RESEARCH AND DEVELOPMENT YEARBOOK 2008

SCANDINAVIAN TURFGRASS
AND ENVIRONMENT RESEARCH FOUNDATION

IMPORTANT EVENTS IN 2008

STERF SEMINAR - THE GLOBAL CLIMATE CRISIS: IMPLICATIONS AND CHALLENGES FOR THE GOLF SECTOR

Every second year, STERF hosts a seminar to discuss new research results and priority future research activities. The 2008 seminar was held at Bioforsk Landvik, Norway, on 2-3 September. More than 40 delegates from the Nordic countries participated.

The keynote speaker was Svein Tveitdal, former advisor to the UN International Panel on Climate Change (IPCC) and devoted golfer. His keynote speech was followed by these presentations, mostly of STERF-funded projects:

- Turfgrass growth as a function of light and temperature. Karin Blombäck, Sweden.
- A milder and wetter climate: Implications for winter survival of perennial grasses. Marit Jørgensen, Norway.
- Climate change: Implications for species and variety selection on Scandinavian golf courses. Bjørn Molteberg and Petter Marum, Norway.
- How will global warming affect *Microdochium nivale* and other diseases on golf courses? Anne-Marte Tronsmo, Norway.
- Chemical growth regulation: A means to reduce CO^2 emissions? Trygve S. Aamlid, Norway.
- Carbon accounting and energy conservation on golf courses: Plans for a new STERF-project. Steen Gyllenkærne, Denmark.

After the presentations, the delegates visited the turfgrass field trials at Landvik.
The second day was devoted to a workshop on future directions for STERF. After invited introductory talks by a golf course architect and turfgrass agronomists, the delegates were divided into groups and asked to identify gaps in knowledge, suggest and prioritize issues for new projects, and suggest strategies for more efficient dissemination and implementation of results.

There appeared to be general agreement among the groups that the following research areas ought to be prioritized:

- Turfgrass seed mixtures, overseeding and population dynamics.
- Golf course winter management: Hardening and dehardening physiology, effects of Primo MAXX, use of covers, measures to promote spring green-up.
- Golf course water management: Surface vs. tile drainage, sand-capping of fairways, irrigation and recycling of waste water.
- Turfgrass breeding and evaluation, with more focus on disease resistance.
- Playing quality, especially of fescue greens.
- Golf course ecosystems: Landscape and biodiversity.

The following strategies were suggested for dissemination and implementation of results:

- Booklets that are easily accessible to practitioners.
- More large-scale demonstration trials on golf courses.
- Regular STERF newsletters.
- Meetings with cross-communication between greenkeepers and researchers.
- Internet-based reference book.

MEETING CONCERNING NORDIC R&D AND THE ROLE OF THE GREENKEEPERS' ASSOCIATIONS

In order to make ready-to-use research results easily accessible to end-users and to implement new knowledge more efficiently, STERF wants to establish a more continuous partnership with the Nordic Greenkeepers' Associations. STERF and the national Greenkeepers' Associations should be jointly responsible for an effective dialogue between researchers and practitioners so as to identify research priorities in new fields and to ensure that new-found knowledge and experience are transferred into practice.

THE MEETING WAS HELD IN COPENHAGEN ON 8 FEBRUARY 2008. IMPORTANT ISSUES DISCUSSED AND AGREED WERE:

- The Greenkeepers' Associations should establish a national group of dedicated greenkeepers to help identify issues important for research. These national groups should each elect one member to join the STERF scientific committee.
- Representatives from national research groups should also be asked for practical input to ongoing projects.
- Dissemination of new R&D knowledge to all training and education programmes is important. The Greenkeepers' Associations will take responsibility for initiating discussions on how to coordinate this at Nordic level.

GEO SCIENTIFIC NETWORK AND INCREASED CO-FUNDING

STERF plays a key role in developing and establishing networks and partnerships with appropriate national and international organisations. This gives STERF a greater influence on international level, enlarges its financial base and increases its international network.

More than 60% of STERF research projects have established partnerships and are obtaining matching funding from universities and research institutes, research councils, public authorities, commercial companies and other organizations.

The Golf Environment Organisation (GEO) scientific network is chaired by STERF. GEO advocates sound scientific understanding of golfers' relationship with the environment based on facts rather than on opinions. The scientific network comprises a partnership of universities, research institutes and environmental organisations that share an interest in the environmental sustainability of golf.

SIX NEW RESEARCH PROJECTS

By the 15 April 2008 deadline for its call for proposals, STERF had received 22 applications for funding. Of these, the STERF board approved funding for the following six projects:

- Evaporative demands and deficit irrigation on sand-based golf greens.
- Impact of mowing height and late autumn fertilizing on winter survival of golf greens in the Nordic countries.
- Re-establishment of green turfgrass after winter damage, spring 2009.
- Carbon accounting and energy conservation.
- Preservation of cultural landscapes and cultural heritage elements on golf courses.
- Multifunctional golf courses with unique natural and cultural values.

ABOUT STERF

The Scandinavian Turfgrass and Environment Research Foundation (STERF) is a research foundation set up in order to support existing and future R&D efforts and to deliver ready-to-use research results that will benefit the Nordic golf sector. STERF is jointly funded by the golf federations in Sweden, Denmark, Norway, Finland, Iceland and the Nordic Greenkeepers' Associations.

VISION

- STERF is the leading international centre of expertise in sustainable golf course management.

PRINCIPAL STRATEGIES

- **Approach:** Research funded by STERF should be carried out at universities or research institutes (or equivalent), where most research capacity is concentrated. STERF has no research capacity in the form of staff or facilities. The work is carried out in project form and is user-driven.

- **Capacity:** STERF strengthens research capacity by encouraging and supporting networks and by collaborating actively with key organizations in the field of turfgrass management.

- **Application:** STERF delivers ready-to-use results allowing excellent playing quality through environmentally sound management.

- **Resources:** STERF allocates funding from participating golf associations, which can be complemented by funding from other sources.

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BACKGROUND

The Nordic Golf Federations have approx. 900 000 members, playing golf on over 900 courses that cover a total area of more than 58 000 ha. Any societal activity as significant as golf must take responsibility for building knowledge through research and development (R&D). R&D is, and will continue to be, a necessary and strategically important investment for the Nordic 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 the golf facility and improving the environment.

The golf sector relies on natural resources and co-existence with the environment and there are several important reasons why Nordic R&D is necessary. Central Scandinavia, Oslo, Stockholm and Helsinki lie at the same latitude as the southern tip of Greenland (~60^{o}N). This gives a unique climate resulting from a combination of factors such as light, temperature and precipitation during the playing season and, in particular, during the winter season. The Nordic climate creates conditions for plant growth and the construction and management of golf courses that are not found anywhere else in the world. Changes in climate will also have significant and profound implications for the Nordic golf business. Golf needs to plan for adaptation to climate change. Golf must also seek to play a credible part in minimizing factors affecting climate change, through the adoption of greater resource efficiency actions, combined with measures to protect and enhance ecosystems.

The depletion of the earth's natural resources is one of the most pressing environmental concerns, as it is directly linked to ecosystem damage and the emission of climate changing greenhouse gases. Reducing resource consumption is central to this effort. It also makes absolute business sense to reduce unnecessary expense and waste through efficient consumption of energy and materials. For the golf sector this means continuous improvement in energy and resource efficiency combined with improved waste management maximizing reuse and recycling. It also means applying new renewable energy alternatives, utilizing products made from recycled materials, and reducing embodied energy through the development of low energy supply chains, which would also promote the purchase of local products and services.

Few leisure activities have such an intimate interaction with the environment as golf. Golf does not have an inherent positive or negative impact on nature and biodiversity. Its actual impact depends on the attributes of the particular site and the attention to detail in planning, design, construction and management of facilities. Continual support is needed for R&D to provide protection for the unique Nordic ecosystems and to prove that golf courses are often positive within local environments, and may be equal to many natural and semi-natural habitats in terms of animal and plant diversity.

The golf sector is influenced by the requirements of public authorities and by an increasing environmental awareness among the general public. Good examples of this are the new European pesticide, water and soil

directives, which will soon be implemented by the Member States. In the new European Framework Directive on Sustainable Use of Pesticides (January 2009), golf is directly mentioned with a view to minimizing and prohibiting the use of pesticides. There is also strong emphasis on the development of National Action Plans to implement the Framework Directive, which will include quantitative reductions in pesticide use and the need for Member States to describe how they plan to ensure the implementation of the principles of Integrated Pest Management.

The golf sector should play its part by reducing the need for chemical plant protection products and their use, consistent with environmental and human health protection. The promotion of an integrated approach to pest and disease management (IPM) is central to this. The Nordic golf sector must support improvements across the sector in education and environmental programme development, based on research and science, to ensure that non-chemical alternatives are available and prioritized and that pesticide use is minimized. Only by continually supporting R&D can we keep ahead of developments and influence the new national and European legislation affecting the golf industry.

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STRATEGIC RESEARCH OBJECTIVES AND PRIORITY R&D AREAS

The Nordic golf sector's vision with respect to golf course quality and the environment is:

- To promote high-quality golf courses, whilst guaranteeing that ecosystem protection and enhancement are fully integrated into golf facility planning, design, construction and management.

The aim of STERF is to support R&D that can help the golf sector to fulfil this vision. The activities of STERF are intended to lead to improvements in golf course quality, as well as economic and environmental gains. The strategic objectives for STERF-funded R&D activities are that:

- The design, construction, management and administration of golf courses provide optimal conditions for playing quality, degree of utilisation of the course and management inputs.

- The design, construction, management and administration of golf courses are economically and environmentally sustainable, for example with respect to plant nutrient requirements, water and energy use, drainage and control of weeds and plant diseases.

- Golf courses contribute to improving the relationship between golf and ecosystems, maintain the natural and cultural value of the landscape and promote biodiversity.

PRIORITY R&D AREAS

STERF has decided on the following important categories of research for a period of about five years:

- Turfgrass breeding and evaluation.
- Winter stress management.
- Control of diseases, pests and weeds.
- Efficient use of energy, water and plant nutrients.
- Ecosystems, biodiversity and cultural preservation.

More information about STERF, and ongoing and finished projects can be found on the STERF website sterf.golf.se

EVALUATION OF TURFGRASS VARIETIES FOR USE ON SCANDINAVIAN GOLF GREENS, 2007-2010

Results from the sowing year 2007 and first green year 2008

Project period: January 2007 – December 2010
Principal investigator/contact person: Bjørn Molteberg, Norwegian Institute for Agricultural and Environmental Research, Bioforsk Øst Apelsvoll, N-2849 Kapp, Norway. **Telephone:** + 47 40 48 27 18.
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Co-applicants: Trygve S. Aamlid, Norwegian Institute of Agricultural and Environmental Research. Gudni Thorvaldsson, Agricultural University of Iceland.Anders Hammarlund, Östra Ljungby naturbruksgymnasium.

Talks at conferences, meetings, seminars, field days, etc. (2008)

7 Jan.: Danish Greenkeepers' Association winter meeting, Sandmose, Denmark
20 May: First European Turfgrass Society Conference, Pisa, Italy.
15 May: Swedish Greenkeepers' Association visit to Apelsvoll, Norway
3 Sept.: STERF Seminar & Workshop, Landvik, Norway
9 Oct.: Sandmose Greenkeepers' School, Denmark, visit to Landvik, Norway.

Funding (kSEK):

	2007	2008	2009	2010	TOTAL
STERF	380	380	380	380	1 520
Other sources	87.5	87.5	87.5	87.5	350
TOTAL	467.5	467.5	467.5	467.5	1 870

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2009:

This project comprises variety trials on USGA greens at Östra Ljungby, Sweden, and Bioforsk Landvik, Norway (climate zone 1, see Figure 1), and Bioforsk Apelsvoll, Norway, and Keldnaholt GC, Iceland (climate zone 2). A total of 42 varieties within seven species and subspecies are being tested at each site. Due to incomplete establishment at Östra Ljungby and Keldnaholt, the following preliminary results are mainly from Landvik and Apelsvoll (Figure 2):

The rather tough winter 2007-08 discriminated strongly among species and varieties. On average for varieties within species, chewings fescue and slender creeping red fescue had significantly better winter survival than colonial, velvet and creeping bentgrass, perennial ryegrass and rough-stalked meadowgrass in both zones. As of 1

Jan. 2009, the fescues are therefore ranked ahead of the bentgrasses. Within the bentgrasses (*Agrostis*), the preliminary ranking order is velvet bentgrass > creeping bentgrass > colonial bentgrass. The 'new' species for golf greens, perennial ryegrass and rough-stalked meadowgrass, had high scores in the seeding year, but in the first green year they did not produce sufficient quality to replace any of the 'established' species.

The preliminary results for colonial bentgrass show that different varieties have to be used in zones 1 and 2. 'Aberroyal' and 'TAT 720' tended to have higher scores than the control variety 'Jorvik' in zone 1, while 'LøEk 0015' may replace 'Leirin' in zone 2.
The control variety 'Villa' of velvet bentgrass had significantly higher overall score and tended to have better winter survival than 'Vesper' and 'Legendary' in zone 2. Differences among these varieties were small in zone 1.
Creeping bentgrass 'Nordlys' had superior winter survival and should be the number one variety for zone 2.
'Declaration', 'CY-2' and 'IS AP 14', along with the control variety 'Independence', may become new alternatives in zone 1.
'Musica' had higher overall scores than any other chewings fescue in both zones. Other chewings fescue varieties equal to or better than the control variety 'Center' in zone 1 were 'Barswing' and 'Greensleeves'.
Within slender creeping red fescue, 'Amarone', 'Frt 04213' and 'Viktoria' showed promising results in zone 1, while the control variety 'Cezanne' was among the best fescues in zone 2.
Within perennial ryegrass, 'DP17-2147' was somewhat more promising than the other varieties, and within rough-stalked meadowgrass, 'Qasar' was slightly, but not significantly better than 'Race Horse'.

Figure 1: Division of Scandinavia into two climate zones. The turfgrass variety trials are located in Apelsvol, Landvik, Östra Ljungby and Keldnaholt.
Figure 2: Variety greens at Apelsvoll (left) and Landvik (right), September 2008. Photos: Bjørn Molteberg and Trygve S. Aamlid.

Figure 1


Figure 2


Figure 2

POTENTIAL FOR VELVET BENTGRASS (AGROSTIS CANINA) ON SCANDINAVIAN GOLF GREENS

Project period: January 2006 – December 2010

Principal investigator/contact person:
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Co-applicants: Trygve S. Aamlid and Bjørn Molteberg, Norwegian Institute of Agricultural and Environmental Research.
Anne Marte Tronsmo and Arne Tronsmo, Norwegian University of Life Sciences (UMB). Bingru Huang, Bruce Clarke and James A. Murphy, Rutgers University, USA.
Katerina Jordan and Eric Lyons, University of Guelph, Canada.
Frank Rossi, Cornell University, USA.

Talks at conferences, meetings, seminars, field days, etc. (2008):
1 Apr.: Velvet bentgrass reference group meeting, Landvik
19 May : Poster at European Turfgrass Conference, Pisa, Italy.
2 Sept. : Information about the project, STERF seminar & workshop, Landvik.
9 Oct.: Information on project for visitors from Sandmose Greenkeepers' School, Denmark.

Founding (kSEK)

	2006	2007	2008	2009	2010	TOTAL
STERF	200	600	585	480*	260*	2 125
Other sources		750	1 000	1 000	811	3 561
TOTAL	200	1 350	1585	1 480	1 071	5 686

*Reserved, not granted

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2009:
Major questions regarding the use of velvet bentgrass (VB) on Nordic golf greens are whether VB cultivars are sufficiently winter hardy and how to control thatch in this species. Our project is divided into four sub-projects:

1) VB cultivars are being tested for winter survival in controlled environments. Hardened and unhardened plants of VB 'Avalon', 'Villa' 'Greenwich', and 'Legendary' are being compared with creeping bentgrass 'Penn A-4' and evaluated for resistance to freezing tem-

Figure 1

Figure 2

peratures, ice encasement, snow cover and various types of snow mould. Preliminary results from two trials suggest that VB is equally or more resistant to freezing temperatures than 'Penn A-4' but more susceptible to the combination of winter diseases and snow cover. So far, there has been little difference among VB cultivars in these characters.

2) Field trials combining two fertilizer levels, two top-dressing levels and four methods for mechanical/biological thatch control are being conducted on USGA greens at Apelsvoll and Landvik, SE Norway. Our data indicate that VB greens should receive at least 1.50 kg N/100 m2 during the grow-in year. So far, an increase in topdressing from 0.5 to 1.0 mm every two weeks has increased thatch thickness from 12 to 15 mm, but reduced thatch organic matter content from 8.6 to 5.5%. The consequences of this difference on turfgrass diseases and winter survival will be studied over the coming years.

3) A trial comparing two root zones (straight sand (SS) and SS + 20% (v/v) garden compost) and two irrigation regimes (light and frequent (LF) vs. deep and infrequent (DI) irrigation), is being conducted using field lysimeters at Landvik (Figure 2). LF irrigation resulted in less hydrophobicity and better turfgrass quality of both root zones during drought periods in Aug./Sept. 2007 and May/June 2008. Irrigation regime had no effect on thatch thickness, surface hardness, green speed, or nutrient leaching. These results speak in favour of LF as the preferred irrigation strategy on velvet bentgrass greens, but more experimental data are needed to draw final conclusions.

4) Practical evaluation/large-scale demonstration trials with VB are being carried out on nine Nordic golf courses (one in Denmark, two in Finland, two in Sweden and four in Norway). The head-greenkeepers at these golf courses have formed the 'VB reference group', which meets regularly. A booklet with practical recommendations for VB greens in Scandinavia will be produced by the end of the project.

Figure 1. Top-dressing sand being spread by hand in velvet bentgrass trial at Apelsvoll.
Photo: Trygve S. Aamlid

Figure 2. Experimental irrigation wagon being used in velvet bentgrass irrigation trial at Landvik. Photo: Trygve S. Aamlid

BREEDING OF WINTER HARDY TURFGRASS VARIETIES FOR CENTRAL AND NORTHERN SCANDINAVIA

Project period: January 2007 - December 2009
Principal investigator/contact person:
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Co-applicants: Bjørn Molteberg, Bioforsk Øst Apelsvoll, 2849 Kapp.
Kristin Daugstad, Bioforsk Øst Løken, 2940 Heggenes.

Funding (kSEK):

	2007	2008	2009	2010	2011	TOTAL
STERF	50	60	50			160
Other sources	50	60	50			160
TOTAL	100	120	100			320

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2009

Sub-project 1. Improving the leaf texture, uniformity and playing quality of winter hardy creeping bentgrass (*Agrostis stolonifera*)

'Nordlys' creeping bentgrass is outstanding in winter hardiness. Its major drawback is a variable leaf texture. The objective of this sub-project is to develop new and more uniform varieties based on 'Nordlys' germplasm. About 1000 plants from Nordlys were established in a field trial at Bioforsk Øst Løken in 2007. Density, fineness of leaves and number of inflorescences in the sowing year were recorded in August and September 2007. Plants for four synthetic populations were selected among the plants with high winter survival, narrow leaf width and good density, based on growth habit and earliness. The plants were planted in 20 cm pots around 26 June and set in isolation chambers for production of Syn1 seed. The seed was harvested in September, and sent to Graminor for threshing, cleaning and further seed increase and testing.

SUB-PROJECT 2. PRELIMINARY TESTING OF ADVANCED BREEDING MATERIALS ON AN EXPERIMENTAL GREEN

The objective of this sub-project is to test eight candidate varieties of chewings fescue (*Festuca rubra commutata*) and four candidate varieties of colonial bentgrass (*Agrostis capillaris*) from Graminor AS in green trials. The trial was established at the Bioforsk Øst Apelsvoll experimental putting green in 2007. The breeding material of chewings fescue had good plant cover,

acceptable winter survival and relatively high tiller density. 'LøRc0008' had the best score for overall visual merit and visual merit in the spring, summer and autumn of the first green year. It was significantly better than 'Center' in the spring. 'Center' had the highest incidence of winter damage. In colonial bentgrass the reference variety 'Jorvik' had the lowest score for overall visual merit and visual merit in the first green year. This was due to 'Jorvik' having the highest incidence of winter damage and lowest plant cover in the growing season. The advanced breeding materials tended to be denser, darker and have finer leaves than 'Leirin', the other reference variety in this trial. 'LøEk9806', 'LøEk0013' and 'LøEk0218' tended to be more resistant than 'Leirin, 'Jorvik' and 'LøEk0224' against 'in season diseases'. The rather tough winter of 2007-08 showed that several of the advanced breeding materials from Graminor AS have potential as varieties for putting greens in northern Scandinavia of establishment.

EVALUATION OF PLANT GROWTH REGULATOR TRINEXAPAC-ETHYL (PRIMO MAXX®) ON NORDIC GOLF COURSES

Project period: May 2007 – May 2009
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Co-applicants: Oiva Niemelainen, Agricultural Research Centre (MTT), Jokioinen, Finland
Maire Rannikko, HAMK University of Applied Sciences, Lepaa, Finland
Talks and posters at conferences, meetings, seminars, field days, etc. (2008):
31 Mar.: Norwegian Golf Federation seminar, Ullevål Stadium, Oslo
2 Sept.: STERF seminar on climate change, Bioforsk Landvik, Norway
28 Nov.: Norwegian Golf Federation seminar, Ullevål Stadium, Oslo

Funding (kSEK)

	2007	2008	2009	TOTAL
STERF	88	88	44	220
Other sources	237	237	-	474
TOTAL	325	325	44	694

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2009:
The plant growth regulator Primo MAXX® (trinexapac-ethyl) offers prospects for reduced mowing costs, lower CO^2 emissions, improved playing quality and better winter survival of turfgrass used for golf. The main objective of this project is to provide documentation for potential registration of Primo MAXX® for use on Nordic golf courses.

The project started in 2007 with trials according to Good Experimental Practice standard at Landvik, Norway, and Lepaa, Finland. Primo MAXX® was applied at monthly rates varying from 0.2 to 0.8 L ha^{-1} on greens and 0.5 to 3.0 L ha^{-1} on fairways. These treatments resulted in average clipping yield reductions of 18% on bluegrass/fescue fairways and 21% on creeping bentgrass greens. Unfortunately, growth suppression during the first two weeks after application was often followed by a rebound effect during the remaining two weeks until next application. While significant losses in turfgrass quality occurred at rates 1.0 L ha^{-1} and higher in the fairway trial at Landvik, monthly applications of

at least 1.5 L ha^{-1} ha resulted in significantly less snow mould (*Microdochium nivale*) and better overall appearance in the following spring in the green and fairway trials at Lepaa.

Because of the discoloration and rebound effects in 2007, Primo MAXX® was applied at lower rates but higher frequencies in new trials established in 2008. In a green trial at Landvik, weekly or biweekly applications of 0.15, 0.30 and 0.45 L ha-1 were compared with an unsprayed check. On average for application rates and frequencies, Primo MAXX® had no effect on turfgrass overall appearance or density but reduced clipping yield by 25% and increased ball roll distance by 6%. In a new fairway trial at Lepaa, biweekly applications of 0.4, 0.8, 1.2 and 1.6 L ha-1 had no effect on turfgrass quality but reduced clipping yield by 15, 23, 23 and 34%, respectively. Rebound effects were virtually absent in the 2008 trials.

In conclusion, we consider these results sufficient to recommend Primo MAXX® being labelled for use on Nordic golf courses. As a starting point, we recommend the following rates and application frequencies to be printed on the label:

	Primo MAXX®, rate*	Application interval
Greens (creeping bentgrass)	0.2 - 0.4 L ha^{-1}	Every 1 to 2 weeks
Fairways (Kentucky bluegrass/red fescue)	0.6 - 1.2 L ha^{-1}	Every 2 to 3 weeks
Roughs & semi-roughs (Kentucky bluegrass/red fescue)	1.0 - 2.0 L ha^{-1}	Every 3 to 4 weeks

*Always use lowest rate for the first seasonal application of Primo MAXX®.

Research technician Trond Pettersen measures ball roll distance with a modified stimpmeter in Primo MAXX® trial at Landvik. Photo: Trygve S. Aamlid.

PREDICTION OF TURF GROWTH AS A FUNCTION OF LIGHT AND TEMPERATURE UNDER NORDIC CONDITIONS

Project period: January 2007 - April 2009
Principal investigator/contact person: Karin Blombäck, Department of Soil & Environment,
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E-mail: karing.blomback@mv.slu.se
Co-applicants: Mats, Höglind, Bioforsk Vest, Sœrheim, Norway
Talks and posters at conferences, meetings, seminars, field days, etc. (2008):
2 Sept.: STERF seminar on climate change, Bioforsk Landvik, Norway

Funding (SEK)

	2007	2008	2009	TOTAL
STERF	290	-	-	290
Other sources	-	-	-	-
TOTAL	290	-	-	290

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2009

The aim of the project is to find a method to predict the potential growth and winter hardening processes of three turfgrass species as a function of different light and temperature conditions from early spring to late autumn. Good knowledge of potential growth is the basis for planning a maintenance programme that is sound and sustainable as regards turfgrass quality and economic and environmental concerns.

A simulation model for grass growth is being used to estimate growth curves for three different turfgrass species (*Agrostis stolonifera, Festuca rubra and Poa annua*) for different climatic conditions. The model will be further developed to include winter hardening functions to enable modelling of the winter stress. Potential growth for five locations in the Nordic countries (Umeå, Västerås and Lund in Sweden, Særheim in Norway and Joensuu in Finland) is being modelled. The three different locations in Sweden represent different light and temperature conditions due to different latitudes. Særheim in Norway was selected to represent a more maritime climate, while Joensuu in Finland represents a more continental climate. The effect of dif-

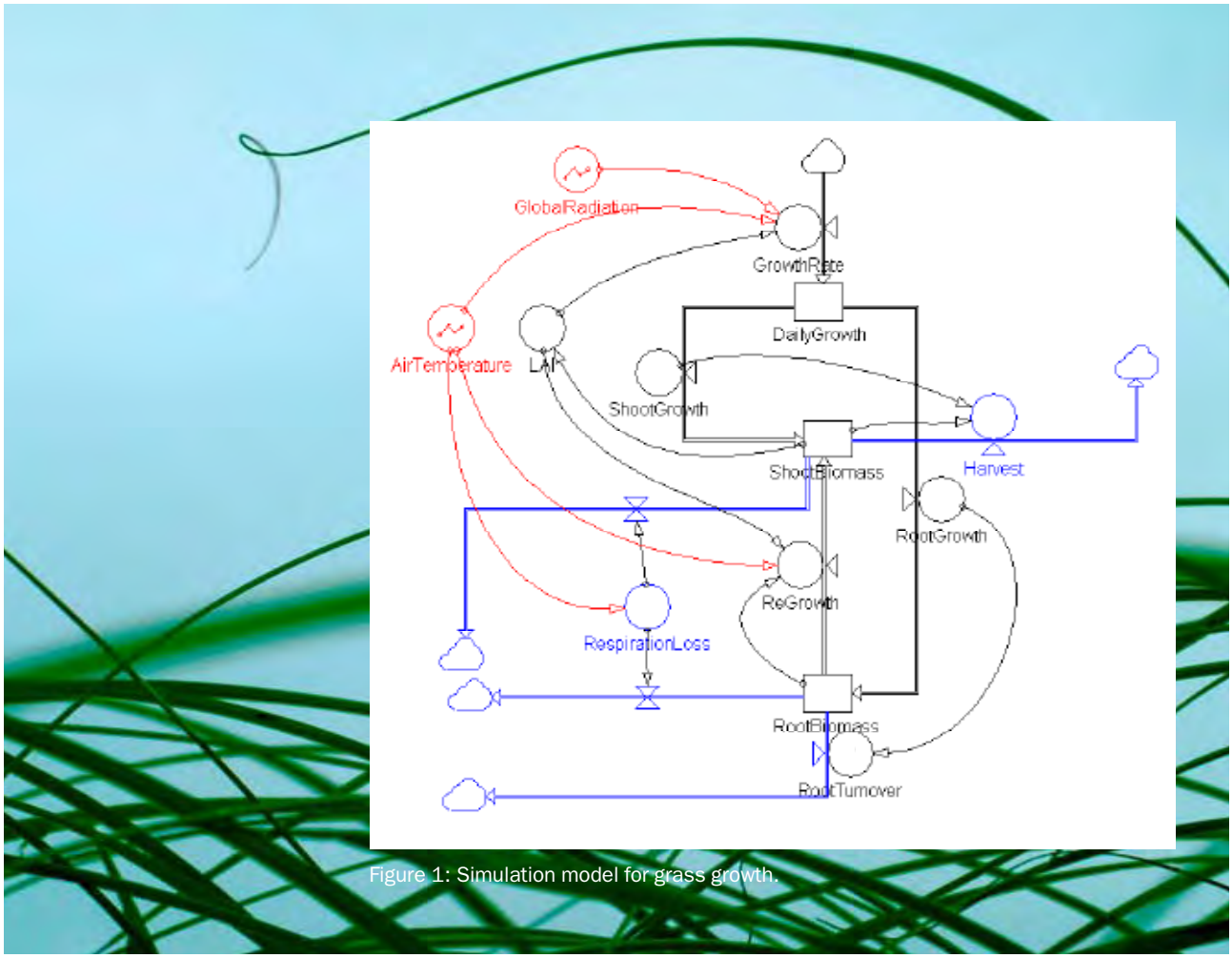

Figure 1: Simulation model for grass growth.

ferent climate change scenarios will also be tested. Field data were obtained from Fullerö GK, Västerås, during 2007 and 2008 to be used for calibration of the model.

The outcome from the project will be a simulation tool to predict growth of the turfgrass. Based on the simulated growth curves, recommendations for fertilization and other maintenance practices can be fine-tuned according to light and temperature conditions.

DEVELOPMENT, EVALUATION AND IMPLEMENTATION OF PLAYING QUALITY PARAMETERS IN A CONTINUOUS GOLF COURSE EVALUATION CONCEPT

Project period: February 2007 - May 2009
Principal investigator/contact person: Anne Mette Dahl Jensen, Forest & Landscape, University of Copenhagen, Rolighedsvej 23 1958 Frederiksberg, **Telephone:** + 45 35331706 **E-mail:** amdj@life.ku.dk
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Funding (kSEK)

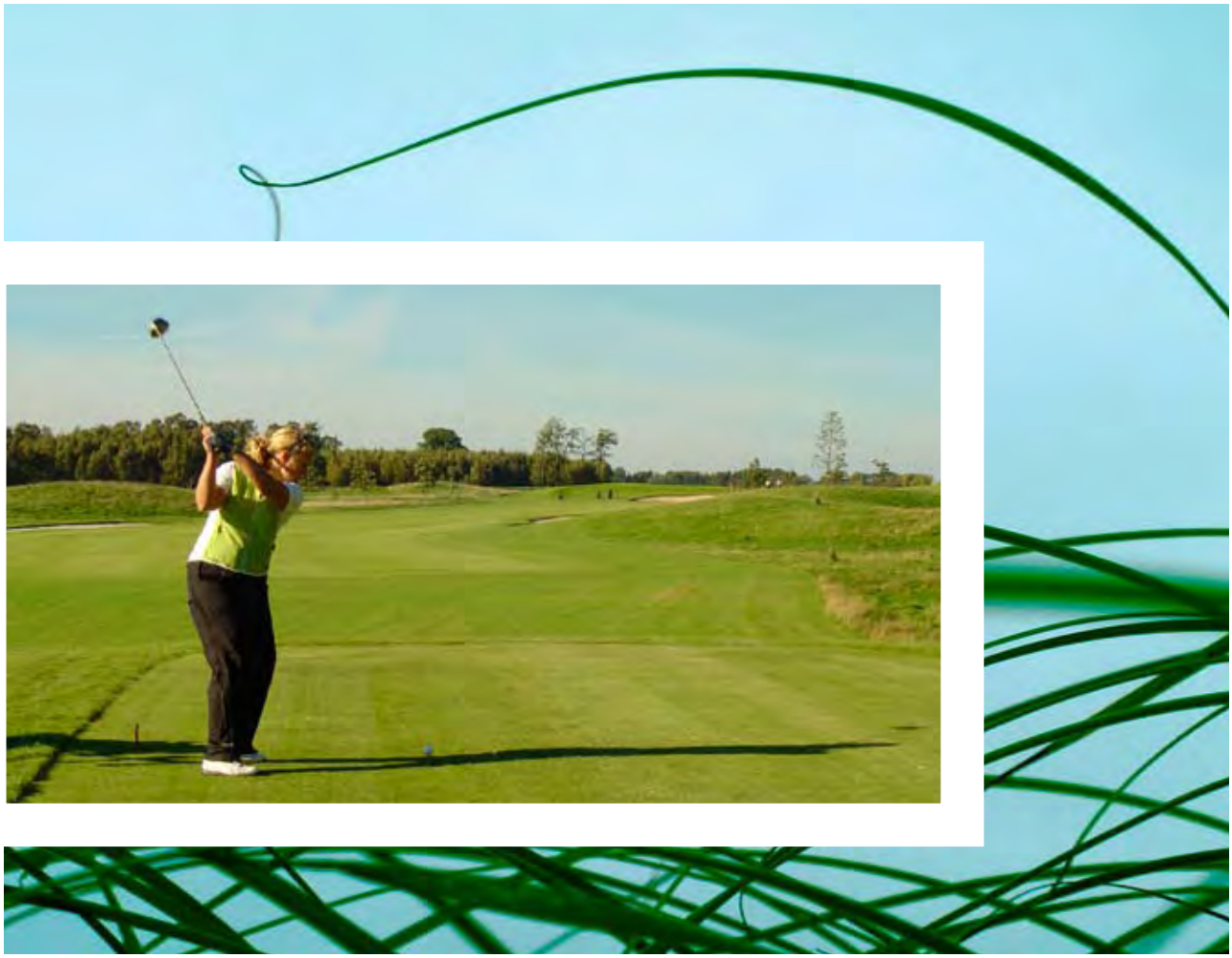
	2007	2008	2009	TOTAL
STERF	70	-	-	70
Other sources	33	-	-	33
TOTAL	103	-	-	103

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2009

Golf players´ opinion, definition, understanding and ranking of course and playing quality parameters provides important supporting data for defining course and playing quality in a broader sense. Therefore it was deemed important to carry out a user survey in Scandinavia among golf players with different skills and in different geographical regions.

In autumn 2008 a (Danish) user questionnaire was drawn up in collaboration with the Danish Golf Union (DGU). This questionnaire has been constructed to examine course and playing quality through questions asking people about their experiences, with the main focus on course appearance and playing quality parameters. The questionnaire deals with the different elements on the golf course: greens, fairways, tee areas, roughs and bunkers. Comments in relation to grass, trees, weeds, etc. are invited, so all the elements with which a player comes into contact from hole 1 to hole 18 are covered. However, there are no questions about extraneous elements such as pro shop, restaurant, parking facilities, etc.

The questionnaire was tested on a number of players with different skills before being translated into English



and Swedish. The DGU uploaded the translated questionnaire into an internet version, which was sent out to contact individuals in different clubs by 1 February 2009. These contact individuals have been asked to send the internet link on to all their club members via e-mail.

Of the golf clubs contacted in Denmark, Norway, Sweden, Finland and Iceland, so far 13 Danish, four Norwegian and two Swedish clubs have agreed to participate in the user survey. In Finland, Kristiina Laukkanen will be in charge of contacting players at Finnish golf clubs, who will have the opportunity to answer in English or Swedish. No clubs in Iceland responded to our contact.

The results from this user survey will hopefully help us to identify specific goals regarding course and playing quality for golf courses in Scandinavia. The next step will be to develop strategies for achieving these goals.

TURFGRASS DEMONSTRATION TRIAL IN DALARNA

Principal investigator/contact person:
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Co-applicants: Bengt Pettersen DGDF, Mikael Lagestam, Samuelsdals GK

Talks and posters at conferences, meetings, seminars, field days, etc. (2008):
2 Sept.: STERF seminar on climate change, Bioforsk Landvik, Norway

Funding (kSEK)

	2006	2007	2008	TOTAL
STERF	40	-	-	40
Other sources	40*	40*	40*	120*
TOTAL	80	40*	40*	160

*Labour costs

Project summary and status by 1 January 2009
During 2008, the fescues continued to show the best overall results. They did not develop any diseases during the year and showed great environmental quality and playable ability. 'Leonora' was the outstanding fescue variety and 'Baroyal' was the only variety that did not show the same quality as the other fescues. Of the creeping bentgrass varieties, 'Nordlys' showed very promising results and was the second best performer of the year after 'L-93'. The colonial bentgrass variety 'Leirin' was at the bottom of the list quality-wise, mostly because of repeated damage from snow mould.


Musica
Calliope
Baroyal
Cezanne
Leonora

OPTIMAL MAINTENANCE FOR HARDENING AND EARLY SPRING GROWTH OF GOLF GREEN TURFGRASS

Project period: 1 January 2005 – 30 June 2010
Principal investigator/contact person: Dr Mats Linde, Department of Soil & Environment, Swedish University of Agricultural Sciences, Box 7014, SE 750 07 UPPSALA, Sweden, Telephone: + 46 (0)18 671273,
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Co-applicants: Magnus Barth, Head Greenkeeper, Fullerö Golf Club
Dr Karin Blombäck, Swedish University of Agricultural Sciences (SLU)
Dr Tom Ericsson, Swedish University of Agricultural Sciences (SLU)
Maria Strandberg MSc, Swedish Golf Federation (SGF)
Professor Arne Tronsmo, Norwegian University of Life Sciences (UMB)

Talks at conferences, meetings, seminars, field days, etc. (2008)
February: Article in the Swedish Greenkeepers' Association journal, Greenbladet no. 1 2008
10 June: Presentation on research greens and trials to approx. 50 researchers participating in the European Grassland Federation (EGF) conference 2008.
22 Sept.: Presentation of the trials to delegates from the RNA Greens Committee, agronomists from Swedish Golf Federation and Professor Frank Rossi from Cornell University, USA.

Funding (kSEK)

	2005	2006	2007	2008	2009/2010	TOTAL
STERF			1 000	1 100	1 200	3 300
Other sources			500	500	500	1 500
TOTAL			1 500	1 600	1 700	4 800

PROJECT SUMMARY AND STATUS AS OF 1 JANUARY 2009

Winter damage to turf, especially on putting greens, is a major problem on golf courses in Scandinavia in most years. This causes increased maintenance and reconstruction costs, as well as delaying re-opening of the golf courses in spring.

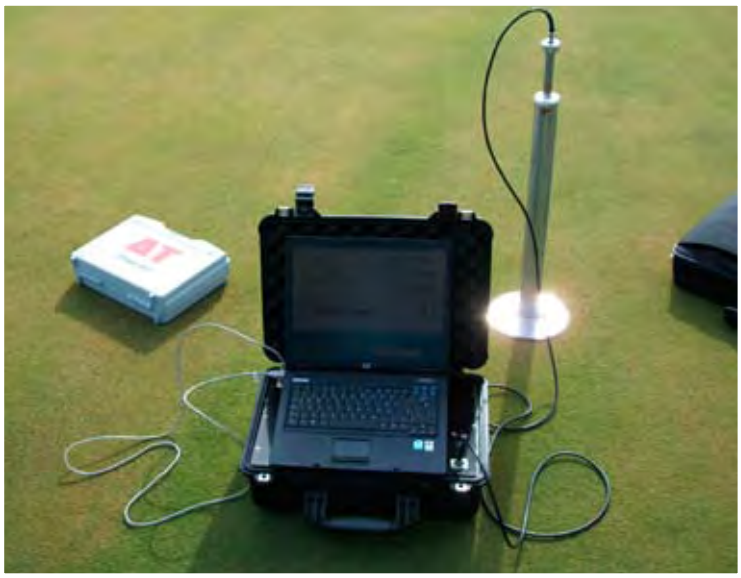
This project consists of three parts: 1) Construction of new research greens; 2) studies of how winter hardening and early spring growth are influenced by management strategy; and 3) information and communication.
The first part of the project was finished in late summer 2006, when the two chipping and research greens at

Fullerö GK were opened for play and the management regime was completely changed, from establishment of the grass to fertilization and fungicide treatment, according to the research plan. One of the greens is seeded with red fescue and one with creeping bent. In addition to the new test greens, an existing green with annual meadowgrass is being used in the project. The research plan includes four different fertilization regimes (traditional, traditional with late N supply, demand-driven and demand-driven with late N), with or without fungicide and with or without early spring cover.

Winter 2007/2008 was dry and very mild. The turf at Fullerö GK survived the winter in very good condition. On the red fescue green, no visual damage at all was recorded in spring 2008. The creeping bent and annual meadowgrass turf also showed much less damage than in spring 2007 and in almost all plots the damaged surface was less than 1-2% of the total area. The highest value recorded for both species was 7% surface damage. To conclude, the winter was very good for the turf but not for the overwintering project.

In 2008, aboveground biomass (grass clippings) was sampled on three occasions according to the research plan. In addition, whole plants with roots were sampled in April, July and early December for analyses of carbohydrate concentration in tissue. The practical problems with preparing the plant tissue for analysis have been solved but the procedure is time-consuming and the project still has a backlog when it comes to preparing and analysing the plant material due to lack of time for technical staff.

The network and knowledge base for communication about the project have expanded in the past year. Through cooperation with Cranfield University, UK, two students from the Master's programme in Sport Surface Management did their project work in Sweden. The field trials at the research greens were used by one of the students for a study about how fertilization regime influences the playing properties of the turf. The results were presented at a seminar at the Department of Applied Sciences, Cranfield University and will form the basis of a written report that will be published by Cranfield University library.



DEMONSTRATION TRIALS WITH WINTER COVERS

Project period: January 2007 – December 2010

Principal investigators/contact persons: Boel Pettersson, Svenska Golf Federation, Idrottens Hus, Mullbergsvägen 11 B, SE-931 37 Skellefteå. Telephone: +46 70 556 04 24, E-mail: boel.pettersson@sgf.golf.se
Maire Rannikko, HAMK University of Applied Sciences, Lepaa Unit, Lepaantie 129, FIN-14610 Lepaa.
Telephone: +358 3 646 5241

Co-applicants: HAMK University of Applied Sciences, Lepaa Golf Course, Aulanko Golf Oy, Swedish Golf Federation, Timrå Golf Course, Bodens Golf Course

Talks and posters at conferences, meetings, seminars, field days, etc. in 2008:
14 Aug.: Meeting of Finnish greenkeepers at LEPAA 08 professional exhibition
24 Apr.: Field Day for Swedish greenkeepers, Timrå Golf Course
20 Nov.: Training for Greenkeepers (VUB), Linköping
28 Nov.: Conference for Norwegian greenkeepers, Oslo

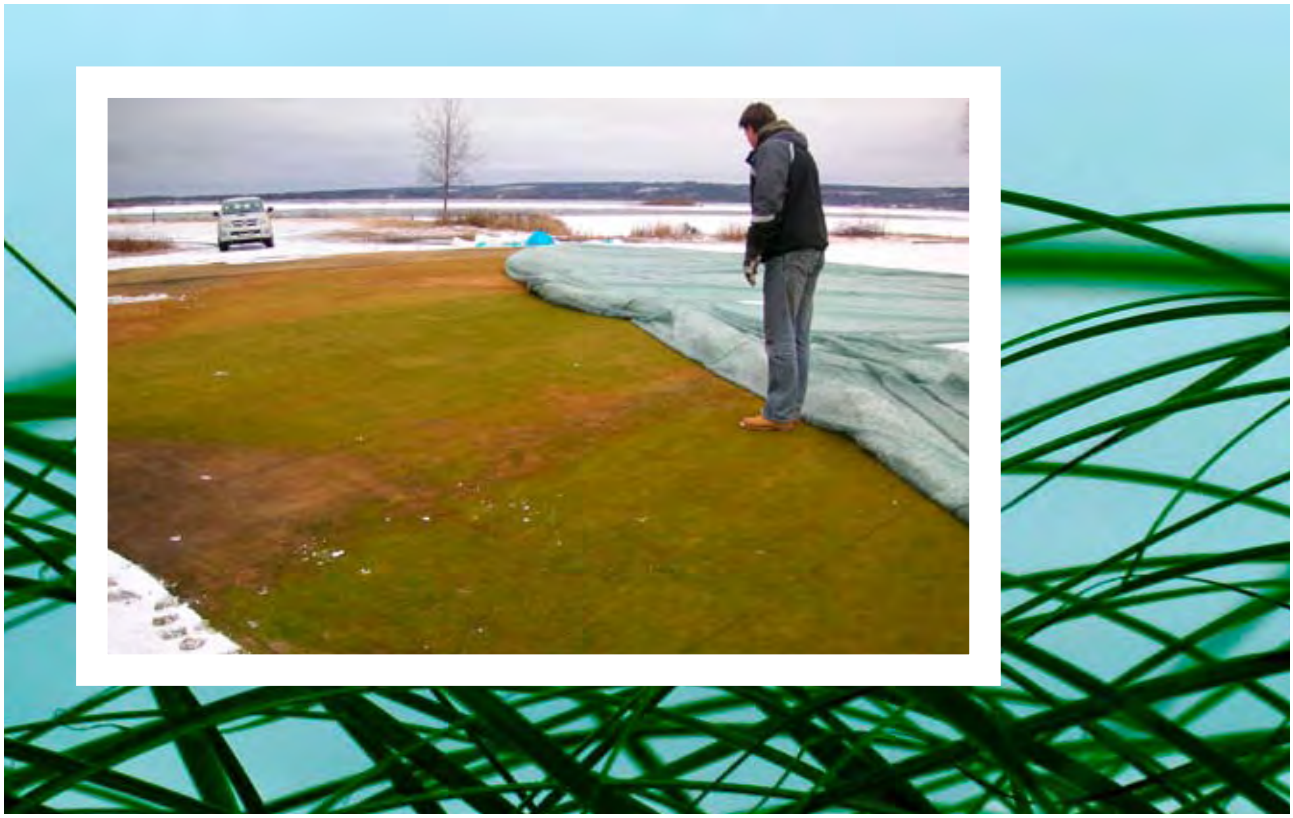
Funding (kSEK)

	2007	2008	2009	TOTAL
STERF	100	45	-	145
Other sources	100	46	-	146
TOTAL	200	91	-	291

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2009

The intention of demonstration trials is to provide more information on winter protection possibilities for greenkeepers, improving the overwintering of greens and extending the golf season. Eight different winter covering materials were compared in Sweden and Finland. Two golf courses from each country took part.

In Finland, because of the serious disease situation, only one green was covered all winter. The fungicide treatments were applied as usual just before the covers were laid down. The covering time of the green was short since covers were laid on the green late (13 Dec 2007), due to the warm autumn, and taken off on 11 March 2008. The only observable difference between the control area and covered areas was the colour of annual meadowgrass, which was slightly greener under covers compared with uncovered. The winter kill (30%) and disease damage (10%) were similar on covered and control areas. The differences in soil temperature under the covers were insignificant.



In autumn 2008 the fluctuating temperature, snowing and thawing presented problems in covering and only one green at Lepaa Golf Course was covered, on 8 Dec. 2008.

In Sweden, it was not possible to spray the trials with fungicide due to the ice and water conditions at the greens in the end of October and beginning of November 2007. After the snow and ice had melted, the greens at Bodens Golf Course were covered on 15 Nov and those at Timrå Golf Course on 21 Nov. The covers were taken off on 31 March and 7 Apr. 2008 at Timrå and on 5 May at Boden. The weather during the winter was very wet (mostly rain) at Timrå, which caused problems with ice from the end of November until March. At Boden there was mostly snow but some ice formation occurred during thaw periods. Problems with leaching water under the covers caused some dead areas in the trial in Timrå. Best winter survival was seen under the areas with impermeable cover, especially in combination with bubble plastic. 100% winter kill were observed in the control area. At Boden, there were small differences between the different areas and overall winter survival was poor. The differences in soil and ground temperatures under the covers and in the control area were small.

In autumn 2008, the greens at both courses were covered on 4-6 Nov., with fungicide treatment immediately prior to covering. In an attempt to create a better air space, a layer of leca (dried clay material) was applied between the cover and the ground.

IMPACT OF MOWING HEIGHT AND LATE AUTUMN FERTILIZING ON WINTER SURVIVAL OF GOLF GREENS IN THE NORDIC COUNTRIES

Project period: July 2008 – November 2010

Principal investigator/contact person:
Agnar Kvalbein, Norwegian Institute f Agricultural and Environmental Research, Bioforsk Øst Landvik, N-4886 Grimstad, Norway. **Telephone:** +47 406 22 916
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Talks at conferences, meetings, seminars, field days, etc. (2008):
28 Nov.: Golf Course seminar, Norwegian Golf Federation, Oslo

Funding (kSEK):

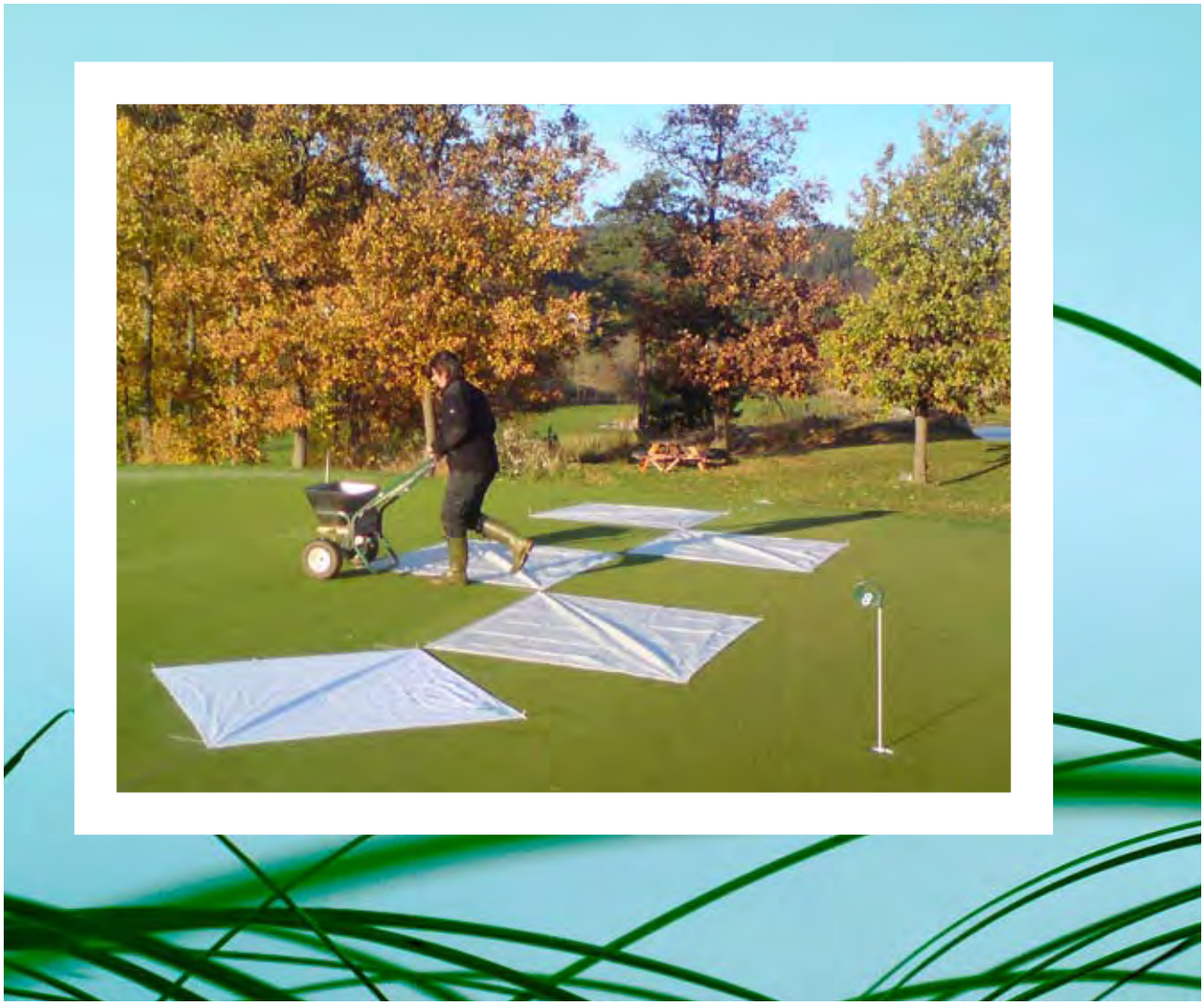
	2008	2009	2010	TOTAL
STERF	150	140	90	380
Other sources	0	0	0	0
TOTAL	150	140	90	380

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2009:
The background to this project was the discussion amongst greenkeepers about mowing height in the autumn, especially for new varieties of creeping bentgrass. The other question was whether fertilizing in late autumn had any positive effect on winter survival and spring green-up time under Nordic conditions.

Greenkeepers from Finland (3), Sweden (3), Norway (9) and Iceland (1) were trained at a one-day seminar on 4 September 2008 to perform experiments on their own greens.

In autumn 2008, experiments were established at their respective courses and at two test greens at Bioforsk Landvik (total of 18 trials). During the last 3-5 weeks before winter closure, two different mowing heights (100% and 150% of the summer mowing height normally used at the course) were established. When the turf had stopped growing (soil temperature expected to stay under 5ºC), a balanced soluble granular fertilizer was applied at a rate of 0.2 kg N/100 m2.

Although the 18 trial golf courses represent different climates, turfgrass species and maintenance practices,



we expect the high number of replicates in this project to lead to useful conclusions and guidelines for winter preparations on golf courses. The greenkeepers involved will also get hands-on experience of research and will contribute to increased awareness of STERF in the Nordic countries. The greenkeepers will meet again in autumn 2009 to discuss their results and to refine their methods before repeating the experiments during the winter 2009/2010.

RE-ESTABLISHMENT OF GREEN TURFGRASS AFTER WINTER DAMAGE, SPRING 2009

Project period: November 2008 – November 2009
Principal investigator/contact person: Agnar Kvalbein, Norwegian Greenkeepers' Association, Skien, Norway.
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Talks at conferences, meetings, seminars, field days, etc. (2008):
November 28: Golf Course seminar, Norwegian Golf Federation, Oslo

Funding (kSEK):

	2008	2009	TOTAL
STERF	0	50	50
Other sources	0	50	50
TOTAL	0	100	100

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2009:
Quick re-establishment of putting surfaces suffering from winter injuries can be vital for the golf club economy. Reseeding into dead turf is a challenging task and the results are often disappointing.

This full-scale demonstration experiment at two golf greens will compare traditional reseeding with radical removal of all thatch before seeding. The main objective is to see how fast a green can be re-established, but the costs and subsequent playing quality will also be reported.

A chipping green at Vestfold golf club was sprayed with herbicide in autumn 2008 to be prepared for re-establishment. Another partly or completely dead green will be selected for the experiment in spring 2009. Greenkeepers and others will be invited to evaluate these experiments on field days.

IMPROVED STRATEGY FOR CONTROL OF MICRODOCHIUM NIVALE ON GOLF COURSES

Project period: January 2006 – December 2008
Principal investigator/contact person: Anne Marte Tronsmo, Department of Plant and Environmental Sciences, Norwegian University of Life Sciences, P.O. Box 5003, NO-1432 ÅS, Norway.
C/O Bioforsk Plantehelse, Plantevernbygningen, Høgskolevegen 7,1430 Ås, **Telephone:** +47 92605766,
E- mail: anne-marte.tronsmo@umb.no
Co-applicants: Ingerd Skow Hofgaard, Bioforsk Plantehelse (ingerd.hofgaard@bioforsk.no)
Bjørn Molteberg, Bioforsk Apelsvoll (bjorn.molteberg@bioforsk.no)

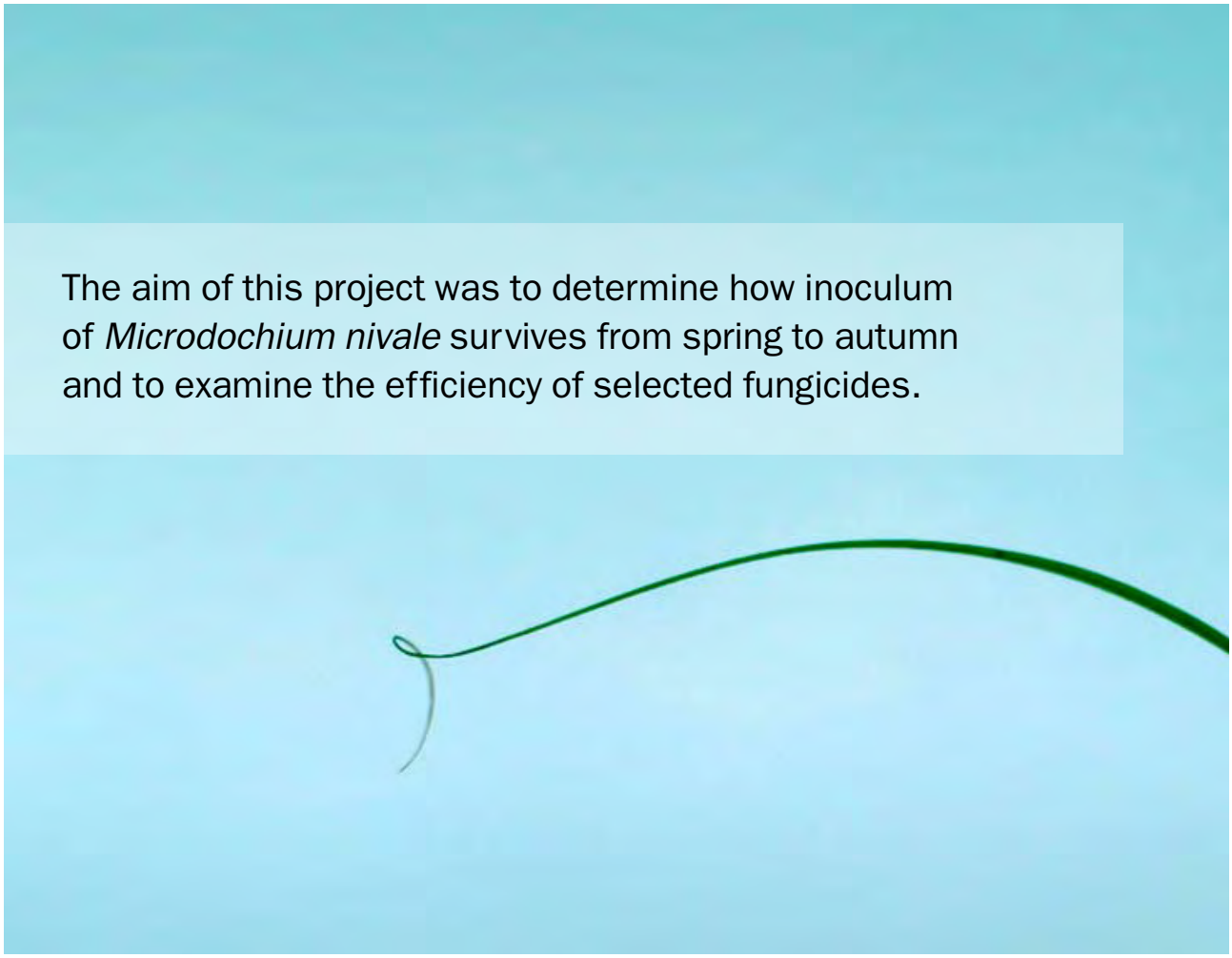
Funding (kSEK)

	2006	2007	2008	TOTAL
STERF	370	380	350	1 100
Other sources	-	-	-	-
TOTAL	370	380	350	1 100

Project summary and status by 1January 2009:
The most important and widespread disease on golf courses is snow mould caused by *Microdochium nivale*. Attempts to control this disease mainly involve prophylactic spraying with fungicides in autumn. The aim of this project was to determine how inoculum of *M. nivale* survives from spring to autumn and to examine the efficiency of selected fungicides.

Snow mould symptoms and the occurrence of *M. nivale* in leaves and stems of grasses sampled from golf greens and foregreens declined during the growing season. Despite a low rate of occurrence in autumn, M. nivale was re-isolated in some of the original locations in the following spring. The *M. nivale* isolation rate was similar at sites located on greens and foregreens, and on greens at more sunny sites and more shady sites. We concluded that this fungus survives from year to year within the same locations on greens and foregreens.

A significant correlation was found between mycelial growth rate of *M. nivale* isolates at 2°C and at 20°C. At 20°C, a greater variation in growth rate was observed between strains isolated immediately after snowmelt compared with strains isolated in spring, summer, autumn or prior to snowfall. No clear picture emerged in growth



rate differences between groups of *M. nivale* strains isolated at different time points throughout the year.

A significant reduction in mycelial growth rate of *M. nivale* on agar was observed on addition of low concentrations of all the fungicides tested. The products were: Acanto Prima (cyprodinil, picoxystrobin), Amistar (azoxystrobin), Amistar duo (azoxystrobin, propiconazole), Baycor (bitertanol), Bumper (propiconazole), Comet (pyraclostrobin), Proline (prothioconazole), Rovral 75WG/Chipco Green 75WG (iprodion), Sportak EW (prochloraz), Stratego 250 EC (propiconazole, trifloxystrobin), Topsin WG (thiophanate methyl). Sportak, Stratego and Topsin were the most efficient products, with 90-100% reduction in mycelial growth rate on agar recorded for the 0.1% fungicide concentration recommended for disease control on golf greens. Acanto Prima, Bumper, Comet and Stratego were also field-tested for their effect to reduce snow mould damage on golf greens. Due to severe water damage on the greens in the second season, only the results from one season of the fungicide field trial could be used. Acanto Prima was ranked as the best product, significantly reducing winter damage on average from 21% in control plots to 6% in treated plots.

DEVELOPMENT OF METHODS FOR NON-PESTICIDE WEED CONTROL ON GOLF COURSE FAIRWAYS

Project period: February 2008 – January 2111

Principal investigator/contact person: Anne Mette Dahl Jensen, Forest & Landscape, University of Copenhagen, Rolighedsvej 23 1958 Frederiksberg. Telephone: + 45 35331706, E-mail: amdj@life.ku.dk
Ken S. Krogholm, Forest & Landscape, University of Copenhagen, Rolighedsvej 23 1958 Frederiksberg.
Telephone: + 45 35331842, **E-amil:** kens@life.ku.dk

Talks and posters at conferences, meetings, seminars, field days, etc. (2008):

2 Sept.: Presentation of project at STERF seminar at Landvik
22 Sept.: Presentation of project in a grass course for landscape architect students at the University of Copenhagen
7 Oct.: Presentation of project on a field day at Furesoe Golf Club for the Danish Ministry of Environment
1,2 Nov.: Presentation of project at a Course and Environment seminar held by DGU in Aarhus and Copenhagen
4 Nov.: Presentation of project at a meeting for Scandinavian golf course architects at Simons Golf Course

Funding (kSEK)

	2008	2009	2010	2011	TOTAL
STERF	65	125	250	-	440
Other sources	612	612	6112	-	1 836
TOTAL	677	737	862	-	2 276

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2009

A pesticide agreement in Denmark has necessitated the development of pesticide-free methods for controlling pests, especially weeds, because most of the pesticides used on golf courses in Denmark are herbicides. The fundamental hypothesis in pesticide-free grass management is that weeds can be controlled indirectly through a plant nutrient supply strategy that allows the grass to repress the weeds. However weeds can also be reduced directly by mechanical practices such as verticutting and grooming. The aim of the project is to develop new and improved strategies for pesticide-free mechanical management of grass and weed on fairways, with the focus on timing and frequency of the management techniques. In order to represent the different management principles, fertilizer regimes, verticutting (time and frequency), grooming (time and frequency) and topdressing have been included as factors in the two field experiments set up in spring 2008. These experiments are being carried out on two golf courses on Zealand (Furesoe Golf Club

and Asserbo Golf Club), one situated on a clay soil and one on a sandy soil. The effects are being recorded four times a year.

In addition, a detailed study of the different weed species is planned. The aim is to generate knowledge about the weeds under turfgrass conditions (morphology, physiology, etc.) and to examine how they react to the different management techniques (cutting and grooming). Most of these experiments will take place in a controlled environment and on golf course fairways.

FERTILIZER STRATEGIES FOR GOLF TURF: IMPLICATIONS FOR PHYSIOLOGY-DRIVEN FERTILIZATION

Project period: January 2007 – December 2010

Principal investigator/contact person: Tom Ericsson, Department of Urban and Rural Development, Swedish University of Agricultural Science, P.O. Box 7012, SE 750 07 Uppsala, Sweden. Telephone: +4618672534.
E-mail: tom.ericsson@sol.slu.se **Co-applicants:** Karin Blombäck, Department of Soil & Environment, Swedish University of Agricultural Science
Trygve S. Aamlid and Agnar Kvalbein, Norwegian Institute of Agricultural and Environmental Research, Bioforsk Øst Landvik

Talks and posters at conferences, meetings, seminars, field days, etc. in 2008:
20 Nov.: Slovenian Greenkeepers Association, Education Conference, Bled

Funding (kSEK)

	2007	2008	2009	2010	TOTAL
STERF	91	386	462	284	1223
Other sources	133				133
TOTAL	224				1356

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2009

The objective of this study is to determine the relationship between plant N status and growth for creeping bentgrass, velvet bentgrass, colonial bentgrass, slender creeping red fescue, chewing fescue and annual bluegrass. Furthermore, the effects of plant N status on biomass allocation, playing quality and fructan storage are being evaluated. The study is being performed in two steps. In 2007, a pot experiment was carried out under controlled climatic conditions in order to determine the basic linear relationship between plant N status and growth. In 2008, a field experiment was set up. The findings from the pot experiment are being validated at the Bioforsk turf research site at Landvik, Norway. The results will be used to improve the precision of current recommendations for demand-driven fertilization.
In the field experiment, three intensity levels of nitrogen supply were studied, 100%, 60% and 40% of estimated requirements for maximum growth. The 100% rate was set to 3 kg N/100m^2 for creeping bentgrass and annual bluegrass, 2.13 kg N/100m^2 for velvet bentgrass and colonial bentgrass, and 1.50 N/100m^2 for the red

fescues. The nutrients were applied weekly as a complete liquid fertilizer, and according to a plan based on normal temperature and light conditions. The green was mowed and maintained according to good practice. The turf did not develop satisfactorily during the growing season of 2008. Although the fertilizer level in the 100% treatment, independent of species, far exceeded the N-requirement for the achievement of a fresh looking green, the colour was pale green and the N-concentration in the clippings did not reach the threshold value of 3% determined in the pot experiment until August. The deficiency symptoms were more pronounced in the sub-optimal N treatments, indicating that a fraction of the weekly nutrient additions were unavailable for root uptake. Red fescue in particular showed poor establishment and full percentage cover was not reached until the end of the season. The shortage of N cannot be explained by leaching or denitrification. At present, N immobilization in the soil offers the most probable explanation. The green was established in July 2007. The field experiment will be repeated in 2009.

EVAPORATIVE DEMAND AND DEFICIT IRRIGATION ON GOLF COURSES AND OTHER TURFGRASS AREAS

Project period: July 2008 – December 2012

Principal investigator/contact person:
Trygve S. Aamlid, Norwegian Institute for Agricultural and Environmental Research, Bioforsk Øst Landvik, N-4886 Grimstad, Norway. **Telephone:** + 47 90 52 83 78.
E-mail: tryggve.aamlid@bioforsk.no
Co-applicants:
Jan Stavås, Rainbird Irrigation Company, Sweden
Jerry Knox, Cranfield University, UK
Agnar Kvalbein and Hugh Riley, Bioforsk, Norway

Talks and posters at conferences, meetings, seminars, field days, etc. (2008):
31 March: Norwegian Golf Federation seminar, Ullevål Stadium, Oslo

Funding (kSEK):

	2008	2009	2010	2011	2012	TOTAL
STERF		400	400	400	300*	1 500
Other sources	94	365	459	459	365	1 742
TOTAL	94	765	859	859	665	3 242

*Reserved, not granted

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2009:
Lack of irrigation water is a threat to golf and other turfgrass sectors world-wide. In parts of Scandinavia, golf courses have often been over-irrigated, resulting in thatch, moss, algae and disease problems, nutrient and pesticide leaching, and reduced playing quality. Moderate drought stress is likely to lower turfgrass top/root ratios and reduce clipping yields before wilt symptoms appear, but the acceptable limits for drought stress are poorly defined for various turfgrass species and mowing heights.

The objective of this project is to provide a foundation for water-saving irrigation practices. Four sub-projects (SPs) will be conducted: In SP1, the evapotranspiration (ET) of various turfgrass species will be determined by daily weighing of mini-lysimeters (10 cm diameter, 30 cm deep) installed into the experimental greens and fairways at Landvik, Norway (Figure 1). The measurements will be conducted during natural dry-down periods in 2009, 2010 and 2011. In half of these lysimeters, ET under non-limiting water supply (ET_0) will be determined by daily replenishment of the ET weight

Figure 1

Figure 2

losses. These ET_0 rates will be compared with ET values estimated by an automatic 'Rainbird' weather station (Figure 2). In the other half of the lysimeters, actual ET (ETa) and leaf elongation rates will be determined under progressive drought stress. Our hypothesis is that leaf elongation is reduced, but ETa remains relatively constant, until a critical water potential that is species-dependent.

The principle of deficit irrigation is to maintain turf quality but limit growth by always replacing less than the ET_0 of well-watered turf. The objective of SP2 is to find the limits for this strategy on a creeping bent-grass (Agrostis stolonifera)-dominated green and a red fescue (Festuca rubra)-dominated fairway. Replacement of 50, 75 and 100% of ET_0 will be compared at 2, 4 or 6 day irrigation intervals. The trials will be conducted under a fully automated mobile rainout shelter during the seasons 2009-2011. Our hypothesis is that frequent replenishment of 50-75% of ET_0 will save water and give better turfgrass quality than deep and infrequent irrigation.

In SP3, the preliminary findings from WPs 1 and 2 will be implemented in demonstration trials on four golf courses, two football pitches and two public parks from 1 July 2010 onwards. These trials will be actively used for dissemination of project results.

SP4 involves the publication of scientific papers and a 'Scandinavian Turfgrass Manager's Irrigation Handbook'.

Figure 1: Rainbird weather station.

Figure 2: Minilysimeter used to measure ET in greens.

CARBON ACCOUNTING AND ENERGY CONSERVATION

Project period: April 2008 - October 2009
Principal investigator/contact person: Steen Gyldenkærne, Section on Emissions and Risk Analysis, Department of Policy Analysis, National Environmental Research Institute, Aarhus University, Frederiksborgvej 399, DK-4000 Roskilde, Denmark. Telephone: +46 30 1223. **E-mail:** sgy@dmu.dk
Co-applicants: Ole-Kenneth Nielsen, NERI
Kasper Saunders Bang and Helle Lytmann, COWI, René Gislum, FAS

Funding (kSEK)

	2008	2009	TOTAL
STERF	-	650	650
Other sources	-	-	-
TOTAL	-	650	650

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2009

There are currently no established carbon accounting methodologies for the operation of golf facilities or for the organization and running of golf events. In order to keep up with the expectations of society and the increasingly carbon-orientated policies of government, there is a need to equip the golf sector, for example golf facility managers, course managers and golf event organizers, with credible methodologies to enable them to undertake accurate carbon accounting.
Minimizing carbon emissions and optimizing energy consumption have two equally important general objectives – to lower environmental impacts and to reduce financial costs. Both objectives are important for all aspects of living. The carbon emissions and carbon sequestration from golf can be related to the consumption of fossil fuel and to carbon stock conservation in the golf course.

The objective of this proposal is to develop a carbon accounting and energy conservation tool for the golf sector. The tool developed will help golf managers and greenkeepers to estimate the greenhouse gas (GHG) budget from golf courses and events. The tool will be based on international guidelines and on national data for the Nordic countries and will be state of the art, with the highest scientific standard. The tool will be downloadable via the internet, easy to use and able to compare emission estimates, as well as benchmarking of individual golf clubs. Due to large regional variations in e.g. soil characteristics, climate conditions and emission factors for fossil fuel within the Nordic countries, the CO2 calculator will be designed for regions with different soil characteristics and climate conditions.

PRESERVATION OF CULTURAL LANDSCAPES AND CULTURAL HERITAGE ELEMENTS ON GOLF COURSES

Project period: January 2009 – December 2011
Principal investigator/contact person: Ole R. Sandberg, Department of Landscape Architecture and Spatial Planning, Norwegian University of Life Sciences, P.O. Box 5003, N-1432 Aas, Norway. Telephone: +47 6496 5300 (5357 direct) alt. +47 92202011, Email: ole.sandberg@umb.no
Co-applicants: Gary Fry, Department of Landscape Architecture and Spatial Planning, Norwegian University of Life Sciences
Mari S.Tveit, Department of Landscape Architecture and Spatial Planning, Norwegian University of Life Sciences

Funding (kSEK)

	2009	2010	2011	TOTAL
STERF	300.	300	300	900
UMB/ILP	165	165	165	495
TOTAL	465	465	465	1 395

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2009

The objective of the study is to produce tools that can be used by golf course architects, greenkeepers and authorities to assess the impact of golf courses on cultural landscapes and cultural heritage elements.
The methods applied are a combination of case studies and a literature review. The study is assessing how planning processes and environmental impact assessments related to golf courses differ in New Zealand, Britain and Scandinavia. The study will also explore the different scientific methods that have been applied in these countries, and possibilities for mutual development of methods for analysis of visual landscape character and heritage values applied in the project.

MULTIFUNCTIONAL GOLF COURSE WITH UNIQUE NATURAL AND CULTURAL VALUES

Project period: January 2009 - December 2010
Principal investigator/contact person: Carina Wettemark, ecologist, Biosfärskontoret, Kristianstads kommun,
Telephone: +46 (0)44136486, **E-mail:** carina.wettemark@kristianstad.se
Co-applicants: Kristianstad Golf club, Åhus, Sweden

Funding (kSEK)

	2009	2010	TOTAL
STERF	125	125	250
Other sources	125	125	250
TOTAL	250	250	500

PROJECT SUMMARY AND STATUS BY 1 JANUARY 2009

In addition to serving as important recreation areas for golfers and outdoor leisure activities, many golf courses possess high natural and cultural values. Since 2004, Kristianstad Golf Club has been working together with the Kristianstad Vattenrike Biosphere Office towards achieving environmental certification for the golf club's course and its operations in general accordance with the guidelines for Golf Environment Europe (GEE). As one aspect of this work, the club applied some time ago for the Swedish Golf Federation's environmental diploma. STERF has now approved project funding to proceed further with the work of promoting the multifunctional utilization of the golf course and to preserve and develop the natural and cultural values by means of a number of demonstrations and pilot schemes on and adjacent to the golf course.

The objectives of the project include the creation of a multifunctional golf course where a greater awareness of the use of pesticides and watering, etc. (according to GEE guidelines) will lead to their more economical use, and where this is combined with nature conservation measures to promote greater biodiversity (including measures to benefit a number of the endangered insects to be found on the course), cultural conservation measures, greater access for other forms of outdoor leisure activities through the use of paths, etc., and the dissemination of information in the form of information boards, field excursions, a nature school, etc.

Another aspect of the project involves producing a simple manual explaining how to document the natural and cultural values of golf courses and how to integrate this work into the other environmental activities of the golf club.

The project will commence during winter 2008/2009 and is scheduled for completion in December 2010.

Another aspect of the project involves producing a simple manual explaining how to document the natural and cultural values of golf courses and how to integrate this work into the other environmental activities of the golf club.

FINISHED PROJECTS

The projects listed below were funded by STERF during the period 2001-2008. More information about the projects can be found on the STERF website sterf.golf.se

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

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

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

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

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

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

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

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

- **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).

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

ECONOMIC OVERVIEW

INCOME STATEMENT

	01-01-2008–12-31-2008	01-01-2007–12-31-2007
Revenue		
Net revenue	4 925 737	4 704 286
	4 925 737	4 704 286
Expenses		
Other external expenses	-8 224	-17 736
	-8 224	-17 736
	4 917 513	**4 686 550**
Income from financial items		
Interest	144 713	82 321
Surplus	**5 062 226**	**4 768 871**

BALANCE SHEET

	12-31-2008	12-31-2007
Assets		
Cash and bank balances	3 757 470	1 204 724
Other receivables	0	2 016 728
Total assets	**3 757 470**	**3 221 452**
Liabilities and equity		
Equity		
Restricted reserves	254 780	247 545
Non restricted reserves	2 969 784	2 435 793
Total equity	**3 224 564**	**2 683 338**
Current liabilities		
Other current liabilities	532 906	538 114
Total current liabilities	**532 906**	**538 114**
Total liabilities and equity	**3 757 470**	**3 221 452**

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Aamlid, T.S. & B. Molteberg 2004a. Evaluation of Agrostis and Festuca varieties for use on Scandinavian golf greens. Results from the sowing year 2003 and first green year 2004. Report to the Scandinavian Turfgrass and Environment Research Foundation. Sterf.golf.se 24 pp.

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