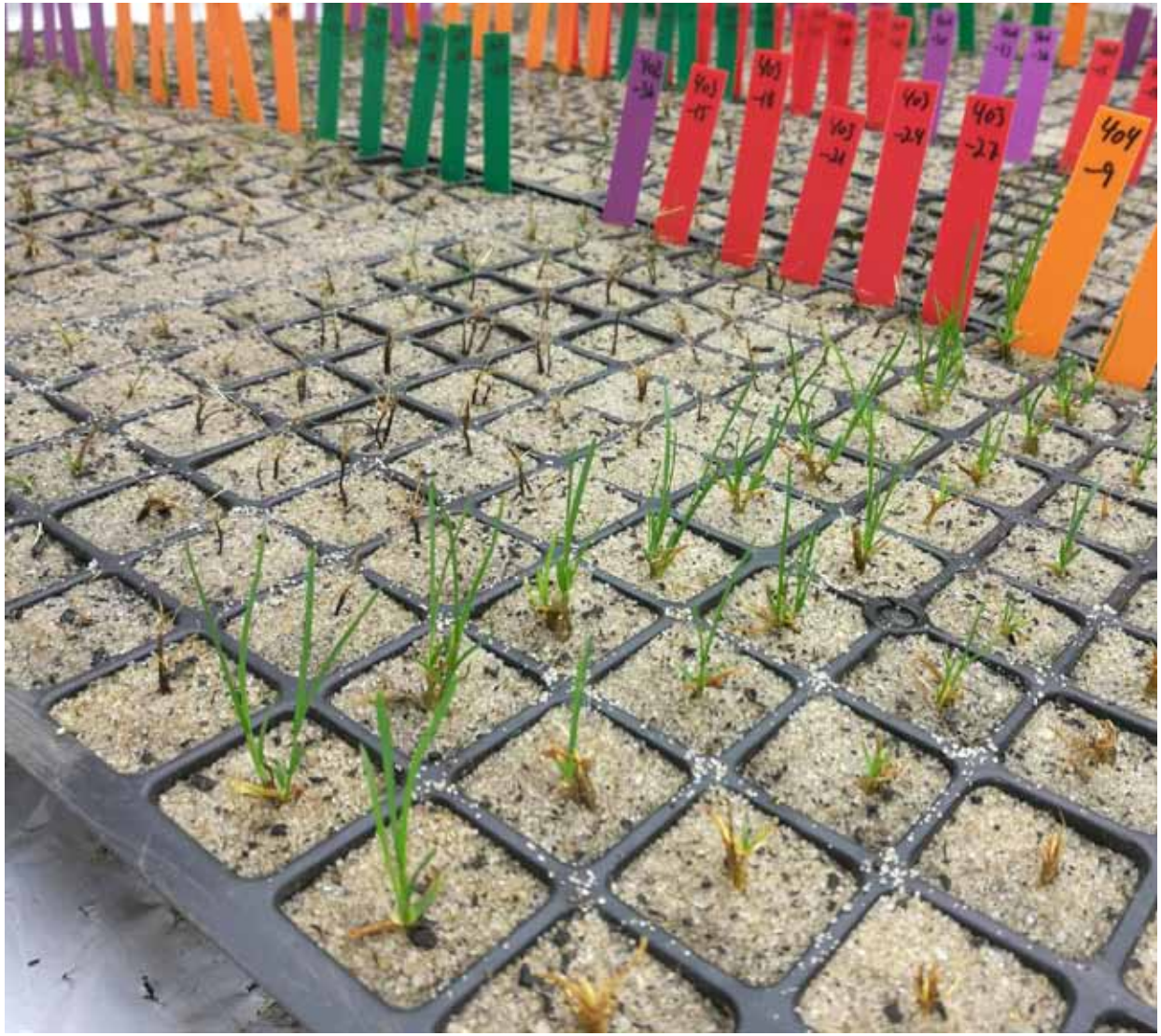
29. Optimal maintenance for hardening and early spring growth of green turfgrass. Karin Blombäck, Department of Soil and Environment, Swedish University of Agricultural Sciences (2006-2013)

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. Engineering better irrigation in turf - Quantifying impacts of application uniformity on turf quality in golf. – Jerry Knox, Cranfield University (2014-2019)

60. Effect of fertiliser type, silicon and copper on turf quality and Microdochium infection on Poa annua putting greens. Tanja Espevig, NIBIO (2016-2019)

61. Effect of irrigation, fertiliser type and soil amendment on turf quality and organic matter accumulation/thatch control on creeping bentgrass greens. Bert Sandell, NIBIO (2017-2019)

62. Testing the effect of AlgeaGreen® on winter stress tolerance. Bert Sandell, NIBIO (2016-2019)

63. Selection and management of bentgrass cultivars for genetic and induced resistance to microdochium patch and pink snow mould. Trygve Aamlid, NIBIO (2014-2019)

64. Practical re-establishment of golf greens following winter damage – a field study. Carl-Johan Lönnberg, Swedish Golf Federation (2017-2019)

65. Winter damage to golf greens in the Nordic countries: Survey of causes and economic consequences (part II). Tanja Espevig, NIBIO (2017-2019)

66. Golf clubs as landscape players – Establishment of collaboration networks in the landscape for enhanced contribution to the 2030 Agenda on sustainable development. Anders Esselin, Man & Nature (2017-2019)

Restored water course GC Eichenried, Germany. Photo Johannes Kollmann

STERF KEY INDICATORS 2006 - 2019

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
2019	2 412 000 SEK	17	6	7	2	4	49	122	5	1303	1271

The key indicators are based on information in project annual reports. STERF has an open call for proposal approximately every second year. If there are specific reasons a project application in between the open call for proposals could be approved for funding by STERF board.

FINANCIAL SUMMARY

INCOME STATEMENT

	01/01/2018 12/31/2018	01/01/2019 12/31/2019
Revenue		
Net revenue	3 640 441	3 147 209
	3 640 441	3 147 209
Expenses		
Other external expenses	–104 751	-38 591
	3 535 690	**3 108 618**
Income from financial items		
Interest	0	0
Surplus	**3 535 690**	**3 108 618**

BALANCE SHEET

	2018	2019
Other receivable	0	0
Cash and bank balances	4 694 457	**5 404 146**
Total assets	**4 694 457**	**5 404 146**
Liabilities and equity		
Equity		
Restricted reserves	262 719	262 719
Non restricted reserves	4 207 085	4 904 080
Total equity	**4 469 804**	**5 166 799**
Current liabilities		
Other current liabilities	224 653	237 347
Total current liabilities	**224 653**	**237 347**
Total liabilities and equity	**4 694 457**	**5 404 146**

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Vallda GC, Sweden. Photo: Jacob Sjöman

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A collated list of publication can be found on **www.sterf.org**

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