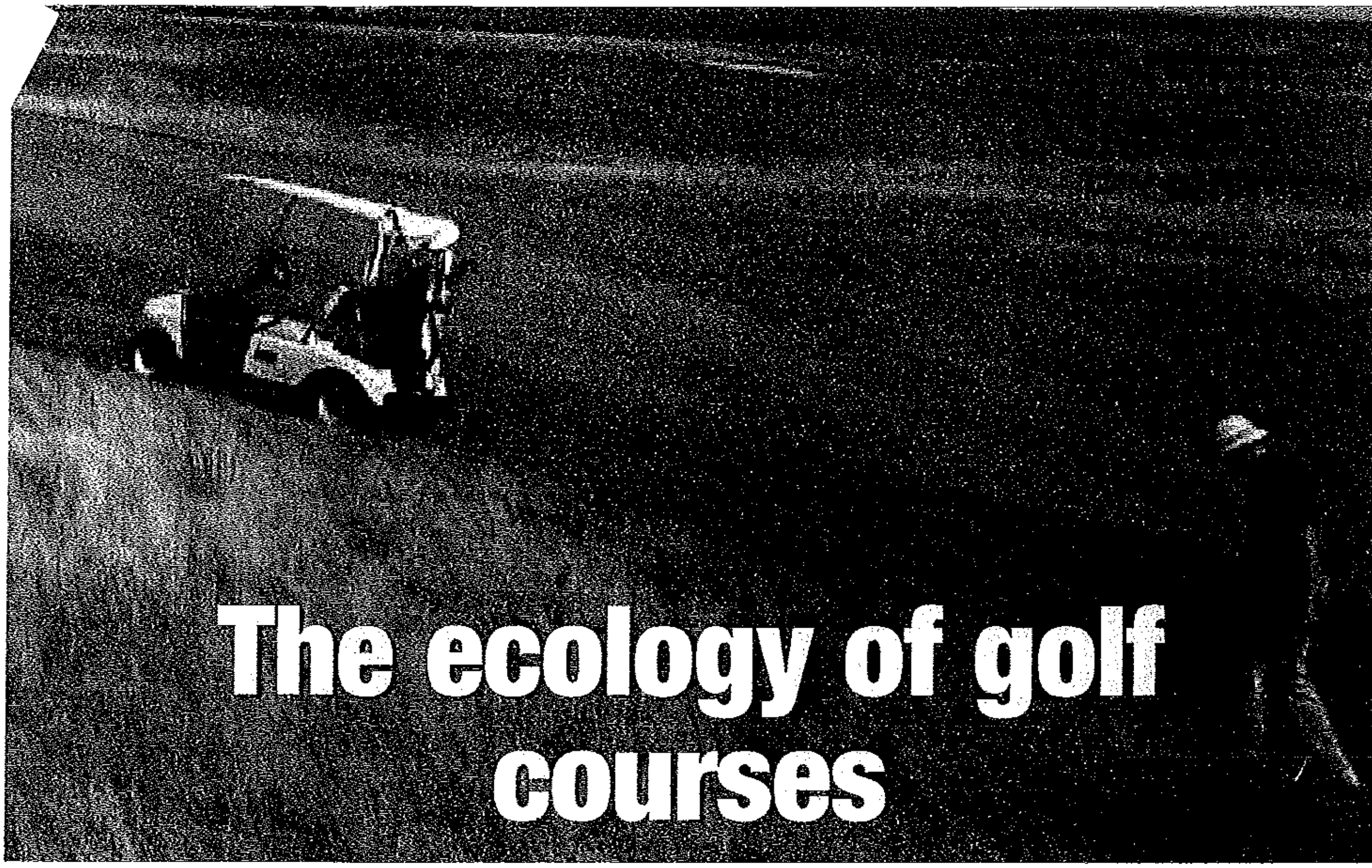


The ecology of golf courses

Alan C Gange, Della E Lindsay and J Mike Schofield*

*Royal Holloway, University of London and *Oundle, Peterborough, UK*

The public perception of golf courses is overwhelmingly that they are bad for the environment. However, many golf courses actively promote nature conservation and harbour some of our rarest plant and animal species. Golf courses can now participate in environmental management programmes and their efforts are being recognised through a national awards programme.

There are few land-based sporting activities that have such an intimate interaction with the environment as golf, and no other sport occupies and manages such large areas of the countryside. Worldwide, there are over 25 000 golf courses, with almost 10% of these being located in the UK. In England alone, there are about 650 000 golf club members and a further 1 500 000 others who play on pay-as-you-play courses.

Golf courses average between 50 and 60 ha in size, meaning that, in total, they occupy about 0.6% of the land area of Britain. This is more than the total occupied by RSPB reserves, country parks or local (not national) nature reserves (Dair and Schofield, 1990). Every golf course consists of highly managed areas (the greens and tees), less intensively managed areas (the fairways) and non-playing areas (natural habitat or rough). The extent of each area owes much to the architect who designed the course and subsequent management, but the non-playing areas generally represent between 25% and 40% of the total area of the course. This represents a significant amount of land that can be used for nature conservation purposes.

The public perception of golf

Before you read on, stop and ask yourself this question: are golf courses good or bad for the environment? The chances are that the answer you give depends on whether you are actively involved with the game. In a survey of 400 people in south-east England during 2002, we found that 80% of respondents who play golf answered that courses are good for the environment, while among non-players, this figure fell to 36%. Among players, the most commonly cited reason for courses being beneficial was that they preserve areas of natural habitat. However, among non-players, the most common reason for courses being detrimental was that they destroy areas of natural habitat! This clear disparity of views shows that many people may be misinformed about the value of golf courses from an environmental point of view. The survey also showed that there is much anti-golf feeling amongst the general public. In the past, such antipathy has been harnessed in some very vocal and active bodies, such as the Global Anti-Golf Movement (GAGM). These bodies cite a variety of reasons (including habitat loss, water use depletion, chemical contamination of soil and groundwater from pesticides and fertilisers, and increasing urbanisation) for golf courses being environmentally unfriendly. However, until recently, there was little credible research that had addressed any of these claims. There are now a number of studies that have sought to determine whether golf courses are major polluters of the environment through pesticide and fertiliser use. In a review of these, incorporating 36

Figure 1. Gleneagles GC, Scotland. An excellent example of a well-managed, mature course.

courses, Cohen *et al.* (1999) could find no evidence that this was a problem in the USA.

Natural habitats on golf courses

The age of a golf course is an important factor in determining its value for wildlife. Courses that were founded over 100 years ago in the UK made use of natural areas of habitat, with open spaces being made suitable for the game by the construction of greens and tees (Figure 1). Natural habitats were soon exhausted and, as the popularity of the game grew, meadowland and parkland were widely used. This approach does fragment or destroy natural habitats. It almost certainly accounts for anti-golf respondents in our questionnaire thinking that course construction meant loss of habitat. However, the majority of courses are now built on reclaimed land or land that was used for agricultural production, particularly pasture grassland. The conservation value of the older sites is therefore likely to be greater, because they contain areas that may have been undisturbed for over 100 years. Natural habitats need to be constructed and then established on the newer sites, a process that may take some time. However, the potential does exist for these new courses to enhance local biodiversity significantly if appropriate habitats are created from relatively species-poor farmland, used for intensive agriculture.

The word 'appropriate' clearly requires definition. If a golf course is constructed on ex-agricultural land, soil fertility may be high after years of fertilisation. However, many of our endangered plant communities, such as heathland, only occur on nutrient-poor soils. It may be very difficult to establish such communities on new courses, but this does not mean that nothing can be done. Ecologists helping golf course architects and greenkeepers need to advise on which plant communities would be most appropriate for the given soil type. The Wisley GC in Surrey was constructed on ex-pasture grassland and has greatly increased local biodiversity by sowing wildflower meadows on part of its land.

In order to best promote biodiversity, native species of plants should be established, because they support a greater diversity of animals, such as insects and birds, than do exotic plants. In the past, this has not always been so (Figure 2). Many non-native evergreens have been planted in the past, to maintain the 'green' appearance of the course all year round. This is probably another reason why many members of the general public regard golf courses as glorified gardens. Nowadays, one commonly finds native species of tree being planted, so that the course blends in with the surrounding countryside.

Currently, the established golf courses in the UK encompass a wide variety of habitat types (Figure 3). The majority of courses in the UK are considered to be of the parkland type, with wide areas of grass and specimen trees. However, there are also a number of habitat types represented on courses that have seen large declines on a national basis during the last century. These include heathland and chalky grassland.

In recognition of the importance of some of these sites, many have been designated as sites of special scientific interest (SSSI). There are now over 100 SSSI's in England that include either all or part of a golf course. A wide variety of rare species have been recorded on these courses, including the sand crocus (*Romulea columnae*) on Dawlish Warren GC, Devon, the pasque flower (*Pulsatilla vulgaris*) on Therfield Heath GC, Hertfordshire, and the natterjack toad (*Bufo calamita*) and the sand lizard (*Lacerta agilis*) on Royal Birkdale GC, Lancashire. Perhaps one of the most celebrated examples of a golf course providing a habitat for endangered species is that of Royal St George's GC in Kent, a course that will host the Open Championship in 2003. In the undisturbed natural areas of the course, 11 orchid species have been recorded, and the lizard orchid (*Himantoglossum hircinum*) is especially common there. Indeed, the fact that this species has been found on other golf courses in the local area has led to speculation that seeds may be transmitted on golf shoes as players move from one course to another! (Simons and Jarvie, 2001)

Figure 2. In the past, many exotic conifers have been planted on courses to maintain a 'green' appearance all year round. However, these support few species of wildlife compared with native trees.

Can golf courses enhance local biodiversity?

The case of the lizard orchid on Royal St George's is a perfect example of how golf courses

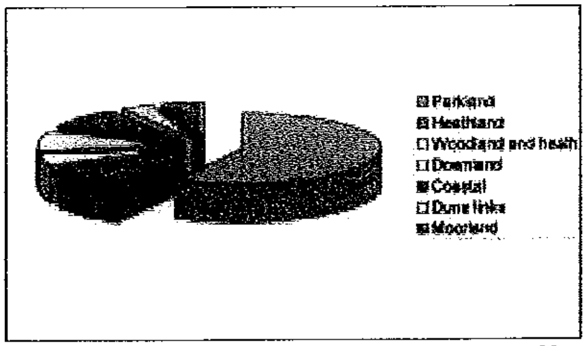


Figure 3. The distribution of golf course types in Britain. Most courses are of the parkland type, with large areas of natural grassland and specimen trees.

can be of conservation benefit. As many are on pri-vate land, accessible only to mem-bers, the impact of human activity on the natural habitats can be relatively low. The use of appropriate man-agement regimes allows for the development of these habitats and for rare species to flourish (Fordham, 1988). However, to date, there have been very few rigorous ecological studies on golf courses in the UK. Some have taken place in the USA, where it has been found that golf courses can act as reservoirs for rare species of mammals (Jodice and Humphrey, 1992) and birds (Terman, 1997).

Over the last few years, students at Royal Holloway have helped us in conducting ecological surveys of several golf courses (Gange and Lind-say, 2001). In each case, we compared the diversity of target groups of organisms on the golf course with that of the adjacent habitat(s), which the land would have supported if the course had not been constructed. We studied bumblebees at Haverfordwest GC, south Wales and the adjacent pasture grassland, and ground beetles at Frilford Heath GC, Oxfordshire and the adjacent arable farm. In addition, we studied birds at GC Buxtehude, Germany and the adjacent set-aside farmland, and birds at St Andrews GC, Trinidad and the adjacent cocoa plantation. In all cases, the diversity of organisms over a season was significantly higher on the course than it was on the nearby cultivated land (Figure 4). In Trinidad, we compared the diversity of birds using (*i.e.*, perching, feeding or nesting in) the course with an area of undisturbed grassland and found that diversity was similar. These preliminary data show that if cultivated land is converted into a golf course development, then the variety of habitats that can be created can lead to an enhancement of local biodiversity.

Ecological theory applied to golf courses

There are many questions about golf course ecology that we do not yet know the answers to. For example, do courses act as 'sinks' into which species are attracted from neighbouring habitats, only to be killed by exposure to pesticides? Do courses act as 'sources' for weedy or pest species that can infest nearby areas of agricultural land? Or do they act as areas where rare species can find refuges and maintain their populations at a landscape scale?

In many cases, the answers are likely to depend on the quality and quantity of the natural habitat areas present on a course. By its very design, a golf course is fragmented and the patches of habitat are either on the boundary of the course or exist as linear fragments alongside the fairways (Figure 5). We must know whether these patches are of sufficient size, quality and proximity to neighbouring patches for species to move between them and persist in the local environment. The theory of metapopulation dynamics can help us to understand these problems.

A metapopulation is a collection of populations. Metapopulation dynamics state that a species is more likely to persist in an environment if the patches of habitat it can potentially occupy are sufficiently close together for movement between patches to occur. A graphical representation of this idea is shown in Figure 6. Here, shaded areas represent occupied patches, while striped areas represent currently unoccupied patches. Arrows indicate movement between patches. For a species to persist in an environment, it is important that there are enough patches of sufficient size where it can live, but the movement of individuals between patches is equally important. If, for any reason, the population in one patch becomes extinct, recolonisation can take place from neighbouring patches,

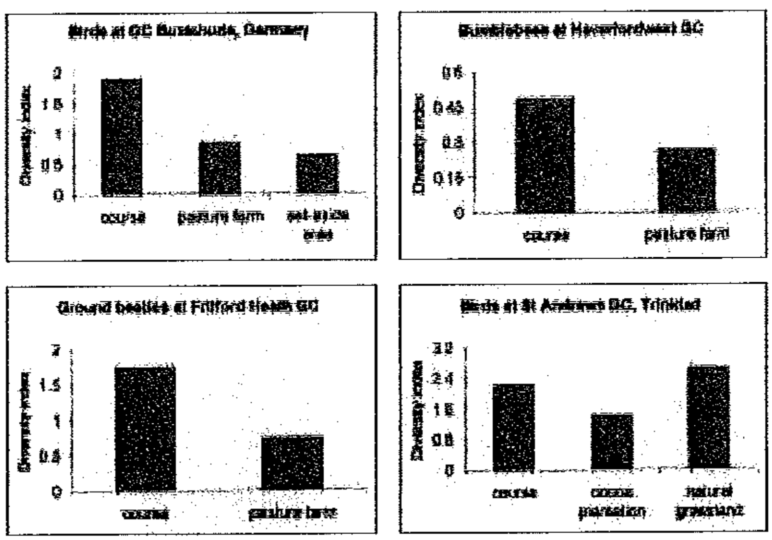


Figure 4. The diversity of bees, beetles and birds at four golf courses, compared with surrounding areas of habitat. In all cases, the golf course supports a greater diversity of species than the cultivated land from which it was created.

Figure 5. Many natural habitats exist as linear fragments, constituting the rough. These can be useful for conservation purposes, as well as trapping the unwary golfer!

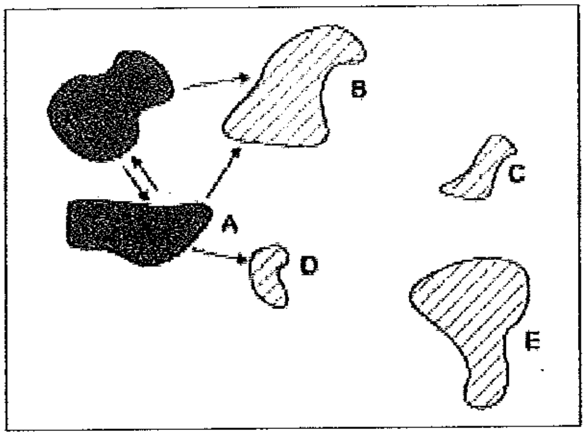


Figure 6. Metapopulation theory applied to golf courses. Patch A is currently producing emigrants that can colonise the unoccupied patches B and D. However, at the moment, patches C and E may be either too isolated or too small to be part of the metapopulation. However, once D is colonised, then the potential exists for E to become so too. The patches may represent habitat fragments on courses, or courses and areas of natural habitat at the landscape scale.

thus maintaining the overall population. If there was no movement between patches (*i.e.*, each population is 'closed') then extinction events in any one patch would be permanent, and, over the course of time, the overall population would be less likely to persist.

This idea is now being applied to the conservation of heathland on golf courses, in a project at Royal Holloway, funded by the Royal and Ancient Golf Club of St Andrews. This is the first study of its kind and one aim is to determine whether the patches of heathland on any one golf course act in a metapopulation context, as depicted in Figure 6. However, an equally important target is to determine the scale at which the processes of inter-patch movement occur. For example, the areas in Figure 6 could represent patches on one course, or they could represent individual courses, separated by areas of farmland or urbanisation. Furthermore, the patches could represent golf courses and areas of natural heathland. In the latter case, golf courses would be of immense benefit to the environment because they might provide stepping stones for movement between larger natural areas. The overall population of any given species might thus stand a better chance of long-term persistence in the event of a catastrophe (*e.g.*, a major fire) in any one of the natural areas. This is because the individuals in the golf course could recolonise the natural area when conditions became suitable again.

In an initial study of heathland invertebrates on golf courses, it was found that invertebrate density in patches declined with increasing degree of isolation of a patch (Gange, 1998). In that study, it appeared that the critical inter-patch distance may be about 100 m. Above this figure, invertebrate density in patches began to decline rapidly. However, it is not just the absolute distance between patches that is important, but the nature of the barrier between them (Figure 7). In the current work, it has been found that fairways (which are considerably less than 100 m wide) represent serious barriers to ground-dwelling invertebrates. In a mark-release-recapture experiment involving several thousand ground beetles, no beetle was ever found to cross a fairway (Lindsay, unpublished). Data such as these will be of importance to golf course architects when designing new courses, and also to greenkeepers, to help them in maximising the potential of the habitats they currently possess.

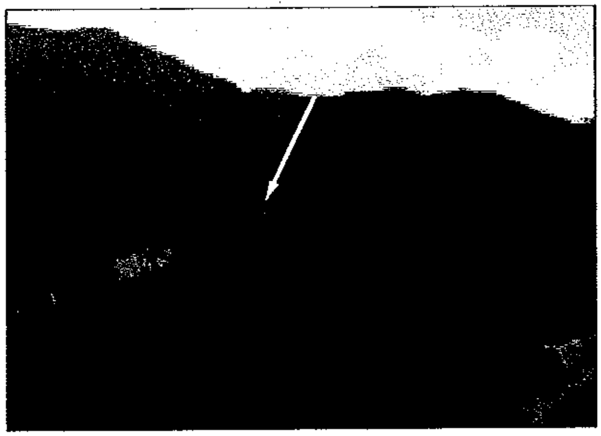
It is very important to realise that, although we perceive a golf course to occupy a defined area, bounded by a fence, such a distinction is not made by mobile animals, such as insects or birds. We need to realise that golf courses can be important at a landscape scale, by providing connections or corridors between one natural area of habitat and another. Good golf courses should blend into the natural environment and not be distinct from the surrounding area (Figure 8).

Some examples of good practice

While ecologists can help golf course managers to maximise the conservation potential of specific habitats, there is much that golf courses can do generally to enhance the quality of the habitats they possess. One excellent example is that of Lindrick GC in south Yorkshire (Newlands and Roworth, 2000). This course supports a large area of Magnesian Limestone grassland (a nationally scarce habitat) and this, together with woodland, scrub and open water habitats, is included in a 32 ha SSSI, covering 40% of the total course area. Since 1980, the club has been involved in a restoration programme of the grassland, encompassing a rotational cutting scheme. Many nationally rare species, including pale St John's wort (*Hypericum montanum*), autumn lady's tresses (*Spiranthes spiralis*) and the glow worm beetle (*Lampyris noctiluca*) occur there. The club's success in enhancing the SSSI was recognised when they won the British and International Golf Greenkeepers Association (BIGGA) Golf Environment Competition (see below) in 1998.

Another beautifully managed course is Temple GC, in Berkshire. The course is situated on undulating land, overlying chalk. This makes for thin, calcareous (chalky) soils that provide habitat for a rich downland flora. The local Naturalist's Trust has performed a number of field surveys of the course, and the wildlife associated with it is now remarkably well documented. This is a very good example of how clubs can engage their members in wildlife surveys that provide important information on the species inhabiting the course. The course possesses good colonies of green-winged orchids (*Orchis morio*) and several nationally rare

Figure 7. Barriers to wildlife movement between patches may be small such as paths or tracks, or large, such as a fairway or sand in a bunker!



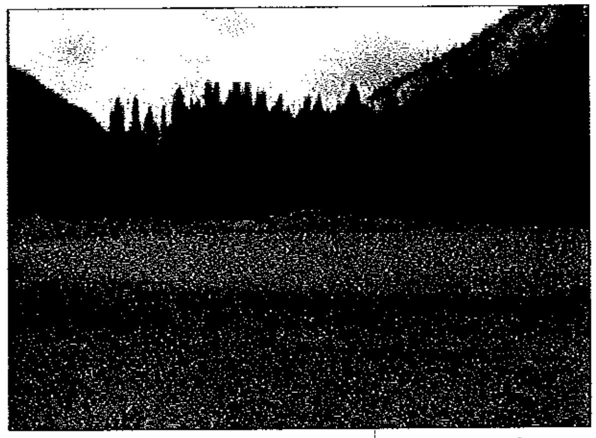


Figure 8. Banff GC, Canada (arrowed). An excellent example of a course that blends in with its surroundings. The designers have not destroyed the natural pine and spruce forest, but have made the course a part of it.

species of fungi. Temple also won the Golf Environment Competition, in 1999.

Simpson (2000) provides a very good account of the golf courses on the Sefton coast, Merseyside. These include Royal Birkdale, where the Open took place a couple of years ago. The golf courses here support a stunning array of dune habitats and associated species. Much practical conservation work has taken place to protect species such as the sand lizard, natterjack toad and the green tiger beetle (*Cicindela campestris*).

There are many other examples of positive conservation planning on golf courses in the UK; the examples selected here are designed to provide an idea of what can be achieved.

National and international initiatives

In 1994, the European Golf Association Ecology Unit was set up as a joint initiative between the European Golf Association, the Royal and Ancient Golf Club of St Andrews and the PGA (Professional Golfers Association) European tour. This represented an important step forward and has resulted in some important publications (see Further Reading).

The First European Birdwatching Open (1998) was a one-day event, coordinated by the Ecology Unit across 116 courses in 18 countries in Europe. A total of 272 species of birds were recorded in the 24 hr period of sampling on 17 May 1998, consisting of 4680 individual records. Overall, 40.3 bird species were recorded per course, on average, confirming that golf courses can act as valuable habitats for many species of birds.

One important ecological initiative produced by the Ecology Unit was the *Valderrama Declaration* (1999). This was issued in November 1999 and identified the advantages of golfers and environmentalists working together for *'the benefit of golf, the environment and people'*. It was signed by representatives of the United States Golf Association (USGA), the Royal and Ancient Golf Club of St Andrews, the European Golf Association, the International Olympic Committee, the World Wide Fund for Nature, the United Nations Environment Programme and the European Commission.

In the USA, the Audubon Society and the USGA have created the Audubon Cooperative Sanctuary System for golf courses. This programme is designed to enhance active participation in conservation by golf courses, thereby improving the quality of courses for wildlife. The USGA also acts as a funding agency for a wide variety of ecological projects on golf courses under their *Wildlife Links* programme. In 2000, the total funding commitment to this programme was over three quarters of a million dollars. No comparable research programme exists in Europe, which is a sad state of affairs, given that Europe supports 20% of all the golf courses in the world.

There are now some initiatives that are designed to acknowledge excellence in ecological practice by golf clubs. On a national level, BIGGA have teamed up with industrial sponsors to stage an annual Golf Environment competition. In this, clubs are judged by a panel of professional ecologists, against a number of ecological and management criteria. The standards are extremely high and the award is very prestigious. The competition has been well received by golf clubs and is an excellent way of demonstrating and rewarding best practice in environmental management by clubs.

The Ecology Unit has now been superseded by the independent Committed to Green Foundation. This encourages voluntary environmental management programmes for golf courses and other sports facilities and events. It is an excellent way for golf clubs to be involved in practical projects, thus realising their 'green' potential. It encourages a holistic view of course management, encompassing all aspects of maintenance.

A green future

There is no denying that golf courses do occupy large areas of land that could, in theory, be natural habitat. However, it is also a fact that, in our crowded island, if golf did not exist, the land might equally be used for urbanisation or intensive agriculture. Furthermore, the game will not diminish in popularity, and new courses are opening all the time. With the number of recognition schemes now in operation, golf clubs have realised that they are custodians of some very important areas of land. Much ecological work needs to be done to fully understand how golf courses affect biodiversity at a landscape scale. Golf would appear to have a green future – not just from the turf point of view, but also from the environmental aspect.

Acknowledgements

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www.committedtogreen.org
The homepage of the Committed to Green Foundation, giving access to information about various environmental schemes available.

www.golfecology.com/new/declare.htm
Information on the *Valderrama Declaration*.

www.bigga.org.uk/news.html
Information on the Golf Environment Competition from the British and International Golf Greenkeepers Association.

www.stri.co.uk/
Homepage of the Sports Turf Research Institute, where information on golf course ecology can be found.

***Dr Alan Gange** (corresponding author) is Senior Lecturer in Environmental Biology in the School of Biological Sciences at Royal Holloway, University of London and has never played golf in his life. Neither has* **Della Lindsay,** *who is researching the ecology of heathland on golf courses at Royal Holloway, funded by the Royal and Ancient Golf Club of St Andrews.* ***Dr Mike Schofield** does play golf and since retiring from English Nature has performed a number of environmental surveys of golf courses.*
School of Biological Sciences
Royal Holloway, University of London
Egham TW20 0EX, UK
a.gange@rhul.ac.uk

A look back

The following text is reproduced from 'Biological replication' by N W Pirie (1907–1997) published in New Biology *by Penguin Books, 1960.*

The growth and differentiation of normal organisms and tissues is so familiar that biochemists sometimes forget that these are almost wholly un-understood processes... Auto-synthesis or self-replication ... is much more often assumed than demonstrated... Tobacco mosaic virus (TMV) will multiply on many different host species. Different strains differ in their host range and in the characteristic symptoms they produce on host plants, but it is generally asserted that, regardless of the host, the same substance is being made. The evidence for this is superficial... Another line of evidence show[s] that the host has its own predilections about what it will make... It is now indubitable that fragments of TMV can be infective. The effective fragments consist predominantly of ribonucleic acid, but the virus made is, so far as is known, the normal TMV for that host... It is commonly asserted that the infective agent is pure nucleic acid. In the nature of things this could not be demonstrated because such large amounts of the relatively uninfective fragmented material have to be used to get infection that there is nothing implausible about the suggestion that infection is caused by a minor contaminant, amounting perhaps to 0.1 per cent, in the infective nucleic acid preparations... The only reasonable conclusion to come to on present evidence is that, although ribonucleic acid may well be an essential part of the infective fragment, ribonucleic acid ... is not the only component.

There is obviously no *a priori* reason why RNA, DNA, or for that matter any other type of molecule should not be the stimulus needed to start a synthesis... DNA is so firmly established as the active agent in ... bacterial transformation, that it is reasonable to assume that it is the agent in other transformations and in the genes of plants and animals as well. It is possible that the conclusion will prove correct, but the same type of logic fostered the now exploded idea that a similarity in the biological effects of different vitamins or hormones could be used as evidence for their chemical similarity... DNA is peculiarly stable and so is a suitable store for 'information'. [This] may mean no more than that the selective mechanisms of the cell are at a loss to know what ultimately to do with molecules with tritium in them...

To many this article will seem irritatingly negative... But the tag is in the present tense, it does not mean 'I cannot know' or 'I will never know'... A willingness to 'kick over the traces' is indispensable for it leads to the discovery of new phenomena; to integrate these into an ordered body of science some quantitative argument is needed to see whether the conclusions follow of necessity or are simply some out of many rival possibilities.