LAKE PEDDER - A LIMNOLOGIST'S LIFETIME VIEW

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Lake Pedder was a small, shallow lake of great beauty and spiritual inspiration located in the heart of Tasmania's south-west. A major and evocative feature of the lake was the beach at its eastern edge, rising steeply from the bed of the lake at "the step" then shelving gently to flanking dunes. It was underwater in winter but as water levels fell with the advance of summer it was progressively exposed. To the east of the dunes was a series of small lakelets, the largest of them, Lake Maria, giving its name to the Lake Maria Complex. The Serpentine River took a sinuous course through its valley to Lake Maria, through which it then flowed, leaving by a deep channel (known as Maria Creek) to fan out over Lake Pedder's eastern beach. At the western end of the lake the Serpentine continued its sinuous course to join the Gordon River.

In the 1960's plans were announced to flood Lake Pedder as part of an hydro-electric power scheme. In political parlance, the lake would be "somewhat modified". The reality was the creation of a reservoir, the Huon-Serpentine Impoundment, of 240 km^2 and 3 km^3, drowning the original lake. The new reservoir filled quickly, submerging the natural lake beneath about 16m of water in 1972. At that time, practically nothing was known about the limnology of Lake Pedder or about the natural history of the surrounding region.

The widespread desires of restoring the lake, never fading, have been met with assertions that the lake would have been destroyed at flooding and now lies beneath "metres of silt". Recent investigations have shown with considerable precision that the morphometric determinants of Lake Pedder are faithfully preserved, the principle channels of influx and efflux still open, surrounding soils still bound by roots. The "metres of silt" are ~3mm of dy, a light sediment composed of gyttja and humus colloids, all produced naturally within the lake. Lake Pedder lies as a latent phoenix beneath the waves.

Key Words: Australia, Tasmania, Lake Pedder, limnology, restoration

When I first knew Lake Pedder (Figure 1) it lay remote in a National Park in what was then known as the Empty Quarter. South of the Lyell Highway and beyond Maydena there was practically no habitation and no roads. There were a few tracks, like the one to Jane River and one to the lighthouse at Low Rocky Point. Walkers and naturalists made their way to Lake Pedder along a walking track from Maydena to Port Davey, passing to the south of Mt. Mueller. To the north of this peak, pushing south-west from the logging roads of the Florentine Valley, was a bombardier track to Hermit Valley near what is now Strathgordon. This was the way in for the teams investigating an hydro-electric power scheme on the middle reaches of the Gordon River, the scheme that would lead to the flooding of Lake Pedder. When this track became a road, open to the public, it gave access to a shorter route, across the Sentinel Range, for the last few years of the lake's existence.

Little was known about the limnology or the aquatic biota of the lake at that time. In fact little was known about any of Tasmania's many lakes. Limnology was in its infancy there (Tyler 1974, 1986, 1992). When it became clear that Lake Pedder was to be destroyed there was something of a scramble to get in and find out about the lake and its environs. The Botany Department of the University of Tasmania applied to the State Government for funds to carry out a biological survey. These were refused on advice from the constructing authority (Burton *et al.* 1974) who commissioned the Tasmanian museums to carry out a survey and report (Knight 1972). This was done, the unpublished report confirmed the presence of wombats, and the conclusion was drawn that nothing of value would be lost when the lake was flooded (Knight 1972). The unedifying history of this period is given in detail by Burton *et al.* (1974), Johnson (1972) and Anon. (1972).

In contrast to the findings of this official, unpublished report, whose authors fully recognised its shortcomings (Burton *et al.* 1974, p. 89-95), evidence was accumulating from a number of sources that the Lake Pedder area was a treasure trove of rare and endemic plants and animals. Details are given by several authors (*loc. cit.*), by

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Figure 1: Lake Pedder, 1969, from the east, with part of the Lake Maria complex of lakes and pools (far right).

Bayly (1965), Bayly *et al.* (1966), Bayly *et al.* (1972) and Tyler *et al.* (1996). These publications, and the references therein, tell how little was known about the lake before it was flooded.

Limnologically the lake was in no way outstanding. It was shallow, too shallow to stratify. A bathymetric map and scant other detail is given by Bayly *et al.* (1966). Its waters were acid, brown (dystrophic) and in ionic composition akin to highly diluted seawater (Buckney & Tyler 1973a), like most lakes of south-western Tasmania (Buckney & Tyler 1973b; Bowling *et al.* 1986; Tyler 1974, 1992).

At the time of flooding, 17 species of animals and plants were thought to be endemic to the lake and its beaches. Mostly, the animals lived in, and the plants on, the sand of the beaches (Bayly *et al.* 1966, Bayly 1972). That is an impressive total given that most of them were only recognised, i.e. "discovered", during the brief flurry of biological investigation consequent upon the realisation that Lake Pedder would be flooded. Such information, largely adduced by a handful of biologists with the scantiest of resources (Burton *et al.* 1974), flew in the face of official dogma. Not all of the 17 were validly published and a recent review (Tyler *et al.* 1996) reduces the total to 15 that can be accepted authoritatively. All of the 17 were invertebrates, vertebrates or angiosperms, the more obvious constituents of the biota. Study of the latter two groups was reasonably advanced in Tasmania but knowledge of many invertebrate groups was in a deplorable state, with no specialist, practising taxonomists in Australia. Nonetheless invertebrates are readily collected and big enough not to be overlooked. They still can, of course, be passed by but in the case of Lake Pedder a combination of local and overseas expertise provided proper taxonomic evaluation and description of a number of new species (Tyler *et al.* 1996). New species of vertebrates and angiosperms are still turning up occasionally in Tasmania. For invertebrates it is immeasurably easy to find new forms (e.g., Fulton 1983; Neboiss 1977). With this in mind the obvious question is what else might have been found had there been time and resources for a more thorough-going study. A possible answer may be gained by reference to what were probably least-known of all the Tasmanian biota, the protistans, that is the algae and protozoa.

When Lake Pedder was flooded in 1972 there existed only 6 slender publications specifically on the freshwater algal flora of Tasmania (Harrop 1868; Borge 1896; Burbury 1902; Hustedt 1955a, b; Tyler 1970). There had not been a strong tradition of freshwater algal taxonomy in Australia since the early days of Bailey, Hardy and Playfair (Tyler & Wickham 1988). The freshwater planktonic algae of Lake Pedder were examined (Bayly *et al.* 1966), but the necessary expertise was lacking; the plankton was identified to genus

Figure 2: A wave-cut shelf along the Frankland shore of the Huon-Serpentine Impoundment (1994).

level only. Furthermore, with the then state of knowledge and with restraints on time and money, collecting was confined to Lake Pedder and the major lakes and ponds of the extensive Lake Maria complex. Regrettably the many small, swampy pools of the complex were virtually ignored.

We may enquire what expectation might have been held for new and exciting micro - organisms. While the considerable degree of endemism and Australian novelty was well-known for both aquatic and terrestrial flora and fauna (Bayly & Williams 1965; Tyler 1992; Williams 1965) a prevalent view across the world was that freshwater algae were more or less cosmopolitan, as indeed, at face value, many are. Nonetheless, from the earliest, dilatory investigations, late last century, it seemed likely that there were uniquely Australian species. By the 1920's it was clear not only that this was so but that, in several cases, their Australianism was as distinctive as was that of kangaroos when first brought to the attention of Europe (Day *et al.* 1995; Tyler 1992; Tyler & Wickham 1988).

The validity of endemism, and its considerable extent in the Australian protistan biota, is now well-established and has been reviewed (Tyler 1996). What is now emerging is that the strongholds of endemism and novelty are not the romantic highland lakes of the Central Plateau and south-western ranges, but small, coastal lagoons and rush-grown pools. Further it seems likely that there is further restriction to wild places, surrounded by native vegetation and out of reach of agricultural practices. The epicentre of this Australian endemism is south-west Tasmania. We shall not know what the extensive mire complex of Lake Maria held in this regard but one can expect a high probability of its former richness. The point to be made is that on all fronts the biological significance and value of Lake Pedder is a far cry from official pronouncements of the day, and was known to be so then.

The only alga from Lake Pedder that in 1967-72 I recognised as being clearly distinctive was a macroscopic, tufted thallus belonging to the rhodophyte genus *Batrachospermum* (Bayly *et al.* 1966), one of the very few freshwater representatives of the red algae. It grew along the water line on the beaches. The taxonomy of the rhodophytes, both marine and freshwater, is among the most difficult of all algal groups. The reigning expert at the time was Professor Heinrich Skuja in the University of Uppsala. Specimens were dispatched to Skuja who confirmed its distinctiveness and gave it the manuscript name of *B. nothogeae*, now a *nomen nudum*. Skuja died before describing the Lake Pedder specimens but another two decades saw the emergence of an Australian specialist in freshwater red algae. The specimens passed to him and in 1992 he formally described *Batrachospermum diatyches* Entwisle 1992 (Entwisle 1992). The Greek doublet of the

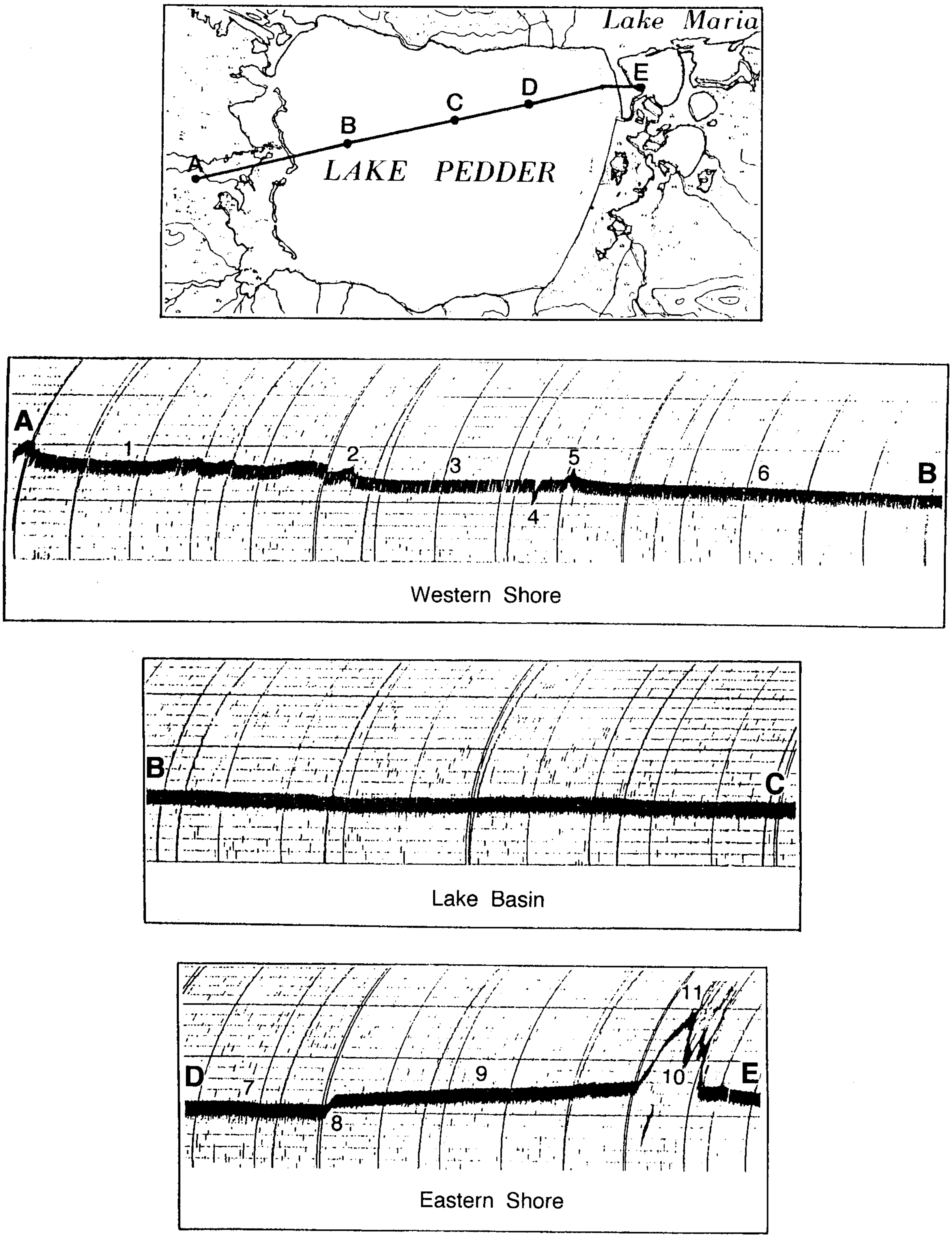

Figure 3: A west-east transect of echo soundings from A to E across the bed of old Lake Pedder under the Huon-Serpentine Impoundment.

1: hummock plain to west of lake; 2: western rim of embayment; 3: bed of embayment; 4: creek entering embayment; 5: western sand bar; 6,7: bed of Lake Pedder; 8: beach step; 9: eastern beach; 10: dunes; 11: tree skeletons; E: bed of Lake Maria No.1

specific epithet, twice unfortunate or double tragedy, refers to the deaths in 1972 of Skuja (1892 AD - 1972 AD) and Lake Pedder (?x10^3 BP - 1972 AD).

Twenty years after the flooding of Lake Pedder all of the plants thought to be endemic there have been found elsewhere in Tasmania (Tyler *et al.* 1996). Many, however, as well as some of the animals, are scantily distributed (Smith & Gilfedder 1993; Fulton & Tyler 1993); Lake Pedder was a stronghold of such species. Of the animals, some have been located elsewhere, but three have never been found other than at Lake Pedder (Tyler *et al.* 1996), despite careful sampling in other localities with beaches apparently similar to that of Lake Pedder (e.g. Lake Rhona, Lake Curly). Of the sand-dwelling invertebrates, in particular, only one, the amphipod *Uramphisopus* sp., survived inundation and adapted to the new conditions of the Huon-Serpentine Impoundment (Tyler *et al*. 1996).

On present evidence, then, the flooding of Lake Pedder appears to have caused the loss of a few species of sand-dwelling invertebrates and of a major habitat for some other rare and endemic plants and animals. This much can be adduced from a very brief period of rather cursory investigation. The full environmental effects of the entire power development may not be known for many years but already unsuspected effects are emerging, far from the dam at Strathgordon (King & Tyler 1982; Bowling & Tyler 1984, 1986; Hodgson & Tyler 1996; Tyler & Vyverman 1995).

For a little over twenty years now Lake Pedder has lain about 16m beneath the waters of the Huon-Serpentine Impoundment. The reservoir has gone about its business, etching wave-cut shelves around the perimeter where shores slope sufficiently (Figure 2). In the absence of light, and with waterlogging, the plant life would have soon died over the large area of land inundated. All evidence is that the unique animal life, with one exception, failed to adapt to the new conditions (Lake 1995; Tyler *et al*. 1996). The physico-chemical limnology of the reservoir is of no great interest, unlike that of its deeper, near-neighbour, Lake Gordon (Steane & Tyler 1982).

"Pedder 2000" is a campaign of the conservation movement to drain and restore Lake Pedder. For the notion to have a clear basis it was necessary first to demonstrate that the features that defined Lake Pedder had survived inundation. I accepted the commission of the Lake Pedder Study Group to investigate these possibilities as well as the condition of surrounding soils and flooded vegetation and the fate of the original biota. I carried out these investigations with colleagues in 1993. The results were reported to the Lake Pedder Study Group (Tyler *et al.* 1993, 1994) and have since been published formally (Tyler *et al.* 1996). A brief summary only is given here. The methods used are shown in Table 1. Videographic evidence is deposited as Exhibit 18 of the Inquiry into the Proposal to Drain and Restore Lake Pedder (Langmore 1995).

We considered that four mandatory criteria (Table 2) had to be satisfied before draining and restoration could be considered. In addition we had other criteria, desiderata, that, if satisfied, would enhance the case and speak loudly for the integrity of Lake Pedder beneath the waves (Table 3). All criteria were satisfied. The results have been published in full (Tyler *et al.*, 1996) and have been accepted and their significance summarised by the Committee of Enquiry (Langmore 1995). The fate of the biota has been detailed above. A few aspects of the results are now selected for further comment and illustration.

If Lake Pedder escaped destruction then echo-sounding along a west-east transect across the old lake bed should reveal the original contours

Investigation	**Method**
Morphometry	High - resolution, inter-calibrated echo-sounders
Navigation	Global Positioning System (satellite-based, ~± 20m)
Recovery of Substrates	Glew corer + Ekman grab (bottom biter)
Undisturbed sediment/lake bed stratigraphy, underwater photography	SCUBA (Courtesy of ABC)
Site and navigation course	Intimate knowledge of old lake

Table 1: Methods used to investigate the state of drowned Lake Pedder beneath the Huon-Serpentine Impoundment.

Requirement	How Satisfied?
That the original lake morphometry remains.	Wide eastern beach, beach step, beach ripples, sandy lake bed.
That the lake would be contained if the reservoir were drained.	Integrity of eastern dunes and other lake rims.
That original drainage patterns into and out of the lake would re-establish.	Integrity of original major channels (e.g., Maria Creek, Serpentine River).
That the original lake basin could be re-occupied.	Basin not occluded by silt or other sediments.

Table 2: Mandatory criteria to be satisfied as a minimum basis justifying restoration of Lake Pedder.

Desiderata	How adduced
Pedder pennies still present on lake bed.	Ekman grab samples, Scuba divers.
Texture and integrity of surrounding peats.	Dissection of grab samples.
Ability to detect small, remembered features, as evaluation of precision of methods and integrity of such features.	Specially-selected small creek used as target for echo-sounding.

Table 3: Desirable criteria which, if met, would demonstrate the integrity of Lake Pedder.

and features such as lake rims, lake bed, dunes, Lake Maria lake beds. The expected bathymetry at the eastern end would correspond to the cross-section illustrated by Johnson (1972). A composite, summary trace, shows that this is so (see Figure 3). Constituent detail is illustrated elsewhere (Tyler *et al.* 1996). Features No. 4 & 5 (Figure 3) are the small creek and western rim selected as a test of precision of methods. Both are clearly visible in aerial photographs.

Figure 4: Pedder Pennies dredged from Lake Pedder's bed under the Huon-Serpentine Impoundment, 1994.

An Ekman grab (= bottom biter) was used to recover substrates from sites chosen on the basis of remembered features. Over the beach, pink sand was recovered, where Pedder Pennies (Figure 4) used to be, pennies were recovered, where reeds emerged from shallow pools, their rhizomes are now dredged (Figure 5). From surrounding plains, taxonomically - identifiable leaves, stems and roots are brought up, the latter still complexly interlacing and binding the peats (Figure 6).

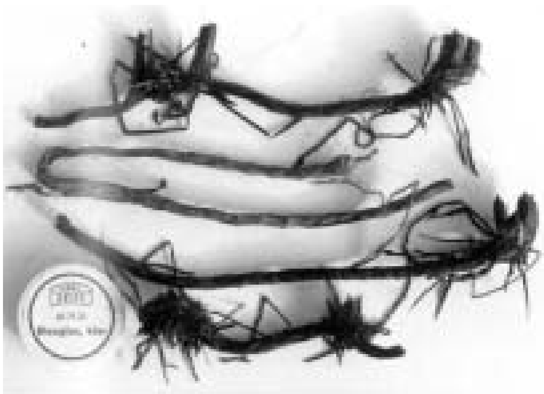

Figure 5: Macrophyte rhizomes dissected from peats of old Lake Maria #1, 1994.

Figure 6: Peat dredged from flooded land east of Lake Pedder, 1994, showing a permeating network of rhizomes, roots and rootlets.

Figure 7: Section of Lake Pedder beach, 1994, obtained by Scuba diver, showing thin (~3mm) layer of gyttja overlying original beach sand.

There have been several unfounded predictions that Lake Pedder would now be buried under metres of silt. If silt were really meant, there would have to be massive erosion in the catchment of the reservoir for this to happen. With the catchment of the Huon-Serpentine Impoundment largely under natural vegetation, in more or less pristine condition, the only expectations for the accumulation of sediment are for the limited amount brought in by inflowing creeks and, overwhelmingly, that produced by natural, autochthonous processes within the lake. The latter includes sedimentary debris produced in the water column and, in the case of recently - created impoundments like the Huon - Serpentine Impoundment, that produced by decomposition of original vegetation. The material of autochthonous sediments, produced in the water column, is known by the Danish word gyttja or, when brown, humic materials participate, by the Danish word dy.

There are not many studies on the accumulation rates of natural lake sediments. Table 4 provides figures for a selection of different lake types. The limited data suggest a greater accumulation rate in oligotrophic lakes. The majority of Tasmania's lakes are either oligotrophic or dystrophic (Tyler 1992; Vyverman *et al.* 1996). Appropriate comparisons are between two oligotrophic Tasmanian lakes and two dystrophic ones (Table 4). On the basis of Table 4 a depth of c. 3mm would be expected for the reservoir. The Ekman grab, not the ideal instrument for the purpose, suggested a sediment depth of a few mm. The Australian Broadcasting Commission sent Scuba divers to the bed of the old lake. They carefully inserted a transparent tube through the sediment and into the sand of the beach, then sealed the tube. It revealed about 3mm of sediment (Figure 7).

Gyttja and dy are light, fluffy deposits, largely coprogenous in origin. Bound up in the deposit are the remains of the natural planktonic organisms of the water body. While still in the water column the particle flocs that become gyttja are known as aquatic snow. They are a key part of the microbial loop of aquatic food webs and are fed upon by a variety of bacteria, flagellates and ciliates. Microscopic examination of the sediment from the bed of Lake Pedder showed it to be typical gyttja containing clearly-recognisable remains of planktonic organisms now living in the impoundment. Sediment samples from the bed of the old lake consisted almost entirely of gyttja, with the occasional plant fragment. This finding was confirmed by videography undertaken by the divers. Sediment samples from outside the

Lake(s)	**Rate, yr.cm^{-1}**
291, USA, various types	ˆR = 11
Global range, oligotrophic	ˆR = 10-20
L. Nicholls, Tasmania, oligotrophic (Cameron *et al.* 1993)	R = 18
Eagle Tarn, Tasmania, oligotrophic (Bradbury, 1986)	R = 28
Lake Vera, Tasmania, dystrophic (Bradbury, 1986)	R = 71
Huon - Serpentine, dystrophic (this study)	R = 70

Table 4 : Published rates (R = spot, ˆR = mean) of accumulation of autochthonous sediments (gyttja or dy) compared with the observed rates in the Huon-Serpentine Impoundment.

Facet	Information needed
Integrity of drowned peat	How firmly is moist peat still bound by roots? How so the dried peat?
Dustbowl	What propensity for aeolian levitation of dried peat?
Potting mix	How suitable for germination of native species is exposed peat?
Pharoah's Tomb	Any survival of drowned plant species by seed or cauline buds?
	[*Verbascum* 90+yrs.; *Nelumbo* in peat bog 800-1250 yrs; *Lupinus*, frozen tundra, 10,000 yrs.]
Seed savers	What is availability and germination ability of species that would be used for revegetation?
Noxious anemophilous weeds	How well do noxious species fare on resurrected peat?
Natural testbed	Do noxious weeds invade exposed beds of impoundments with periodic drawdown? What is the re-colonisation pattern on exposed beds of Tasmanian reservoirs with various periods of exposure?

Table 5: Some simple investigations that could be carried out with peat samples from the bed of the Huon-Serpentine Impoundment to provide informed opinion on the nature and magnitude of the problem of revegetation.

confines of the old lake consisted of gyttja well mixed with plant fragments.

While the integrity of drowned Lake Pedder is not in doubt there remains the multitude of problems, great and small, to do with restoration. Some have already surfaced, such as the strictly procedural one of how to drain the lake without damage occurring to the dunes. Others would doubtless emerge if restoration were undertaken. Perhaps the largest of these would be revegetation of the enormous area of flooded land. Though our studies have shown that the peats remain bound by root networks it is not clear exactly what would happen when vast areas of unvegetated peat were exposed. About this there are plenty of theories abroad in Tasmania, ranging from well-considered concern to utter twaddle. Some opinion advanced by the media in this matter has been disagreeably gratuitous and platitudinous. In addition to this concern there is the undoubted problem of revegetation and how long it would take naturally and whether it would have to be assisted. Between now and any future decision to drain the impoundment there are a number of simple and inexpensive investigations that could be carried out in order to shed light on some of the questions surrounding revegetation. Some of the most obvious of these are summarised in Table 5 and it would be prudent to address them in a simple, perhaps continuing way, if the possibility of restoration is linked to a political change of heart.

The Committee of Enquiry into the restoration of Lake Pedder has found (Langmore 1995) that restoration is feasible and that it will probably still be feasible a few decades hence. It is unlikely that restoration will be part of this limnologist's lifetime view of Lake Pedder but what this lifetime will remember is the excruciating beauty of the lake. It will remember, too, the repugnant way the heart of a global masterpiece was torn out and sacrificed on a failed altar. The blood drips yet.

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