Natural features of a dune lake near Opunake, Taranaki, its conservation rating, and some options for future management

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Abstract

New and existing information has been collated for a dune lake, known locally as Julian's Pond, southeast of Opunake on the ring-plain of Mt Egmont/Taranaki. Julian's Pond had been overlooked in a 1986 rapid inventory of sites to assess the adequacy of the region's Protected Natural Areas network. This was despite being identified in a regional wildlife survey in 1983 and earlier records of two nationally threatened plant species, *Amphibromus fluitans* and a seemingly unnamed species of *Limosella*. Subsequent surveys have revealed a lakeshore 'turf' comprising mostly indigenous plants. The rarity of such habitats in Taranaki means that many of the turf species are regionally rare. They include *Potamogeton pectinatus*, a new record for Taranaki. Unusually for lowland Taranaki, Julian's Pond has a wide variety of water birds, including regular sightings of New Zealand dabchick (*Poliocephalus rufopectus*). Rapid biological inventories have inherent risks of undervaluing or completely missing significant natural areas. The collation of new findings with earlier survey data has produced an elevated conservation rating for Julian's Pond, from "moderate" to "high". Julian's Pond has been modified by past farming practices but now has some protection. However, high nutrient levels have produced rampant growth of some weeds, especially Mercer grass (*Paspalum distichum*) in places where native turf plants would be expected. Several methods are suggested to reduce nutrient levels in Julian's Pond.

Keywords: Dune lake - ephemeral wetland - turf plants - threatened species - *Amphibromus fluitans* - *Limosella* 'Opunake' - weeds - *Paspalum distichum* - water birds - conservation rating - rapid ecological inventory - Taranaki - New Zealand.

Introduction

Julian's Pond is a dune lake lying southeast of Opunake on the ring-plain of Mt Egmont/Taranaki, on the west coast of the North Island, New Zealand. It is privately owned by the Julian family, is located around grid ref NZMS 260/ Sheet P21/869902, covers about 3 ha and is roughly circular. Although

unnamed on topographic maps, the name "Julian's Pond" has been used in print by the Taranaki Regional Council (2000). Julian's Pond is on the seaward side of State Highway 45 and visible from it, with sand dunes between it and the sea. The lake was not identified in the Protected Natural Areas Programme (PNAP) survey of Egmont Ecological Region (the Egmont/Taranaki ring-plain and volcanoes) (Bayfield & Benson 1986) but it is in the Department of Conservation's database of Sites of Special Biological Interest (SSBI) as a result of two surveys, namely by the New Zealand Wildlife Service in 1983 and Wildland Consultants in 1996. This electronic and paper database is held in the Wanganui Conservancy office of the Department of Conservation. Julian's Pond was listed in the Taranaki Regional Council's inventory of wetlands (Taranaki Regional Council [TRC] 2000) with a short description, aerial photograph and a location map. No streams enter the lake. In the past, the lake had fluctuating water levels (TRC 2000) with large areas of shore being exposed during periods of low rainfall. Neil Phillips (Queen Elizabeth II National Trust, pers. comm.) reported that the summer of 2000/01 was very dry and the lake practically dried up for a long period of time.

For some years until the late 1990s, the lake was used as a secondary treatment pond for wastes from the nearby dairy shed (TRC 2000). This had two major effects on the lake ecosystem, namely to reduce the amount of natural seasonal fluctuation in water levels and to raise nutrient levels. Dairy wastes no longer enter the lake and water levels now fluctuate. Another positive move to reduce nutrient influx to the lake from run-off was fencing to exclude livestock, coupled with plantings of native shrubs just inside the fence-line.

The 2002 survey

On April 24 2002, Jim Clarkson of the Stratford Area Office of the Department of Conservation and I undertook a survey of Julian's Pond, mainly to search for plants on the exposed shores. A particular watch was kept for two nationally threatened species, *Amphibromus fluitans* and an unnamed species of *Limosella*, found here by A.P. Druce in 1964 and 1972, respectively. Unfortunately, at the time of the survey, only small areas of lakebed were above water level, but it was possible to paddle the whole margin of the lake, listing every plant species seen. Lack of time meant that only a subjective assessment was made of the abundance of each plant listed; the scale of abundance used the terms 'abundant', 'common', 'occasional', 'uncommon' and 'local' (species confined to a small area, but can be common or abundant there). Turbid water made it impossible to see plants growing below the surface but samples were dredged by hand periodically and the drift line around the shore was examined for detached material of other species. Some drift material with fruit was sent to Paul Champion at National Institute of Water and Atmospheric Research (NIWA) to confirm its identity. Several other plants were collected and pressed for the herbarium at Landcare Research, Lincoln (CHR). Details were sought from herbarium sheets of earlier collections of two threatened species

from Julian's Pond. The water birds seen on and around the lake were listed.

Results

Vegetation and flora

A list of all plants seen is in Table 1. The lake perimeter is dominated by a band 0.5 m – 5 m wide or more of Mercer grass (*Paspalum distichum*). At their lower margin and subject to seasonal inundation, dense beds of the exotic Mercer grass encroach on the habitat of native lakebed herbs. Growing among the Mercer grass in places are creeping bent (*Agrostis*

Table 1. List of vascular plants at Julian's Pond, southeast of Opunake.
Compiled by Colin Ogle and Jim Clarkson, 24 April 2002. The list excludes planted species, mostly around the inside of the fenced wetland. These included harakeke (*Phormium tenax*), karo (*Pittosporum crassifolium*), pohutukawa (*Metrosideros excelsa*), akiraho (*Olearia paniculata*).
* Denotes adventive species. Abundance noted as follows: a = abundant; c = common; o = occasional; u = uncommon; l = local (species in a small area, but can be common or abundant there).

Formal name	Abundance
Monocotyledon herbs	
a) Grasses	
**Agrostis stolonifera*	lc
**Elytrigia repens*	u
**Holcus lanatus*	lc
**Paspalum distichum*	a
**Schedonorus phoenix*	u
b) Sedges	
Carex secta	u
Carex virgata	u(1)
Carex sp. (unidentified; C. *geminata* / *lessoniana* agg.)	la
Cyperus ustulatus	o
Eleocharis acuta	o
c) Monocotyledons other than grasses & sedges	
Juncus edgarae [recorded as *J. gregiflorus* by Taranaki Regional Council 2000]	
Lemna sp. (*L. minor* of NZ authors)	c
Phormium tenax[1]	
Potamogeton cheesemanii	a
P. pectinatus	?[2]
**Zantedeschia aethiopica*	o

Formal name	Abundance
Dicotyledon vines	
Calystegia sepium agg. (pink flowers with white stripes)	c
Muehlenbeckia complexa	lc
**Rubus fruticosus* agg.	o
Dicotyledon herbs	
**Bidens frondosa*	c
Centipeda aotearoana	u
**Cirsium arvense*	u
Cotula coronopifolia	u
Glossostigma elatinoides	c
Gratiola sexdentata	u(3)
Hydrocotyle hydrophila	u
Limosella lineata	u(1)
Lilaeopsis sp. (*L.novae-zelandiae* / *L. ruthiana*)	u
**Lotus pedunculatus*	o
**Lythrum hyssopifolia*	u
Myriophyllum propinquum	a
Polygonum salicifolium	lc
Potentilla anserinoides	u (1)
Pratia perpusilla	u (1)
Ranunculus limosella	lc
**Ranunculus repens*	lc
**Ranunculus trichophyllus*	a
?*Rorippa palustris* (only seedlings seen)	o
**Rorippa* sp. (unidentified)	lc
**Sonchus oleraceus*	u
**Trifolium repens*	o

[1] Recorded without comment on field sheets by Wildland Consultants in 1996, but all plants seen in 2002 appeared to have been planted.
[2] Found as drift on shore, common in one area; abundance under water unknown.

stolonifera), New Zealand willow weed (*Polygonum salicifolium*), beggar's ticks (*Bidens frondosa*) and a few plants of *Carex* spp. Progressively up-shore from the lake edge, the Mercer grass beds contain more convolvulus (*Calystegia sepium*), blackberry (*Rubus fruticosus*) and creeping buttercup (*Ranunculus repens*).

Native turf species occur at the lower edge of the Mercer grass zone on wet sand or silt or in very shallow (<50 mm) water, although the introduced water buttercup (*Ranunculus trichophyllus*) is the dominant turf species, growing almost prostrate. Of the native turf plants, only water milfoil (*Myriophyllum propinquum*) and *Glossostigma elatinoides* are rated as 'common'; most of the other species are found as very small or localised colonies. They included *Pratia perpusilla, Hydrocotyle hydrophila, Ranunculus limosella, Centipeda aotearoana, Gratiola sexdentata, Limosella lineata* and *Potentilla anserinoides.* The observed quantities of several species, especially *Pratia perpusilla, H. hydrophila, G. sexdentata* and *L. lineata*, are less than would fit in the palm of one hand. A fully aquatic species, *Potamogeton pectinatus,* is the main plant identified from the drift material. This is a new indigenous plant record for Taranaki. Black swan probe for the tubers of this plant and they may be having an impact on its abundance in this shallow lake. It is possible that the lake's centre is deep enough for *P. pectinatus* to be beyond the grazing depth of swans.

No plants were found of two threatened plant species found here in the past. In 1964 and 1972, A.P. Druce, of Botany Division, Department of Scientific & Industrial Research, Lower Hutt, visited Julian's Pond, and collected herbarium specimens of two plants now regarded as being nationally threatened species. These were an aquatic native grass, *Amphibromus fluitans*, and a seemingly unnamed species of dicotyledonous herb in the genus *Limosella.*

Birds

A list of the water birds seen on 24 April 2002 is shown in Table 2, alongside data on birds from surveys in 1983, 1996 and 1998-99.

Discussion

Botanical inventories

Julian's Pond has been visited by other biologists over a period of 40 years or more but no comprehensive inventory or description appears to have been made over this time. As indicated above, A.P. Druce collected plant specimens in at least 1964 and 1972. His surveys of the entire coast from Hawera to Waitara resulted in the plant list that no doubt incorporated all the species he saw at Julian's Pond (Druce 1972; 1974), but he did not maintain a separate list for this lake in his extensive database of plant lists from places around New Zealand. Table 1 is the first known substantial plant list for Julian's Pond, but other species would be added by future surveys, especially over the full range of seasons.

Threatened plants

Amphibromus fluitans has a national conservation status of 'nationally endangered' and *Limosella* 'Opunake' is rated as 'nationally critical' under the group of 'indeterminate species' (Hitchmough 2002). Details from the

Table 2. Waterbirds recorded at Julian's Pond, near Opunake, Taranaki, in four surveys between 1983 and 2002. p=present (listed without a record of the number of birds present)

Species	21 May 1983 (New Zealand Wildlife Service 1983)	Dec 1996 (Wildland Consultants 1996)	(B. Hartley, pers. comm., from OSNZ, 1998-99)[a]	16 April 2002 (this survey)
New Zealand dabchick (*Poliocephalus rufopectus*)	p	Reported	3 (Feb 1998) 4 (May 1999)	18
Little shag (*Phalacrocorax melanoleucos*)		p[b]	p	1
Black shag (*Phalacrocorax carbo*)			p	
White-faced heron (*Ardea novaehollandiae*)	p		p	
Black-fronted dotterel (*Charadrius melanops*)			p	
Spur-winged plover (*Vanellus miles*)			p	
Southern black-backed gull (*Larus dominicanus*)			p	
Black swan (*Cygnus atratus*)	p	6	p	2
Paradise shelduck (*Tadorna variegata*)		p	p	>20
Mallard (*Anas platyrhynchos*)	p	100s	p	<10
Grey duck (*Anas superciliosa*)	p	100s[c]	10 (Feb 1998) 2 (May 1999)	
Australasian shoveler (*Anas rhynchotis*)	p	p	p	15
New Zealand scaup (*Aythya novaeseelandiae*)		Reported		
Grey teal (*Anas gracilis*)			p	>25
Pukeko (*Porphyrio porphyrio*)	p	p	p	
Pied stilt (*Himantopus himantopus*)	p	p	p	16
Australasian harrier (*Circus approximans*)			p	
Welcome swallow (*Hirundo tahitica*)	p	p		Many

[a] Barry Hartley's records are from at least two visits between February 1998 and May 1999.

[b] Recorded as pied shag (rare in Taranaki, only from Sugarloaf Islands northwards [B. Hartley pers. comm.]), so this record at Julian's Pond is almost certainly an error for little shag, in which some birds are markedly pied.

[c] Usually much less common than mallards in lowland Taranaki; record may be error for eclipse-phase mallards, especially as mallards were not recorded.

labels on Druce's herbarium specimens at Landcare Research New Zealand Ltd, Lincoln (CHR) are as follows:

- "CHR 159504 *Amphibromus fluitans*. 3 miles south-east of Opunake at the lagoon margin, January 1964."
- "CHR 222625 *Limosella* 'Opunake'. 3 miles south-east of Opunake at the lagoon margin, March 1972. Unnamed species? Growing with *L. lineata*."

1. *Limosella* 'Opunake'

It is important to note Druce's comment on CHR 222625, namely that the unnamed *Limosella* was growing with the widespread species, *L. lineata*. Some years ago, Tony Druce (pers. comm.) stated that it was his seeing two distinctly different plants together at Julian's Pond that led him to believe that they were two species. In his unpublished plant lists for the western Taranaki coast (Druce 1972, 1974) he distinguished the two as follows:

- *Limosella lineata* (leaves linear or linear spathulate; flowers subsessile to distinctly pedunculate; calyx = or > corolla tube; capsule ovoid-globose, >2 mm long).
- *Limosella* sp. (unnamed) (leaves narrowly oblong-spathulate, shorter than those of *L. lineata*; flowers sessile or subsessile; peduncles elongating slightly in fruit; calyx = or < corolla tube; capsule globose, <2 mm long)."

For the unnamed *Limosella* there is no other record from Taranaki substantiated by a specimen, although there is an unsubstantiated report of it from Lake Dive in Egmont National Park. Live material of a *Limosella* was collected from Julian's Pond some years ago by Dr Peter Johnson of Landcare Research, Dunedin. Dr Peter Heenan of Landcare Research, Lincoln (pers. comm. 2003) has examined this plant and suggests that it is simply a spathulate-leaved variant of *L. lineata*. However, it is not known whether this material represents the plants that Druce regarded as the unnamed taxon.

2. *Amphibromus fluitans*

There were three Taranaki collections of *Amphibromus fluitans* prior to Druce's 1964 collection, as follows (Ogle 1987):

- WELT 68452 collected by T.H. Cheeseman in January 1885 in "swamps near Mt Egmont".
- CHR 2814 by T.H. Cheeseman in January 1895 "near New Plymouth".
- CHR 90828 by R. Mason in January 1956 "Waipu Lagoon, Bell Block".

Druce's 1964 collection from Julian's Pond is the last-known record of *Amphibromus fluitans* in Taranaki.

Two plant species still present at Julian's Pond are listed by Hitchmough (2002). Neither is known from any other site in Egmont Ecological Region. *Potamogeton pectinatus* is rated as a nationally threatened species with a status of 'gradual decline'. *Centipeda aotearoana* has a status of 'data deficient', meaning that further surveys are needed to determine whether it is nationally threatened.

Birds

Any single-day visit to a site can give only a narrow window on the bird life that uses it. Daily, seasonal and year-to-year fluctuations occur in bird species and bird numbers at any site. However, the combined list of birds for Julian's Pond (Table 2) shows some notable features, including the repeated

(and, therefore, presumably regular) presence of New Zealand dabchick (*Poliocephalus rufopectus*), which has a conservation rating of 'sparse' nationally (Hitchmough 2002). The flock of 18 dabchicks seen on 24 April 2002 was unusual for Egmont Ecological Region. Throughout their North Island range, dabchicks occur in ones and twos for much of the year, but Heather & Robertson (1996) state that in autumn, many birds gather on favoured lakes and congregate to form large loose flocks. It is unknown whether autumn flocking is a regular event at Julian's Pond, but the only other recent record of a substantial flock in Taranaki was from the Hawera oxidation ponds, which had over 40 in April 2002 (B. Hartley, pers. comm.). In the period 1998-2001 there were records of single dabchicks or pairs in several other Taranaki lakes, mostly coastal, such as Waiau Lake at Opunake, Komene Beach, Waiongana River mouth and Patea oxidation ponds, but also inland, e.g., at Lakes Mangamahoe, Umutekai and Looneys (B. Hartley, pers. comm.). From the Waverley area southwards, dabchicks occur also on a number of lakes, especially dune lakes. Julian's Pond is also notable regionally for its wide variety of waterfowl, including species seen at few other lakes on the Egmont/ Taranaki ringplain.

Evaluating conservation significance

In 1983, the New Zealand Wildlife Service, as part of its national inventory of 'wildlife habitats of note' (later to become Sites of Special Wildlife Interest (SSWI)), rated the lake's wildlife value as 'moderate', which is equal to a ranking of '4' on a 5-point scale. The ranking was stated to be mainly for the presence of dabchick. It should be noted, however, that unless the vegetation or particular plants were known to have specific values to wildlife, plants were not used in the assessments of SSWI. As part of a re-survey of SSWI (then renamed 'Sites of Special Biological Interest' – SSBI) for the Department of Conservation in December 1996 the lake was re-assessed by Wildland Consultants. The data included a list of birds, including a report of dabchick presence by the lake's owners, and an account of the changes that had occurred at the lake, such as plantings, removal of grazing and the growth and spread of exotic grasses. Although plants can be used to rate the importance of SSBIs, almost nothing was said of the native vegetation and the report named just two native plant species that appeared not to have been planted. The report contained a diagrammatic (no scale given) profile sketch of the lake edge showing a submerged zone of the exotic water buttercup, with higher zones of creeping bent and tall fescue (*Schedonorus phoenix*) with Yorkshire fog (*Holcus lanatus*). The earlier rating of 'moderate' was not changed.

Julian's Pond either had been missed or its importance not realised in a rapid inventory of sites in Egmont Ecological Region to assess the adequacy of the region's Protected Natural Areas network (Bayfield & Benson 1986). The survey report (loc. cit.) used a land systems approach and showed small areas of 'coastal sands'. No areas of indigenous vegetation on sand topography were shown as being already protected. Several lakes were described in the coastal zone, but all were described as having fringing beds of

reeds. No mention was made of turf mats or fluctuating water levels. In other words, Julian's Pond is a different kind of lacustrine ecosystem from any other identified in Egmont Ecological Region during the Protected Natural Areas Programme survey (Bayfield & Benson 1986).

A one-page description with an aerial photograph and map of Julian's Pond appeared in TRC (2000). It mentioned the two endangered species of plant known to have been here in the past but named no other native turf plants except to imply that *Limosella lineata* was not uncommon (only one tiny plant was found in 2002). The lake was stated to be 'important for native water birds' though only three relatively common species were named, pied stilt (*Himantopus himantopus*), white-faced heron (*Ardea novaehollandiae*) and pukeko (*Porphyrio porphyrio*). Earlier and more significant records regionally were overlooked, including New Zealand dabchick, grey teal (*Anas gracilis*), New Zealand scaup (*Aythya novaeseelandiae*), and black-fronted dotterel (*Charadrius melanops*). By not making use of all existing information, the regional significance of Julian's Pond was still under-stated by Taranaki Regional Council (2000).

Rapid biological inventories have inherent risks of undervaluing or completely missing significant natural areas. During rapid inventories, sites tend to be visited for a short time in one season of one year, and by one person or a very small team with a necessarily limited range of survey skills. An ecosystem assessment approach can reduce survey limitations, but this requires an ecosystem classification that distinguishes apparently similar but functionally different ecosystem types.

The scarcity of lowland lakes with fluctuating water levels in Taranaki means that a number of the turf species that still occur at Julian's Pond must be regionally very rare or threatened. It is possible that *Amphibromus fluitans* and the unnamed *Limosella* 'Opunake' remain there, and their re-discovery would make the lake nationally significant. The findings of our 2002 survey show that past assessments of Julian's Pond have under-rated its importance for native vegetation, flora and fauna. It certainly should have been identified as a Recommended Area for Protection in the PNAP survey in 1983. Although considerably modified, the lake is still highly significant on a regional basis. Its conservation rating should be raised from "moderate" to "high", using the SSBI criteria.

Changes in lake shore vegetation

The margins of lakes having marked water level fluctuations constitute one type of ephemeral wetland (Ogle 1991; Johnson & Rogers 2003). A suite of native plants is adapted to live in such conditions by surviving for long periods fully submerged and mostly not flowering and fruiting until they are exposed by lowered water levels. Many plants of ephemeral wetlands have rhizomes, very small leaves and minute flowers and fruits.

Native plant communities of fluctuating lake margins are usually quite resistant to change, including weed invasions. This is especially true where lake levels fluctuate 'naturally' i.e., within natural limits that are dictated by seasonal climatic conditions; and where there is little or no

disturbance of the lakebed by vehicles or livestock, and where nutrient levels are not artificially raised. Unfortunately, Julian's Pond does not meet all of these provisions. Although the landowners are to be congratulated for ring-fencing the lake, planting buffering shrubs and diverting dairy effluent away from the lake, there remains a legacy of past grazing and water contamination. Indicators of continuing 'unnaturally' high nutrient levels appear in the water quality, in the substratum and in dense weed growth.

File notes made by Wildland Consultants in 1996 gave a good account of the lakeshore vegetation, except that they omitted any mention of Mercer grass. By 2002, Mercer grass was the single most invasive grass around almost the entire shoreline. If this apparent change is the result of the arrival and spread of Mercer grass since 1996, as opposed to its not being recognised in 1996, Mercer grass is a major threat to the remaining native plants on the shores. Some of these are among the rarest native plants in Taranaki, and they are already very rare at this lake. From a single visit, it is impossible to say much about the dynamics of the Mercer grass/native turf boundary but it certainly looks as though Mercer grass is encroaching on turf plant habitat. It forms a dense sward that eliminates the habitats of native turf species.

The only truly aquatic weed seen was water buttercup. Turbid water conditions prevented a good assessment of its abundance and extent in April 2002, but it appeared to be ubiquitous. Paul Champion (pers. comm., April 2002) believes that the threat posed by water buttercup is not "in the same league as the oxygen weeds and usually indigenous plants can survive under its cover". At Julian's Pond it might be in competition with at least one regionally rare plant, namely *Potamogeton pectinatus*.

Managing the lake

Weed encroachment on native turf

Some transect lines at right angles to the shore and marked with permanent pegs might be installed and monitored to show change over time. However, other (or additional) approaches could include looking for an advance up the lakeshore of native turf plants as the grass disappears following a trial spraying of part of the Mercer grass margin with a grass-selective herbicide such as 'Gallant', or the laying of sheets of black polythene or old carpet underlay over selected patches for several months.

Water quality

This survey made no quantitative assessments of the lake water. However, it was obviously turbid and 'smelly' in April 2002. Digging through the top surface of substratum revealed a black, anaerobic sand layer about 20-30 mm underneath, with a sulphurous odour. These features, coupled with the super-abundant weed growth, mean that the lake is still affected by dairy-shed wastes that entered it years ago. There are additional ways by which nutrient might still be entering the lake:

- In April 2002 there were signs that stock had been inside the fence quite recently (droppings, grazing, hoof prints).

• Water birds are probably adding more to the lake than they remove, especially birds like black swan and paradise shelduck that graze in the paddocks and return to the lake to roost.

• The decay of rank vegetation in and close to the lake will return nutrients to it (spraying weed growth would exacerbate this problem).

• Despite fencing and planting of the lake's margins, there might still be run-off from the cattle race along the inland side of the lake. If further study shows this to be a significant and continuing source of nutrients to the lake, consideration should be given to moving the race further away. Outside agencies would need to consider ways to assist the landowner with the costs and inconvenience of moving the race.

Dune lakes are naturally low fertility systems and, if Julian's Pond is to become something like 'natural', then nutrient levels need to be reduced. At times of high lake levels there is an outflow stream that should result in a slow flushing of the lake (M. Bayfield, pers. comm., April 2002).

It is important to know whether the lake is currently losing nutrients faster than it is gaining them. Nutrients are lost mainly through the stream and immobilisation in the lakebed sediments. An experimental approach is suggested to this problem. It should be noted that the following options are simply suggestions; the benefits and other effects of each option are speculative at this stage, and other approaches might be possible also.

1. Do nothing more than maintain the present fencing and 'let nature take its course'.

2. Use a rotary mower to cut and take away the material from dense beds of Mercer grass and other exotics. Repeated mowings would be better than one-off[3]. At Julian's Pond, care would have to be taken not to encroach on the shore, nor to cut the patches of native *Carex* and *Cyperus* species. (Use of grazing animals would not achieve the same ends, because they return nutrients to the system.) It is likely that ungrazed, vigorously growing vegetation 'mops up' nutrients more efficiently than rank vegetation that has a mass of dead material under it. Mowing would thus enhance the plant growth and take away nutrients.

3. Periodic siphoning or pumping water from the lake to remove dissolved nutrients. The timing of this needs careful consideration, for although it might be logical to do it at times when the lake would be dropping in level anyway, this might favour the spread down-shore of Mercer grass and other weeds.

4. Explore the possibility of mechanically scraping (maybe 50-100 mm deep) parts of the lake bed during a period of low water, and dumping the sand outside the lake system. This would remove nutrients and provide a new surface for native turf plants, provided, of course, that only part of the bed is scraped in a given year, so as to retain seed sources and vegetative parts of native plants in the system.

Options 2 and/or 3 would have slower benefits than option 4, but would be less costly and perhaps less risky to the system. However, they should produce benefits, unlike the

[3] This approach is used in Britain e.g., at Kew and Hyde Park, to reduce the fertility of lawns that are retired to provide butterfly habitats where more wildflowers and less grass are desired.

'do-nothing' option under which already rare native plant species are likely to be lost completely.

Any management should be coupled with monitoring of changes. However, before there is any change in management, baseline data should be gathered over at least a whole year, on factors such as water quality, substratum nutrients (lakebed and shore), vegetation boundaries (e.g., current positions of the lower boundary of the Mercer grass zone).

Conclusions

Thanks to actions of the landowners, Julian's Pond has been protected and some actions taken to restore its natural character. This paper collates data on the lake's flora and fauna for the use of the owners and other managers and stresses that the lake's conservation importance is greater than has hitherto been stated in previous reports. While this paper makes suggestions for actions to accelerate the recovery of the lake, it has not identified who might undertake this work. It is hoped that various interested agencies might come together with the landowners to debate further actions.

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