

Chapter 8

Discussion and Conclusions

This thesis aimed to determine the ecological parameters that control the distribution and abundance of *J. articulatus* and *G. australis*. The ecology of *J. articulatus* and *G. australis* within the New England lagoons was investigated in relation to water regime. This included research into the hydrology of water regime in the lagoons as well as the affect of water regime on the growth and interaction of both species.

A variety of methods were developed that can provide a structure for water regime research. A model of a lagoon water balance was constructed that can be used as a framework for understanding of lagoon hydrology and for future data collection (Chapter 2). The effect of water regime on plant growth was investigated in combination with other factors important for growth (Chapter 5). Water regime was investigated in detail using a technique that separated the effects of the individual components of proportion of time flooded, amplitude and frequency of fluctuations in water levels (Chapter 4). Finally, water regime was manipulated in a field experiment to assess the effects of temporal and spatial variation on plant communities (Chapter 6). This combination of methods allowed much greater flexibility than monitoring or investigating simple regimes such as one-off changes from one static depth to another (Casanova 1994; Rea and Ganf 1994c).

These methods enabled the integration of information that was required to determine the ecological parameters controlling the abundance of *G. australis* and *J. articulatus* at Mother of Ducks Lagoon (see Section 1.2, Figure 1.1). The findings are discussed in three areas: water regime; the ecology of the coexistence of *J. articulatus* and *G.*

australis; and management implications of findings including the invasive potential of *J. articulatus* in the New England lagoons.

8.1 Water regime

The simulation of a lagoon water balance (Chapter 2) gave some insight into the fundamental process of hydrology in the lagoons and provided a method for comparisons of broad hydrological behaviour between lagoons, which is important in the investigation of species ranges and distributions (Figure 1.1, section 1.2). The simulated water balance showed that, contrary to the dominant paradigm that the lagoons are sealed by a clay layer (Briggs 1976; Creek 1982; Lloyd 1992), groundwater seepage is probably important for variation in water levels in the lagoons. The water balance also showed that all components of the hydrological cycle investigated, rainfall, runoff, evaporation and groundwater seepage, were important in determining water levels in the lagoons. The distribution of water levels in the lagoon simulations tended to be bimodal. If there are bimodal distributions of water levels in the lagoons, this will present problems if averages are used to describe water levels, such as has been the case in more seasonal wetland systems (Froend and McComb 1994; Rea and Ganf 1994a; Rorslett 1984). Bimodality implies dual states that should ideally be treated separately to maximise precision in measurement, as is often done in seasonal climates where the two states are distinct.

The simulation results provided some insight into the effects of the history of alteration of water regime in the lagoons and the possible effect of future management actions. While draining a lagoon will have the effect of removing aquatic life, the effects of damming will depend on the physical characteristics of the lagoon. Damming will often be undertaken with the purpose of creating a deeper and more permanent wetland. Damming will result in greater depths at any point in the lagoon, but the proportion of time those depths are attained may be short lived if catchment size is small compared to the surface area of the lagoon (Figure 2.8). This was the case for simulated conditions at Pinch and North Llangothlin lagoons. Few of the lagoons surveyed have a greater ratio of the catchment area to surface area than Pinch

and North Llangothlin (Table 1.1). The owner of Loch Abbra lagoon confirmed that since damming of his lagoon some 20 years earlier it had overflowed only once. Therefore damming may make water levels more “permanent”, in as much as the lagoon will dry out less often, however the amplitude or range of depths over which water levels fluctuate will be greater.

From a plant perspective, damming will result in all positions within a lagoon experiencing greater amplitudes of water depth fluctuations. This may result in changes in the dominance of species within plant communities (Barrat-Segretain 1996) or in species being unable to survive. One of the major consequences of more severe fluctuations is a change in importance from vegetative reproduction to seed (Chambers and McComb 1992; Grace 1993). Increased seed bank diversity can result in increased floristic diversity (Keddy and Reznicek 1986), however the relationship between seed bank presence and vegetation is variable (Leck 1989a). If fluctuations become too extreme few species will survive.

Several lagoons show a relationship between damming and the composition of communities where *G. australis* and *J. articulatus* were found (Figure 1.1, Section 1.2). Where a lagoon does not overflow for a large enough proportion of time the dominance of transition zone or lagoon edge specialist species is reduced. This was found to be the case in North Llangothlin and Loch Abbra lagoons (Chapter 3). In some cases terrestrial opportunistic species such as *T. repens* and *A. avenacea* were found when lagoons were dry. In Pinch and North Llangothlin lagoons, species rich quadrats contained semi-aquatic species such as *Isotoma fluviatilis*, *Schoenus apogon*, *Brachycome radicans* and *Gnaphalium involucreatum* that were not present in other lagoons that had edge communities dominated by *C. gaudichaudiana* and *H. lanatus* (Figure 3.2).

These patterns suggest a general scheme of species distributions in relation to the proportion of time flooded and the variation in water depths. Variation in water depth is used here to mean amplitude, but also more prolonged drought and flooding. The broad habitat preferences of *J. articulatus* and *G. australis* and the distribution of *E. sphacelata* and *Typha sp* in the New England region may be explained by this scheme. The distribution of *J. articulatus* suggests that it prefers water levels that are

less variable compared to *G. australis* (Chapter 3). It occurs in creeks and drains in the region and at Mother of Ducks and Little Llangothlin lagoons, both of which have restricted fluctuations in depth due to manipulation of the hydrology (Brock *et al.* in press.). In contrast *G. australis* occurred with a wide variety of species suggesting it is tolerant of wide range of water regimes (Chapter 3). *J. articulatus* was less tolerant than *G. australis* of a dry period in the field during winter 1994 and 1995 and in the experiment testing individual plant response to water regime (Chapter 4, Chapter 6). These results suggest that *J. articulatus* is less drought tolerant than *G. australis* or other native species.

Examples of two species which dominate plant communities in deep water but in different habitats are *Typha* sp. and *E. sphacelata*. *Typha* sp. is dominant in creeks in the region but rarely occurs in the lagoons. The hypothesis is that *Typha* sp. is intolerant of the variability of water regimes in lagoons. Even though creeks can experience deeper water levels than the lagoons during floods, these are short lived and water levels soon return to base flow conditions. Also creeks dry out less often than lagoons.

The slope of the edge of a water body can confound the effect of water regime. In some cases damming a lagoon has the effect of inundating areas that are steeper than the original lagoon edges. Also dam walls and levee banks are usually steep. Damming at Loch Abbra and North Llangothlin lagoons has caused steeper areas surrounding lagoons to be inundated. This may result in changes to species composition because increased slope reduces the space available in any particular range of water levels. If a species has a limited range of water depths where it can successfully compete it may be excluded as slope increases. In an experiment testing germination and establishment of wetland plants on different slopes, Sansom (1997) found that species richness was lower on slopes greater than 15 degrees. The levee banks in Mother of Ducks Lagoon Nature Reserve or the dam walls and some of the lagoon edges at North Llangothlin or Loch Abbra are close to this gradient.

8.2 Ecology of *J. articulatus* and *G. australis*

Study of the autecology of and interaction between *J. articulatus* and *G. australis* revealed that they co-exist via different responses to water regime and other environmental factors at several life cycle stages (Figure 1.1). Water regime significantly affects every stage of growth from germination to establishment, competitive interaction and reproduction. Several aspects of the growth and reproduction of *J. articulatus* and *G. australis* are similar. Both *G. australis* and *J. articulatus* have a similar growth form and size (Figure 1.2, Figure 1.3), have long lived soil seed banks and reproduce by stolons (Chapter 4). *J. articulatus* seeds continued to germinate from sediment for seven years and *G. australis* for 4 years after repeated annual wetting without replenishment of the seed bank (Figure 7.5). The seeds germinating represented only a small percentage of the seed bank of both species and both *J. articulatus* and *G. australis* germinated from the seed banks of lagoons where they were not found in the vegetation (Chapter 3, Chapter 7).

Brock and Casanova (1997) classified sixty species occurring in Racecourse and Llangothlin lagoons on the basis of germination from the seed bank, growth and reproduction in response to presence or absence of water. *G. australis* and *J. articulatus* were both classified as amphibious plants which tolerate fluctuations by being emergent (fluctuation-tolerators). Of the other common species at Mother of Ducks Lagoon reported in Chapter 6, *E. acuta* and *A. avenacea* also classified as fluctuation-tolerators while *M. variifolium* and *P. tricarinatus* were classified as amphibious species that responded to fluctuations in water level by changing growth pattern. These latter two species responded to water level variation more rapidly than the fluctuation-tolerators in the field experiment (Section 6.3.2).

Species in the fluctuation-tolerator group had similar germination, growth and reproduction in response to presence or absence of water (Brock and Casanova 1997). However, the closer examination in this thesis reveals more subtle differences between these two species in their germination from the seed bank, reproduction and growth in response to fluctuations in water level. Lavorel *et al.* (1997) proposed the use of a hierarchical system of functional classification. After initial general groupings based on growth form, separate classifications are based on a flexible pool

of characters that relate to species response to disturbance. The identification of which characters to include in such lower level analyses will benefit from examination of shared and contrasting traits in similar species such as *G. australis* and *J. articulatus*.

J. articulatus and *G. australis* both changed the allocation to shoots in response to the different proportions of time flooded, but *G. australis* always had a higher root / shoot ratio than *J. articulatus* (Chapter 4), indicating that root / shoot ratio may be good indicator of drought tolerance (Chapter 4 & Chapter 6; Lavorel *et al.* 1997). Similarly, differences in stolon and inflorescence production in response to the amplitude and frequency of water depth fluctuations (Chapter 4) may be useful characters for distinguishing between species. One of the greater differences between *G. australis* and *J. articulatus* is the difference in seed size and seed production (Chapter 5). Differences in seed size are surprisingly common in species that coexist (Westoby *et al.* 1996). Large seeds confer advantages but can only be produced in small numbers. However, the influence of the competitive advantage gained by seedlings from large seed size on vegetation composition is unclear (Westoby *et al.* 1992; Westoby *et al.* 1996).

Competition was important in the coexistence of *J. articulatus* and *G. australis* (Section 1.2, Figure 1.1, Chapter 5, Chapter 6). *J. articulatus* was a superior competitor to *G. australis* in the first season of growth, but *G. australis* was superior in the second season (Chapter 5) (Smith and Brock 1996). The outcome of competition was also dependent on water regime. *J. articulatus* was more competitive when flooded whereas *G. australis* was competitive under dry conditions. Given this competitive outcome, high seed production and a residual or persistent seed bank would be advantageous for *J. articulatus*. If *J. articulatus* was excluded in the longer term, it could regenerate from seed at the next germination event. The number of *J. articulatus* seeds germinating from the Mother of Ducks samples is very high compared to *G. australis* (Figure 7.3). The numbers of *J. articulatus* seeds germinating from Mother of Ducks were much higher than any other species that germinated from six sites, under both glasshouse and outdoor conditions (Britton and Brock 1994).

Rapid early growth has been shown to be a successful strategy in several pairs of species, allowing one species to shade the other (Barrat-Segretain 1996). *J. articulatus* had rapid early growth and was competitive for the first season. However, the biomass of *J. articulatus* was correlated with height (Figure 5.5) but not tiller number at early stages of growth. Such a growth pattern sacrifices height in early growth for the sake of tiller number. While this could be competitively disadvantageous, allowing other species to inhibit growth by shading, it avoids any limitation to seed production caused by insufficient tiller numbers (Watson 1984). It would be disadvantageous if water level fluctuations were large during the early stages of growth as plants would be more likely to be 'drowned'.

In contrast to *J. articulatus*, the biomass of *G. australis* was highly correlated with numbers of tillers that were of similar height (Figure 5.5). In this respect the growth of *G. australis* is less varied, although it is more responsive to changes in water levels (Figure 5.4). Germination of *G. australis* from the seed bank was more responsive to differences in water regimes than *J. articulatus* (Figure 7.4). The importance of the competitive switch between *G. australis* and *J. articulatus* in the second season will depend on how often disturbances occur. In more stable environments or where one species is more tolerant of environmental fluctuations, findings of early competitive superiority may be misleading.

A trait consistent with a species reliant on seed production is the maintenance of constant biomass allocation to inflorescences by *J. articulatus* despite differences in biomass caused by water regime (Figure 5.6). In contrast *G. australis* rarely produced large amounts of reproductive biomass in experiments. However, a large seed production year was observed at Mother of Ducks in summer 1992, evidenced by the large increase in germination from the seed bank in the 1993 trial (Figure 7.4).

These contrasting strategies exhibited by *G. australis* and *J. articulatus* are apparent in growth, reproductive and seed bank characteristics. This knowledge can be used to examine reasons for the dominance of *J. articulatus* at Mother of Ducks and likely effects of management actions on the species.

8.3 Management implications in New England lagoons and invasive of potential of *J. articulatus*

Some past management practices have contributed to the success of *J. articulatus* at the Mother of Ducks Lagoon. *J. articulatus* has a comparative advantage in areas which are grazed (Figures 5.6 & 5.7) and are disturbed frequently (wetter areas where cattle disturb the soil in the drained part of the lagoon and areas which are disturbed by birds within the nature reserve). Exclusion of cattle during wetter periods and limiting grazing to drier times, when feed is more valuable, would create less favourable conditions for *J. articulatus*.

In the drained part of the lagoon large areas are relatively dry and less disturbed, favouring *G. australis*. Areas in which *G. australis* is established are less likely to be invaded as this species produces large amounts of vegetative matter which inhibit germination and establishment, especially of smaller seeded species (Blinman 1993). The artificial watering regime of the golf course may have allowed the establishment of *J. articulatus* on adjacent areas of the lagoon by minimising drought conditions. This is consistent with *J. articulatus* being a problem in agricultural drains where drought conditions are also reduced. In the nature reserve water levels fluctuate more. This will favour *J. articulatus* over *G. australis*, but may favour other species such as *M. variifolium*, *P. tricarinatus* and *E. sphacelata* even more. The maximum depth of water levels within the levee bank at the nature reserve were greater than at other sites where *J. articulatus* and *G. australis* were found.

J. articulatus has not been as successful in other lagoons where cattle graze the edges, such as Llangothlin Lagoon. This can be related to a variety of factors. Broad factors common to most plant invasions are proximity to and intensity of human activity (Crawley *et al.* 1996). These fit very well with Mother of Ducks Lagoon (Brock *et al.* in press.). More specific site factors such as the peaty nature of the Mother of Ducks soil could increase the chances of successful establishment for the small seeded *J. articulatus*. The intensive use of the drained lagoon for cattle grazing provides a large area suitable for colonisation. Few of the other larger lagoons in the region have been drained to a similar extent as Mother of Ducks. In lagoons that have not been drained only small zones on the steeper edges have suitable water regimes and therefore much

more limited areas are available for recruitment. This may greatly influence the chances of successful establishment (Rea and Ganf 1994b).

The consistent allocation to inflorescence biomass by *J. articulatus* across different water regimes and under clipping (grazing), despite significantly different overall production (Figure 5.7), indicates a mechanism by which invasives such as *J. articulatus* could establish. Higher allocation to seed production under sub-optimal conditions and reduced germination under those same conditions, together with a long term persistent seed bank (Chapter 7) and germination of only a small percentage of the seed bank at any germination event would lead to a build up of numbers in the seed bank. Once a certain density has been reached, a change in environmental conditions (such as draining or damming) or even a chance event could lead to a rapid build up in seed numbers, as *J. articulatus* is capable of producing high densities of seed in a single season (Chapter 7). The probability of successful establishment events would be enhanced by an increase in suitable area such as occurred with the draining of Mother of Ducks Lagoon. Once established at high enough densities in the seed bank, seed numbers allow dominance over a wider range of environmental conditions due to the increased probability of germination and successful establishment. This will be enhanced by mechanisms such as lottery models or chance occurrence of species (Kazmierczak *et al.* 1995; Laurie and Cowling 1994; Zedler 1987) and eventually to reduced competition. Such a mechanism could also inhibit change for the reverse situation when reduction in numbers is the management aim. In the case of Mother of Ducks Nature Reserve, the response of vegetation communities to the restoration of variation in water levels carried out by the New South Wales National Parks and Wildlife Service in 1998 (Brock *et al.* in press.) will require a longer period than might be expected before there is a decrease in the abundance of *J. articulatus*.

8.4 Future research

Prior to this study there was little understanding of the ecology of *G. australis* and *J. articulatus*. This study has highlighted the variety of water regimes in the New England lagoons and life histories characteristics of two of the amphibious species that inhabit them. More research is also needed on the hydrology of the New England

lagoons. In this area modelling has the advantage that it can be used to simulate long term aspects of water regime for which data are not available. Also, work can begin with little data and can be improved as resources allow. The results on the coexistence of *J. articulatus* and *G. australis* suggest that investigation of more of the diverse group of amphibious species with which *G. australis* and *J. articulatus* commonly occur would be beneficial to understanding plant traits in coexisting species. The various growth forms, life history types and plant functional groups make this group of species ideal for comparative investigation. The unpredictability of the water regimes in the lagoons makes for a challenging and perhaps enlightening study of species coexistence in a variable environment.

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Appendix A

Program code used for lagoon depth simulation (Microsoft Quickbasic).

```

DECLARE SUB depth2vol (deep!, sarea!, vol!)
DECLARE SUB finddepth (deep!, sarea!, vol!)
DECLARE SUB evapmult (deep!, evaporation!)
REM Lagoon hydrology simulation model
REM This program simulates the water levels in the New England Lagoons.
OPEN "C:\data\lagoons\model\blggihyd.csv" FOR INPUT AS #1
OPEN "C:\data\lagoons\model\NTHLLAN.reg" FOR OUTPUT AS #3
REM as well as changing values and filenames here for a new lagoon,
REM the filenames in the two subs must be changed
catchment! = 76.73
mindepth! = 0
maxdepth! = 218
maxvol! = 1.5
depth! = 103
seepage! = 1.5
DO UNTIL EOF(1)
    INPUT #1, thedate$, rain!, runoff!, evap!, grain!
    depth! = depth! + rain! / 10 - seepage!
    evap! = evap! / 10

    CALL evapmult(depth!, evap!)
    REM PRINT depth!, evap!
    depth! = depth! - evap!

    IF depth! > maxdepth! THEN depth! = maxdepth!
    IF depth! < mindepth! THEN depth! = mindepth!

    CALL depth2vol(depth!, area!, volume!)
    REM PRINT depth!, area!, volume!

    catch! = catchment! - area!
    runin! = catch! * runoff!
    volume! = volume! + runin!
    IF volume! > maxvol! THEN volume! = maxvol!
    IF volume! < 0 THEN volume! = 0

    CALL finddepth(depth!, area!, volume!)
    REM PRINT depth!, area!, volume!

    IF depth! > maxdepth! THEN depth! = maxdepth!
    REM waterlevel! = depth! - 100
    PRINT depth!
    PRINT
    WRITE #3, thedate$, depth!, rain!, evap!, runin!
LOOP
RESET
END

SUB depth2vol (deep!, sarea!, vol!)
OPEN "C:\data\lagoons\model\NTHLLAN.csv" FOR INPUT AS #2
    WHILE deepness! < deep!
        INPUT #2, deepness!, sarea!, vol!
    WEND
CLOSE #2

```

END SUB

SUB evapmult (deep!, evaporation!)

OPEN "C:\data\lagoons\model\evapmult.csv" FOR INPUT AS #4

deeper! = deep!

IF deeper! > 150 THEN deeper! = 150

IF deeper! < 50 THEN deeper! = 50

WHILE depth! < deeper!

INPUT #4, depth!, multiplier!

WEND

evaporation! = evaporation! * multiplier!

CLOSE #4

END SUB

SUB finddepth (deep!, sarea!, vol!)

OPEN "C:\data\lagoons\model\NTHLLAN.csv" FOR INPUT AS #2

WHILE volume! < vol!

INPUT #2, deep!, sarea!, volume!

WEND

CLOSE #2

END SUB

Appendix B

Species referred to in this thesis and those recorded in the survey reported in Chapter 3. All species identified as per Harden (1990; 1991; 1992; 1993).

Family	Species
Amaranthaceae	<i>Alternanthera denticulata</i> R.Br.
Apiaceae	<i>Hydrocotyle</i> sp. <i>Hydrocotyle tripartita</i> R.Br. ex A. Rich. <i>Lilaeopsis polyantha</i> (Gand.) H. Eichler
Asteraceae	<i>Brachycome radicans</i> Steetz ex Lehm. <i>Centipeda minima</i> (L.) A. Braun & Asch. <i>Conyza bonariensis</i> (L.) Cronq. <i>Cotulla</i> sp. <i>Gnaphalium involucreatum</i> Forster f. <i>Gnaphalium americanum</i> Miller <i>Gnaphalium sphaericum</i> Willd. <i>Helichrysum rutidolepis</i> DC. <i>Hypochaeris</i> sp. <i>Lactuca</i> sp. <i>Pseudo-gnaphalium luteoalbum</i> (L.) Hilliard & B. L. Burt
Azollaceae	<i>Azolla filiculoides</i> Lam.
Brassicaceae	<i>Rorippa palustris</i> (L.) Besser
Campanulaceae	<i>Wahlenbergia</i> sp.
Caryophyllaceae	<i>Stellaria angustifolia</i> Hook.
Characeae	<i>Chara</i> sp.
Clusiaceae	<i>Hypericum japonicum</i> Thunb.
Convolvulaceae	<i>Dichondra</i> sp.
Crassulaceae	<i>Crassula helmsii</i> (Kirk) Cockayne
Cyperaceae	<i>Carex appressa</i> R. Br. <i>Carex chlorantha</i> R. Br. <i>Carex gaudichaudiana</i> Kunth. <i>Carex inversa</i> R.Br. <i>Carex</i> sp. <i>Carex tereticaulis</i> F.Muell. <i>Cynodon dactylon</i> (L.) Pers. <i>Cyperus eragrostis</i> Lam. <i>Cyperus sanguinolentus</i> Vahl. <i>Cyperus</i> sp. <i>Cyperus sphaeroideus</i> L. A. S. Johnson & O. D. Evans <i>Eleocharis acuta</i> R.Br. <i>Eleocharis dietrichiana</i> Boeck. <i>Eleocharis pusilla</i> R.Br. <i>Eleocharis sphacelata</i> R.Br. <i>Isolepis fluitans</i> (L.) R.Br. <i>Isolepis gaudichaudiana</i> Kunth

	<i>Lipocarpa microcephala</i> R.Br. (Kunth)
	<i>Schoenus apogon</i> Roem. & Schult.
Elatinaceae	<i>Elatine gratioloides</i> Cunn.
Fabaceae	<i>Medicago</i> sp
Fabaceae	<i>Trifolium glomeratum</i> L.
	<i>Trifolium repens</i> L.
Gentianaceae	<i>Centaurium spicatum</i> (L.) Fritsch
Geraniaceae	<i>Geranium</i> sp.
Goodeniaceae	<i>Goodenia</i> sp.
Haloragaceae	<i>Haloragis</i> sp.
	<i>Myriophyllum variifolium</i> Hook. f.
	<i>Myriophyllum pedunculatum</i> Hook.f.
Juncaceae	<i>Juncus articulatus</i> L.
	<i>Juncus bufonius</i> L.
	<i>Juncus holoschoenus</i> R.Br.
	<i>Juncus</i> sp.
Lentibulariaceae	<i>Utricularia australis</i> R.Br.
	<i>Utricularia dichotoma</i> Labill.
Lobeliaceae	<i>Isotoma fluviatilis</i> (R.Br.) F. Muell. ex Benth
Lythraceae	<i>Lythrum salicaria</i> L.
Malvaceae	<i>Modiola caroliniana</i> (L.) G. Don
Marsileaceae	<i>Marsilea mutica</i> D.L.Jones
Menyanthaceae	<i>Nymphoides geminata</i> (R.Br.) Kuntze
Musci	<i>moss spp</i>
Onagraceae	<i>Epilobium billardierianum</i> Ser.
Plantaginaceae	<i>Plantago</i> sp.
Poaceae	<i>Agrostis avenacea</i> J.F. Gmel.
	<i>Amphibromus sinuatus</i> Jacobs & Lapinpuro
	<i>Anthoxanthum odoratum</i> L.
	<i>Aristida</i> sp.
	<i>Briza minor</i> L.
	<i>Eragrostis</i> sp.
	<i>Eragrostis trachycarpa</i> (Benth.) Domin
	<i>Festuca</i> sp.
	<i>Glyceria australis</i> C.E. Hubb
	<i>Hemarthria uncinata</i>
	<i>Holcus lanatus</i> L.
	<i>Lolium perenne</i> L.
	<i>Microlaena stipoides</i> (Labill.) R.Br.
	<i>Panicum gilvum</i> Launert
	<i>Panicum obseptum</i> Trin.
	<i>Paspalum distichum</i> L.
	<i>Pennisetum</i> sp.
	<i>Poa pratensis</i> L.
	<i>Vulpia bromoides</i> (L.) Gray
	<i>Vulpia myuros</i> (L.) C. C. Gmel
Polygonaceae	<i>Acetosella vulgaris</i> Fourr.
	<i>Persicaria hydropiper</i> (L.) Spach
	<i>Persicaria lapathifolia</i> (L.) S.F. Gray
	<i>Persicaria prostrata</i> (R.Br.) Sojak

	<i>Polygonum arenastrum</i> Boreau
	<i>Rumex crispus</i> L.
	<i>Neopaxia australasica</i> (Hook. f.) O Nillson
Potamogetonaceae	<i>Potamogeton tricarinatus</i> F.Muell. & A.Benn. ex A.Benn
Ranunculaceae	<i>Ranunculus inundatus</i> R.Br. ex DC
	<i>Ranunculus</i> sp.
Rubiaceae	<i>Asperula conferta</i> Hook. f.
Scrophulariaceae	<i>Glossostigma</i> sp.
	<i>Gratiola peruviana</i> L.
	<i>Limosella australis</i> R.Br.
Verbenaceae	<i>Verbena bonariensis</i> L.
Violaceae	<i>Viola</i> sp.

Appendix C

Map sheets and grid references for the Lagoons referred to in this thesis.

Lagoon -	Map sheet - 1:100,000	Map sheet - 1:25,000	Grid reference 1:100,000
Elmwood	Guyra	Guyra	717582
Mother of Ducks	Guyra	Guyra	710545
Pinch (Ditton's, Little)	Guyra	Black Mountain	733488
Kyoma	Guyra	Guyra	763662
Loch Abbra	Guyra	Clevedon	876446
North Llangothlin	Guyra	Backwater	808762
Llangothlin	Guyra	Backwater	808735
Little Llangothlin	Guyra	Backwater	825708
Billy Bung	Guyra	Backwater	817704
Tubbamurra	Guyra	Backwater	798683
Abbey Green	Guyra	Backwater	834688
Wyanbah	Armidale	Armidale	677214
Barleyfield	Armidale	Gostwyck	589111
Dangars	Armidale	Uralla	565045
Racecourse	Bendemeer	Uralla	554054

Appendix D

Publications containing material from this thesis

