TYPHA HERBICIDE EXPERIMENT: FORRESTDALE LAKE - PHASE 1

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

ENVIRONMENTAL SCIENCE LANDSCAPE ARCHITECTURE MAPPING SCIENCE

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Prepared by:

Ecoscape (Australia) Pty Ltd

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Typha Herbicide Experiment: Forrestdale Lake – Phase 1

The Department of Conservation and Land Management commissioned Ecoscape to design and implement an experiment to test methods of controlling *Typha orientalis* at Forrestdale Lake.

Forrestdale Lake is located within Forrestdale Lake Nature Reserve, a class A reserve gazetted for the conservation of flora and fauna located approximately 25 kilometres south-east of Perth, in the City of Armadale.

The reserve is one of the most important conservation reserves in south-western Australia (CALM, 2003). It is of international importance as a habitat and refuge for water birds. It is included on the List of Wetlands of International Importance (Ramsar) and is also included in the *Directory of Important Wetlands in Australia* (ANCA, 1996)

A total of 30, 1x10 m plots were established at Forrestdale Lake (6 treatments, 5 replicates) and sprayed according to the following treatments on the 17th February.

- No Spray (C)
- 3% concentration Roundup® Biactive™ (3B)
- 5% concentration Roundup® Biactive™ (5B)
- 1% concentration Roundup® Biactive™ plus Pulse® (1BP)
- 3% concentration Roundup® Biactive™ plus Pulse® (3BP)
- 5% concentration Roundup® Biactive™ plus Pulse® (5BP)

The quadrats were assessed on 2nd April, 2004. Counts were made of dead (brown stems to the ground) and alive (green visible on stems) in two size classes (>1m and <1m). Additionally 5 rhizomes from plants identified as 'dead' were excavated in each quadrat to determine if the rhizome had died and was rotten.

The results indicated that increasing the concentration of herbicide results in a greater proportion of apparent mortality (stems completely browning off), however the significance becomes weaker as the concentration increases. A significantly higher mortality rate is therefore not expected at concentrations higher than 5%.

The addition of the penetrant Pulse® did not appear to make much difference to the effectiveness of Roundup® Biactive™. A two-factor ANOVA performed on two concentrations (3% and 5%) found that while the effect of increasing concentration on observed mortality was significant (P=0.007), there was no significant difference observed by the addition of Pulse® (P=0.683).

A two-factor ANOVA was also undertaken to determine if different concentrations of Roundup® Biactive™ produced different observed mortalities between two size classes (0-1m; <1m). No significant difference was observed between mortality of different size classes (P=0.32), suggesting that resistance to Roundup® Biactive™ did not increase with size or age.

Mortality rates were calculated by examining the aboveground parts of the stem. A Typha stem was classified as 'dead' when no green was observed at any part of the stem. Examination of the rhizomes of Typha that had been classified as 'dead', found that in all cases it had survived 6 weeks following spraying. It was also observed that the number of shoots arising from the rhizome decreased with increased concentration.

While this may be attributed to an insufficient time between application of the treatments and the assessment, it suggests that a single application of Roundup® Biactive™, regardless of concentration, is unlikely to completely kill the plant. A follow-up treatment, or a combination of treatments are likely to be necessary to successfully control Typha at Forrestdale Lake.

The following conclusions were drawn from the study:

- A 5% concentration of Roundup® Biactive™ is the most effective in controlling Typha and this concentration should be used for management in this area;
- the addition of the penetrant Pulse® does not appear to increase the effectiveness of Roundup® Biactive™ for controlling Typha;
- there is no difference in Typha susceptibility to Roundup® Biactive™ between size classes; and
- a single application of Roundup® Biactive™ of any concentration will not completely kill the plant. A follow up spray and/or a combination of techniques (e.g. slashing) is likely to be more effective.

The following recommendations were made based upon the results of the study:

- A 5% concentration of Roundup® Biactive™ should be used when undertaking herbicide control of Typha at Forrestdale Lake;
- Pulse® should not be used with Roundup® Biactive™ for controlling Typha at Forrestdale Lake;
- Further study should be done to determine the most effective spraying regime for controlling Typha at Forrestdale Lake. This should involve a follow up spray at the optimum time and can also include associated control methods such as mowing.

1.0 Introduction

Typha Herbicide Experiment: Forrestdale Lake – Phase 1

1.1 Introduction

The Department of Conservation and Land Management commissioned Ecoscape to design and implement an experiment to test methods of controlling *Typha orientalis* at Forrestdale Lake. *T. orientalis* is an aggressive coloniser of wetland areas and has been present at Forrestdale Lake since the 1960's. Aerial photography shows a rapid increase in area infested, particularly in recent years. This is possibly due to reduction in water levels caused by prolonged drought and increased levels of groundwater abstraction.

This report represents the results of the first stage of trials to determine the most effective approach for controlling *T. orientalis.* This stage compares different concentrations of the herbicide glyphosate (1%, 3% and 5%), and the effect of adding a penetrant.

The next stage of the experiment will test the most appropriate control times using the most successful herbicide rate.

1.2 Study Aims

The aim of this experiment is to determine the most effective herbicide application rate for controlling *Typha orientalis.*

To determine this the following hypotheses will be tested:

- $H_0$1 There is no significant difference in mortality of Typha with no treatment (control)
- $H_0$2 There is no significant difference in stem mortality of Typha after application of 3% concentration Roundup® Biactive™
- $H_0$3 There is no significant difference in stem mortality of Typha after application of 5% concentration Roundup® Biactive™
- $H_0$4 There is no significant difference in mortality of Typha after application of 1% concentration Roundup® Biactive™ plus Pulse®
- $H_0$5 There is no significant difference in mortality of Typha after application of 3% concentration Roundup® Biactive™ plus Pulse®
- $H_0$6 There is no significant difference in mortality of Typha after application of 5% concentration Roundup® Biactive™ plus Pulse®

Additionally significant differences in the means of mortality and the overall effect of the addition of Pulse® will be tested for each treatment in two size classes.

1.3 Study Area

Forrestdale Lake is located within Forrestdale Lake Nature Reserve, a class A reserve gazetted for the conservation of flora and fauna located approximately 25 kilometres south-east of Perth, in the City of Armadale.

The reserve is one of the most important conservation reserves in south-western Australia (CALM, 2003). It is of international importance as a habitat and refuge for water birds. It is included on the List of Wetlands of International Importance (Ramsar) and is also included in the *Directory of Important Wetlands in Australia* (ANCA, 1996)

The key values of Forrestdale Lake Reserve are (CALM, 2003):

- it is an internationally significant waterbird habitat which regularly supports over 1% of the known Australian population of the long-toed stint;
- it is important for maintaining genetic and ecological diversity;
- It is a particularly good representative of natural or near natural wetland characteristic of Wetlands on the Swan Coastal Plain before European settlement;
- it has rich aboriginal heritage;
- it is important for the protection of Rare, Threatened and Priority Flora and Fauna, and Threatened Ecological Communities;
- it is representative of plant communities on the eastern side of the Swan Coastal Plain that have been heavily cleared; and
- it provides natural and cultural values close to urban centres that provide opportunities for nature appreciation and education.

Of the 99 weeds recorded in the reserve, *Typha orientalis* is one of the four most threatening weeds and is a major management issue in Forrestdale Lake Reserve (CALM, 2003). *T. orientalis* poses a major threat to the above identified values as in summer it presents a significant fire hazard and has the potential to significantly alter waterbird habitat (CALM, 2003).

Control of *T. orientalis* is therefore a high priority in the Forrestdale Lake Reserve, however control of this species is widely acknowledged to be difficult and many attempts have met with little success. It is also important that control methods do not threaten the values identified for the Forrestdale Lake Nature Reserve.

1.4 Herbicide Control

Herbicides may be the cheapest and most effective form of control of *Typha* at Forrestdale Lake. Repeated slashing and other mechanical methods have thus far failed to eradicate Typha from Forrestdale Lake. This is likely to be because of the high potential for vegetative reproduction of the rhizome. Any parts of the rhizome left in the soil have the potential to resprout. For effective, long-term control the rhizome must either be removed completely or killed. The former is likely to be very time consuming, expensive and may potentially damage the lake bed.

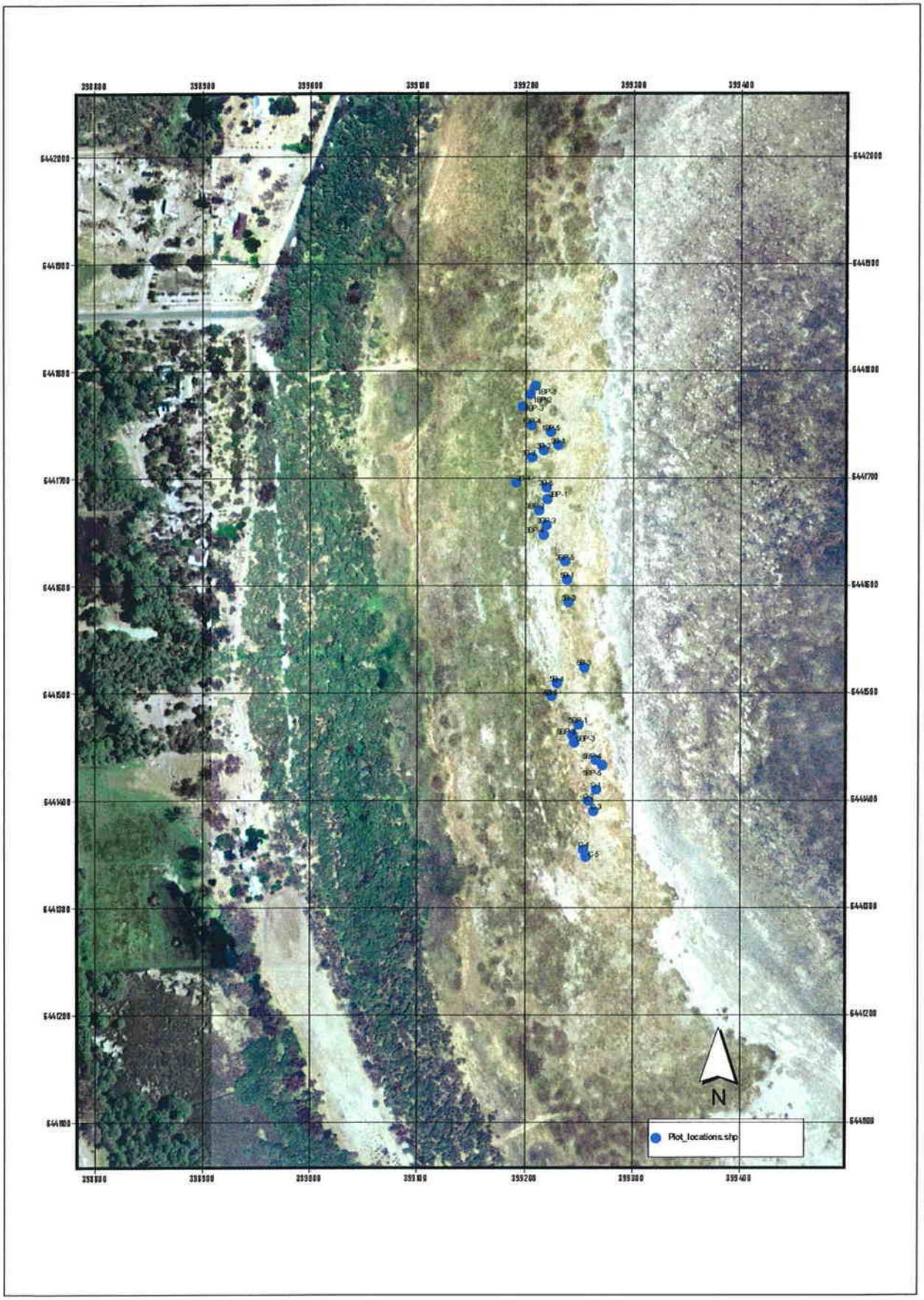

Figure 2.1 Study Area showing location of quadrats (GDA 94)

Due to the high conservation values of Forrestdale Lake, only herbicides registered for use in aquatic areas are likely to be accepted as a method to control *Typha.* Herbicides registered for use in wetland areas in Western Australia are (WRC, 2001):

- Glyphosate (Roundup® Biactive™, Roundup®,Rodeo®, Davison® Glyphosate 450®)
- Flauzifop-p-butyl (Fusilade®)
- Metasulfuron-methyl (Brushoff®, Ally®, Groper® and Escort®)
- Chlorsulfuron (Glean®, Siege®, Tackle®)
- Diquat (Aquacide® / Reglone®)

Of these, only glyphosate appears to have been used with any success to control *Typha.* 2,2-DPA has also shown to produce good results however this has not been approved for use by the Department of Environment.

The use of a penetrant such as Pulse® is used enhance the uptake of the herbicide. This is important as *Typha* has a waxy cuticle on its leaves which greatly inhibits its ability to absorb herbicides, particularly Roundup® Biactive™, which tends to form droplets on the leaves which run off and are not absorbed. The addition of a penetrant should reduce the amount of herbicide necessary to kill the plant.

Concentration of herbicides is an important variable to be tested. It is important to determine the amount of herbicide necessary to obtain an effective kill without exposing the wetland to excessive chemicals. The herbicide mixes tested were:

1. No Spray (control)
2. 3% concentration Roundup® Biactive™
3. 5% concentration Roundup® Biactive™
4. 1% concentration Roundup® Biactive™ plus Pulse®
5. 3% concentration Roundup® Biactive™ plus Pulse®
6. 5% concentration Roundup® Biactive™ plus Pulse®

2.0 Method

Typha Herbicide Experiment: Forrestdale Lake – Phase 1

2.1 Methods

A total of 30, 1x10 m plots were established at Forrestdale Lake (6 treatments, 5 replicates) and sprayed according to the following treatments on the 17th February.

- No Spray (C)
- 3% concentration Roundup® Biactive™ (3B)
- 5% concentration Roundup® Biactive™ (5B)
- 1% concentration Roundup® Biactive™ plus Pulse® (1BP)
- 3% concentration Roundup® Biactive™ plus Pulse® (3BP)
- 5% concentration Roundup® Biactive™ plus Pulse® (5BP)

The quadrats were positioned so that they had a similar density, distribution and alignment, and were situated near the inner margin of the infestation. Plots were established at least 10 metres apart to minimise spray-drift. The location of the quadrats is shown in Figure 2.1. GPS references for the north-east corner of each quadrat are listed in Appendix One.

Herbicide was applied using a backpack sprayer. Coverage overlapped the boundaries of the quadrat by 0.5 – 1 m to ensure complete coverage. Weather conditions at the time were hot (over 40^0 C), and there was little breeze.

The quadrats were assessed on 2nd April, 2004. Counts were made of dead (brown stems to the ground) and alive (green visible on stems) in two size classes (>1m and <1m). Additionally 5 rhizomes from plants identified as 'dead' were excavated in each quadrat to determine if the rhizome had died and was rotten. This was not observed in any of the quadrats, however increased mortality of buds on the rhizomes was observed as concentration of herbicide was increased. Field data is included in Appendix One.

2.2 Analysis

The following statistical analysis of the proportion of *Typha* individuals classified as 'dead' was undertaken to determine the significance of the mean results.

1. Two sample T-test between all pairs of treatments
2. Two-factor ANOVA (Analysis of Variance) between
    a. 3% and 5% concentrations
    b. Pulse® / no Pulse®
3. Two Factor ANOVA between
    c. 3% and 5% concentrations
    d. penetrant / no penetrant

Statistical analysis was undertaken using Microsoft Excel.

3.0 Results

Typha Herbicide Experiment: Forrestdale Lake – Phase 1

3.1 Descriptive Statistics

Descriptive statistics for each treatment are given below for each treatment. Mean and standard error have been plotted in Figure 3.1.

Table 3.1 Descriptive Statistics for each Treatment

	C	*1BP*	*3B*	*3BP*	*5B*	*5BP*
Mean	0.036	0.491	0.714	0.749	0.874	0.879
Standard Error	0.016	0.048	0.050	0.050	0.044	0.044
Median	0.017	0.516	0.726	0.745	0.897	0.895
Standard Deviation	0.036	0.107	0.112	0.112	0.098	0.098
Sample Variance	0.001	0.011	0.012	0.013	0.010	0.010
Kurtosis	-3.059	4.003	2.566	1.724	-0.457	1.040
Skewness	0.460	-1.908	-1.340	0.087	-0.810	-0.976
Range	0.076	0.272	0.299	0.315	0.241	0.257
Minima	0.000	0.306	0.531	0.593	0.729	0.727
Maxima	0.076	0.578	0.830	0.908	0.970	0.983
95% Confidence Level	0.045	0.132	0.139	0.139	0.122	0.122

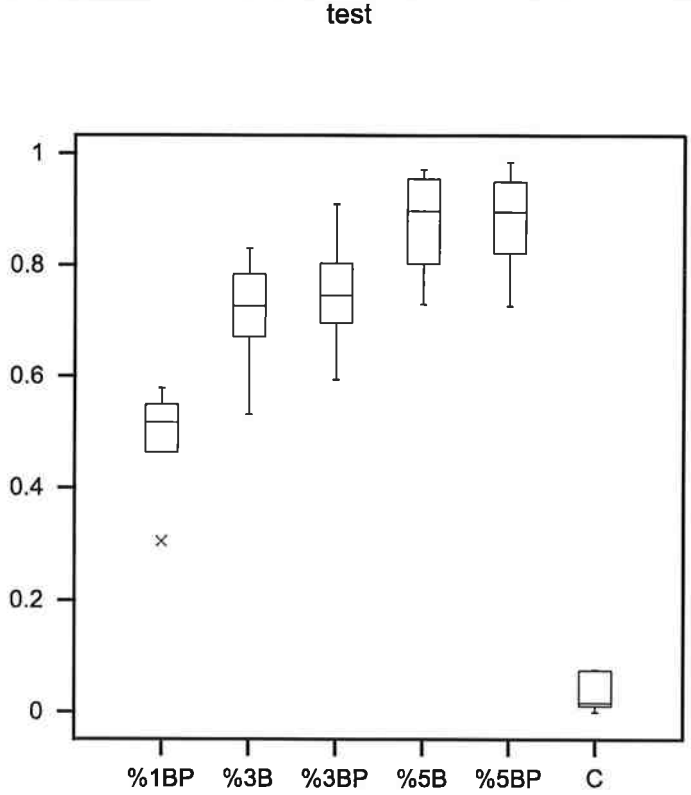

Figure 3.1 Box plot showing mean, interquartile range, maxima and minima of mortality rates for each treatment.

3.2 Two Sample T-test

Table 3.2 shows the results of the two-sample t-test undertaken between all treatments. There was a highly significant statistical difference (P<0.001) between the control group and all other groups.

Table 3.2 Results of t-test analysis

	C	1%BP	3%B	3%BP	5%B	5%BP
C		<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
1%BP	<0.001**		0.012*	0.006*	<0.001*	<0.001**
3%B	<0.001**	0.012*		0.640	0.043*	0.038*
3%BP	<0.001**	0.006*	0.640		0.097	0.087
5%B	<0.001**	<0.001**	0.043*	0.097		0.941
5% BP	<0.001**	<0.001**	0.038*	0.087	0.941	

** is significant to 0.001

* is significant to 0.05

3.3 Two-factor ANOVA (concentration & penetrant)

The results of the two-factor analysis of variance between concentration and the addition of the penetrant Pulse® is shown in Table 3.3 below. There was no significant difference (P=0.683) between treatments with Pulse® added and those without, however a significant difference (P=0.007) was observed between treatments with different concentrations of Roundup® Biactive™.

Table 3.3 Results of two-factor ANOVA between 3% & 5% concentrations of Roundup® Biactive™, with and without the addition of Pulse®.

Source of Variation	*Sum Sq.*	*df*	*Mean Square*	*F*	*P-value*	*F crit*
Pulse®	0.001915	1	0.001915	0.17258	0.683347	4.493998063
Conc.	0.104993	1	0.104993	9.460396	0.007238	4.493998063
Interaction	0.001098	1	0.001098	0.098892	0.757226	4.493998063
Within	0.17757	16	0.011098			

3.4 Two factor ANOVA (concentration and size class)

The results of the two-factor analysis of variance between concentration and size class is shown below in Table 3.4. There was no significant difference in mortality between size classes (P=0.322), and a weak relationship was observed between different concentrations within size classes (P=0.078).

Table 3.4 Results of two-factor ANOVA between 3% & 5% concentrations of Roundup® Biactive™ between <1m & >1m size classes.

Source of Variation	*Sum Sq.*	*df*	*Mean Square*	*F*	*P-value*	*F crit*
Conc.	0.187409248	1	0.187409	3.538283	0.078294	4.493998063
Size class	0.055431222	1	0.055431	1.04654	0.321525	4.493998063
Interaction	0.0092727	1	0.009273	0.175068	0.681208	4.493998063
Within	0.847458463	16	0.052966			

4.0 Discussion

Typha Herbicide Experiment: Forrestdale Lake – Phase 1

4.1 Concentration of Roundup® Biactive™

A significant difference was observed between the means of observed mortality between the control and all concentrations of herbicide ($P<0.001$). Similarly a significant difference was observed between a 1% concentration of Roundup® Biactive™ plus Pulse® and all other treatments ($P<0.05$).

A significant difference was also observed between the 3% Roundup® Biactive™ and all other treatments except 3% Roundup® Biactive™ plus Pulse®. This suggests that the addition of Pulse® did not significantly increase apparent mortality of *Typha*. A weak difference was also observed between 3% Roundup® Biactive™ plus Pulse® and 5% Roundup® Biactive™ without Pulse® ($P = 0.097$) as well as with 5% Roundup® Biactive™ with Pulse® added ($P = 0.087$).

These results indicate that increasing the concentration of herbicide results in a greater proportion of apparent mortality (stems completely browning off), however the significance becomes weaker as the concentration increases. A significantly higher mortality rate is therefore not expected at concentrations higher than 5%.

4.2 Addition of Pulse®

The addition of the penetrant Pulse® did not appear to make much difference to the effectiveness of Roundup® Biactive™. A two-factor ANOVA performed on two concentrations (3% and 5%) found that while the effect of increasing concentration on observed mortality was significant ($P=0.007$), there was no significant difference observed by the addition of Pulse® ($P=0.683$).

4.3 Size-class effects

A two-factor ANOVA was undertaken to determine if different concentrations of Roundup® Biactive™ produced different observed mortalities between two size classes (0-1m; <1m). No significant difference was observed between mortality of different size classes ($P=0.32$), suggesting that resistance to Roundup® Biactive™ did not increase with size or age.

4.4 Apparent mortality vs actual mortality

Mortality rates were calculated by examining the aboveground parts of the stem. A Typha stem was classified as 'dead' when no green was observed at any part of the stem. Examination of the rhizomes of Typha that had been classified as 'dead', found that in all cases it had survived 6 weeks following spraying. It was also observed that the number of shoots arising from the rhizome decreased with increased concentration.

While this may be attributed to an insufficient time between application of the treatments and the assessment, it suggests that a single application of Roundup® Biactive™, regardless of concentration, is unlikely to completely kill the plant. A follow-up treatment, or a combination of treatments are likely to be necessary to successfully control Typha at Forrestdale Lake.

5.0 Conclusions and Recommendations

Typha Herbicide Experiment: Forrestdale Lake – Phase 1

5.1 Conclusions

The following conclusions can be drawn from this study:

- A 5% concentration of Roundup® Biactive™ is the most effective in controlling Typha and this concentration should be used for management in this area;
- the addition of the penetrant Pulse® does not appear to increase the effectiveness of Roundup® Biactive™ for controlling Typha;
- there is no difference in Typha susceptibility to Roundup® Biactive™ between size classes; and
- a single application of Roundup® Biactive™ of any concentration will not completely kill the plant. A follow up spray and/or a combination of techniques (e.g. slashing) is likely to be more effective.

5.2 Recommendations

The following recommendations are made based upon the results of the study:

- A 5% concentration of Roundup® Biactive™ should be used when undertaking herbicide control of Typha at Forrestdale Lake;
- Pulse® should not be used with Roundup® Biactive™ for controlling Typha at Forrestdale Lake;
- Further study should be done to determine the most effective spraying regime for controlling Typha at Forrestdale Lake. This should involve a follow up spray at the optimum time and can also include associated control methods such as mowing.

References

Typha Herbicide Experiment: Forrestdale Lake – Phase 1

ANCA (1996) *A Directory of Important Wetlands in Australia Second Edition.* Australian Nature Conservation Agency, Canberra.

CALM (2003) *Forrestdale Lake Nature Reserve Draft Management Plan 2003.* Conservation Commission of Western Australia and the Department of Conservation and Land Management, Perth.

WRC (2001) *Water Notes – Advisory Notes for Land Managers on River and Wetland Restoration.* WN22 April 2001. Water and Rivers Commission, Perth

Appendix One: Field Data

Typha Herbicide Experiment: Forrestdale Lake – Phase 1

Treatment: 1% Roundup® Biactive™ plus Pulse® (1BP)

Replicate	Easting	Northing	Corner	Direction	Dead		Alive		No Dead rhizomes
					<1m	>1m	<1m	>1m	
1BP-1	399290	6441788	NE	270	2	35	9	75	0
1BP-2	399204	6441777	NE	300	5	58	4	42	0
1BP-3	399196	6441776	NE	300	6	63	2	57	0
1BP-4	399207	6441750	NE	270	4	60	5	55	0
1BP-5	399223	6441748	NE	270	9	41	5	42	0

Treatment: 3% Roundup® Biactive™ (3B)

Replicate	Easting	Northing	Corner	Direction	Dead		Alive		No Dead rhizomes
					<1m	>1m	<1m	>1m	
3B-1	399231	6441731	NE	290	18	99	6	18	0
3B-2	399217	6441724	NE	300	8	68	0	23	0
3B-3	399205	6441719	NE	300	0	60	7	46	0
3B-4	399191	6441695	NE	300	4	95	3	36	0
3B-5	399219	6441691	NE	290	8	69	6	23	0

Treatment: 3% Roundup® Biactive™ plus Pulse® (3BP)

Replicate	Easting	Northing	Corner	Direction	Dead		Alive		No Dead rhizomes
					<1m	>1m	<1m	>1m	
3BP-1	399220	6441680	NE	295	8	62	6	42	0
3BP-2	399213	6441669	NE	295	5	68	0	25	0
3BP-3	399219	6441655	NE	270	6	113	4	40	0
3BP-4	399217	6441647	NE	290	8	101	3	30	0
3BP-5	399237	6441621	NE	280	9	110	1	11	0

Treatment: 5% Roundup® Biactive™ (5B)

Replicate	Easting	Northing	Corner	Direction	Dead		Alive		No Dead rhizomes
					<1m	>1m	<1m	>1m	
5B-1	399239	6441605	NE	270	18	80	0	3	0
5B-2	399240	6441584	NE	265	34	96	1	6	0
5B-3	399255	6441523	NE	270	8	120	0	27	0
5B-4	399229	6441508	NE	280	8	105	7	35	0
5B-5	399224	6441496	NE	255	4	109	3	10	0

Treatment: 5% Roundup® Biactive™ plus Pulse® (5BP)

Replicate	Easting	Northing	Corner	Direction	Dead		Alive		No Dead rhizomes
					<1m	>1m	<1m	>1m	
5BP-1	399249	6441470	NE	260	12	92	5	13	0
5BP-2	399244	6441459	NE	270	7	111	1	1	0
5BP-3	399246	6441453	NE	270	15	121	6	10	0
5BP-4	399266	6441436	NE	255	3	98	5	33	0
5BP-5	399272	6441432	NE	240	15	105	1	7	0

Treatment: Control (C) – No Spray

Replicate	Easting	Northing	Corner	Direction	Dead		Alive		No Dead rhizomes
					<1m	>1m	<1m	>1m	
C-1	399266	6441409	NE	260	1	1	17	102	0
C-2	399259	6441399	NE	280	0	9	12	99	0
C-3	399263	6441389	NE	280	0	0	3	105	0
C-4	399254	6441353	NE	265	0	2	14	119	0
C-5	399256	6441347	NE	280	0	12	10	136	0