RED FESCUE MANAGEMENT

GUIDELINES BASED ON NEW RESEARCH AND GREENKEEPERS' EXPERIENCES

Sterr

PREFACE

This red fescue management handbook is based on results from the research project "FESCUE-GREEN: Best management of red fescue (*Festuca rubra*) golf greens for high sustainability and playability". The project was funded by the Scandinavian Turfgrass and Environment Research Foundation (STERF) and conducted by NIBIO Turfgrass Research Group in close cooperation with Anne Mette Dahl Jensen at University of Copenhagen and Course Manager Per Rasmussen at Smørum Golf Course, Denmark.

A preliminary text summarising greenkeepers' experiences with red fescue was published based on the outcomes from a workshop in October 2012. Participants at the project's final seminar "Low input management of golf courses" in Copenhagen in 2015 also gave valuable input to this handbook.

The Fescue project started in 2011 and was concluded in 2015. Information and reports from the research can be found on the STERF FESCUE website: **www.sterf.org**. As of 20 February 2016, one scientific paper has been published, two have been submitted and two are planned for 2016.

The reference list is short and perhaps incomplete. The reason is partly because most research on fescue or fescue/bent greens was conducted primarily in UK 10-30 years ago, on establishing turf requiring higher fertiliser inputs. This makes these results less relevant when focusing on the benefits from low input management. Therefore, our text is based on a combination of recent research and not referable experiences, and we use *italic fonts* when referring to results from the FESCUE-GREEN project.

We hope that the text will be useful and that it may contribute to more sustainable golf course management without compromising the quality of surfaces produced for the sport of golf.

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CONTENT

Royal Troon golf links. Photo: Håkon Wergeland, September 2003.

WHY RED FESCUE?

Red fescue is a widespread native grass species in the temperate zone that probably dominated the first links courses on the British Isles where it resisted summer drought, play and very low inputs of fertiliser and water. In these times of the promotion of sustainability and reducing resource use, traditionalists use this as an argument for reintroducing red fescue.

Increasing interest for more sustainable golf course management and also advocacy from golfers who want to play "the running game" are a part of the argument, but even stronger support has recently come from EU and national authorities who prohibit chemical pesticides and restrict the amount of water and nutrients that can be applied on golf courses.

Red fescue has proved to be a good alternative under these limitations[1], but it is not the only answer to the aforementioned challenges. Bent grasses (*Agrostis* sp.) can be managed with low input of fertiliser and water, and specific varieties have shown good resistance to disease. Traditionally red fescue has been seeded in a mixture with browntop bent (*Agrostis capillaris*) and later we will discuss fescue/bent mixes. Annual meadow-grass (*Poa annua*) is probably the only grass species that cannot successfully be grown on golf greens without access to chemicals.

1) See the article by Robert Vavrek (references) to find arguments against turning American golf courses into red fescue courses.

PREMISES FOR SUCCESS

It should be emphasised that red fescue is not the best choice for all golf courses, and that there are some important factors that should be taken into consideration[1a] before seeding or renovating golf courses with this species.

CLIMATIC CONDITIONS

Red fescue performs well under cool and wet conditions in Iceland (63° N) and in Normandy (48° N). It survives well on greens in continental Norway at 500 meters above sea level and on courses exposed to sea spray. It is relatively salt tolerant and slender creeping red fescue (*F.rubra* ssp. *litoralis*) is among the most highly ranked cool season grasses for this characteristic. We have no experience with red fescue from the Mediterranean climate, but it performs well in continental Europe. Its heat tolerance is limited, however, and diseases such as summer patch and Pythium blight can be a problem in hot and humid climates. Red fescue also seems to be less persistent under ice encasement than the bent grasses. Climate change may cause more variability in winter climate and increased risk of ice encasement in the northern part of Scandinavia and Finland. See page 17 for the chapter about winter issues.

SOIL /DRAINAGE

Red fescue tolerates a wide range of soil conditions, but it will be outcompeted by other grass species if the soil is moist and fertile. Well drained soil is always a key factor to success with pure red fescue and low spots which can be prone to standing water after rain can make it impossible to produce a uniform red fescue fairway.

Well drained soil is an essential for success with red fescue, and ponding water cannot be accepted. Photo: Stefan Nilsson.

Seeded with fescue/bent, as 60% of Norwegian golf courses, but luckily dominated by the softer bent grass. Photo: Agnar Kvalbein, Hallingdal GK Sept. 2014.

ARCHITECTURE

Pure red fescue greens are firm and after pitching on the surface the ball will roll 2-3 times longer when compared to a green with creeping bent (*A. stolonifera*). Firm greens is one of the criteria for successful red fescue management. Red fescue greenkeepers aim for what they refer to as the "drum skin effect" when the playing surface is very resistant to wear and hardly any pitch marks are to be found. A golf course seeded with pure red fescue on the greens must be designed for the running game. Otherwise it is not fun to play. Golf courses with water hazards in front of greens and unplayable roughs around the green will have to be modified or find other grass species if they want to adapt their golf course to promote fescue through low input management.

MEMBERS' EXPECTATIONS

Golfers visit traditional links courses and accept that the greens are firm, that the wind impacts on play and that the course looks a different colour to what they are used to at home. When they return they bring stories and talk about the different and enjoyable experience from the links. Yet, many golfers have been frustrated and angry when their home golf course has introduced red fescue because it has a dramatic impact on how the course should be played.
It cannot be overstated that, in such circumstances, the club members must learn not only to accept, but to embrace the fact that their course is less green and that the ball rolls further than at the neighbour club. Golfers will have to adapt to the new playing conditions, which can cause conflict in the club. It can be difficult to teach old dogs new tricks!

Dry summer at the Swedish island Gotland.
Photo: Agnar Kvalbein, Visby GC, June 2011.

CHARACTERISTICS OF RED FESCUE

VISUAL APPEARANCE

Red fescue has narrow, folded and needle-like leaves. Greens dominated by red fescue (especially Chewing's fescue) usually have a dark green colour off season. In season the colour of fescue greens is less intense than of greens seeded with other species, and golfers will characterise them as greyish, especially when maintained properly.

GENETICS

The taxonomy of red fescue is very complicated and European and American categorisation is not the same. Varieties sold as red fescue vary in the numbers of chromosomes, and it is difficult to find reference plants that can be used to define the different subspecies.

This means that there are discussions among botanists about taxonomy, names and subspecies. We will leave this to the experts.
In this text we refer to three subspecies (ssp.) of red fescue. This categorisation is used among red fescue grass breeders and in the reports from the variety testing programmes in the Nordic countries and elsewhere. These programmes have identified some typical characteristics for each subspecies that are useful for golf course managers when choosing seed. The division is based on the existence and length of the rhizomes.

F. rubra ssp *rubra* [L.] has the English name 'strong creeping red fescue' because of its long rhizomes. Varieties in this group form a sparse and open sward when seeded alone and their density is not good enough to be included in seed mixtures for greens. In other areas many varieties of this subspecies retain their green colour during long-lasting drought better than varieties of other subspecies.

F.rubra ssp *litoralis* [Meyer] (= ssp *trichophylla* [Gaud]), slender creeping red fescue, has short rhizomes. Compared to the other subspecies it has a fresher green colour in the autumn and off season. The presence of rhizomes means that varieties of ssp. *litoralis* should be a part of the seed mixture to increase the ability to repair divots on fairways and pitchmarks on greens[b] . It is slightly less tolerant to diseases,e.g. red thread (*Laetisaria fuciformis*) and microdochioum patch (*Microdochium nivale*) and winter stress than ssp. *commutata*.

F.rubra ssp. *commutata* [Thuill.], Chewing's fescue, grows in tufts without rhizomes. It forms a relatively dense sward that gives a good lie for balls on fairways. Its density on greens is on a level with slender creeping red fescue but lower than most bent grasses. Varieties of Chewing's fescue have good winter tolerance and high resistance to disease.

ECOLOGICAL CONCERN

Botanists and ecologists are concerned that the widespread use of imported red fescue seed lots along roads and in industrial areas will pollute the genetics of naturally occurring fescues ecotypes. They probably have good reason for their concern because wind is one of the main factors in red fescue cross-pollination. We, therefore, recommend use of local ecotypes when golf courses establish high roughs that will flower and produce seed. This concern is not restricted to red fescue, but at least in Scandinavia, red fescue has receive special attention as it is the most commonly seeded species for landscape purposes.

ROOTS / THATCH

The fresh roots of red fescue are not white like most other grass species, but brownish. The lignin content in the thatch is high[c] and degradation slow. Most agronomists will characterise red fescue thatch as fibrous, drier, more persistent and providing more structure than thatch produced by other grass species.

Red fescue has brown and deep roots. Creeping bent to the left. Photo: Agnar Kvalbein.

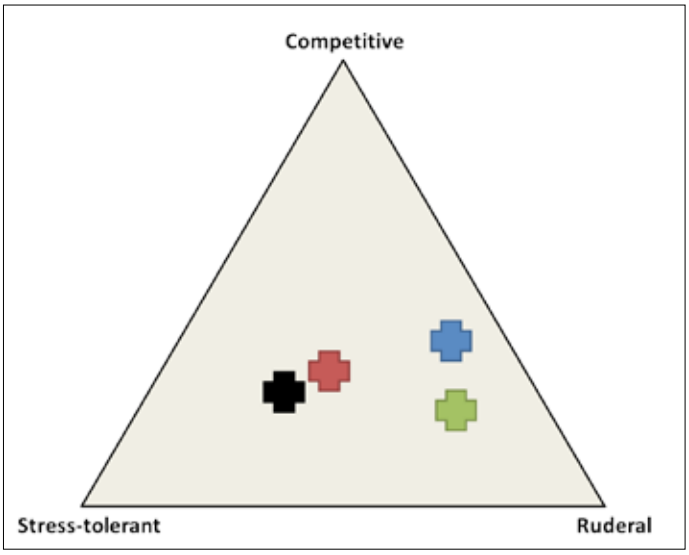
DISTURBANCE THEORY

Some years ago, the Sport Turf Research Institute (STRI)[d] in England presented the disturbance theory. They introduced the C-S-R (Competitive, Stress tolerant, Ruderal= early colonisers) classification of plants[e] to greenkeepers, and gave them a theory to better understand the differences between some of the grass species. A key point was that annual meadow-grass is different from the other species because it can tolerate, and will have an advantage if the soil is disturbed. Plants that are classified into the same R-group as annual meadow-grass do usually produce seed that are dormant and can wait for a good opportunity to germinate.

The authors stated that red fescue, which is a slow growing and stress tolerant plant, will be outcompeted by annual meadow-grass if the maintenance is based on little stress (=plenty of water and fertilizer) and mechanical disturbance. The key to success with finer grasses is moderate fertilizer levels and less water because this will reduce the thatch production and eliminate the need for aggressive verticutting, hollow-coring and other types of "disturbance".

In Grime's classification browntop bent (*A. capillaris*) was categorised as being similar to red fescue, while creeping bent was slightly closer to annual meadow-grass (*P. annua*), probably because it has the ability in nature to spread more quickly thanks to its long, creeping stolons.

The research that we present in this handbook has partly tested elements related to the disturbance theory, but we will not discuss the results using the terms disturbance or stress because this would presume that the reader is familiar with these ecological and evolutionary theories.



Grime's classification system. The crosses indicate the classification of P. annua (green), A. capillaris (red) F.rubra (black) and A. stolonifera (blue). Compared to common literature we have switched the positions of F.rubra and A. capillaris because we find red fescue more stress tolerant than browntop bent.

Green from a very low cost golf course where all inputs, even top dressing material, has been minimised for many years. The result is a good fescue dominated sward. Photo: Agnar Kvalbein.

AGRONOMIC CHALLENGES

In many ways red fescue is an easy grass to grow, benefitting from what be termed "managed neglect" as a good playing surface is usually not a result of the greenkeepers' toil but rather their omissions.

The growth capacity of red fescue is low compared to other turfgrass species. Tom Ericsson from the Swedish University of Agricultural Sciences compared the maximum growth of five grass species maintained at green mowing height in a pot experiment and ranked their relative growth capacity (see table). More detailed studies show that bent grasses respond to high fertiliser levels by excessive leaf growth at the expense of root development, while the root/shoot ratio for red fescue was less than that for the bents.

Species /variety	Ranking
Annual meadow-grass, *Poa annua*	1.12
Creeping bentgrass, *Agrostis stolonifera* 'Independence'	1
Browntop bent , *Agrostis capillaris* 'Barking'	0.72
Velvet bent, *Agrostis canina* 'Legendary'	0.71
Chewing's fescue, *Festuca rubra* ssp. *commutata* 'Center'	0.55
Slender creeping red fesuce, *Festuca rubra* ssp. *litoralis* 'Cezanne'	0.33

Deep roots and slow growth are characteristics that are well adapted to dry and infertile environments in nature, but this does bring some challenges on the golf course.

WEEDS, ESPECIALLY ANNUAL MEADOW-GRASS (POA) AND MOSS

Other grass species than red fescue will predominate if the soil fertility is high[f] . If fairways are situated on former agricultural land it can be difficult to establish red fescue dominance from a seed mixture of different grass species. Perennial ryegrass (*Lolium perenne*), smooth-stalked meadow-grass (*Poa pratensis*) and browntop bent all have higher growth capacity than red fescue and will become dominant on loam, clay or soil rich in organic material. Germination of annual meadow-grass (referred to from here as Poa) from the soil's seed bank is a common problem, and pure fescue greens are often invaded by Poa from surrounding areas.

The image to the right shows a plug of annual meadow-grass which suffered from drought when only irrigated once per week for two months. The green to the left was irrigated to field capacity three times a week. Annual fertiliser rate was 1.1 kg N/100 m2. Fescue has weaker vertical growth and it takes time to invade space left by Poa loss. Photo: Agnar Kvalbein, NIBIO Landvik experimental green, 23 July 2014, plots 102 and 111.

On infertile soil one of the most difficult broad leaved weeds to counter is white clover (*Trifolium repens*) which tolerates fairway mowing and supplies its own nitrogen.

Mosses (*Bryopsida*) can become a big problem on pure fescue greens. Most mosses are not persistent to wear, and we often see less moss around the most popular pin positions. The double cut in the clean-up round (with a triplex mower) may increase the opportunity for moss to invade the turf because the grass becomes weaker. Mosses take up all nutrients through their "leaves" and using liquid fertilisers, especially foliar feeding, is likely to result in more moss than granular products.

One of the experiments in the research project FESCUE GREEN showed that the occurrence of moss on a pure fescue green was influenced both by irrigation quantity and irrigation frequency. Most moss occurred on plots irrigated abundantly to field capacity three times a week, but at the same time there tended to be more moss is if the green was deficit irrigated, which provides small amounts of water (see late chapter on irrigation) three times a week than with one heavy irrigation once a week.

Mosses can become a problem in an open, low input red fescue sward, especially when it rains frequently. Photo: Agnar Kvalbein, Copenhagen golf club, October 2015

The "divot squad" at St. Andrews Links works hard to repair the fairway playing surfaces with seed and divot mix. Slow repair of divots is a part of the picture when growing red fescue fairways. Photo: Agnar Kvalbein, February 2006.

LOW REGROWTH CAPACITY

On fairways or tees divot recovery can become a problem when red fescue is the dominant species. Greens are usually so firm that pitch marks can be hard to see, but if repaired properly they are not a bigger challenge than on greens seeded with other species.

Since few golf courses go for pure red fescue on tees, the problem is most pronounced on fairways. Regularly filling divots with sand and a seed mix of all three red fescue subspecies should be normal maintenance procedure on wall to wall red fescue courses. This low regrowth capacity also provides a challenge if the red fescue is injured and needs repair for other reasons. This is discussed further in the chapter 'Winter issues' on page 17.

SEED QUALITY

New varieties of red fescue are introduced to the market every year, and today's varieties are generally better in density, colour, stress tolerance and disease resistance than varieties released 10-20 years ago. Before buying seed greenkeepers should, therefore, consider an updated list of recommended varieties based on testing under relevant climatic conditions and appropriate management. For the Nordic countries, and areas with similar climatic conditions, greenkeepers can find updated variety lists for red fescue at green and fairway mowing height at www.scanturf.org. A good red fescue seed blend is comprised of at least two top-ranked varieties of each of the appropriate subspecies, and it is recommended to blend varieties from different breeding companies in order to increase the genetic diversity.

According to international certification standards, red fescue seed can contain up to 1.5 % weeds and 1.0 % of one specific weed species. If a red fescue seed blend containing 1.0 % Poa is seeded at a rate of 3 kg per 100 m^2, 300 seeds of Poa will be sown per m^2. Greenkeepers are advised to request certificates of purity for the seed that they purchase, and for greens it is usually a good insurance to pay the extra price for seed of premium (greens) quality.

The minimum germination requirement for certified seed of red fescue is 75 %. If stored over several years there is often a greater reduction in the germination of fescue seed than bent grass seed or smooth-stalked meadow-grass seed.

SEEDING AND GROW IN

Hydro-seeding pure red fescue at Vallda GCC. Photo: Stefan Nilsson

Red fescue seed is relatively large (800-1100 seed per gram) and field germination is rarely higher than 40 % under good sowing conditions. If the goal is one seedling per cm^2 (or 10,000 per m^2), you should seed 3-4 kg per 100 m^2.

Compared to bent grasses, and especially Poa, the germination and seedling growth of red fescue is slower. Under less favourable sowing conditions (low temperature or oxygen level), the advantage will swing further in favour of Poa. We recommend late summer as the optimal time for sowing red fescue or at least when soil temperature is over 10 degrees at night.

For successful germination good contact between seed and soil is crucial, and we generally recommend light protective covers to retain moisture until seedlings are 1 cm high. Our experience is also very good with raking 20 kg /100 m^2 fine granular organic fertiliser (not enriched by chemical salts)

We do not find good evidence for slow grow-in of pure fescue greens. To the right a "weed" of local bent. Photo: Agnar Kvalbein, Castle Course, St. Andrews, March 2006.

into the green rootzone mixture before seeding USGA greens. The seed should not be left on the surface but raked into the soil and the optimal sowing depth is 0.5-1.0 cm depending on irrigation practices.

Some greenkeepers do not apply much fertilizer during growing in. We find no strong evidence for this practice when using a pure red fescue seed mixture. On the contrary we recommend frequent (weekly) application of a complete and balanced fertiliser to exploit the maximum growth capacity of the plant, which is achieved when nitrogen is 5 % of the leaf dry matter. Achieving a dense sward quickly is the best way to prevent weed ingress. Start mowing at 15 mm on golf greens and 25 mm on fairways and reduce the mowing height one mm per week until you reach 6 mm on greens and 15 mm on fairways. Mow no closer during the first playing season. Remember to start adding top dressing material early to avoid the accumulation of organic layers in your green profiles.

Very good results have been achieved with the inclusion of fine granulated garden compost in the dressing sand (see chapter about maintenance). If you choose this option, be sure to include it from the first applications.

When coverage is complete, fertilisation should be reduced dramatically to achieve a strong and firm playing surface. On greens the N concentration should be 3.0-3.5 % of the dry matter in the clippings. When the fertilisation rates are reduced, Poa becomes visible and easy to weed out.

Vallda GCC, Kungsbacka. Photo: Stefan Nilsson

MAINTENANCE

MOWING

One of the benefits with red fescue is that the grass leaves are narrow and easy to bend. The ball speed will be high even if the mowing height is about 5 mm[g]. From the plant's point of view high mowing is beneficial as it will then absorb more light for photosynthesis. We have not seen any studies on how low pure red fescue can be cut over time without compromising plant health, but we have observed good stands of red fescue in dry parts of creeping bentgrass golf greens that have been cut at 3.5 mm for many years. This is, however, not our recommendation for pure red fescue!

Most red fescue greenkeepers use 5 mm as the standard mowing height but some reduce the height down to 4.5 mm in the summer and even down to 4.0 mm for tournaments. *Our research has confirmed that the competition from Poa on red fescue greens is stronger at 4.0 than at 5.5 mm mowing height.*

ROLLING

Rolling can replace mowing without compromising the ball speed on greens when the growth is limited by temperature or drought or controlled with low nitrogen input. The frequency of rolling must be adapted to the mowing frequency and the vigour of turf growth. Even rolling is stressful when the grass is not growing in the autumn and it should be done only when necessary to maintain acceptable playing conditions. The aim for rolling is to reduce mowing stress and fuel consumption.

In the FESCUE GREEN experiments at Smørum GolfCenter the cutting height could be raised from 5 to 6 mm with no compromise on green speed if greens were rolled 4 times per week. Additionally in some cases mowing frequency could be reduced and the same green speed obtained if greens were rolled instead. However this means that more man hours must be devoted to green maintenance.

Some of the mowing operations can be replaced by rolling. Photo: Agnar Kvalbein, Portmarnock, GC, February 2005.

One year old green of pure fescue on USGA rootzone. All plots received the same amount of fertiliser. Differences in density and colour were due to the use of organic amendments to the rootzone or top dressing:

- *First plot (in foreground): Peat in rootzone, pure sand top dressing.*
- *Second plot: Compost in rootzone and in top dressing.*
- *Third plot: Peat in rootzone, compost in top dressing.*
- *Fourth plot (background): Compost in rootzone, pure sand top dressing.*

Photo: Trygve S. Aamlid, NIBIO Landvik experimental green, 8 Oct. 2012.

TOP DRESSING

Sand dressing is an essential maintenance practise on golf greens regardless of grass species. It is the most efficient way to control thatch build up and many greenkeepers are able to keep the organic matter content of the mat on red fescue greens at a target level around 3.5 % with only dressing and aeration. The monthly dressing rates should be adjusted to the plant's growth rate to avoid layering. This is the number one rule. If the greens are open for winter play they should have more sand in the autumn, without smothering the turf, to protect the grass crowns from physical damage.

The quality of the dressing material is important for red fescue as for all other species on golf greens. Sand material and dressing in general will not be discussed here.

There is no simple relationship between the production of organic material and the need for top dressing because thatch degradation depends on moisture, compaction, temperature and soil microbiology. Generally we recommend that red fescue should receive the same amount of sand as other, more rapidly growing, species. This seems odd, but it can be explained by the higher lignin content in red fescue thatch and that the microorganisms which degrade organic matter in a red fescue green will be limited by the high C:N ratio brought about by the low nitrogen fertiliser level. For effective degradation the C:N ratio should not exceed 25.

Some greenkeepers have access to high quality, fine-graded compost and have good experiences with using a mix of sand and compost for dressing. It is difficult to provide recommendations because compost material will vary a great deal and it can also contain fine mineral particles.

In the project FESCUE GREEN we compared rootzone materials with either peat or garden compost, and we dressed red fescue greens contaminated with annual meadow-grass with either pure sand or a sand/compost mix over a period of three years2. The dressing mix contained 10 % by volume of garden compost and 32 ppm mineral nitrogen and 59 ppm phosphorus. The levels of potassium, magnesium and calcium were also high and the pH was 8.0 as opposed to 6.5 in the pure sand top dressing. The effects on the visual quality of red fescue and other characteristics could be explained by the higher content of nutrients and by the fact that pure sand produced an integrated mat with lower organic matter content and hence a slightly dryer green surface. By the end of the project we could see a tendency to more Poa after dressing with the sand/compost top dressing to peat-amended rootzones.[h]

VERTICUTTING, SCARIFYING AND BRUSHING

Verticutting is stressful to the grass plants, and Poa will easily invade while red fescue is set back by excessive use of verticut units. We recommend this treatment only as a part of a cure to reduce moss and scarifying only when it is necessary to address layers in the green profile. Brushing before mowing will give faster and more even greens in May and June when red fescue plants grow.

IRRIGATION

General recommendations for turf grass irrigation can be found in STERF's handbook: 'Irrigation of turf on golf courses – a greenkeeper's guide to understanding the theory and practice'. Of special importance for red fescue is that abundant irrigation, while keeping a high visual red fescue grass quality, will compromises surface firmness, lead to more moss and weed ingress and not exploit the character of red fescue as a much more drought tolerant species than Poa.

We should keep in mind that controlling green soil moisture with irrigation is only of theoretical interest in areas with high precipitation during the growing season. If the uniformity of the irrigation system is poor, then "control" is also an inappropriate term. Even in such situations, the information from irrigation experiments on red fescue can still be useful when setting up an optimal management programme.

The evaporation from close-mown turf is strongly related to sward density. Determination of ET-values[2] for various grass species shows that relatively open-textured red fescue

2) Evapotranspiration (ET) is the sum of evaporation from soil and transpiration from the plants. ET_0 is the reference ET which is calculated from meteorological data. The actual ETc from a crop can be calculated if we know the crop coefficient, kc: $ETc = kc * ET_0$ Except for the first day after heavy precipitation or irrigation to field capacity, a kc=0.8 can be regarded as a rough guideline for low-cut turf.

greens have a higher ET than the denser bents. On fairways, red fescue will be the densest species and smooth meadow-grass and perennial ryegrass have slightly higher ET than red fescue. This variation in ET between species is hardly of practical importance, but the take-home message is that the drought tolerance of red fescue is primarily a result of the deeper roots, not of a canopy structure that retains water. Drying the turf out over a period in the summer will be highly beneficial to red fescue when competing with Poa, because of its deep rooting.

All closely mown grasses will use a lot more water when it is readily available in the rootzone. This means that the turf's daily ET is twice as high on the first day after excessive rain or irrigation compared to the average ET during the rest of the week[i].

Keeping the soil moisture content between 40 and 60 % of field capacity (in our experiment corresponding to TDR values between 8 and 12 % as measured with 20 cm long probes on a USGA green) is an efficient way to save water without compromising turf quality. This strategy, which is called "deficit irrigation", is recommended for red fescue as well as for creeping bentgrass. Our research also showed that the quality of red fescue greens will decline to unacceptable levels if the soil water content is kept below 8 % for long periods of time. Yet, the risk for the development of distinct dry patches ('localised dry spots') was less in red fescue than in former trials with creeping bent.

The practical consequence of this knowledge is that water can be used to regulate the competitiveness of red fescue against other plants. Many greenkeepers irrigate with minimal amounts of water and allow their fescue greens to become very dry during the summer when Poa is heat stressed. Our research confirmed that this is a good strategy, but it also showed that, unlike moss, the competition from Poa was virtually the same if a limited amount of water was split between three light irrigation applications per week (light and frequent deficit irrigation) or if it was given as one irrigation application per week.

FERTILISER

General recommendations can be found in the STERF handbook "Fertilization – from theory to practice". Important principles are that the ratio between nutrients (ideal type of fertiliser) is the same for all grass species and that nitrogen will always be the factor that controls turf grass growth. The grass plants can be spoon fed at rates adapted to their genetic growth potential and the actual growing conditions; temperature, light, moisture etc. and the cutting height and need for repair of turf injuries.

The special challenge with devising a strategy for feeding red fescue is to create a strong playing surface, which is the result of low fertility, and the competitiveness to weeds.

After establishment, red fescue greens can be managed with annual nitrogen rates between 0.4 and 1.0 kg per 100 m^2. Low nitrogen input will stimulate root growth and produce a lignin-rich, strong putting surface. During good growing condition the weekly rate on well-established greens should be about 0.04 kg N per 100 m^2. This will limit the growth of Poa. When temperatures are sub optimal and when high temperatures are experienced in July and August, the rates should be reduced. Avoid any excess application of nitrogen because this can reduce the valuable mycorrhiza colonies on the grass roots.

In practice, there is variation in the way golf course managers approach the seasonal distribution of nitrogen, and the rationale for this is the greenkeepers' different experiences with weeds.

Poa has an exceptional ability to germinate and grow at low temperatures in the spring, and it does not, as the perennial grasses, stop growing in the autumn. High fertilization rates in early spring and autumn will therefore favour Poa.

Experiments with three different fertiliser curves (see figure) show that enhanced rates in the late spring or flat rates across the seasons gave deeper roots and significantly less Poa than the 'Early autumn +' strategy. Enhanced fertiliser application in autumn resulted in faster green-up and higher clipping yields of red fescue in April, but this effect disappeared as soon as the ordinary fertiliser inputs started in early May.

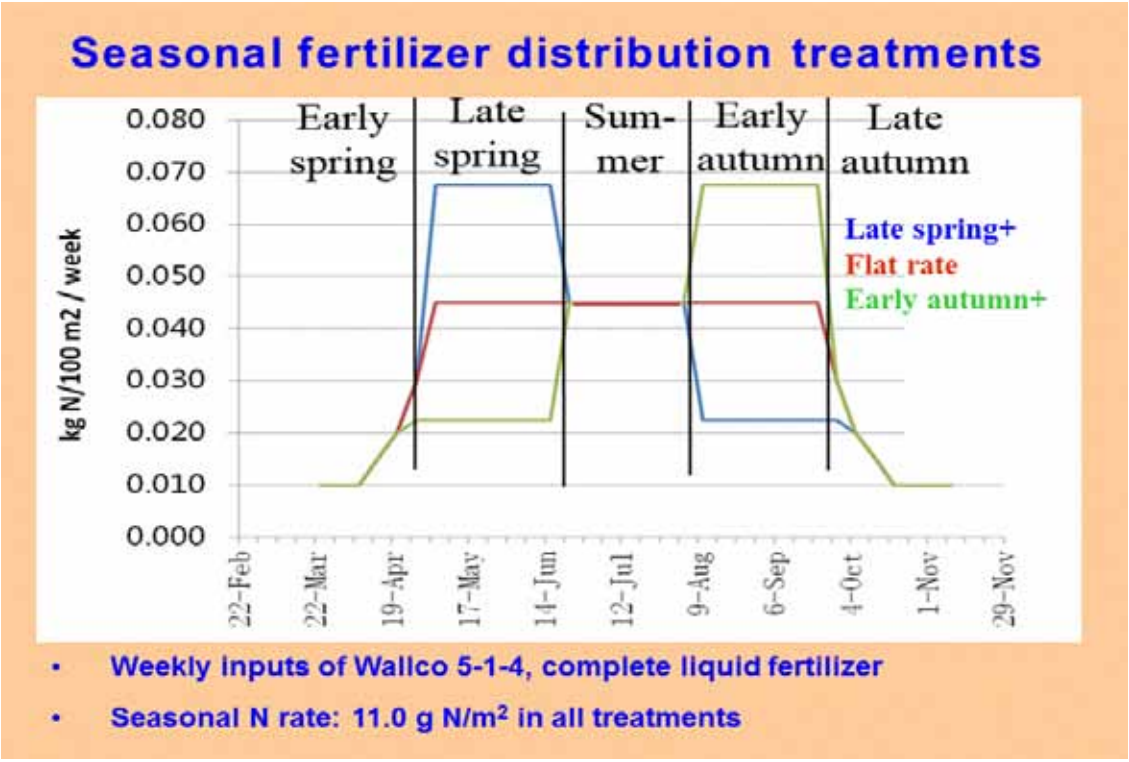
Some greenkeepers propose that high nitrogen levels in the autumn make Poa less resistant to microdochium patch disease. This is true, but we will not recommend this as a decisive argument for enhanced autumn feeding.

OVER-SEEDING

Many greenkeepers regularly seed red fescue into their greens and fairways. If the sward is dense we find no good reason for this practise unless the aim is to introduce new and better varieties. Dense, established red fescue makes it very difficult for seedlings to receive enough resources (nutrients and light), and most of them will die without producing new tillers.

Of course, scars and patches from disease or thin turf must be repaired, and we recommend that resources are spent on these gaps in the sward rather than on general over-seeding. All viable seeds of red fescue will usually germinate as soon as the temperature, water and oxygen conditions are conducive for germination. The proportion of seed with innate dormancy that can act like a seed bank in the soil is much more limited in red fescue than in bent grasses and Poa.

Nitrogen fertiliser application is the strongest tool for regulating turf quality and the competition between grass species (including the fescue/bent ratio). Photos show a fertiliser trial at NIBIO Landvik in September 2009. To the left F.rubra ssp. commutata 'Center' and to the right F.rubra ssp. litoralis 'Cezanne'. Annual N rates from left 0.6/0.9/1.5 kg N. Note the fresher green colour in the slender creeping red fescue. Photo: Agnar Kvalbein



Chewing's fescue (ssp. *commutata*) does not produce rhizomes, and swards with only Chewing fescues can therefore become tufted if the density is low. We, therefore, always recommend sowing a blend that includes slender creeping varieties (ssp *litoralis/trichophylla*) which also bring about better repair of pitch marks on greens than Chewing's.

If over-seeding is practiced, the optimal time will be in July and August as high soil temperature provides quick germination and growth. Good soil contact and moist conditions is important, and the seed should be placed about 1 cm below the soil surface.

When considering over-seeding of fescue greens, always remember that you should have a good reason for any mechanical treatment to the turf. There is no reason to over-seed a healthy and well-established sward. Photo: Stefan Nilsson.

DISEASES

Red fescue is resistant to take-all patch (*Gaeumannomyces graminis*) and less vulnerable to many other diseases than the other grass species on golf greens but some fungi may cause severe injuries. You will find more information about these pathogens under Nordic conditions in STERF's fact sheets on integrated pest management.

DOLLAR SPOT

In the UK red fescue is known to be particularly susceptible to dollar spot (*Sclerotinia homoeocarpa*), probably because the symptoms become more expressed under low fertility and dry conditions. In Scandinavia we only have a few positive identifications of this disease and no reason to suggest that red fescue is attacked more often than other species.

MICRODOCHIUM DISEASE

M. nivale causes the most severe diseases in the Nordic countries and red fescue is also injured by microdochium patch (also known as fusarium patch) when the temperature is low and the sward is moist. The most severe patches appear as pink snow mould, which develops under snow cover when the soil is not frozen. *M. nivale* is able to survive in the thatch and some greens are normally more attacked than others. Local experience suggests it is necessary to spray with fungicides in the autumn to avoid severe injuries over winter.

Dollar spot (Sclerotinia homoeocarpa) on fescue-dominated green in France. Photo: Stepane Rouen.

The risk of pink snow mould damage is increased if there is bent grass in the sward.

RED THREAD

Red thread (*Laetisaria fuciformis*) and pink patch (*Limnomyces roseipellis*) are often found in red fescue dominated fairways when fertiliser rates are low. The damage is normally cosmetic, and slightly increased N levels will reduce the attack to an acceptable level.

Re-establishing winter-killed red fescue greens may favour Poa germination. Consider removing top-soil that is contaminated with Poa seed before re-seeding red fescue. Photo is from Vestfold GC where Norwegian Greenkeepers Association compared strategies for re-establishing dead greens April to June 2009.

WINTER ISSUES

We rank red fescue among the winter stress tolerant species. There are differences between varieties (see www.scanturf.org for updated data), but generally the Chewing's are more winter hardy than the slender creeping red fescues.

Long lasting ice encasement is the most severe winter stress for red fescue. Ice encasement is frequently an issue in the coastal areas of northern parts of the Nordic countries and here dead red fescue greens in the spring are not uncommon. Ice should be cracked and water removed from low spots when possible.

Re-establishing dead red fescue greens takes time and the situation is especially critical if the green has a seed bank of Poa grass as this weed germinates and grows rapidly under cold spring conditions and responds much better to fertiliser than red fescue.

Greens with a thatch layer containing seed of Poa can be re-established successfully if the top soil is removed with a sod-cutter or a small Koro Field Top Maker and the green re-seeded with red fescue. This will take at least two months of the playing season. The alternative can be a step back to greens dominated by Poa.

If the greens are not contaminated with a seed bank, re-establishment is possible by re-seeding dead parts of the green. This process takes longer time with red fescue than with alternative grass species.

The risk for lethal winter injuries after ice encasement is the strongest argument against using red fescue greens in some parts of the Nordic countries.

CHANGE TO RED FESCUE – HOW?

There are good examples from France, the UK and Denmark showing that it is possible to gradually change greens from Poa dominance to red fescue dominance. Common to all were a strong motivation for change, often forced by restrictions on the use of pesticides or water use, and persistence from the club board in sticking to the plan through times when there may have been a deterioration in playing quality during the transformation period.

Keeping the green surface dry is essential. This means that the organic matter content in the topsoil must be controlled and brought down to less than 5 %.

The transformation requires repeated over-seeding during the summer months and maintenance that stresses Poa by drought and low fertility. This makes Poa flower over a longer period, anthracnose patches will occur and the colour diversity will give a very poor visual expression.

We have not seen golf greens that have been fully transformed from bent grasses to red fescue. From a turf agronomy perspective it is probably difficult to get that far because the optimal maintenance of bents and red fescue are similar to each other. Bent grasses will survive also under very low input management. Golfers normally have only a few arguments against bents. Take-all patch can sometimes be severe. Browntop bent dominance can slow the greens if the mowing height is 5 mm. Environmental and economic arguments to reduce bent grasses are relevant. See next chapter.

We think that a slow transformation from bent grass to red fescue dominance is possible, and that the negative impact on the putting surface is less dramatic than with a transformation from Poa to red fescue. Transformation through browntop bent to a bent/fescue blend may be the best option from the starting point of Poa dominance. If you are aiming for pure red fescue, full reconstruction is probably the best way to do it.

Golf de Granville in Normandy transformed their greens into red fescue dominance. Seedlings of red fescue appearing 1 April 2015. Photo: Stephane Rouen.

PURE FESCUE OR FESCUE / BENT?

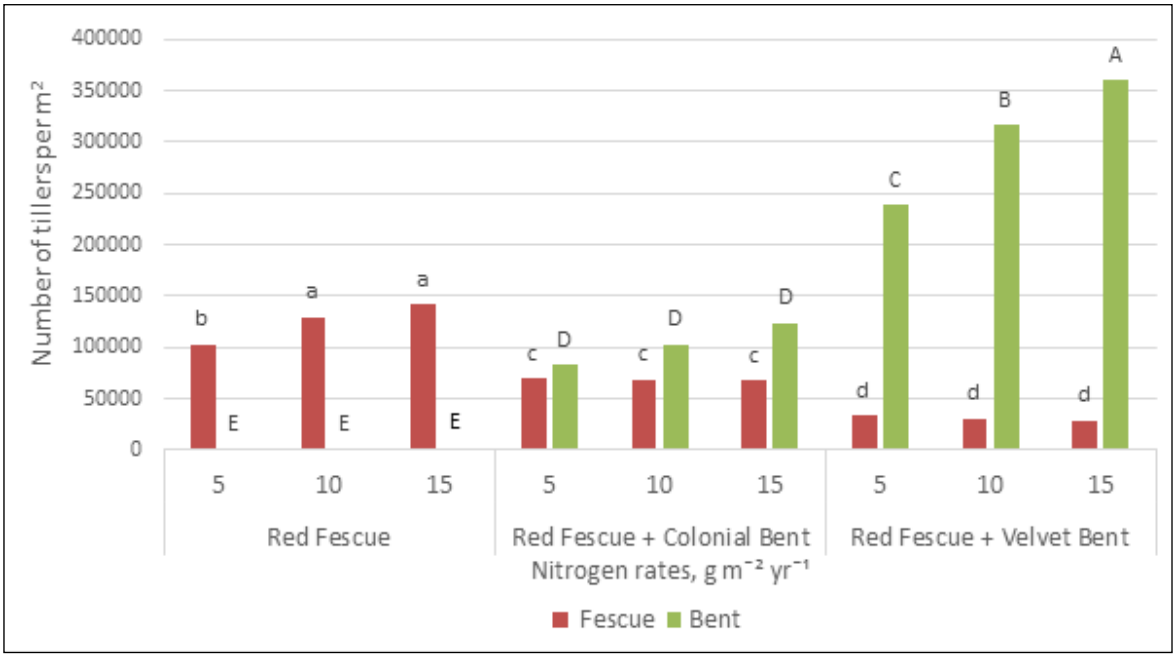
So far this document has focused on pure red fescue greens, while the traditional green seed mixture in the British Isles and in the Nordic countries has been fescue/bent. The bent grass found in this traditional scenario is the colonial or browntop bentgrass (*A. capillaris*).

We have asked greenkeepers who are aiming for red fescue dominance on their greens if they would recommend a new golf course to seed with pure red fescue or a fescue/bent mixture. We have received diverging answers from them, and this indicates that this decision is difficult and needs careful consideration. There is probably not one answer for all courses, and we also recommend that alternative bent grasses are taken into account. Some modern creeping bentgrass varieties can be managed without verticutting and with less input of fertiliser and chemicals than traditionally used on creeping bentgrass greens.

It is difficult to extract general information from research on this matter. Comparing stands of different seed mixtures is done under standard maintenance procedures, and the results often reflect optimal treatment of one sward mixture which was suboptimal for another.

Fertiliser (N) rates and soil moisture are more important factors than mowing height when balancing between fescue and bent, but mowing height should not be neglected.

Our two year experiment showed that in a fescue/bent sward the number of bent grass tillers increased with higher fertiliser levels, while the number of fescue tillers was constant. In a pure red fescue green the density was improved 40% when N levels were enhanced from 0.5 to 1.5 kg/100 m^2 /year. See figure on next page.



Number of grass shoots in a two year old green seeded with pure red fescue (RF), red fescue + browntop (=colonial) bent or red fescue + velvet bent (VB). Bars shows the effect of three nitrogen levels; 5, 10 or 15 g/m²/year applied weekly as a complete, balanced, liquid fertiliser. Results are the average of two mowing heights, 4.0 and 5.5 mm, which in this experiment had less influence than the fertiliser rate on the fescue/bent ratio. Pure red fescue plots were contaminated with a few bent grass plants.

RED FESCUE ARGUMENTS

Red fescue is the most extreme low input species for golf greens. From an economic and environmental perspective this makes pure red fescue the obvious choice. The need for fertiliser is about 60% that of browntop bent and the species can tolerate long lasting drought with less use of surfactants than other species. Red fescue is more resistant to disease than the bents, and some courses can manage red fescue without using any fungicides. The low growth rate reduces the need for mowing to less than every second day during most of the year, and verticutting is not recommended. This reduces the fuel consumption and need for grinding. Altogether this makes pure red fescue greens far more economic than fescue/bent greens.

There are golfers that desire the original game of golf with firm and open greens, but in most golf clubs they seem to be in the minority. A common argument against pure red fescue is that their firm surface makes the game different, more difficult, and that the design of the golf course, and green approaches in particular, is extremely important in making golf on a pure red fescue course enjoyable. The second argument is that the slow growth rate makes it difficult to control weeds. Poa can only be controlled if the maintenance is taken to the extreme regarding low fertility and drought. Moist autumns and mild winters when Poa continues to grow become challenging, and moss can be a severe problem.

Some will point out wear resistance as a problem with pure red fescue. For fairways this is generally accepted regarding divot repair, and trials from the USA with golf cart traffic confirm lower wear tolerance than for other species, but

Beautiful pure red fescue green at Furesøe GC although one single Poa plant can be seen. Photo: Agnar Kvalbein, Oct. 2012.

these trials were performed on relatively young turf. Regarding greens there are different experiences. Some claim that really hungry and well lignified red fescue thatch creates a green surface that is resistant to normal wear from golfers – and that really low input management eliminates most of the wear from maintenance.

Maybe there is an explanation to the divergence between experiences if we look in more detail at factors like rounds of golf in January and February or mowing height throughout the winter season. Maybe closing the course for play in January and February makes a difference.

Some greenkeepers like to have some red fescue in their creeping bent greens because they fill in patches from disease, especially take-all scars. Photo: Agnar Kvalbein, Nøtterøy GC.

TRADITIONAL FESCUE / BROWNTOP BENT MIXTURES

Most experiments show that this mixture gives a better visual impression throughout the season than pure red fescue. The two species complement each other and level out variations caused by season, growing conditions, disease pressure and wear. This makes the mixture more robust. If the turf gets injured, bent grass will provide a much quicker recovery. A final argument is that the bent makes it easier to regulate green speed and firmness at locations where wind or small green area makes high speeds a problem for the sport.

On the other hand, the purists will say that the complementary growth of fescue and bent can make it difficult to set up consistent greens with a uniform firmness and ball roll. Browntop bent dominance creates slower greens, and greenkeepers feel pressure from golfers to lower the cutting height to the limit of what the red fescue can withstand. However, in our opinion, this situation should rather be resolved by lowering fertility levels than by lowering mowing height.
It is difficult to rank grass species for thatch production, but some fescue/bent greenkeepers claim that they have to verticut to control the thatch from bent grass. *This was confirmed by our two year experiment which showed especially red fescue/velvet bent, but also red fescue/browntop bent, to accumulate more thatch than pure red fescue.*

WHICH BENT GRASS SPECIES TO USE?

In the UK it seems to be an established fact that browntop bent is the only bent species that successfully can be mixed with red fescue. The moist, mild climate with year-round play is used to explain why this mixture is popular and often recommended ahead of pure red fescue. We have not tested mixtures of fescue and various bent grasses systematically, but our variety trials in Iceland have never given creeping bentgrass high scores. This confirms that a moist and cold climate is not optimal for creeping bentgrass.

In Germany and continental Europe greens have sometimes been established with seed mixtures of fescue and creeping bent. To our knowledge this has resulted in creeping bentgrass dominated greens, with no sign of the red fescue. Some greenkeepers still find a low percentage of red fescue valuable as they see it as a backup plant when disease occurs, and it is interesting to observe that red fescue can survive many years under creeping bentgrass management.

We have worked some years with velvet bentgrass. From a theoretical point of view this species should be a better fit in complementing red fescue than other bents. It has the growth capacity of browntop bent and will thrive under low nutrient input. Velvet bent is the highest ranked species for maintaining quality and green colour under long lasting drought. Its leaves are finer and less visible in a mixed stand than that of browntop bent.

But velvet bent can easily become dominant on moist parts of the green. The shoot density is high and it is extremely competitive. We conclude, so far, that a mixture of red fescue and velvet bentgrass can be a risky project. For those wishing to try, we recommend very low irrigation and fertility levels and only 2% velvet bentgrass in the seed mixture.
For the time being, this leaves us with the conclusion that browntop bent is the best alternative for golf courses aiming for fescue/bent greens.

Velvet bent has narrow leaves and fits very well with red fescue if it does not become the dominant grass. But velvet bent is aggressive and can become difficult to control. Photo: Agnar Kvalbein, Furesøe GC, 2012.

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RECENT RESEARCH

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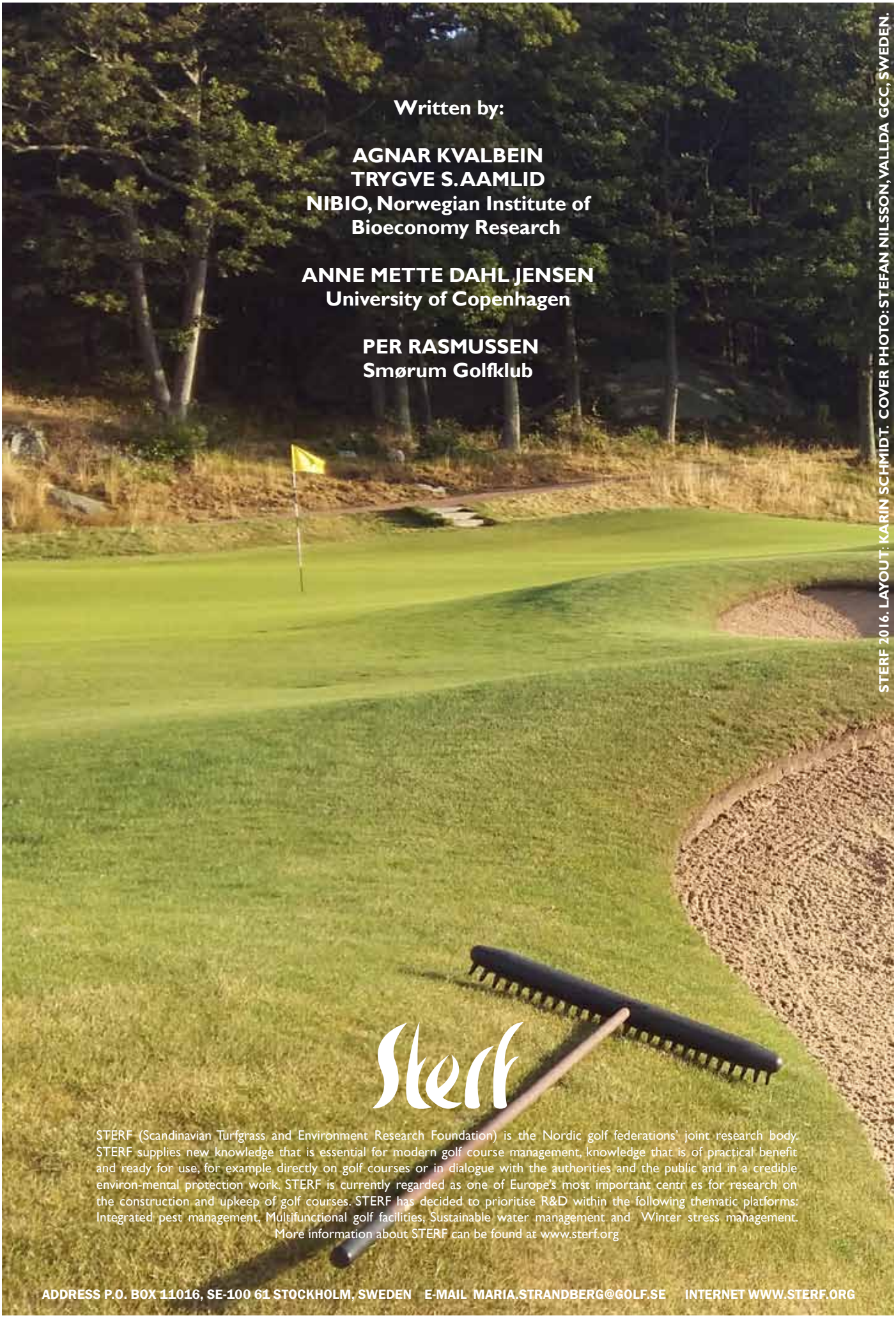

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STERF (Scandinavian Turfgrass and Environment Research Foundation) is the Nordic golf federations' joint research body. STERF supplies new knowledge that is essential for modern golf course management, knowledge that is of practical benefit and ready for use, for example directly on golf courses or in dialogue with the authorities and the public and in a credible environ-mental protection work. STERF is currently regarded as one of Europe's most important centr es for research on the construction and upkeep of golf courses. STERF has decided to prioritise R&D within the following thematic platforms: Integrated pest management, Multifunctional golf facilities, Sustainable water management and Winter stress management. More information about STERF can be found at www.sterf.org

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