RESEARCH AND DEVELOPMENT YEARBOOK 2020
Plan for a new start, not a restart

2020 was to be a year when we started large STERF projects with numerous international collaborators and looked forward to many interesting meetings, seminars and workshops, final preparations for the International Turfgrass Research Conference in Copenhagen 2021 and much else. However, a pandemic overturned almost all our plans.

The first Coronavirus consequence for STERF was that the golf federations were forced to cut their economic contributions, which resulted in STERF having to re-prioritise and cut funding for several new projects, with severe consequences for researchers. Fortunately, the golf federations were able to restore their funding, due to better financial conditions, so for most projects we were able to go back to the original plans. A positive factor that backed the intentions to start large international projects was the cooperation with the R&A under their ‘Golf Course 2030’ initiative, where STERF and the R&A jointly finance large international projects that you can read about in this yearbook. So, overall, the prospects for the STERF project portfolio are positive.

A consequence of the restrictions on travel and meetings due to the pandemic was that most technology transfer events were cancelled but, as need is the mother of invention, the scientists in all STERF projects started using digital solutions to overcome these problems.

We arranged an international webinar for the project “From dense swards to biodiverse roughs” with almost 100 participants from all over the world. Several instructional and inspirational videos were produced and hundreds of meetings were held between scientists on different digital platforms. This experience of digital communication and delivery will most certainly affect and improve STERF’s knowledge and technology transfer during the coming years.

Another notable observation is that the number of reports, publications and articles was one of the highest in STERF history. The Coronavirus crisis demonstrated in a brutal way the delicate relationships between Man and Nature and showed that violation of biological principles can be devastating. We have many more crises induced by human mismanagement of the Earth’s resources ahead of us. Climate change, exponential loss of biodiversity, global chemical pollution, deforestation and microplastics in the oceans are just some of the many that require actions now!

There are many indications that we will not have a restart after the Coronavirus pandemic. Instead we must expect and plan for a new start. All aspects of sustainability (environmental, economic, social) will have a higher priority after the Coronavirus crisis. Therefore, new knowledge built on research and science is crucial for supporting the turfgrass industry to meet new critical challenges. These include the pressures arising from government demands for more extensive 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 an urgent need to adapt. New knowledge is also necessary for the industry to contribute to fulfilment of the 17 United Nations Sustainable Development Goals (SDGs) set out in Agenda 2030.

STERF YEARBOOK 2020

We hope that when reading this yearbook, you will see that all our activities are part of the battle for a better world!

Bruno Hedlind
STERF Chairman
IMPORTANT EVENTS IN 2020

WEBINAR ON BIODIVERSITY OF GOLF COURSES AND URBAN GRASSLANDS
On 5 November 2020, STERF and NIBIO (Norwegian Institute of Bioeconomy Research) hosted a webinar focusing on how golf courses can support biodiversity and ecological processes in the landscape. The webinar attracted almost 100 participants: Golf course managers, landscape architects, landscape planners, park managers, urban conservation officers and those in similar professions.

A set of six presentations, from UK, Germany, Switzerland and the Nordic countries, addressed approaches for diversification of golf course vegetation. Measures to overcome limitations in restoration were pointed out, notably how to reduce competition from established grasses and to overcome seed limitations.

All presentations were pre-recorded and were available some days before the seminar. The webinar itself was then a recap of the key points of the presentations and a discussion of key topics by the presenters, with questions from the audience. This worked really well, and it provided valuable experience on webinars as an efficient presentation and communication tool. Thanks to Valentine Klaus, Johannes Kollman, Mona Chor Bjørn, Jörgen Wissmann, Rowan Rumball and Hans Martin Hanslin for their contributions to the very successful event.

TWO VIDEOS ABOUT DOLLAR SPOT
Dollar spot is one of the most economically important diseases on golf courses in the USA, Europe and Australia. On Scandinavian golf courses, the disease has been reported since 2009 in both Sweden and Denmark, while it was first officially documented in Norway in 2013. In some years, the damage from dollar spot on Scandinavian golf courses has resulted in up to 70-80% dead turf on greens and fairways. Since 2014, dollar spot has been the focus of STERF projects. The aim of the 4-year STERF project ‘Risk assessment, management and control of dollar spot caused by Clarireedia spp. on Scandinavian golf courses’ (2017-2020) was to reduce the spread of dollar spot in the Nordic countries and to provide the golf sector and greenkeepers with non-chemical measures for control of this disease. The project was conducted by researchers at NIBIO Landvik in collaboration with researchers, agronomists and greenkeepers from Denmark, Sweden, the UK and the USA. The project results, including those on rolling and in vitro variety testing, are now presented in two new films:

Cultural control of dollar spot on golf courses in Scandinavia. https://youtu.be/JzmkrIOkn0k

SIX NEW PROJECTS
The last decade was critical for planet Earth, with more record-breaking temperatures and more severe rainstorms, hurricanes, droughts and flooding than ever before. The rate of biodiversity loss accelerated, and more species came under threat. All this has consequences for the golf and turfgrass industry and requires more research and knowledge building in order to conquer these challenges. During 2020, STERF started six new projects to ensure that we have the knowledge we need to build and maintain sustainable golf courses and sports fields and meet global challenges.

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

SCANGREEN: Turfgrass species and varieties for integrated pest management of Scandinavian putting greens.

ROBO-GOLF: Robotic mowers for better turf quality, reduced fertiliser cost and less use of fossil energy on golf course fairways and semi-roughs.

ICE-BREAKER: Reducing the agronomic and economic impact of ice damage on golf courses and other grasslands.

IPM-GOLF: Integrated management of important turfgrass diseases and insect pests on European golf courses.

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.

LONA GOLF: Practical measures to increase biodiversity on golf courses.

ARTICLES, HANDBOOKS AND FACT SHEETS
An unusually high number of articles, handbooks and fact sheets on a broad variety of subjects were published on the STERF website this year. These included articles introducing the new research projects that started during 2020, as well as articles and fact sheets about:

- The use of impermeable covers for better winter survival of putting greens.
- Risk of dollar spot on Norwegian golf courses.
Several publications were translated into Finnish in 2020 (3 articles, 3 handbooks and 2 fact sheets). They can be found on the Finnish part of the STERF website, www.sterf.org/fi. One article was translated into Icelandic, which can be found at www.sterf.org/is.

MEDIA ACTIVITIES FOR MARKETING STERF
STERF is a leading international centre of expertise in sustainable golf course management. The activities of STERF are today leading to improvements in the quality of golf courses, as well as economic and environmental gains for the golf industry and society as a whole. The aim of this media initiative is to communicate the importance of STERF’s activities to golf clubs, golfers, the industry and society. Numerous journalistic articles, chronicles, videos etc. have been published within and outside the golf sector in all Nordic countries. Responses and feedback to these have been very positive.

IMPLEMENTATION OF OUTDOOR TEACHING ON GOLF COURSES
STERF’s concept The golf course as an outdoor classroom will be implemented in Stockholm and Jönköping municipality. Experiences of the project “Go outdoors and use the golf area in a pedagogical way”, carried out at Motala Golf Club in collaboration with Motala Smedsby school, Sweden, show that children’s learning experience can be improved if part of the teaching takes place in a natural outdoor environment. A consequence of the Coronavirus crisis is higher demand for outdoor activities in the urban landscape, including outdoor teaching. Stockholm is a densely populated city and has 149 schools looking for green areas suitable for everyday outdoor teaching. Using golf courses and the land that surrounds them as outdoor classrooms is 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. STERF’s inspirational handbook describing experiences, ideas and practical activities that can be used in everyday outdoor teaching will be used by the schools in Stockholm and Jönköping. The preparation work is ongoing, and in autumn 2021 the children will get to know their new classrooms on the golf courses.
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.

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Maria Strandberg, STERF

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Michael P. Kenna, USGA Green Section Research, (independent international expert)
Asbjørn Nyholt (coordinator for golf course consultants/agronomists employed by the Nordic golf federations and Scandinavian greenkeeper associations)
Nilla Nilsdotter-Linde (coordinator for researchers at universities/research institutes in the Nordic countries)

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Ellert Thorarinsson, Golf Union of Iceland
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 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.

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 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 (~60°N). 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.
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 environments 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 broader 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 natural and cultural environments, and retention and expansion of ecosystem services, and can help to improve people’s health and quality of life by providing facilities for active outdoor recreation.

Through STERF’s R&D programme within multifunctional facilities, the societal benefits of golf can be improved and the Nordic area can become a model region as regards multifunctional golf courses and collaborations between different interests in society. Four central research and development areas have been identified: (1) The everyday landscape and peri-urban nature, (2) Nature and culture, (3) Dialogue and cooperation, and (4) Business promotion.
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 Sustainable 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, STERF has created Golf Course 2030 Scandinavia. 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 necessary 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).

Thirteen projects, including STERF’s IPM GOLF project, are match-funded by the Golf Course 2030 programme for the next four years. The aim of all projects is to improve sustainability 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
The Coronavirus situation all over the world does not look very optimistic and we all have to face long-term restrictions on travel, social gatherings and conferences. According to the Health Directorate of the EU, the sanctions and restrictions related to the Coronavirus/Covid-19 situation will last for at least the next 12 months; effects of general vaccination are not expected to be seen until autumn 2021.

Due to this uncertainty created by the global Covid-19 pandemic, the ITRC Planning Committee and the ITS board made the final decision in December 2020 to postpone the 14th International Turfgrass Research Conference until July 10-15, 2022.

The 14th International Turfgrass Research Conference in 2022 will be held as an on-site conference under the existing plans. The venue at Copenhagen University and the hotel reservations have been rebooked.

The conference organiser CAP Partner has agreed to the postponement. Main sponsors for ITRC have been contacted and all are in favour of postponing the conference. Conference programme, technical tours, the one-day practitioners’ seminar, and social events will be rearranged and set up in 2022 according to the existing plans.

Development and Sustainability is the theme of the conference and the United Nations Sustainable Development Goals (SDGs) set out in Agenda 2030 will act as the conference programme framework. The programme will focus on: increased sustainability by a multidisciplinary approach; science in action by ready-to-use research; and mobilising forces from academia to industry.

This is one conference that you will not want to miss. ITRC2022 will be packed with educational and social activities, so be sure to check out the ITRC2022 Website www.ITRC2022.org for updates and additional details about the conference.

We very much hope to see you at the 14th International Turfgrass Research Conference, ITRC2022, to be held in Copenhagen on 10-15 July 2022 and arranged by the Scandinavian Turfgrass and Environment Research Foundation (STERF).
SCANGREEN: TURFGRASS SPECIES AND VARIETIES FOR INTEGRATED PEST MANAGEMENT OF SCANDINAVIAN PUTTING GREENS, 2019-2022

PROJECT PERIOD: 2019 - 2022

FUNDING (kSEK)

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1) Reserved but not granted

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Eric Watkins, University of Minnesota, USA.
Karin Juul Hesselsøe, Trygve A. 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 in turfgrass breeding for high-latitude environments.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2020
13 August: Field day at Apelsvoll. Trygve Aamlid and Karin J. Hesselsøe visited the Scangreen trial. The decision was made to reconstruct and re-establish the bentgrass part of the green.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2021
Since 2003, STERF has tested species and varieties under realistic green conditions, and 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 at NIBIO Landvik, Norway (58°N) in the southern zone. A trial at Sydsjælland GC in Denmark was seeded in 2019, but closed down in spring 2020 because of uneven emergence and lack of staff due to Covid-19. There are also supplementary trial sites in Massachusetts and Minnesota, USA.

In the ongoing trials, 30 new varieties and 24 controls representing eight species are being tested. Seed mixtures of 85% Festuca rubra + 15% Agrostis stolonifera, 85% Festuca rubra + 15% Agrostis capillaris and 85% Festuca rubra + 7.5% Agrostis stolonifera + 7.5% Agrostis capillaris (designated varieties) are being tested in the southern zone.
As usual, winter 2020-21 offered some challenges in the northern zone. In Iceland, the snow melted in the beginning of April, but a very cold May resulted in slow green-up. None of the plots needed to be reseeded except for that with chewings fescue 'Dancing'. Higher attacks of microdochium in winter were recorded in the slender creeping fescues than in the chewings fescues. The same trend was not seen at Apelsvoll, where all creeping bentgrasses died and most of the colonial and velvet bents died too. The dead plots were reseeded in May, but did not recover until after reconstruction of the bentgrass area and reseeding in August. In the southern zone at Landvik, winter 2019-20 was very mild. Attacks of microdochium appeared in the bentgrasses in March and signs of take-all patch appeared in the mixtures and in the creeping bentgrasses in August.

The most promising entries of creeping bentgrass at Landvik, better than the check varieties ‘Independence’ and ‘Riptide’, were ‘Matchplay’, ‘L-93 XD’, ‘Ardent’, ‘007’, ‘DLF PS AP 3018’ and ‘Tripleseven’. Within slender creeping red fescue, ‘Barswilcan’ performed better than the check varieties ‘Cezanne’ and ‘Finesto’ at all sites. None of the newcomers outperformed the check varieties ‘Barlineus’ and ‘Musica’ of chewings fescue.

The trials in the USA made it through the winter very healthy. In coming years, these sites will allow varieties to be ranked, including for dollar spot. In the southern Scandinavian zone, a new trial will be established in spring 2021 at Smørøm GC, Copenhagen, to replace that at Sydsjælland closed in 2020.
SUSPHOS: SUSTAINABLE PHOSPHORUS (P) FERTILISATION OF GOLF COURSES

PROJECT PERIOD: APRIL 2017 - DECEMBER 2021

FUNDING (kSEK)

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Wolfgang Prämassing, University of Applied Sciences, Osnabrück, Germany

PROJECT OBJECTIVES
Economic savings and lower environmental impact by reduced and more targeted fertilisation with phosphorus (P) according to soil analyses.

Subgoals (corresponding to workpackages (WPs)):
1. 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).
2. 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).
3. 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 2020
17 March: Project and reference group meeting on Skype.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2021
WP1 and WP2 were completed in 2019 (see STERF yearbook for 2019) and published scientifically in Agronomy Journal in June 2020.

WP3: Field trials were started in China, Netherlands, Sweden and Norway in 2017 and a new trial in Germany was added in 2018. The trials compare three different P fertilisation concepts: MLSN, SLAN (old American standard) and 'Scandinavian Precision Fertilisation' (SPF).
By January 2021, all data from the project were collected except on soil samples from China, which are still to be shipped to Norway for analyses because of flight cancellations. Data from the German trials have been analysed and the results (2018-2020) show few significant effects on turfgrass quality, which indicates that switching from conventional SLAN-based fertilisation to MLSN or SPF-based fertilisation has no impact on turf quality. Results from the other countries will follow, with scientific and popular publications in the first half of 2021.
RISK ASSESSMENT, MANAGEMENT AND CONTROL OF DOLLAR SPOT CAUSED BY CLARIREEDIA SPP. ON SCANDINAVIAN GOLF COURSES

PROJECT PERIOD: APRIL 2017 - OCTOBER 2020

FUNDING (kSEK)

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

CO-APPLICANTS
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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 resistance to the Scandinavian isolates of Clarireedia spp. in vitro (WP3).

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2021
The field trials and laboratory experiments were competed in 2019. In 2020, two popular science articles were produced, in English and Scandinavian languages, a scientific manuscript from WP3 was submitted to ITSRJ, and a final report and two videos were produced. Thus, the project summary below is the same as in 2019. The aim of this project is to reduce the spread of dollar spot in the Nordic countries and to provide the golf sector and greenkeepers with non-chemical measures for control of this disease. Dollar spot (DS) was officially documented in Scandinavia in 2013. The damage from DS in Scandinavia varies and can be up to 70-80% dead turf on greens and fairways. The project consisted of three work packages (WP):

WP1. In summer 2017, on golf greens with red fescue (Vallda GC) and on foregreens with red fescue, colonial bentgrass and annual bluegrass (Roskilde GC), rolling 2 times per wk reduced DS by 61% and 37% and rolling 4 times per wk reduced DS by 95% and 54%, respectively. In 2018, DS did not develop on these golf greens, most likely due to an extremely dry summer. At Kävlinge GC, the effect of N was not significant in 2017 on a creeping bentgrass golf green. In 2018, an increase in the annual N amount from 150 kg ha⁻¹ to 240 kg ha⁻¹ reduced DS by 24% (from 100 to 76 infection centres per m²). However, in March 2019 on the plots which received 240 kg N ha⁻¹ in 2018, the microdochium patch incidence was 30%, vs. 14% on the plots which received 150 kg N ha⁻¹. Thus, it is impossible to draw unambiguous conclusions about the advisability of using increased rates of N to fight dollar spot on golf greens which are exposed to microdochium patch during winter time.
WP2. As determined in autumn 2017, all Scandinavian isolates of *Clarierea* spp. had 24 °C as the optimal temperature for growth (OGT), while isolates from US had both 16 °C and 24 °C as the OGT. Both 0 °C and 40 °C reduced growth of all isolates by almost 100%. After 3 wk at 40 °C, all isolates were dead. After 3 wk at 0 °C, the growth of Scandinavian isolates and British isolates was reduced by 7-36% and 23-38%, respectively, while there was no reduction in American and a Norwegian isolate. This indicates certain potential of the isolates for winter survival.

WP3. In spring 2018 and 2019, 20 widely used turfgrass species and cultivars were tested for resistance to 10 different *Clarierea* isolates from Norway, Denmark, Sweden, UK and US in the laboratory at NIBIO Landvik (Photo 1). The preliminary results show that the most aggressive isolates were one *Clarierea* sp. from the UK and two from the USA (*C. jacksonii* and *C. monteithiana*), while the weakest isolate was *C. jacksonii* from Norway. *Clarierea* isolates from Denmark and Sweden were intermediate. It appears that *C. jacksonii* isolates from USA are more aggressive than those from Sweden and Norway. However, based on the current data, we cannot conclude that aggressiveness in *Clarierea* spp. is species-specific, as the aggressiveness of *C. jacksonii* isolates varied in different turfgrass species and varieties. Generally, cultivars of perennial ryegrass and slender creeping red fescue were the most resistant. There was great variation among the 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.
FROM DENSE SWARDS TO BIODIVERSE ROUGHS

PROJECT PERIOD: JUNE 2017 - DECEMBER 2020

FUNDING (kSEK)

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PRINCIPAL INVESTIGATOR / CONTACT PERSON
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Harald Bratli, University of Oslo
Jörgen Wissman, CBM/SLU

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

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2020
22 June: Several newspaper articles and TV interviews, when the Minister of Food and Agriculture visited field plots at Blindern. Trygve Aamlid and Anders Nilsen
13 August: Project field day Nannestad. Methods and experiences from the project ‘Fra grasmark til blomstereng’. Trygve Aamlid and Ellen Svalheim
18 August: Full-day course Norges Grønne Fagskole Vega “Establishment of flower-rich grasslands. Trygve Aamlid
5 November: STERF Webinar: Biodiversity of golf courses and urban grasslands: Current knowledge and future trends. Two presentations from the project: Golf courses in a broader perspective by Johannes Kollmann and From dense swards to biodiverse roughs by Hans M Hanslin

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2021
For golf courses to support biodiversity and ecological functions such as pollination services, there is a need to convert rough areas into more diverse vegetation. In most cases, this transition is hampered by low seed input and highly competitive grass vegetation under high nutrient conditions. Methods and strategies to overcome these limitations are needed. This project comprised field experiments at Oslo GK and in four other species-poor grasslands in Norway, plus a demo trial at Sigtuna GK, Sweden. These involved a set of treatments to reduce the competitive dominance of grasses (cutting frequency, hay removal, nitrogen im-
mobilisation by sawdust application, seeding of the hemiparasitic species *Rhinanthus minor* in 2017, and addition of seeds of regional seed mixtures in 2018 to overcome seed limitation.

In 2020, some of the seeded species had established and some had started to flower, but there were large differences between locations and some differences between treatments. Apart from seeding, removal of cut hay was the single most important management measure to improve plant diversity. Whether the vegetation was cut once or twice was not as important at this stage. Addition of sawdust had no major effect on results. Establishment of *Rhinanthus* was not successful on most sites, but reduced rough density and improved playing quality at Oslo GK.

Seedling establishment was good in many plots, but the transition from seedling to flowering plants was difficult at four of the five locations. The most likely reason is asymmetric competition, as dense grass was negative for seedling survival. In addition to measures to reduce grass dominance such as cutting and hay removal, a good strategy for sites with dense grass cover is to interseed the more competitive species, e.g. *Leuchantemum vulgare, Achillea millefolium* and *Lotus corniculatus*, from the regional species pool.

Three years is a very short time to reduce grass dominance and obtain substantial changes in species composition. Despite that, we found preliminary effects on flower resources and pollinator abundance two years after seeding and three years after initiation of treatments. Contributions to flowering abundance came partly from seeded species, but also from the development of existing species and spontaneous establishment. Treatments to ease establishment of seeded species were also positive for development of species present before seeding.
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)

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PRINCIPAL INVESTIGATOR / CONTACT PERSON
Edwin Roald, Director, Eureka Golf ehf., Langalina 22, 210 Garðabær, Iceland.
Tel: +354 693 0075, email: edwin@eureka.golf, web: eureka.golf

CO-APPLICANTS
Jón Guðmundsson, Agricultural University of Iceland.

PROJECT OBJECTIVES

- Estimate CO₂ losses and carbon storage from land use of cultivated and managed areas on Icelandic golf courses, in total and by facility.
- Discuss if/how the estimation process can be streamlined further.
- Determine what is required in terms of funding, time and other resources to produce a similar estimation for other Scandinavian countries.
- Identify marked trends, if any, revealing or suggesting how golf facilities can, in a general sense, easily improve their carbon status from land use without negatively influencing the playing experience.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2020
27 November: Launch of website: http://www.carbonpar.org
8 November: Creation of the following social media pages and accounts:
Facebook: https://www.facebook.com/CarbonPar
Instagram: https://www.instagram.com/carbonpar/
Twitter: https://twitter.com/CarbonPar
LinkedIn: https://www.linkedin.com/company/73927851/admin/
17 December: Feature on Golf Union of Iceland website:
https://www.golf.is/vinna-hafin-vid-mat-a-kolefnisforda-allra-golfvalla-innan-gsi/

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2021
The development of some golf courses has included wetland drainage or the use of previously drained wetlands. Through this, many clubs have unintentionally caused large emissions of greenhouse gases. Emissions from golf courses on drained organic soils can thus be very high, while courses on mineral soils can sequester carbon. Grass can sequester considerable levels of carbon. Furthermore, managed grasslands, or turf, can sequester more carbon than unmanaged. This indicates that carefully located golf courses, thoughtfully planned, designed and built, have a reasonable chance of becoming net carbon sinks.
To estimate the carbon status of land used by all golf courses within the Golf Union of Iceland, a variety of methods will be used, including mapping, references to national soil databases, soil sampling, interviews and analysis. Perimeters of various golf course land use elements, such as fairways, managed roughs and native areas will be drafted up in architectural software, using underlying georeferenced aerial photographs. Each golf course area will be broken down into 3-4 basic soil types. Soil samples will be collected from a selection of golf facilities and analysed by dry combustion, delivering %C and %N content.

Access to IGLUD (Icelandic Geographic Land-Use Database) and the ÝMIR-soil database will allow soil C content to be compared to that in corresponding areas near the perimeter of the golf facilities. This should indicate loss or sequestration of carbon during the lifetime of the golf course compared with surrounding areas and land uses. The project will then produce:

- A “leaderboard” of Icelandic golf facilities, by carbon status, or carbon par, from land use.
- A breakdown of each/all courses by the chosen 3-4 basic soil types.
- A report on the estimation process and recommended protocol for estimation in other countries.
- Identification of wetlands that can be reclaimed.
- General recommendations on how golf facilities can make quick and easy improvements to their carbon status from land use.

Special efforts will be made to ensure that suggestions in (d) and (e) do not negatively influence the golf playing experience. Scapegoating is not an objective. Rather, the aim is to present an opportunity to improve upon unintended harm to the climate.
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)

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PRINCIPAL INVESTIGATOR / CONTACT PERSON
Trygve S. Aamlid, NIBIO Department for Urban Greening and Vegetation Ecology, Turfgrass Research Group, Landvik, N-4886 Grimstad, Tel: + 47 90 52 83 78. E-mail: trygve.aamlid@nibio.no

CO-APPLICANTS
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Carl Johan Lönnberg, Swedish Golf Federation.
Michelle DaCosta, University of Massachusetts.
Eric Watkins, University of Minnesota.

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
1. Develop an efficient laboratory method for screening of grass cultivars and breeding lines, including a first evaluation of 30 new and/or commonly used cultivars of creeping bentgrass, red fescue (Festuca rubra L.), colonial bentgrass (Agrostis capillaris L.) and velvet bentgrass (Agrostis canina L.) for LDIE50 (Lethal Duration of Ice Encasement for 50% of plants).
2. 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 O2/CO2 concentrations under ice.
3. Determine to what extent an impermeable plastic barrier between the grass and the ice, including aeration pipes under the plastic, can protect grasslands from damage from long-lasting ice encasement and meltwater.
4. Determine whether snow and ice removal from greens at different times during the winter can reduce ice and water damage.
5. Analyze to what extent impaired photosynthesis due to formation of reactive oxygen species (ROS) upon re-exposure to aerobic conditions after ice melt or ice removal can contribute to ice damage and if such damage can be alleviated by the use of shade cloths.
6. Identify toxic metabolites in the thatch/mat of young and old greens of various species and determine the extent to which these inhibitors delay germination and/or seedling growth when reseeding golf greens after ice encasement.
7. Compare, in large-scale trials, various sowing machines/methods and explore the advantage of using primed seed of slowly vs. quickly germinating creeping bentgrass cultivars when reseeding greens that have been killed by ice encasement.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2020
5 March: ICE-BREAKER Kick-off meeting, Haga GC.
18 June: Norwegian Golf Federation Field Day at Losby GC: To års erfaringer med vinterdekking av greener med tette duker: Hvordan videreføres disse erfaringer i ICE-BREAKER? Trygve S. Aamlid, NIBIO.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2021
Winter kill due to ice encasement (IE), meltwater and subsequent problems with re-establish-
ment is a severe problem on grasslands. This project is a joint effort by the golf industry and the Research Council of Norway, with the Norwegian Golf Federation as the project owner. It includes six work packages (WPs). WP 1-4 focus on how to prevent ice and water damage and WP 5-6 on how to re-establish winter-killed greens from seed.

In WP1, we will screen turfgrasses for tolerance to anoxia. On 3 December 2020, disc samples of 35 varieties representing seven species were taken from the SCANGREEN trial at Landvik, Norway, vacuum-sealed and incubated at 0.5°C to simulate IE. Samples will be taken out weekly after 5 to 13 weeks of anoxia and tiller survival will be determined in the greenhouse.

In WP2, we will study the effect of direct ice cover, plastic sheets under the ice and timing of snow/ice removal on the survival of creeping bentgrass (CRB), annual bluegrass (AB) and red fescue (RF) greens at Apelsvoll, Norway.

WP3 includes four large-scale trials started in November 2020. Ventilation systems and ventilation frequencies will be tested on a total of 60 covered greens at four golf courses. Temperatures and CO$_2$/O$_2$ concentrations will be monitored by wireless sensors installed under the covers.

WP4 focuses on the risk of pytoinhibition during the transition from IE to high light intensities/cold temperatures in spring. This work will be carried out in close collaboration with US researchers.

In preparation for WP5, CBG and RF greens were established from sod at Apelsvoll in June 2020. On 30 November 2020, the greens were covered by a 10 cm ice layer that will most likely cause 100% winter kill. At ice melt in spring 2021, toxic metabolites will be identified and their impact on germination and seedling growth determined in laboratory and field trials.

WP6 is a joint effort with the USGA project ‘Understanding Factors Associated with Successful Re-Establishment of Golf Course Putting Greens Following Winterkill’. The combined effect of temperature, light intensity and photoperiod on photosynthesis and growth of seedlings of four CBG varieties will be studied in parallel field trials in Minnesota (45°N), USA, and Landvik (58°N) and Tromsø (70°N), Norway, in spring 2021. A demo trial testing sowing methods and tarp materials for faster and most secure re-establishment of the same CRB varieties will be conducted on an ice-killed green in Central/Northern Sweden in collaboration with the Swedish Golf Federation.
INTEGRATED MANAGEMENT OF IMPORTANT TURFGRASS DISEASES AND INSECT PESTS ON EUROPEAN GOLF COURSES

PROJECT PERIOD: FEBRUARY 2020 - JULY 2023

FUNDING (kSEK)

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PRINCIPAL INVESTIGATOR / CONTACT PERSON
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Christian Spring, STRI - Sports Turf Research Institute, UK
Martin Nilsson, Københavns Golf Club, Denmark
Wolfgang Prämäßing, Lukas Borlinik, Daniel R. Hunt and Jan Rosenbusch, University of Applied Sciences Osnabrueck, 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 and Anna Antropova, XEMA, Finland
Ingeborg Menzler Hokkanen and Helikki Hokkanen, University of Eastern Finland

PROJECT OBJECTIVES
The overall aim 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 minimum use of pesticides. Specific objectives are:

- 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).
- To identify the fungal species causing dollar spot in Northern and Central Europe and investigate immunoassay for identification of *Clarierea* spp. and *Microdochium nivale* in plant tissue and commercial seeds (WP2).
- To compile a review of the management and potential innovation options of monitoring, warning and control of chafer grubs and leatherjackets on golf courses (WP3).
- To provide technology transfer to the golf course industry, to disseminate the results from the project through popular and scientific publications, videos and fact sheets, and to participate in international seminars and meetings, which will provide exchange of knowledge and experience among scientists, superintendents, the industry, turfgrass agronomists and consultants.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2020
26 March: Skype, IPM-GOLF 2020-23: Start meeting.
14 April: Skype, IPM-GOLF 2020-23: Start meeting.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2021
This project is a concerted effort by researchers and greenkeepers from the Nordic countries, Germany, Portugal, the UK, Finland and Russia, suppliers (ICL, Syngenta, Suståne and Aqua-Yield), Golf Federations in Germany and Netherlands and The Danish Environmental Protection Agency to investigate cultural practices, alternative products and new technologies for managing important diseases, namely microdochium patch (MP) (work package (WP1) and dollar spot (DS) (WP2) with no or strongly reduced pesticide inputs. In May-June 2020, seven field trials were established: in Denmark (1), Norway (2), the UK (2) and...
Germany (2). Preliminary results from Copenhagen Golf Club in Denmark showed that rolling two and four times per week reduced MP from 5% (no rolling) to 2% and improved overall impression from 4 (no rolling) to 6 (scale 1-9). In the field trial at Osnabrueck GC (Photo 2), UV-C radiation dosages of 35-40 mJ cm$^{-2}$ and 70-80 mJ cm$^{-2}$ (both 3 times per week) reduced dollar spot from 4.3% (untreated control) to 2.8% and 2.3%, respectively. Turf quality, density and colour (NDVI index) were not influenced significantly by UV-C radiation. The second trial at Osnabrueck GC showed that Suståne 5-2-4+Fe of 130 kg N ha$^{-1}$ yr$^{-1}$ reduced DS from 4.1% (local fertilisation programme of 110 kg N ha$^{-1}$ yr$^{-1}$) and 4.5% (Suståne 5-2-4+Fe of 70 kg N ha$^{-1}$ yr$^{-1}$) to 2.5%. In the field trial on alternative products for MP at STRI (12 treatments), MP was reduced from 8.3% (control, 140 kg N ha$^{-1}$ yr$^{-1}$, weekly fertilisation) to 1.5% by weekly applications of 8 kg ha$^{-1}$ iron sulphate from August to November. Non-frequent nutrition (2-weekly fertilisation), citric acid from June to November, low nutrition (100 kg N ha$^{-1}$ yr$^{-1}$) and organic slow release nutrition (Suståne 5-2-4+Fe) reduced MP from 8.3% to 5.3%. In the DS trial at STRI (6 treatments), the ICL dollar spot programme (128 kg N ha$^{-1}$ yr$^{-1}$) consistently improved turf quality, colour and density and reduced DS from 3.8% (control, no N) to 0%. Suståne 5-2-4+Fe at low rate (86 kg N ha$^{-1}$ yr$^{-1}$) and high rate (137 kg N ha$^{-1}$ yr$^{-1}$) both reduced DS spot from 3.8 to 1%. The data from the MP field trial (15 treatments) at NIBIO Landvik (Norway) and from Syngenta microdochium patch field trials (4 treatments) at NIBIO Landvik and STRI will be analysed after measurements in spring 2021. All field trials will continue until spring 2022.

In 2020, NIBIO Landvik received 40 turfgrass samples with DS symptoms from Denmark, Sweden, Norway, the UK, Portugal and Germany. DS fungi were recovered from 15 of these samples, and *Clarireedia* species will be identified using PCR in winter-spring 2021. For immunoassay and identification of *Microdochium nivale* in plant tissue, immunisation of animals with fungal extracts was completed and preliminary validation of ELISA prototype for *M. nivale* is ongoing in Finland and Russia. The same will be done for *Clarireedia* species. For WP3, a brief survey was held in Denmark and Sweden in 2020. It revealed that problems with chafer grubs are concentrated to sandy soils, primarily in southeast Sweden and in northern Jutland in Denmark. The problems from these pests are mainly related to the damage from crow foraging rather than direct damage. A review will be compiled in 2021.
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)

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PRINCIPAL INVESTIGATOR / CONTACT PERSON
Trygve S. Aamlid, NIBIO Division for Environment and Natural Resources, Turfgrass Research Group, Landvik, N-4886 Grimstad, Norway. Tel. +47 90528378. E-mail: trygve.aamlid@nibio.no

CO-APPLICANTS AND COLLABORATORS
Mona Roskvist Jansson and Hugo van Bijsterveldt, Husqvarna AB
Karin Juul Hesselsøe and Tatsiana Espevig, NIBIO, Norway
Atle Revheim Hansen, Bærheim Golfpark, Norway
Lars Henrik Schovbye Nielsen, Grenå GC, Denmark
Marcus Rehnström, Jönköpings GK, Sweden
Janne Lehto, Hirsala Golf, Finland
Bjarni Hannesson, Ness GC, Iceland

PROJECT OBJECTIVES

- To generate and disseminate knowledge about implications for turfgrass quality, fertiliser requirement, weed encroachment and susceptibility to various diseases of switching from conventional manual mowers to robotic mowers on fairways and semi-roughs with grass species typical for Nordic golf courses.
- To generate and disseminate knowledge about implications for labour and energy use, CO2-emissions and soil compaction of switching from conventional manual mowers to robotic mowers on fairways and semi-roughs with grass species typical for Nordic golf courses.
- To generate and disseminate knowledge about implications for 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.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2020

16 April: Reference group meeting on Teams.
27 August: Field day at Bærheim GC, Stavanger with Teams connection to the indoor presentations. Presentations (in Scandinavian) by Atle R. Hansen, Bærheim GC, Olle Marcusson, Husqvarna, Trygve S. Aamlid and Karin J. Hesselsøe, NIBIO. Presentation in English by Michel Pirchio, University of Pisa, Italy.
10 September: Reference group meeting on Teams.
PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2021

This project consists of three work-packages (WP):

**WP1:** Impact of robotic vs. manual mowers on turf quality of commonly used grasses on Nordic golf course fairways and semi-roughs. Two field trials, one with subplots (10 m x 10 m) of *Festuca rubra*, *Poa pratensis* and *Agrostis capillaris* at fairway mowing height (15-20 mm) and the other with subplots of *Lolium perenne*, *Festuca rubra* and *Poa pratensis* at semi-rough mowing height (35-40 mm) were seeded at NIBIO Landvik in May 2020. Once grow-in was completed, on 11 August three robotic mowers were installed on main plots in each trial. Turfgrass quality, chlorophyll content, diseases and broadleaved weeds were then assessed monthly in robotic-mown plots and in plots mown manually with a triplex reel mower (fairway) or rotary mower (semi-rough). Preliminary observations in the fairway trial in autumn 2020 showed significantly less *Microdochium nivale* and a tendency (P=0.07) for higher turf quality with robotic mowing in the fairway trial, but no advantage of robotic mowers in the semi-rough trial. The trials will continue in 2021 and 2022.

**WP2:** Impact of return of clippings using robotic vs. manual mowers on fertiliser requirements: This WP was established in the same trial area as used for WP1, in a section seeded with a fairway mixture. Fertilisation is scheduled for 2021 and 2022.

**WP3:** Demonstration trials with robotic mowers on golf courses: Demos were established at the golf courses Bærheim (N), Grenå (DK), Jönköping (S), Ikaalisten (FIN) and Ness (ISL) in May-June 2020. Husqvarna sponsored each course with two robotic mowers, one for a designated fairway and one for a designated semi-rough. Neighbouring fairways/semi-roughs of similar size/shape/soil type and grass composition serve as controls. Parameters recorded by the course managers are turfgrass quality, petrol/electricity consumption and labour use.

Results from 2020 showed few significant differences in turfgrass quality, but many greenkeepers found the fairway mown with the robotic mower to be more consistent than the control fairway.

A survey among more than 400 players on their attitude to robotic mowers vs. conventional mowers was conducted in autumn 2020 at Jönköping, Grenå and Bærheim. The responses showed an overall positive attitude to robotic mowers, but many players asked about implications of the new technology for the rules of the game. Good communication with players is therefore important before introducing robot mowers. The survey will be repeated at the end of the project in 2023.
PRACTICAL MEASURES TO INCREASE BIODIVERSITY ON GOLF COURSES

PROJECT PERIOD: MAY 2020 - DECEMBER 2023

FUNDING (kSEK)

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* 50% in SEK and 50% in in-kind funding

PRINCIPAL INVESTIGATOR / CONTACT PERSON
Peter Edman, Swedish Golf Federation, Box 11016, 10061 Stockholm.
Tel +46 70 266 5686. Email: peter.edman@golf.se

CO-APPLICANTS AND COLLABORATORS
Ingela Danielsson, Falkenberg Municipality ingela.danielsson@falkenberg.se

PROJECT OBJECTIVES
• To create a model for local collaboration between the golf club, the municipality and other actors in the community, with the aim of creating rich plant and animal life.
• To improve biodiversity on golf courses through increased knowledge of how different measures and maintenance routines on the golf course can contribute to creating rich plant and animal life.
• To study the effects of different care routines to increase the number of pollinating insects and the playability of the golf course’s roughs.
• To evaluate how different care routines benefit specific insect species.
• To spread knowledge and experience to golf clubs, municipalities and other organisations in society nationally and internationally.

TALKS AT CONFERENCES, SEMINARS, MEETINGS ETC. IN 2020
May-December: Initial inventories were made by Kill Persson and Marcus Franzen, to establish the number of vascular plants and insects at the starting point of the project. Inventories, field visits and design of maintenance plans were carried out on each golf course, on the following dates:
• Hofgård GC: 29/5, 30/9, 3/11
• Harabäcken GC: 29/5, 30/9, 11/12
• Ullared-Flädje GC: 4/6, 24/9
• Vinberg GC: 5/6, 30/9, 10/11
• Falkenbergs GC: 5/6, 24/9, 7/12
21 September: Field visit, to present the plans and activities in the project at Götaströms Golf Club. Employees at golf facilities, the two municipalities and the regional County Administration Board participated.

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2021
Biodiversity loss and ecosystem collapse are among the greatest threats humanity faces in the next decade. The EU Biodiversity Strategy for 2030 proposes a more holistic approach to biodiversity policy. Protecting and restoring nature cannot solely be imposed by regulation, and must include all relevant actors in the peri-urban and rural landscape. Golf courses could contribute to the production of biological diversity, the conservation of natural and cultural environments and the retention and expansion of ecosystem services in peri-urban environments and the cultivated landscape.
The project includes several measures to promote biodiversity. The methods are adapted to each golf club's conditions. The project aims to benefit insects by creating flower-rich soils with exposed sand. The selection of measures and maintenance efforts can be adapted to a golf course anywhere in the municipality, region or country. The goal is that the final inventories by 2023 will show improved flora and insect diversity on the golf courses.

Individual action plans have been drawn up for five golf courses; Falkenbergs GC, Ullared Flädje GC, Harabäckens GC, Hofgårds GC and Vinbergs GC. The action plans describe what, where and when measures for biological diversity can take place on each individual course and include an assessment of the time required, as well as costs.

During the summer of 2020, inventories were carried out partly to document the initial situation and partly to identify suitable locations for what and where measures can be carried out. In parallel with this, a dialogue has been held with the Golf Federation and the golf club’s course staff to make sure that the action proposals can be coordinated with the golf game itself.

During the autumn of 2020, the preliminary action plan was communicated and implemented in each course's management plan for 2021.
The projects listed below were funded by STERF during the period 1999-2020. More information about the projects can be found on the STERF website www.sterf.org


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


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


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

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

33. Integrated pest management - communication project within the park and golf sector. Maria Strandberg, Scandinavian Turfgrass and Environment Research Foundation (2011-2013)

34. Evaporative demands and deficit irrigation on sand-based golf greens. Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research (2008-2014)


38. Effects of mowing height, N-rate and P-rate/mycorrhiza on quality and competition against annual meadowgrass on putting greens with red fescue as predominant species. 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)


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

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

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

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


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

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


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


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


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)


67. SCANGREEN: Turfgrass species, varieties and seed blends and mixtures for integrated pest management of Scandinavian putting greens. Trygve Aamlid, NIBIO (2015-20220)

68. Risks for surface runoff and leaching of fungicides from golf greens varying in rootzone composition and amount of thatch. Trygve Aamlid, NIBIO (2016-2020)

69. Invite the starling to help the greenkeeper. Henning Heldbjerg, DOF Birdlife Denmark (2018-2020)

70. Go outdoors and use the Golf area in a pedagogical way – creativity, learning and health in the unlimited classroom. Anders Szczepanski, Linköping University/Spetsa (2017-2020)
## STERF Key Indicators 2006 - 2020

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# FINANCIAL SUMMARY

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**LIST OF PUBLICATIONS 2020**

**FULL PAPERS IN INTERNATIONAL PEER REVIEWED JOURNALS**


**OTHER PUBLICATIONS IN ENGLISH AND GERMAN**


EXTENSION PAPERS OR REPORTS IN NORDIC LANGUAGES


