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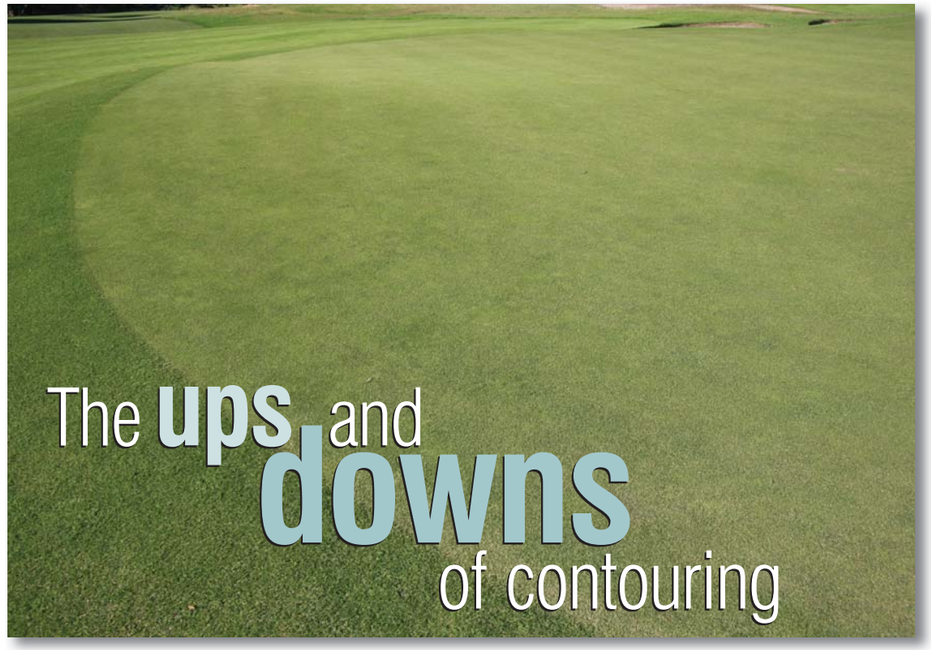

The ups and downs of contouring

Greens contouring can provide a number of management challenges for superintendents especially the profound effect it can have on the uniformity of soil moisture distribution. To kick of this instalment of AGCSATech Update John Neylan looks at the effect of greens shape on soil moisture and surface performance, while in part two reviews the findings on biodiversity from the recently published golf course literature review conducted by Dr Ross Higginson and Peter McMaugh.

Over the past few years there has been extensive remodelling of greens taking place on many golf courses around Australia. The impetus for this work has often been the poor performance of greens in terms of drainage and the ability to produce firm and fast playing surfaces. The solution, in part, has been to construct high drainage rate sand profiles.

The architectural features of golf greens can have a significant effect on the moisture characteristics of the green and in particular in the upper part of the rootzone. Since the inception of high drainage rate sand profile constructions, and in particular USGA style greens, there has been a belief that surface shape has minimal effect on drainage characteristics of the green and that all water movement and drainage is by uniform, vertical movement.

Consequently, in recent times we have seen new greens constructed with severe slopes in them and a lack of consideration towards sloping greens to multiple points around the perimeter. The end result can be water being directed into concentrated areas of the putting surface, resulting in inconsistent putting surfaces, black layer and turf thinning.

The concept behind the USGA recommendations for putting green construction is to build a green that provides a measure of resistance to compaction in the rootzone and drains quickly to an optimum soil moisture level (USGA, 2004). Specifications for a USGA putting green require that the sandy rootzone mixture be placed at a uniform depth of 300mm across the entire surface of the green.

If greens lacked slopes there is little doubt that most, if not all, USGA greens would perform well. However, with the slopes present on putting greens today, USGA greens do not always perform ideally. Putting greens constructed to USGA specifications function very well on a level surface (Taylor et. al. 1993), however, when the green has undulating areas, moisture extremes in the rootzone can occur at different elevations and lead to turfgrass decline (Prettyman and McCoy, 1999). Two conditions associated with moisture extremes in the rootzone are localised dry spot (LDS) and black layer.

Moisture extremes on USGA putting greens could be attributed to the uniform depth of the rootzone layer. Where there is a level surface, in theory there is minimal lateral flow of water within the rootzone and the putting green drains at a uniform rate. However, Nektarios et al. (1999) have shown that drainage in the rootzone is not always uniform. In an unsaturated putting green rootzone, water does not drain from the rootzone into the gravel layer, thereby allowing water to move laterally along the rootzone/gravel layer interface to lower elevations in the green.

In research undertaken by Prettyman and McCoy (2003), soil moisture conditions were monitored in sand profiles at different slopes. They found that the patterns of soil moisture for greens sloped at 2 per cent were somewhat similar to that observed at 0 per cent slope, however, it still generated some downslope accumulation of soil moisture. Soil water accumulation downslope was accentuated after 48 hours at 4 per cent slope. The 4 per cent slope had the greatest influence on near-surface soil moistures in a sand profile green without a gravel layer where water contents ranged from 37 per cent to 25 per cent within a distance of about 5.5 metres. Their work also demonstrated that in a perched water table green, evidence of water perching was absent near the upslope end.

Prettyman and McCoy (2003) further investigated the effects of slopes on sand profile greens and they demonstrated that on a 4 per cent slope there was a strong downslope to upslope gradient in soil water content yielding wetter soils downslope and drier soils upslope. This difference was around 10 per cent. This work also confirmed earlier observations that there was an absence of a perched water table upslope and that the perched water table may not necessarily serve as a reliable reservoir for water storage.

The contouring of greens, particularly where the slope approaches 4 per cent, will affect the uniformity of soil moisture distribution. This spatial non-uniformity may result in the formation of localised drying or 'hot spots' at upslope locations and excessive soil wetness in downslope locations. Other than the plant health effects, it also impacts on the consistency of the putting surface.

The variation in surface moisture conditions and the resulting effect on putting surface characteristics are likely to increase as the turf matures. It is essential that thatch control is a priority to ensure that the moisture content at the low points is not increased due to the organic matter accumulation.

The shape of putting surfaces cannot always be controlled, however, there are some agronomic factors to consider:

- Direct surface fall away from the centre of the green and not into it;
- Consider what the ramifications will be at the bottom of tiers or where there is a sharp change in slope;
- Make sure that thatch control through regular dusting starts as soon as a complete turf cover is achieved;
- Be prepared to undertake localised aeration of areas that are at the bottom of slopes or where surface flow is concentrated.

BIODIVERSITY VALUE OF AUSTRALIAN GOLF COURSES

In recent editions of ATM, AGCSATech Update has published excerpts from the Dr Ross Higginson and Peter McMaugh literature review on the environmental and health benefits of golf courses (HAL Project TU07034). Past editions have looked at sediment, nutrient and pesticide movement on golf courses (Vol 11.5) as well as the positive role golf course can play in carbon sequestration (Volume 11.4). Here ATM continues to examine their review and this edition's extract focuses on the valued role that golf courses can play in improving biodiversity.

"Urbanisation significantly reduces the amount of habitat available for flora and fauna with global estimates indicating that a possible 50 per cent or more of all species could be at risk (Fam D., et al., 2008). Promoting urban biodiversity by the use of green space is a feasible option, and obviously golf courses can and do play a major role in this area. Golf courses provide a habitat for flora and fauna in the urban environment as there is much less disturbance of the area than in busy urban streets.

The conservation value of suburban golf courses in south east Queensland was assessed by investigating their capacity to support urban-threatened species of birds, mammals, reptiles and frogs. Terrestrial vertebrate assemblages were compared between golf courses and nearby Eucalypt fragments and with suburban bird assemblages. Biotic diversity varied among golf courses. While some golf courses had conservation value (supporting high densities of regionally-threatened vertebrates), most failed to realise that potential, supporting only common urban-adapted species. Golf courses were generally a better refuge for threatened birds and mammals than for threatened reptiles and amphibians.

While species-specific studies are required to identify the ecological role played by habitats on golf courses and the potential for long-term viability, the results confirm that suburban golf courses can have local conservation value for threatened vertebrates. Given their ubiquity, golf courses present a significant opportunity for urban wildlife conservation. Whilst the golf industry is making genuine attempts to improve its environmental management standards, it is important to ensure that those efforts target the needs of regionally threatened species (Hodgkison S.C., et al., 2007).

In the United Kingdom, Tanner and Gange (2005) studied the diversity of vegetation (tree and herbaceous species) and three indicator taxa (birds, ground beetles – *coleoptera* and *carabidae* – and bumblebees – *hymenoptera* and *apidae*) on nine golf courses and nine adjacent habitats (from which the golf courses had been created) in Surrey, UK.

The main objectives of this study were to determine whether golf courses support a higher diversity of organisms than the farmland they frequently replace and to examine whether biodiversity increases with the age of the golf course. Results showed that both birds and insect taxa had a higher species richness and higher abundance on the golf course habitat than on nearby farmland.

While there was no difference in the diversity of herbaceous plant species, golf courses supported a greater diversity of tree species. Bird diversity showed a positive relationship with tree diversity for each habitat type. It was found that introduced tree species were more abundant on the older golf courses, showing that attitudes to nature conservation on courses have changed over time. Although the courses differed in age by up to 90 years, the age of the course had no effect on biodiversity, abundance, or species richness of any of the animal taxa sampled.

It was concluded from this study that golf courses of any age can enhance the local biodiversity of any area by creating a greater variety of habitats than intensively managed agricultural or urban areas. As

The plug shown top is taken from an upslope area, while the plug below is taken from an area downslope where soil moisture retention has led to the formation of a significant black layer

Golf courses can and do play a major role in promoting urban biodiversity

a consequence, golf courses have a very positive role to play in providing a habitat for flora and fauna.

From a biodiversity point of view, Australian golf courses have made considerable progress in dealing with avian, amphibian and macropod fauna. Despite the obvious emphasis on birds, frogs, kangaroos and wallabies, animal species that are easily identified by golf-playing patrons, there has been an almost total neglect of equally-important and beautiful insect populations such as *lepidoptera* (butterflies and moths) and *coleoptera* (beetles) and also some reptiles such *as squamata* (skinks, lizards and snakes). Admittedly, some reptiles can be hazardous (such as some snakes and crocodiles), but skinks, lizards, monitors, geckos, dragons and goannas are generally harmless and can be encouraged to co-habit with humans in the appropriate environment.

As well, there has been very little research done on the diversity of soil micro-flora and fauna in golf courses, other than those treated as pests (such as soil-borne insect, bacterial and fungal diseases). There are developing and emerging technologies becoming available where the principles of biodiversity are being used for insect and disease control. These are considered as areas requiring further research.

CREATING OR RECREATING INDIGENOUS FLORA AREAS

Martin (2004) has reviewed the potential of Australian native grasses for use as managed turf. He points out that, as greater demands are placed on turf for high performance under increasingly difficult environmental conditions, opportunities are opening up for the addition of new species to the list and/or the transfer of unusual adaptive traits found in some native grasses to traditional turf species.

He concludes that most of the Australian native species thought to have some turf potential (e.g. *Microlaena stipoides, Sporobolus virginicus, Agrostis aemula complex* and *Austrodanthonia*) would not repay the effort required to make them commercially acceptable as recreational turfgrasses. They may, however, have an important role to play in environmental turf plantings such as landscaping, where tolerance to human traffic is not a major requirement. This is particularly relevant to golf courses for areas of rough, or where landscaping is a major consideration.

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Trees, whether native or introduced varieties, offer benefits to a golf course by providing an aesthetic view, shade and habitat for native birds and other animals. They can also significantly increase the biodiversity of a golf course site. Research at the Australian National University's Centre for Resource and Environmental Studies (CRES) on biodiversity conservation in farmlands, native forests and in Australian plantation forests, show that any plantings of trees will have a positive benefit on biodiversity, particularly for birds, reptiles, amphibians, monotremes (echidnas), phalangerids (possums, gliders and koalas) and macropods (kangaroos and wallabies).

The biodiversity benefit to insect species and other invertebrates is also positive but not as well documented (see Lindenmayer, D.B., 2009; Lindenmayer, D.B. & Hobbs, R.J., 2004; 2007). From a golf course manager's point of view, the message is that any plantings of trees (whether introduced or native) or native shrubs will have a positive effect on biodiversity within the vicinity of the golf course.

Trees are valuable to many landscapes, both aesthetically and environmentally, providing shade and acting as effective wind breaks in harsh, windswept environments. Trees, however, have some very negative aspects in that they shade turf. Turf does not perform as well in shady conditions. They are also a significant hazard to golfers in that falling branches can injure or even kill golfers and they can act as very effective lightning conductors during electrical storms (Oatis, D.A., 2006).

Tree roots compete very effectively with turfgrass for moisture and nutrients and when they have surface roots, playability suffers and turf maintenance equipment may sustain damage as well. Trees located in high traffic areas create permanent traffic patterns that funnel traffic and concentrate wear problems. While the cost of planting trees is easy to calculate, the long-term costs of maintenance are impossible to compute and are rarely considered.

Moderation is the best policy with respect to golf course tree plantings. Most courses can be improved by systematically removing undesirable, hazardous and unnecessary trees. Turf and playability can be improved and the value and quality of tree plantings can be increased at the same time (Oatis 2006).

In golf course 'rough' conditions, particularly on links courses, consideration should be given to the management and encouragement of native grasslands. Native grasslands in Australia are defined as vegetation communities in which grass plants are dominant because the groundcover of woody plants is less than 10 per cent.

Native grasslands in their natural state contain a high diversity of other herbs, including sedges, rushes, lilies, orchids and forbs (broad-leaved herbs). About 700 species of native herbs have been identified in the grasslands of south-eastern Australia, the majority of which are not grasses.

The perennial grasses in native grasslands form the structural background of the community, yet this structure can fluctuate dramatically with the seasons and in response to soil moisture, temperature, grazing, fire, frost and management. Such communities have and encourage considerable biodiversity, and are easy to maintain in areas of low traffic, such as rough and borderlands between fairways (Eddy, D.A., 2002).

Ornamental plantings are also an integral part of golf course construction and design. There is, however, a paucity of research on their use in golf courses. This is an area that the authors identify as requiring further investigation, particularly in association with Nursery and Garden Industry Australia (NGIA). As well, native shrubs are an important component of sandbelt areas of both Sydney and Melbourne, and also in links-style courses and areas of rough. Together with ornamental plantings, these areas require further collaborative research in association with NGIA.

WETLANDS AND THEIR BENEFITS

Run-off from urban areas and golf courses is automatically presumed to contribute significantly to non-point source water pollution. This, however, need not necessarily be the case. Generally, golf course drainage directly discharges into surface water systems, whereas urban stormwater is managed in some way, albeit crudely, using direct discharge to surface waters or temporary storage in retention basins that eventually evaporate or drain to surface waters.

Given their ubiquity, golf courses present a significant opportunity for urban wildlife conservation

A significant role that golf courses can play in urban stormwater management is to utilise the stormwater creatively, by incorporating in the golf course design a series of artificial wetlands that serve as both water hazards and water quality management tools (Reicher, Z.J., et al., 2005).

The above study, conducted at Purdue University in the USA, used created wetlands on a golf course as stormwater-receiving locations and as a means of improving water quality. Unlike most stormwater retention basins, a created wetland with active plant growth and anaerobic sediment activity

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will have a significant retention and degradation capacity for introduced materials. Wetlands are able to cleanse the run-off water of nitrate and phosphate nutrients, remove significant amounts of suspended solids and organic matter and help remove heavy metals, trace elements, pesticides and pathogens by chemical, physical and biological processes. The wetlands water, once cleansed, can be returned to the golf course via the irrigation system.

Results of this study using a 10 hectare wetland cell indicate that over a five year period the wetland efficiently removed an estimated 97 per cent of nitrate/nitrite N plus ammonia N and also removed 74 per cent of P nutrient from storm events. Mass loading removal of dissolved solids was 59 per cent, indicating that the wetlands were effective in removing dissolved solids during storms. However, mass loading removal of suspended solids was 0 per cent for this study. Suspended solids passed through the system, rather than being retained for sufficient time to allow sedimentation.

The use of artificial wetlands in golf course design is largely a means of storing and treating stormwater. The main issues to consider are:

- Sufficient catchment area to supply enough water;
- Safety of the water with respect to microbiotic contamination, especially aerosols that may affect staff and golfers (NRMMC, EPHC, AHMC, 2006);
- Design of the storage so that they look good but hold sufficient water to be effective; and
- Risk associated with people falling in – mostly an issue when golf courses have open public access with minimal fencing.

Various references are available to assist with aspects of managing wetlands on golf courses (Kenna, P.K. & M.P. Kenna, 1994; Libby, G., et al., 2004). There are many examples of the successful use of wetlands on golf courses as a means of collecting and treating stormwater, but also as an attractive natural hazard for golf play, and an area for increasing biodiversity within the golf environment (eg: Bacon, P., 2004; 2005a; 2005b; 2008).

Wetlands offer considerable potential for increasing bird biodiversity on golf courses. In the south-western USA, the greatest diversity of breeding birds is normally found in riparian habitats (areas surrounding rivers or lakes). It is estimated that the bird diversity in riparian zones surpasses that of all other western lands combined (Merola-Zwartjes, M. & J.P. Delong, 2005). This scenario is similar to Australia's inland rivers and swamps, such as within the Murray-Darling Basin, where riparian zones act as an oasis for migratory and resident birds (Kingsford, R.T., 2006 (Ed.), Briggs, S., 1990). Golf courses can simulate these environments as part of their design, by providing a combination of habitat characteristics that are reminiscent of the riparian systems used by birds.

The conservation value of golf course habitats has to be carefully planned, however, to exclude the more evasive or pest species of birds (such as the sacred ibis in south-eastern Australia, which can quickly ruin a putting green) by increasing the complex vertical structure and diversity of plant species composition in the out-of-play areas of the course, and in particular, by increasing the extent and usage of native plants (Merola-Zwartjes, M. & J.P. Delong, 2005).

Wetlands also offer potential for increasing amphibian biodiversity on golf courses (Semlitsch R.D., et al., 2007). Amphibians are known to use man-made ponds, such as water hazards, sediment retention basins, or farm ponds. Golf course ponds can be managed in such a way as to promote amphibian abundance and diversity.

Golf courses provide one of the best opportunities for the clean-up of surface water run off from urban streets and hardscape areas, and there are numerous studies to show the effectiveness of cleaning water supplies by passing them through golf courses (Beehag, G.W., 1996; Scaife, D., 1996). Many of the studies of the benefits of turf as a whole, such as pesticide entrapment and water purification, have been carried out on golf course facilities.

When the potential movement of water and dissolved nutrients from a golf course to surrounding areas is a concern, grass buffers, bioswales, wet cells and constructed wetlands can be useful tools in maintaining water quality. Increasing the residence time of the soil solution on the golf course is critical and can allow the grass root system, as well as other soil organisms, to effectively filter nutrients from the water before it leaves the course (Miltner E., 2007).

Golf courses have an enormous amenity value other than their use for sporting pursuits. There are large non-turf areas on a golf course that can provide extensive biodiversity value. The management and promotion of these areas is critical to ensure the golf industry continues to play a positive role in maintain and enhancing the environment within our communities.

REFERENCES

For a full list of references for this article, contact the AGCSA on (03) 9548 8600.