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DRAFT 2

INVESTIGATIONS INTO TYPHA MANAGEMENT - METROPOLITAN REGION OF THE DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

BACKGROUND

Initial discussions began on the need for, and possible techniques involved in, the control of the invasive bulrush *Typha orientalis* in 1983. This focused on concerns over the spread of *Typha* at the Forrestdale Lake Nature Reserve (See appendix 1 for description of this reserve).

This discussion was generated primarily because of local community concern that Forrestdale Lake would become dominated by *Typha* as is Herdsman Lake (See appendix 1). Around March of each year large amounts of airborne seeds blow into the adjacent residential area causing general discomfort, blocking flyscreens and fouling swimming pools. There is also concern about the loss of open water views.

Ornithologists expressed concerns over likely impact on bird habitat at the lake.

The Nature Reserve Management Section of the former Department of Fisheries and Wildlife, as managers of this reserve, had the following concerns:-

- There would be a loss of wading bird habitat. (this remains the major, internationally recognised conservation value of Forrestdale Lake)

- The plant was contributing to the midge problem.

- It contributed to the loss of wetland vegetation diversity due to competition.

- It created a severe fire risk during summer months.

- It contributed to the cycle of fire and natural fringing vegetation loss and when dry burns vigorously.

- Techniques for large scale control of the bulrush on wetlands protected by Nature Reserve land classification had not been explored.

- The plant may be operating as a nutrient `sink' in an increasingly eutrophic wetland. No data is available on the impact of control on the nutrient balance. Questions relating to the weeds `holding capacity' for these nutrients because of the cycle of growth and decay which occurs need to be answered.

In February 1985 a consultant's report was prepared which was required to:

Map the Typha beds of Lake Forrestdale.

Document historical changes in the extent of these beds through the use of Lands Dept. and other aerial photography.

Consider likely causes of historical changes in the extent of Typha beds.

Consider ways in which the development of extensive beds of Typha across the floor of Lake Forrestdale might be prevented by mechanical or chemical means.

Conduct field trials on the control of seedling establishment

Consider ways in which Typha control could be achieved by other non-mechanical, non-chemical means.

Make recommendations concerning long term management of <u>Typha</u> at Lake Forrestdale.

In summary this report found the following:

<u>Typha</u> became established at Forrestdale Lake in the mid-1960's when a small stand was noted off aerial photography at the southern end of the lake. This was apparently introduced via a drain.

Spread of the plant was slow until 1978 when, over the next four years, the plant spread rapidly around the perimeter of the lake via rhizome growth and seedling establishment.

That the best method of mature <u>Typha</u> control at Forrestdale Lake would be cutting the bulrush under the water.

It appears that the spread had been favoured by the regular drying out of the lake and reduced lake depths brought on by diminished annual rainfall (affecting groundwater recharge) over the previous decade.

Four recommendations were made:

1. Seedling growth be monitored in February and March each year.

2. Appropriate management techniques be implemented to prevent the establishment of *Typha* seedlings.

3. The fringing *Typha* stands should be managed to keep them in small blocks and it would be desirable to have them separated from the main Melaleuca stands bordering the lake.

4. That an evaluation be made of the application of a cutting machine operated from a boat for the control of mature *Typha* stands.

TYPHA - THE SPECIES

There are two species of bulrush (Also referred to as cumbungi and yangets), of the 10 to 20 species found worldwide, found in the south west of Western Australia. These are *Typha domingensis* and *Typha orientalis*. The two species are difficult for the untrained eye to distinguish.

Notes on these species in the publication `Flora of the Perth Region' includes the following:

T. domingensis

`Recorded from winter-wet depression on the Coastal Plain near Perth, growing intermixed with T. orientalis. Occurs in other scattered locations in the south west and is much more common in the north of the state. Occurs in all Australian states. Widespread in tropical and warm temperate parts of the world.

This species, alone or together with T. orientalis, has often been referred to as T. angustifolia L., a northern temperate species.'

T. orientalis

`Occurs mainly on the Coastal Plain, in winter-wet depressions and in permanent wetlands, often partially submerged during winter. Also recorded from north of Moora. Apparently introduced in W.A. where it is an aggressive coloniser of disturbed sites. Probably native to S.A., Vic., Tas., N.S.W. and Qld. Extends from the Philippines to New Zealand.'

The debate as to the origin of T. orientalis in the south west of Western Australia continues. There appears to be no doubt that of the two species T. orientalis is the one regarded as the `aggressive' coloniser of wetland areas.

Amongst other factors the increasing eutrophication of wetlands may be assisting in its establishment and spread.

Typha appears to be unable to tolerate saline conditions.

The growth cycle of _Typha_ appears to vary depending on the site but for the seasonal wetlands under discussion the basic pattern is as follows:-

- Following on from the input of water into a wetland at the onset of winter rains the plants start to come out of a period of dormancy.
- At mid winter the first new growth of shoots is noticed. The timing varies between wetlands.
- As temperatures increase at the onset of spring there is rapid growth.
- By early summer the growth of the plant has peaked.
- Flowering occurs from November to January.
- Around February to March the seeds are dispersed.

- As the wetland dries out the plant dies off, leading to a mid to late summer situation of large areas of dry _Typha_ stands. At the locations of the plant within the wetland this cycle of inundation and drying out usually occurs. Further comparative studies are required.

Establishment

Typha spreads primarily by two methods.

1). Seedling Establishment

Dependant on conditions there is a potential for large areas of wetlands to be rapidly colonised due to seedling growth . It is estimated that each mature seed pod of the bulrush can contain in the vicinity of 300,000 seeds which are easily and widely dispersed by the wind. Apart from reference to the spread around the perimeter of Forrestdale Lake, which included rhizome growth and seedling establishment, there are no known examples where large areas have been colonised by this method.

For Lake Forrestdale large areas have been regularly seen to be carrying dense seedling growth. It would appear that the winter flooding of the lake leads to the death of the seedlings. A number of habitat characteristics may also be involved, such as the quality of the substrate.

Factors which research has shown influence seedling establishment, and may well affect the `health' and spread of a mature Typha stand include:-

- water quality - turbidity, nutrient loading, salinity etc.
- water quantity - depth, period of inundation, flow.
- substrate structure - soil type, chemical composition, oxygen levels etc.
- light penetration into the water body - cover from vegetation.

2). Rhizome Growth

A very successful way in which the bulrush becomes established is through shoot development from a gradually extending rhizome system. In mature stands the root mass can become a very dense mat. At Lake Forrestdale this mat starts at some 9 centimetres below the substrate level.

It appears that wetlands that seasonally dry out favour the establishment of the bulrush. This is noted from random observations of lakes Kogolup, Thomsons and Herdsman.

Prior to 1988 Kogolup was a _Typha_ dominated wetland however it was noted that the depth of the water and the period of inundation of the _Typha_ stands has increased over the last two years. The result is that most of the bulrush stands have now been eliminated.

Also at Thomsons Lake it appears that in 1990 water is remaining in the lake for a longer period. An observation in September 1990 indicated that the fringing rush and bulrush beds are retreating and thinning out. Most noticeable is the impact on _Typha_.

Work indicates that mature stands of _Typha_ tolerate water depths to 2 metres but around 30 cm is optimum (Forrestdale Lake Nature Reserve Management Plan). There is also reference to _Typha_ forming floating mats in water 10 metres deep. A great deal of work is required on this issue because of the unknown interaction with other factors such as water quality etc. mentioned above.

USES

The only human use of _Typha_ which has so far been identified in Western Australia is in the construction of archery targets. The amount of material harvested is, relative to the total available, negligible. This activity is known to have occurred at Benger Swamp.

OBJECTIVES OF CONTROL

The Forrestdale Lake Nature Reserve Management Plan stated that;

> `If nutrient levels in Forrestdale Lake continue to increase it is possible that the <u>Typha</u> will spread to cover the entire lake. This would destroy a valuable waterbird refuge, as many species require open water for feeding.'

The entire removal of the plant from the lake was not considered practical because of the amount of material involved, the unknown relationship with water quality and the known function of providing shelter and nesting habitat for some bird species.

The protection of waterbird habitat and the severe fire risk posed by the plant in the summer led to recommendations on limited control

Thus a major objective of control was;

> "Typha stands will be isolated by cutting into `blocks' for fire protection purposes. Further expansion of <u>Typha</u> will be controlled, as far as is possible, to prevent the bulrush covering the entire lake bed."

At Benger Swamp Nature Reserve (See appendix 1) the amount of cover by _Typha_ is 50%. The objectives of control set were `to cater to the needs of the range of waterbirds using the swamp', limit its spread and `to minimise the effect of wildfires on Melaleuca stands'.

Because of the previous history of cultivation (the preparation and use of soil for crops by the technique of tillage) at Benger Swamp this was adopted as a management strategy with leases being issued for the growing of fodder crops. For fire control purposes the stands of _Typha_ were to be separated by clear earth firebreaks.

Reasons For Control

The current reasons for investigating the control of _Typha_ in Western Australia can be summarised as follows:-

Fire Control

As mentioned previously the growth cycle of _Typha_ on the seasonally inundated wetlands of the south west of Western Australia includes a time during summer when the plant dies off. The dry material is highly flammable and fires that do occur can be quite intense. Repeated firing leads to the death of native vegetation where distributions overlap.

The plants of most identifiable concern in terms of this impact are paperbarks (Melaleuca sp) where there is a loss of trees and thickets due to death of the plants. The Typha is then able to spread into the thinned out stands of paperbarks and exacerbate the cycle of firing, loss of fire sensitive vegetation, and further spread.

The objectives of control in this regard are to prevent the spread of large fires and to separate the fire sensitive species from the Typha.

Protection of Species Diversity

The fire cycle contributes to this loss of species diversity as does the straightforward competition which occurs. There is a tendency for Typha to become dominant in wetlands it is invading.

Further work is required as to the interrelationship between Typha and other species as there are locations where it appears a balance is achieved between it and other species of plants (Eg. Baumea articulata).

Work is required on the identification of the characteristics of the habitat which favours Typha and the resultant distribution patterns.

Waterbird Habitat Enhancement

Through control of the bulrush it may be possible to maximise the availability of waterbird habitat for feeding, resting and nesting. The optimum scenario would be for a series of islands of typha, secluded waterways and large open bodies of water.

Aesthetics

There is a justifiable argument in certain areas for the maintenance of corridors through the stands of typha. This may be to provide or maintain open water views, allow for access to the waterbody and/or for bird watching.

CONTROLS

As stated in the study by Watkins and Mcnee;

> `There are two basic ways to control a pest species, one is to remove individuals as they arise and the other is to alter the environmental conditions so they are unsuitable for the pest species.'

The control of aquatic weeds has been taking place on a worldwide basis for centuries. This work has mainly applied to permanent water bodies.

In literature the main reasons given for the need to control the plant are the vigorous invasion of drainage and water supply ditches causing blockages, problems in rice paddies, artificial lakes and rural dams and the blocking of pumps and other equipment.

Control in drainage systems in Australia has occurred in the mainland eastern states. Control methods have been employed in Tasmania because of problems in rural dams.

Overseas, the use of labour intensive control techniques has been occurring for centuries. More recently there have been investigations into the control of aquatic weeds where mechanisation is on the increase. This is primarily because of increasing wages costs. This points to a common major problem in the control of aquatic weeds, being the often high cost involved in what is a maintenance task. Similar considerations exist regarding the control of Typha, for whatever reason in Western Australian wetlands.

As is stated by Robson:-

> `The implements and machines at present in use for the control of aquatic weeds have in most cases been developed to meet a local need by the operators

themselves. As a result a range of tools differing widely in shape and performance has come into being and has been until comparatively recently handed down from generation to generation often with little modification.'

The broad control options available are:

- Alteration of water levels - In the case of Typha this would be through the increase in the depth of water and period of inundation.

  This could be achieved by physically deepening wetlands, drainage scheme controls (retention of water in wetlands for longer periods) and artificially topping wetlands up. (pumping water in), preventing wetlands from draining, managing surface water drainage inputs.

  Water level management might become an option for near urban wetlands such as Thomsons Lake and Herdsman Lake.

- Changing the substrate of the wetland to a type not suited to Typha. This would require further research.

- Increasing the competition with other plants through rehabilitation programmes. An example where this rehabilitation has occurred naturally is at Herdsman Lake. An area adjacent to the Wildlife Study Centre has had fire excluded for some years now. The result has been the rapid growth and spread of the paperbark *Melaleuca rhaphiophylla*. The bulrush does not grow under the closed canopy of these paperbarks. This may be due to some form of phytotoxin produced by the paperbark and/or competition for light.

- Grazing. There are examples where cattle and pigs have removed *Typha* from wetlands. Trampling by horses has also had some effect.

- Chemical control through the use of herbicides.

- Mechanical control.
  In summary the types of techniques developed in the mechanical control of aquatic weeds include:-

  1) Hand-held tools.
     Traditional tools used for centuries in Europe including; the scythe, sickles, grass hooks, rakes, forks, chain scythes, chain knives and increasing use of mechanized forms of the above.

2) Weed-cutting boats

First developed soon after the First World War. Whilst a wide range of cutting implements have been tried there is general agreement that some form of a reciprocating mower blade is the most efficient. Indications are that cutting of the _Typha_ some 30 centimetres below the water is an effective control method for mature stands. It is this technique which has been the subject of much development work by CALM and is discussed in more detail below.

3) Harvesters

An increase in the eutrophication of wetlands has led to an interest in the harvesting of aquatic vegetation and utilization of this material. Again the problems have been associated with the economic application of this technique.

4) Machinery operating from the bank.

Cultivation (ploughing, ripping) of mature stands and seedling appears to be an effective control where it can be applied. For mature stands the cultivation needs to penetrate as far as the root mass and cause major disruption.

CONTROLS INVESTIGATED

The control of bulrush can be broken into two categories of seedling control and mature stand control.

The need for effective control of the bulrush has focussed on those areas which are either Nature Reserves or are areas considered to have high conservation value. Apart from the initial work undertaken by Watkins and Mcnee in the control of seedling in the early stages controls investigated have attempted to find techniques to be applied to mature stands.

In investigating the most effective control of this plant for wetlands three broad options were considered:-

1) Cultivation:

Can be considered where cultivation has traditionally been used or where adequate data is available supporting its use. In the case of Benger Swamp this continues to be an applicable control technique, to create and maintain open water, but for most other areas it is not considered an option because of the status of the land and the lack of environmental impact data.

2) Herbicide:

The Western Australian Department of Agriculture has recognised the possible need for bulrush control and suggests, apart from under water cutting and hand pulling, the use of Amitrole sprayed at the rate of 1 litre per 100 litres of water. The need for a good wetting agent is also stressed in recognition of the need to provide the maximum amount of coverage. The difficulty is to ensure that the large amount of root mass is affected by the herbicide to the maximum degree. A less than adequate job will allow the plant to rapidly regrow.

In this assessment of control techniques herbicide use was not considered to be an option because of concerns over the impact on the aquatic ecosystem. The determining factor was the high conservation values of the areas in question.

3) CUTTING BELOW THE WATER.

The effectiveness of this technique has been the subject of overseas studies and the abstract from the work by Sale and Wetzel indicates what is believed to happen.

`Container and field experiments, in which Typha latifolia and Typha angustifolia were cut either above or below the water level, were conducted to determine the physiological basis for reports that the latter treatment was more effective as a control measure. In containers, measurements of oxygen concentrations within the aerenchyma of the rhizome both with an oxygen electrode and by gas chromatography showed that oxygen could diffuse very readily to plant parts growing in an anoxic environment if there was a small amount of leaf or cut plant stem growing above the water level. When all shoots were cut below water, the oxygen in submersed plant parts was rapidly consumed and anaerobic respiration resulted in the production of ethanol. ... The below-water biomass decayed rapidly under these conditions and the plants had much lower regenerative ability than plants cut above water where oxygen continued to reach the roots and rhizomes. In the field, three cuts during the growing season below water were sufficient to kill nearly all the underwater biomass; similar cuts above water reduced total biomass compared with uncut plants, but much of the underwater biomass remained healthy and able to regenerate.'

Work began at Forrestdale Lake in October of 1985. Three sites were selected (See Map 1). The bulrush was cut by hand using Machetes with the depth below water being variable. The plots were approximately 10 metres wide and between 20 metres to 50 metres long running from the shoreline to open water.

As a matter of principle a decision was made to attempt to remove cut material from the water body. It was realised that large amounts of material would be involved with even the most minimal cutting. The impact of leaving the material in the lake is unknown.

It soon became obvious because of the amount of material involved that this operation was too labour intensive to be an effective method, however results achieved were positive. Two of the sites were still relatively clear of the bulrush in 1989. Changes are most likely from rhizome growth from uncut areas. The third site has returned to the pre-cut situation.

During hand cutting an attempt was made to cut as far below the water surface as possible. For two sites good results were achieved with limited and variable below water cut.

In order to speed up cutting a test was made of an attachment to a hand held `whipper-snipper'. This proved to be a failure with the cutting bite of the blade not being wide enough to cut through the mature green <u>Typha</u> and the motor being underpowered.

Because of the positive results from the initial hand cutting tests and the continued interest in finding a suitable control it was decided to begin the construction of a bulrush cutting boat.

Many of the craft which have been developed in other parts of the world are large, cumbersome craft which are permanently in the water or are transported with some difficulty. The aims in the design of the craft were:-

- minimum number of operators
- light
- easily transportable

Preliminary designs were discussed with Mr Doug Watkins and construction and final design was undertaken by the Engineering Branch of CALM.

All aims were achieved.

The basic design of the craft was:

- 16 foot aluminium punt with extra buoyancy tanks welded to each side. This provided a very stable working platform.

- Front mounted 2 metre reciprocating mower blade which was hydraulically operated and could be raised or lowered hydraulically

- Propulsion from 2 electric outboard motors.

- Single operator centrally placed in the craft.

- Power for hydraulics and electricity supply was from a 5 HP Honda motor.

From the outset two things became obvious:-

1. The mower blade was very successful. Limited success with larger stems

2. Propulsion was (and is) a problem with the craft suffering from a lack of power to push into the stands of bulrush and fouling of the blades and shafts occurring frequently and continuously. Electric motors burnt out. Jet has overcome these problems

Recent test have involved an outboard motor fitted with a jet propulsion unit. This suffers from the same problem of shafts and intake getting fouled with material. Also the cooling system for the motor has been blocked by small amounts of material

now overcome

In order to realise the full potential of this boat there is an urgent need to sort out the means of propulsion. Overseas evidence suggests that the most efficient means is through the use of slow moving paddle wheels. Fast moving machinery, such as propeller shafts, cause rapid fouling. This problem is particularly the case for weeds that float on the surface when cut. In the case of Typha the long strands of plant can rapidly become a strong twine, bound round shafts.

Jet is okay.

A major problem confronting the use of the boat is the density of the stands which are tackled. These stands are usually primarily made up of dead material from previous seasons. It is unlikely that any craft could be operated which can readily cope with this and there are other less expensive options available for assessment. In those areas where stands of new growth only have been cut the boat performs extremely well (Yangebup Lake, North Lake).

Agree

The craft also performs well around the periphery of existing stands where the spread can be arrested. This implies a commitment to an on-going maintenance programme of weed control.

There is indirect evidence to suggest that the later in the season cutting is undertaken the less effective is this control technique. The best approach is to bring the boat into operation as early in the growing phase as is possible. Other problems which occur as one goes further into summer involve the growth of other aquatic vegetation, which fouls propellers and has an impact an the cutting efficiency of the machinery.

none with a jet.

Clearly a series of techniques need to be investigated. If large areas of previously untreated mature stands are to be controlled then the application of the boat alone is not the most effective approach. Techniques need investigating which will in the first instance thin out the stands.

Agree

✓

FUTURE ALTERNATIVES

As previously mentioned much of the development of controls overseas have applied to permanent bodies of water. There are increased control options available on the seasonal wetlands currently being assessed on the Swan Coastal Plain.

Controls are dependent on the management objectives of specific areas and the tolerable level of impact of the control technique along with the `do nothing' option. Solutions are tending toward a case by case assessment including the economics of any large scale operation.

To repeat, the main impediment to the efficient operations of the boat is the large bulk of dead material which is present in mature Typha stands. Thus cost efficient alternatives to, in the first instance, remove most of this material should be sought. Some alternatives are suggested:-

1) Fire

Fire can be considered to be a useful tool. The technique would be to burn the beds of bulrush and then cut the new growth below the water at the time of flooding. A possible time frame would be to burn at the onset of good opening winter rains and then begin cutting new growth later the same year. It has been noted that some dense stands will burn after a few days fine weather in winter even though water is present. Whilst not as efficient in removing the dead material as hotter burns it certainly reduces the bulk and burning could be undertaken with minimum risk to fringing vegetation.

Some preparation may be required where the stands are large in order to break the blocks up into manageable sizes.

This technique would be immediately applicable to Forrestdale Lake where the distribution of _Typha_ around the perimeter is variable with a lot of the plant being naturally split up into blocks. The immediate application at Forrestdale would be to improve fire control. Even without considering cutting there may some benefit in burning several blocks of _Typha_ for this purpose.

Timing for burning would be dependant on the amount to be burnt and season. For example some consideration should be given to the likelihood of birds nesting in the stands (Eg. reed warbler, little grass bird).

Burning should also be judged against whether other species of reed which might be considered to be more 'natural' are present. For example at Thomsons Lake it appears that _Typha_ and _Baumea_ tend to co-exist. Little is known as to the effect of fire on _Baumea_ however there may be an argument to use fire in any case to improve the strategic break up of the current extensive and dense stands of the bulrush and the rush. Summer fires in these types of areas are extremely difficult to control.

2) Dry Cutting

Techniques associated with the cutting of bulrush during the dry period should be investigated. For example one possibility might be to rotary slash stands to lake bed level immediately prior to the onset of winter rains to see if drowning occurs. That is, anaerobic breakdown occurs prior to the start of the growth period. This technique might also be applicable to areas where partial or complete water level control is possible.

If the slashing does not prevent the new growth it will facilitate the operation of the boat.

To be borne in mind in operating machinery on a lake bed (apart from the risk of getting equipment bogged) is the implications of compaction of the substrate by caused by the weight of the machinery being operated. It has been observed that Typha seedling establishment is favoured in wheel ruts on lake beds. Further the effects of compaction on the substrate are not understood.

Slashing could be considered where Typha, not as part of a complex community, is spreading into paperbark stands.

3) Water Level Management

This has been discussed previously. By either increasing the depth of a lake and or extending the period of inundation there is evidence to suggest that stands of *Typha* are at least diminished in area if not controlled completely.

OVERVIEW

Eradication

Calls for the large scale control of *Typha* appear to be to appease human wants rather than satisfying environmental criteria, however this needs to be investigated.

The call for the total eradication of the plant from wetlands mainly comes from those people who believe that it is aesthetically unpleasing or poses a severe fire risk to private properties. This justification then draws on the unsubstantiated concern that the bulrush provides habitat for nuisance species (Eg. midge) and the acknowledged concern that wading bird habitat is being, or has the potential to be, lost.

It is considered that in those wetlands where the bulrush is well established total eradication is not feasible or in a number of cases desirable (See the reasons given for Forrestdale Lake). The best form of eradication is to prevent it becoming established in the first place.

Equally it should be noted that controls (apart from water level modification) may need to be on-going because of adjacent seed stock in non controlled areas (drains, private property etc) and the wide dispersal of thousands of seeds and the continued presence of stands allowing rhizome spread.

The main precursor to the control of seedling establishment in areas under the management control of CALM is to monitor the spread and survivability of the seedlings. It would appear that environmental conditions are not suitable currently for the rapid infestation of Typha by this means. Indications are that good control can be achieved by dragging a metal bar or mesh over the seedlings. Concerns regarding the type of machinery operating on the lake bed need to be kept in mind.

Whilst the spread of Typha poses a potential risk to the habitat of wading birds the only known area where a change in previous management has the greatest possibility for the rapid loss of this habitat is at Benger Swamp. Continued cultivation is likely to maintain the status quo.

For this and other areas the two control objectives are to stop the spread of existing stands with resultant impact on native vegetation and fire control or to maximise waterbird habitat availability .

2) Research

The specific aims contained in the proposal put to CALM in April 1990 by researchers from Murdoch University indicate the types of questions needing to be addressed:-

1) Ascertain the extent of the *Typha* problem on the Swan Coastal Plain, the distribution of *T. domingensis* and *T. orientalis* and their current status at all major metropolitan wetlands.

2) Determine the effectiveness of the cutting technique on *Typha* at selected wetlands using small scale field experiments established by hand.

3) Determine how habitat variables such as water regime, nutrients, sediment type and light availability influence the effectiveness of the cutting technique by considering these variables in the selection of field experiment sites.

4) Determine what type of macroinvertebrate communities are associated with stands of *Typha* and how similar or different are these to the communities present within stands of *Baumea* or nearby open water.

5) Ascertain the effect cutting has on macroinvertebrate communities

6) Monitor the effectiveness of CALM's cutting machine at selected wetlands in field experiments and normal operations, and investigate its potential for integration with other control techniques e.g. herbicides and control burns.

7) Examine directly the effects of cutting on Typha orientalis under controlled glasshouse conditions to accurately assess the species response in terms of internal oxygen supple and rhizome degeneration.

8) Integrate data from the above investigations into management recommendations aimed at maximizing the efficiency and flexibility, and minimizing the environmental impact of the cutting technique.

Other questions might be;

- Studies on the optimum balance to maximise water bird habitat.

- Plants contribution to the midge problem.

- Interaction with other species of rush etc.

- Studies on other changing the water regime as a control method.. Interaction between the plant and the nutrient balance of a wetland.

It is clear that a management problem exists without recourse to the reasons of maximising bird habitat (fire control) and within the grasp of CALM are ways of achieving that control in a cost efficient manner.

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