RESTORE LAKE PEDDER

Review

Vegetation and flora

Coordinated by
Lake Pedder Restoration Inc.
www.lakepedder.org
Aerial photograph interpretation undertaken by ecologists in 2001 showed the original, pre-flooding vegetation to be a mosaic ranging from wetlands, moorlands and scrub to forest vegetation. By far, the wetlands, flat-lying moorlands and tea-tree swamps were the most extensive of the vegetation types flooded in the Huon-Serpentine Impoundment because most of the forests had occurred on elevated slopes above the level of inundation.

The area surrounding the original Lake Pedder had at least 160 higher plant species from 55 plant families present. At the time, fifty-nine of these recorded species were known to occur only in Tasmania.

Seven threatened flora species were recorded in the area before flooding, of these, three species remain listed on threatened species legislation today; the other four species have been either found to not meet the criteria for threatened species, or the taxonomic classification of the species has changed.

The rate and success of natural regeneration of the past vegetation and flora will vary over the impoundment area and will depend on many factors. These will include the availability of seeds or propagules, how intact the peat surface is the amount of water available and protection from desiccation and mechanical disturbance. Other dam restoration projects have shown that areas along drainage lines will restore most rapidly.

Risks to the success of natural regeneration include an increase in the frequency and intensity of wildfire that could burn the peat soils and destroy stored nutrients. Weeds and disease have the potential to alter the trajectory of the restoration; however even without impacts, it is likely the recovering vegetation will remain distinct from the surrounding areas for decades.

If the risks can be mitigated and natural regeneration allowed to proceed, it is probable that the basin will comprise a functional ecosystem and nutrient cycling processes in a relatively short time frame.
Vegetation and flora

This review provides a summary of the current state of vegetation communities that were mapped in the catchment of the Huon-Serpentine Impoundment. The information includes the threatened vegetation communities that were recorded before flooding, the threatened flora species and the potential for natural regeneration following the restoration of Lake Pedder.

Vegetation communities

Aerial photograph interpretation undertaken by Balmer and Corbett (2001) following the surveys of Macphail & Shepherd (1973) and partial mapping by Corbett (1994 a,b) showed the original, pre-flooding vegetation to be a mosaic ranging from wetlands, moorlands and scrub to forest vegetation. By far, the wetlands, flat-lying moorlands and tea-tree swamps were the most extensive of the vegetation types flooded in the Huon-Serpentine Impoundment because most of the forests had occurred on elevated slopes above the level of inundation.

Most of the moorland, sedgeland, scrub, forest and rainforest vegetation communities inundated under the Huon-Serpentine Impoundment are well represented and well reserved in the southwest of Tasmania and the associated conservation reserve system. However, four threatened vegetation communities are known to have been flooded: Banksia marginata wet scrub, alkaline pans, freshwater aquatic herbland and freshwater aquatic sedgeland and rushland. These vegetation communities are listed as threatened for their limited extent, limited reservation status and/or reductions in their extent on State legislation. All the vegetation communities recorded in the area and their associated conservation status is presented in the following table.

Vegetation community classifications have been revised in the intervening time since the Balmer and Corbett study by Harris and Kitchener (2005; 2013) and newly interpreted,
integrated vegetation maps of Tasmania devised and presented in a standard classification system (TASVEG 1.0 to TASVEG 4.0). These improved classification and mapping projects and protocols have resulted in more categories of vegetation communities compared with 2001, therefore some of the communities described by Balmer and Corbett (2001) have more than one vegetation community description applicable now; these are shown in the table below.

Table 1  Vegetation communities as described in 2001 with corresponding TASVEG 4.0 communities and status under the Schedule 3A of the Tasmanian Nature Conservation Act 2002

<table>
<thead>
<tr>
<th>Vegetation community described by Balmer and Corbett (2001)</th>
<th>Equivalent TASVEG 4.0 vegetation communities (code)</th>
<th>Current Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetlands</td>
<td>Freshwater aquatic herbland (AHF)</td>
<td>Threatened</td>
</tr>
<tr>
<td>Wetlands</td>
<td>Freshwater aquatic sedgeland and rushland (ASF)</td>
<td>Threatened</td>
</tr>
<tr>
<td>Noted, but unmapped</td>
<td>Alkaline pans</td>
<td>Threatened</td>
</tr>
<tr>
<td>Banksia wet scrub, usually with <em>Eucalyptus nitida</em></td>
<td><em>Banksia marginata</em> wet scrub (SBM)</td>
<td>Threatened</td>
</tr>
<tr>
<td>Beach sand</td>
<td>Sand, mud (OSM)</td>
<td>Not listed</td>
</tr>
<tr>
<td><em>Restio tetrphyllus</em> swamp</td>
<td>Restionaceae rushland (MRR)</td>
<td>Not listed</td>
</tr>
<tr>
<td><em>Lepropydia</em> sedgeland</td>
<td>Western lowland sedgeland (MSW)</td>
<td>Not listed</td>
</tr>
<tr>
<td>Short buttongrass moorland</td>
<td>Sparse buttongrass moorland on slopes (MBR)</td>
<td>Not listed</td>
</tr>
<tr>
<td><em>Buttongrass / Melaleuca squamea</em> moorland</td>
<td><em>Melaleuca squamea</em> heathland (SMM)</td>
<td>Not listed</td>
</tr>
<tr>
<td></td>
<td><em>Melaleuca squarrosa</em> scrub (SMR) (potential facies on flats)</td>
<td>Not listed</td>
</tr>
<tr>
<td>Scrubby tea-tree/buttongrass</td>
<td>Buttongrass moorland with emergent shrubs (MBS)</td>
<td>Not listed</td>
</tr>
<tr>
<td></td>
<td>Sparse buttongrass moorland on slopes (MBR)</td>
<td>Not listed</td>
</tr>
<tr>
<td></td>
<td>Western buttongrass moorland (MBW)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Western wet scrub (SWW)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Western buttongrass moorland (MBW)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Melaleuca squarrosa</em> scrub (SMR)</td>
<td></td>
</tr>
<tr>
<td>Tea-tree swamp</td>
<td><em>Leptospermum</em> with rainforest scrub (SRF)</td>
<td>Not listed</td>
</tr>
<tr>
<td></td>
<td>Western wet scrub (SWW)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Leptospermum lanigerum – Melaleuca squarrosa</em> swamp forest (NLM)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Leptospermum scoparium-Acacia mucronata</em> short forest (NLA)</td>
<td></td>
</tr>
<tr>
<td><em>Eucalyptus nitida</em> on tea-tree and/or wet forest</td>
<td><em>Eucalyptus nitida</em> forest over <em>Leptospermum</em> (WNL) Nothofagus-<em>Leptospermum</em> short rainforest (RML)</td>
<td>Not listed</td>
</tr>
</tbody>
</table>

¹TASVEG 1.0 to TASVEG 4.0 following Harris and Kitchener (2005; 2013)
²As listed on Schedule 3A of the Nature Conservation Act 2002
The threatened vegetation communities

**Banksia marginata wet scrub (SBM)**

The *Banksia marginata* wet scrub vegetation community occurs only in western and southwest Tasmania, has a limited extent of approximately 2600 hectares state-wide. This community is dominated by *Banksia marginata*, generally with subdominant *Leptospermum* spp. and/or *Melaleuca squarrosa*. It still occurs on the steeper slopes and fringing moorland and creeks adjacent to the Huon-Serpentine Impoundment.

*Banksia marginata* wet scrub occupies the interface between vegetation communities that are adapted to frequent and intense fires such as buttongrass moorland and heathland and the less fire-tolerant rainforests. Therefore, increases in the frequency and intensity of fires can reduce some shrub species changing the community to a more fire-adapted state of moorland; conversely, in the absence of fire, rainforest species may replace the shrub species and the community will transition to a rainforest-dominated community.

Given the specific fire requirements for this vegetation community, the potential regeneration following restoration will depend on re-establishment of appropriate fire regimes and associated vegetation community dynamics. Seed and propagules would be available from the existing slopes adjacent to the fringe of the dewatered area and some vegetative regrowth of sedges is also likely to occur. There may be some medium-term limitations to regeneration due to lack of propagules on more isolated slopes that once were islands in the Huon-Serpentine Impoundment such as Scotts Peak.

**Freshwater aquatic herbland (AHF) and Freshwater aquatic sedgeland and rushland (ASF).**

The freshwater aquatic herbland includes areas of permanent to semi-permanent standing water that supports aquatic vegetation and the freshwater aquatic sedgeland is a subset of these that is dominated by sedge or rush species. Both these communities were previously encountered on the flat plains west of Lake Pedder and on the margins of smaller lakes.

These communities are likely to regenerate in some form following restoration, although they may occur in different areas and to varying extents depending on the way rivers, streams and sediments settle within the restored systems. Most of the species have seeds or propagules that are carried in water and therefore, these communities are unlikely to be limited in their recovery by seed or propagule dispersal.
**Alkaline Pans (AAP)**

Alkaline pans are generally small, isolated largely bare patches that form within moorland scrub mosaics in the south-west river valleys where dolomite or limestone occurs near the surface; only 500 hectares currently mapped in Tasmania. Whilst no alkaline pans were mapped from the Lake Pedder area, they occur along Scotts Peak Road and may have had some localised presence in the Lake Pedder area. Given the requirements for specific geology to support these communities, it is not known if they are likely to regenerate following restoration.

**Threatened flora species**

This 2020 review of the flora has deduced that of the seven threatened flora species recorded in the area before flooding, three species remain listed on threatened species legislation today; the other four species have been either found to not meet the criteria for threatened species, or the taxonomic classification has changed.

**Pedder Bristlewort** (*Centrolepis pedderensis*)

*Image: Richard Schahinger*

**Current status of species and habitat**

This species was not known from any other location at the time of flooding of Lake Pedder. Subsequent surveys have confirmed this species is endemic to southwest Tasmania located the species at Sanctuary Lake, Lake Gordon and the margins of the Huon and Picton Rivers. The species is believed to be extinct at the Lake Pedder and Gordon River sites.

The Pedder Bristlewort grows at the margins of lakes and rivers in areas subject to seasonal inundation and drying. At Sanctuary Lake, west of Lake Pedder, this species grows on quartz gravels in areas that flood to depths of up to 40 cm, while sites along the Huon and Picton River sites are also prone to periodic flooding.

The current highly-regulated and non-seasonal water levels of the current Huon-Serpentine Impoundment would limit habitat for this species and numerous targeted surveys have not located further populations in suitable nearby habitats.
The Pedder Bristlewort is currently listed on the following legislation:
Threatened Species Protection Act 1995: endangered
Environment Protection and Biodiversity Conservation Act 1999: endangered

Opportunities and potential risks of restoration of Lake Pedder

Restoration of Lake Pedder is likely to result in:

- increased potential habitat for the Pedder Bristlewort in the drained lake margins of the restored lakes that are subject to natural wetting and drying processes
- increased potential habitat in the riparian margins of the restored downstream rivers (Huon and Serpentine) due to restoration of more-natural flooding and deposition regimes that may provide habitat.
- Initial impact the species on the Huon River through erosion scouring of plants and habitat, however flood events are also likely to transport sediment, seed and vegetative material downstream allowing the establishment of new colonies in suitable habitats.

Knowledge gaps and essential knowledge and studies required

Additional information on propagation techniques for potential ex-situ transplants and suitability of vegetative propagule transfer for restoration should be obtained.

This species may be useful for targeted planting and restoration purposes if sufficient seed was able to be collected.

Shortleaf Milligania (*Milligania johnstonii*)

![Image: Rob Wiltshire](image)

Current status of species and habitat

This species was not known from any other location at the time of flooding of Lake Pedder. Subsequent surveys have concluded that this species is endemic to Tasmania and found in moist sand or mud on the margins of heath or sedgeland in the south-west. The Shortleaf Milligania is also locally abundant in alkaline pans around the Maxwell, Hardwood and Giblin River Valleys of Tasmania.
The Shortleaf Milligania is currently listed on the following legislation:
Threatened Species Protection Act 1995: rare

Opportunities and potential risks of restoration of Lake Pedder

Restoration of Lake Pedder is may result in:

- increased potential habitat for the Shortleaf Milligania in the drained and naturally hydrologically fluctuating riparian margins of the restored lakes, rivers and tributaries subject to natural wetting and drying processes
- limited impact to recolonising plants due to altered fire regimes because this species is likely to be resilient to fire impacts and is likely to regenerate following such disturbance and colonise gaps.

Knowledge gaps and essential knowledge and studies required

Additional information on propagation techniques for potential ex-situ transplants and suitability of vegetative propagule transfer for restoration should be obtained.

This species may be useful for targeted planting and restoration purposes if sufficient seed was able to be collected.

Dune Buttercup (*Ranunculus acaulis*)

Current status of species and habitat

The Dune Buttercup was known from the wet sands of Lake Pedder and surrounding lakes. Within Tasmania the species is now restricted to the west and northwest coast, where it grows in seepage areas on the seaward sides of dunes. Apart from Tasmania, the Dune Buttercup also occurs in New Zealand and southern Chile.

The Dune Buttercup is currently listed on the following legislation:
Threatened Species Protection Act 1995: rare
Opportunities and potential risks of restoration of Lake Pedder

Whilst restoration of Lake Pedder may result in suitable wet sand habitat on the dunes for the Dune Buttercup, the lack of local or even regional seed sources would likely mean re-establishment would only occur from ex-situ plantings or seedlings.

Knowledge gaps and essential knowledge and studies required

Additional information on propagation techniques for potential ex-situ transplants and suitability of vegetative propagule transfer for restoration should be obtained. This species may be useful for targeted planting and restoration purposes if sufficient seed was able to be collected.

**Western Cushion-Bristlewort (Centrolepis monogyna previously Centrolepis paludicola)**

Current status of species and habitat

The Western Cushion-Bristlewort was not known from any other location at the time of flooding of Lake Pedder. However, the species complex currently has 604 observations largely in the west and south-west of Tasmania. This species is not listed under current legislation.

Research is currently being undertaken to clarify the taxonomic status of this species and *Centrolepis paludicola* although the current Census of Tasmanian Vascular Plants resolves this species as *Centrolepis monogyna*.

**Watertuft (Trithuria filamentosa previously Hydatella filamentosa)**

Current status of species and habitat

The Watertuft currently has 123 observations in the south-west and the Central Plateau of Tasmania. This species is not listed as threatened under current legislation.

**Currant Bush (Leptomeria glomerata)**

Current status of species and habitat

The Currant Bush currently has 129 observations in the west of Tasmania, the Central Plateau and two mainland observations. This species is not listed as threatened under current legislation.

**Alpine Marshwort (Liparophyllum gunnii)**

Current status of species and habitat

The Alpine Marshwort currently has 137 observations in the west and Central Plateau of Tasmania and New Zealand. This species is not listed as threatened under current legislation.
Natural vegetation regeneration following dewatering

Underwater videography in 2020 and depth sounding by Tyler in 1995 showed that much of the tree biomass including large trunks and branches are still present and standing in the Impoundment. The finer materials such as fine branches, shrubs, and understory species will have slowly broken down to organic sediments (classified as Gyttja by limnologist Peter Tyler, 2000) and settled within the Impoundment. It should be noted that due to the cold water and oligotrophic (nutrient poor) status of the Impoundment that such breakdown of organic matter is slow.

A thick mat and network of roots and other plant structures are still present in many areas of the peat substrate; these will provide significant stability and resistance to erosion if the Impoundment were to be drained. In ongoing scientific studies of fauna species on the filling Impoundment, Lake (2001) did note that some of the more wind-exposed areas were eroded, some badly, including down to bedrock. Prior to restoration, assessment of these areas should be undertaken so they can be quantified and prioritised for more-intensive restoration treatments.

In their consideration of restoration of Lake Pedder, Balmer and Corbet (2001) suggested that most evidence of recovery on peat soils was largely from mechanical disturbances such as tracks or translocated peats. The regeneration on this (now) well-drained and less compacted peats resulted in a dominance of woody scrub species and in areas of bare quartzite, moss and small graminoids and herbs dominated. Recovery of the dominant species buttongrass (Gymnoschoenus sphaerocephalus) is an interesting unknown because this species has proven difficult to establish in restoration trials (Mike Comfort pers. Comm.). These observations are supported by studies of translocated peat following hydro-electricity restoration activities (Wild 2010) and these mechanisms may occur in some areas of the impoundment where mechanical disturbance has occurred through erosion processes such as wave action.

Recent low water levels in nearby Lake Gordon in the early 2000s showed that propagules are present on edges and natural germination occurs within months of dewatering and self-sustaining communities have regenerated over years (see photographs below). The natural establishment of buttongrass in one photo set is of interest given the difficulty in establishing this plant in regeneration projects (Mike Comfort Pers. comm.).
Receding water level in Lake Gordon (November 2014) showing commencement of natural regeneration in depressions of snigging tracks.

Rapid Rush and sedge recovery in one growing season (September 2015) with denser regrowth in areas of standing water such as puddles and along past drainage lines.
Logging debris along a (previous) riparian streamline during receding water levels in Ragged Basin (2014)

Rapid native sedge regrowth along the streamline (March 2016)
Previously flooded section of Lake Gordon after 14 years of natural recovery (1988). Bare slopes on the left of the photograph would have been subjected to wave erosion during filling and water level fluctuations that removed the peat surface. Note buttongrass establishment on peat surface.

Area above showing bare areas on quartzite and cover on extant peat.
It is still uncertain if a viable seed bank exists in much of the remaining sediments, and other dam restoration projects have shown that the seed bank is often greatly reduced in species compared with natural vegetation and viability of seed reduces over time (Stroh et al 2010) and viable seed densities peak in shallow areas and decrease with depth (Chenowith 2008). Even in the absence of a highly diverse and dense natural seedbank in the sediments, recently-deposited propagules will be present in the impoundment but would favour those areas closer to extant vegetation or natural current deposition areas.

Research and findings from international restoration works conclude that the regeneration of areas will vary greatly between areas that were originally riparian and wetland, which tend to recover well because water is not a limiting factor in natural regeneration; whereas, those dryland areas are very slow and particularly prone to desiccation and erosion (Auble 2007). This is also apparent from the photographs of regeneration in Lake Gordon where there is a distinct difference in the vegetation cover and species in the drier upland areas and the small drainage lines or wetland areas; similar is expected of areas with groundwater seepage. Evidently, despite the relatively high precipitation in the region, water availability is a limiting factor on seedling establishment.

Other factors that will impact the degree and rate of natural regeneration are shown in the conceptual model below. These include factors such as proximity to extant seed sources, whether the peat substrate is intact and localised protection from harsh environmental factors such as high temperatures on peat surfaces and mechanical disturbance from water and wind erosion.
Conceptual model of the anticipated responses and potential impacts on organic soils during and immediately after drawdown of the Huon-Serpentine Impoundment to restore Lake Pedder.
Fire: a requirement and a threat

Studies of aerial photographs by Balmer and Corbett (1995) showed that large-scale wildfire was not a frequent occurrence in the time preceding damming with the 1934 and 1939 wildfires being the most recent large fires. These fires did impact the vegetation and resulted in exposed quartzite in some areas, however aerial photographs showed almost complete recovery by 1972.

This cycle of fire and vegetation recovery in Tasmania’s southwest has been the subject of much study and conjecture amongst fire ecologists and two ecological models have been proposed to explain the fire-vegetation-soil feedbacks (Jackson 1968; Mount 1979). The two models assess interactions between vegetation, fire and soil to explain the dynamics of fire-promoting and fire-sensitive vegetation in southwest Tasmania (Wood and Bowman 2012). Briefly, Jackson’s (1968) ‘ecological drift’ or alternative stable states model argued that each vegetation promotes its own growth, while hindering the establishment of other vegetation types (Wood and Bowman 2012). However, fire frequencies can push the vegetation over its ‘resilience threshold’ and cause a transition to a different vegetation community (Wood and Bowman 2012). The other model ‘stable fire cycles’, proposed by Mount (1979), suggests that site characteristics (i.e. geology, drainage and topography) are more important than fire alone in determining vegetation patterns (Wood, Hua, and Bowman 2011).

Recent study by Wood and Bowman (2012) assessed the applicability of these two models in southwest Tasmania across a number of vegetation types, including buttongrass moorlands, found support to the Jackson (1968) alternative stable states model as the most suitable vegetation dynamics model on nutrient poor substrates in southwest Tasmania. Taken together, these authors concluded that vegetation communities in southwest Tasmania represent a number of alternative stable states which has important implications for the conservation and management of these areas under projected future climate conditions, especially as rapid vegetation transitions (e.g. from drying out of wet and humid vegetation) may contribute to an expansion of more flammable communities (Wood and Bowman 2012).
These findings all indicate that the dominant vegetation types in the Lake Pedder area are very flammable but also requires fire to help maintain it and protect the nearby fire-sensitive vegetation from wildfires (di Folco and Kirkpatrick 2011; Jackson 1968). Fire frequency in buttongrass moorlands is correlated with vegetation type and decreases in soil carbon and nitrogen content as well as soil depth (Di Folco 2007). Whilst buttongrass moorlands are adapted to fires and indeed require fire to prevent succession to other vegetation types, it is also very flammable and thus poses a management dilemma as management effort should balance between hazard reduction burning while preserving ecological values of this unique ecosystem (Storey and Betts 2011). The organic soils are also at extreme risk once initially exposed and peatlands are considered a high-biomass ecosystem where fires are controlled by heat transfer and water content (Turetsky et al. 2015).

The flammability of these soils appears to be strongly correlated with topographic position which appears to be a consequence of relative drying of soils in addition to fire severity (di Folco and Kirkpatrick 2011). There are certainly examples from overseas and Australian Alps showing that drained peat that was left to dry became highly flammable emitting carbon into the atmosphere and thus contributing to carbon emissions (Page et al. 2004; Wahren and Papst 1999).

**Fire frequency and intensity is changing**

The pattern observed on mainland Australia has been somewhat delayed in Tasmania, but is now being replicated. It appears to be the case as the extent of bushfires is large (Figure 3) and there is evidence to suggest that the size of fires and area burnt in moorlands in Tasmania has steadily increased since 1970 (from ~ 10 000 ha in 1970 to ~ 30 000 ha in 2010) (French et al. 2016).
The cause of these fires is also changing as climatic conditions warm and atmospheric conditions become more ‘unstable’. Lightning-caused fire was rare in the TWWHA before 2000. However, since this time there has been an increase in both the number of fires following lightning storms and the area burnt by these fires (Figures 4 and 5) (Styger, Marsden-Smedley and Kirkpatrick 2018). This study also found that the increase in the proportion of lightning strikes that occur in dry conditions has increased ignition efficiency. These changes have important implications for the potential restoration of Lake Pedder as higher projected fuel loads and drier climates could result in a further increase in the number of fires associated with lightning.
In addition to the increase in potential ignition sources from lightning, a very recent, comprehensive study assessing the effect of soil moisture of organic soils in concert with meteorological data from 63 sites across Tasmania confirmed a potential increase in soil dryness. The study quantified the very strong correlation between moisture content and soil combustibility and that Tasmanian organic soils are likely to be combustible in most areas in most summers (Prior et al. 2020). These findings must be considered especially as fire danger is predicted to increase during 21st century.
In addition to the fire risk, peatlands in Tasmania are suggested to be near their climatic limits and the future drier and warmer climate is very likely to make these ecosystems more vulnerable to hydrologically stress and shrinking (Prior et al. 2020) and at risk of reinforcing positive feedback loops of fire, drying and fire. If this cycle continues, it poses a significant threat to establishment of vegetation in the de-watered impoundment.

**Weeds and diseases**

Weeds and diseases have the capacity to alter the trajectory of restoration of both flora and fauna following dewatering of the Huon-Serpentine Impoundment. The key to managing potential weed and disease threats is understanding the potential known threat organisms, reducing their potential spread and early responses or treatments. The three main risks known at this time include weeds, ‘root rot’ that affects susceptible plants and chytrid fungus, a pathogen that impacts amphibian populations.

**Weed species – existing species and potential threats**

**Declared weeds recorded within 5000m of the Huon Serpentine Impoundment**

Declared weeds are plants that are recognised for their threat to primary industry, the natural environment or public safety. They are regulated under the Weed Management Act and must have a plan to reduce spread and to control, therefore, they are a high priority for consideration in the restoration processes.

The following declared weeds have been recorded in the Natural Values Atlas to occur within 5000m of the existing impoundment. Depending on how many seeds the plants set, how the seeds are spread throughout the landscape and their ability to withstand the hot and drier bare peat, some of these weeds are a greater risk than others for potential invasion. Preliminary notes on their threat potential are given and this would be expanded in any subsequent weed management plan prior to restoration.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Status and threat potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creeping Thistle</td>
<td><em>Cirsium arvense</em> var. <em>arvense</em></td>
<td>Perennial, highly dispersible (&gt;1km) wind borne seed dispersal, high threat for bare peat.</td>
</tr>
<tr>
<td>Karamu</td>
<td><em>Coprosma robusta</em></td>
<td>Perennial shrub, birds disperse seeds. Potential weed of damper sites/riparian but not known if it would germinate on dark, bare surfaces of bare peat.</td>
</tr>
<tr>
<td>Pink Pampas Grass</td>
<td><em>Cortaderia jubata</em></td>
<td>Perennial, highly invasive and highly dispersible (&gt;25km) prolific seeds. Very serious threat for germination on bare peat and increase flammability of reservoir area.</td>
</tr>
<tr>
<td>Common name</td>
<td>Scientific name</td>
<td>Status and threat potential</td>
</tr>
<tr>
<td>---------------------</td>
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<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Silver Pampas Grass</strong></td>
<td><em>Cortaderia selloana</em></td>
<td>Perennial, highly invasive and highly dispersible (&gt;25km) prolific seeds. Very serious threat for germination on bare peat and increase flammability of reservoir area.</td>
</tr>
<tr>
<td><strong>Pampas Grass</strong></td>
<td><em>Cortaderia sp.</em></td>
<td>Perennial, highly invasive and highly dispersible (&gt;25km) prolific seeds. Very serious threat for germination on bare peat and increase flammability of reservoir area.</td>
</tr>
<tr>
<td><strong>English Broom</strong></td>
<td><em>Cytisus scoparius</em></td>
<td>Localised spread by seedpods, animals and some water-borne dispersal of hard seeds. Moderate risk of germination and persistence on peat.</td>
</tr>
<tr>
<td><strong>Berryflower heath</strong></td>
<td><em>Erica baccans</em></td>
<td>Spread by seed dispersal wind and water, animals and movement of soil and mud on machinery. A serious weed threat for establishment on bare peat and exposed quartzite.</td>
</tr>
<tr>
<td><strong>Spanish Heath</strong></td>
<td><em>Erica lusitanica</em></td>
<td>A widespread weed in the Pedder region with a persistent seedbank. Spread by seed dispersal via wind and water, animals and movement of soil and mud on machinery. A serious weed threat for establishment on bare peat and exposed quartzite.</td>
</tr>
<tr>
<td><strong>Montpellier Broom</strong></td>
<td><em>Genista monspessulana</em></td>
<td>Localised spread by seedpods, animals and some water-borne dispersal of hard seeds. Moderate risk of germination and persistence on peat.</td>
</tr>
<tr>
<td><strong>Holly</strong></td>
<td><em>Ilex aquifolium</em></td>
<td>Perennial shrub/tree, birds disperse seeds. Potential weed of damper sites/riparian and likely to also germinate on dark, bare surfaces of bare peat.</td>
</tr>
<tr>
<td><strong>Himalayan Honeysuckle</strong></td>
<td><em>Leycesteria formosa</em></td>
<td>Deciduous shrub, birds disperse seeds. Potential weed of damper sites/riparian but uncertain if it would germinate on dark, bare surfaces of bare peat.</td>
</tr>
<tr>
<td><strong>Blackberry</strong></td>
<td><em>Rubus fruticosus spp agg</em></td>
<td>Group of rambling berries, seeds dispersed by animals and running water and vegetation expansion into dense thickets. A serious weed threat for establishment on bare peat and exposed quartzite.</td>
</tr>
<tr>
<td><strong>Goat Willow</strong></td>
<td><em>Salix caprea</em></td>
<td>Salix species have been significant weed species of peat soils in Victoria, particularly post-fire. A serious weed threat for establishment on bare peat and exposed quartzite.</td>
</tr>
<tr>
<td><strong>Basket Willow</strong></td>
<td><em>Salix x rubens</em></td>
<td>Salix species have been significant weed species of peat soils in Victoria, particularly post-fire. A serious weed threat for establishment on bare peat and exposed quartzite.</td>
</tr>
<tr>
<td>Common name</td>
<td>Scientific name</td>
<td>Status and threat potential</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Ragwort</td>
<td>Senecio jacobaea</td>
<td>A biennial herb flowering in the second year. Locally spread seed, some dispersed (up to 1km) by strong winds) and by attachment to animals and machinery. A high weed threat for establishment on bare peat and exposed quartzite.</td>
</tr>
<tr>
<td>Gorse</td>
<td>Ulex europaeus</td>
<td>Localised spread by seedpods, animals and some water-borne dispersal of hard seeds. High risk of germination and persistence on peat increase flammability of reservoir area.</td>
</tr>
</tbody>
</table>

**Priority weeds within 5000m**

Priority weeds are those that are known to pose a potential risk threat to primary industry, the natural environment or public safety. The following priority weeds have been recorded in the Natural Values Atlas to occur within 5000m of the existing impoundment. Depending on how many seeds the plants set, how the seeds are spread throughout the landscape and their ability to withstand the hot and drier bare peat, some of these weeds are a greater risk than others for potential invasion. Preliminary notes on their threat potential are given and this would be expanded in any subsequent weed management plan prior to restoration.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Status and threat potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yarrow</td>
<td>Achillea millefolium</td>
<td>Rhizomatous herb, short dispersal by wind. A moderate weed threat for establishment on bare peat.</td>
</tr>
<tr>
<td>Wild Teasel</td>
<td>Dipsacus fullonum</td>
<td>A biennial herb flowering in the second year. Locally spread seed, also spread by animals and water flows. A moderate weed threat.</td>
</tr>
<tr>
<td>Broadleaf Dock</td>
<td>Rumex obtusifolius</td>
<td>A perennial herb. Winged fruits dispersal by wind, water, animals and humans. A moderate weed threat.</td>
</tr>
</tbody>
</table>

**Weed control considerations and mitigation measures for restoration**

Given the presence of weeds in the catchment and environs and potential for introduction, prior to any restoration works a series of plans and actions would be required to reduce the risk of large-scale weed invasion on the newly-exposed reservoir basin. The plans should focus on control of weed or invasive species and rapid revegetation of the reservoir areas with native grasses, shrubs and trees as the primary method for restoration. This approach is consistent with other dam removal and reservoir restoration plans by ensuring restoration efforts emphasise revegetation of newly exposed floodplain areas with native plants while actively
controlling weeds and invasive species.

Weed management activities would aim to reduce the potential seed and propagule sources of weeds that could disperse into the newly exposed reservoir by undertaking the following measures:

1. Field survey of weed species in surrounds and along machinery and visitor access routes
2. Model potential high risk, windblown weeds to understand areas at risk and species posing greatest risk
3. Assign weed severity priority
4. Develop a control target species list based on identifying plants with the largest potential to (1) spread quickly, (2) take over extensive areas, (3) compete for resources with native species, and (4) cause any other environmental damage.
5. Pre-restoration weed treatment (minimum 1 to 2 years pre-drawdown)
6. Identify species that can be controlled by water level management (i.e. *Typha* spp.)
7. Identify ruderal weed species that are likely to reduce in abundance once natural regeneration processes establish
8. Ongoing treatment and monitoring during drawdown with ongoing monitoring and treatment of weed species
9. Identify any poorly-colonising bare areas at high risk of weed invasion in the reservoir area
10. Continue weed monitoring and adaptive management as required.

Overall, the restoration project would require a well developed and implemented Integrated Pest Management Plan for the project area. At a minimum, this should consist of the following key elements:

- Measures to prevent invasive exotic weeds from establishing through use of weed-free plant materials and straw (i.e. clean source, clean machinery)
- Regular monitoring to facilitate early detection of emerging invasive exotic weeds
- Utilize appropriate and cost-effective strategies to reduce or eliminate weed populations
- Planning and scheduling - coordinate weed management with all aspects of the revegetation and dam removal management activities to prevent introduction of any new weed species into the project area and limit existing weed species
• Training – require weed awareness and prevention training and efforts amongst staff and contractors through contract requirements or incentives.

• Expedite revegetation with native plants.

• Monitor to identify and eradicate any invasive exotic species impeding achievement of the revegetation objectives

• Evaluate effectiveness – A continual process of active management ensures the success of the weed control program.

• Adaptive management - revisit and re-establish goals or methods to achieve the objective.

 Threatening processes and biosecurity risks

Root rot (*Phytophthora cinnamomi*)

Root rot (cinnamon fungus, jarrah dieback) is an introduced pathogenic water mould that causes the dieback of susceptible plant species and impact the species composition of plant communities. It is believed to have been introduced to Tasmania following European settlement and is now well established in many areas of mooland, including many records around the Huon-Serpentine Impoundment. In these areas, the disease has reduced the abundance of susceptible plant species from the shrub and herbaceous families Dilleniaceae, Ericaceae (except *Sprengelia incarnata*), Fabaceae, Proteaceae and Rutaceae. Buttongrass (*Gymnoschoenus sphaerocephalus*) is the dominant species in the moolands and is resistant to the disease so the buttongrass mooland vegetation can look superficially intact but it will have reduced species richness and an absence of many flowers in spring and summer.

The pathogen is spread by the movement of soil or infected material both by people on field equipment and/or from existing infections with the movement of water and animals. Given the capacity of humans to spread the fungus over long distances and natural barriers and the existing widespread distribution in Tasmania, the goal for reducing the impact of the fungus is aimed at reducing its spread to new priority areas. These priority areas include:

- threatened species that are susceptible to disease
- large disease-free areas of susceptible native vegetation
- highly susceptible communities

The Huon-Serpentine Impoundment has areas of the threatened vegetation community Banksia wet scrub which, given the dominance of Banksia plants, is heavily susceptible to the...
fungus, therefore this would be a priority for management actions to prevent infection to existing communities or in areas where this community may regenerate.

Measures to prevent the introduction of Phytophthora root rot to uninfected areas should include:

- managing developments and works that increase the risk of introduction eg roads and walking tracks;
- track rerouting, track hardening and drainage management, one-way tracks and access management
- sourcing materials to be used in management works from *P. cinnamomi*-free stock
- sequencing and timing operations to reduce risk of introduction
- hygiene prescriptions such as washdown requirement and washdown stations on walking tracks like the ones on the Mount Anne track.

**Chytrid fungus (*Batrachochytrium dendrobatidis*)**

Chytrid fungus (*Batrachochytrium dendrobatidis*) causes a disease (chytridiomycosis) that currently threatens Tasmania’s native amphibians. The fungus infects the skin of frogs destroying its structure and function and can ultimately cause death. Sporadic deaths occur in some frog populations, and 100 per cent mortality occurs in other populations.
In Tasmania, chytrid infection has spread widely in most habitats including two records of infection at Lake Gordon adjacent to the Huon-Serpentine Impoundment. It is currently not known if the fungus affects amphibians in the proposed restoration area. Despite these nearby positive records, it is still a management priority and a precautionary approach to exclude or reduce the spread of the pathogen in remote areas, therefore, hygiene measures would be necessary during restoration works.

Chytrid fungus, or infected frogs or tadpoles infected by it, can be spread by people carrying water and mud on boots, camping equipment and vehicle tyres, and in water used for drinking, or spraying on gravel roads or fighting fires.

**What rate of de-watering would reduce risks to vegetation? Does the season matter?**

The optimum rate of dewatering varies greatly between the various environmental factors and what may be best for one factor, may not be the best for others. The rate could also be varied at different stages in the process to manage specific risks based on the shape and bank slopes of the impoundment.

Assuming a constant rate of dewatering, the following diagram shows the optimum rate of dewatering from the minimum practical time of 100 days to a nominal 24 months with shading to show the impact on various components. Green represents the optimal or preferred rate with the highest chance of meeting the aim, orange represents sub-optimal rate with less certainty of meeting the aim and red represents the highest risk rate with the lowest likelihood of meeting the aim.

<table>
<thead>
<tr>
<th>Component</th>
<th>Risk mitigation aim</th>
<th>100 days</th>
<th>6 mths</th>
<th>12 mths</th>
<th>24 mths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural vegetation regeneration processes</td>
<td>Maximise natural vegetation regeneration and expansion</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Provide favourable substrate conditions</td>
<td>Maximise safe sites for seedling establishment</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Minimise desiccation and subsequent oxidation of peat</td>
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</tbody>
</table>

The seasonality of dewatering assessment represents the time when the maximum surface area exposed over the dewatering period and assumes that vegetation cover will establish quickly on exposed surfaces. For example, dark peat surfaces will absorb heat and dry out
more quickly in summer, so it would be best to reduce the amounts of bare peat exposed in summer if possible.

<table>
<thead>
<tr>
<th>Risk mitigation aim</th>
<th>Summer</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximising natural vegetation regeneration</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximising germination of seeds and propagules</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimising wind action erosion risks to shoreline</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimising desiccation of peat surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimising extreme peat surface temperatures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
References and further reading


Cambecedes, J, Potts, BM and Vaillancourt, RE (1999) 'Morphological and genetic variation in Centrolepis paludicola and C. monogyna (Centrolepidaceae)' *Australian Systematic Botany*, vol. 12, no. 5 , pp. 679-688


Macphail M, and Shepherd RR (1973) Plant Communities at Lake Edgar, South West Tasmania *Tasmanian Naturalist* 34:1–23


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