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Study upon the Wildlife Impact and Potential Economic Habitat Management Benefits of Introducing Asian Water Buffalo *Bubalus bubalis* into the Freshwater Ponds at Mai Po Nature Reserve (ECF Project 7/2005)

FINAL PROJECT REPORT : 2008



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[Cover photo: Water Buffalo "Siu Mai" inside Pond #24c. Photo by: Bena Smith]

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EXECUTIVE SUMMARY

- i In May 2006, WWF Hong Kong commenced an 18-month field-based pilot study to investigate the ecological impact and potential economic benefit of introducing Asian Water Buffalo into freshwater habitats at the Mai Po Nature Reserve (MPNR). The study was funded through the Environmental Conservation Fund and made possible with in-kind support from the Hong Kong Jockey Club, Kadoorie Farm and Botanical Gardens and the HKSAR Agriculture, Fisheries and Conservation Department.
- ii The study objectives were:
1. To investigate the impact of buffalo grazing upon the composition and structure of freshwater pond vegetation;
 2. To investigate the impact of buffalo grazing upon avifauna; and
 3. To undertake a comparison of the cost effectiveness of habitat management between buffalo and human methods.
- iii Three different management zones were established in the series of freshwater ponds at Pond #24 in southern MPNR. In the Grazed Zone (1.83 ha), grazing treatment was provided by a single water buffalo. Treatment in the Managed Zone (1.04 ha) was the normal WWF manual cutting of bund and bankside vegetation at an application rate of 2-3 times between April-October each year. A non-intervention approach was adopted in the Unmanaged Zone (1.26 ha). Field surveys were undertaken in each zone throughout the study period to generate comparative avifauna and vegetation data sets. Water-level measurements and fixed point photography sets were also taken on a regular basis.
- iv Three Indicators of Success were chosen:
1. The water buffalo is able to create a more diverse (a) grass sward structure and (b) plant composition in comparison to ungrazed and managed areas.
 2. The water buffalo is able to control^a the coverage of target^b grasses, e.g. Common Reed *Phragmites australis* and *Paspalum conjugatum* in areas where it grazes.
 3. The water buffalo is able to attract a greater number and diversity of birds in comparison to ungrazed and managed areas.
- (^a – ‘Control’ is defined as that achieved through normal WWF management practices
^b – Species considered problematic to conservation efforts because of their aggressive growth)
- v Bird data results showed a higher mean density of birds (= 19.3 individuals ha⁻¹) and mean bird species density (= 5.7 individuals ha⁻¹) in the Managed Zone. Mean density was 102.5% and 14.3% higher, and mean bird species density was 25.8% and 22.8% greater, in the Managed Zone compared to the Unmanaged and Grazed Zones. Bird density is shown to be statistically greater in both the Managed Zone and Grazed Zone compared to the Unmanaged Zone, whereas bird species density was statistically greater only in the Managed Zone when compared to the Unmanaged Zone. Bird composition was not significantly different between zones.
- vi Fifty-seven bird species were observed within the study area and period; the Grazed Zone attracted 46 of these, Managed Zone 40 and the Unmanaged Zone 36. Several species showed an affiliation to a particular zone or zones. Of interest is Great Egret *Casmerodius albus* in the Managed Zone, where it is speculated regular cutting maintained a more attractive foraging habitat along pond margins, and Scaly-breasted Munia *Lonchura punctulata* which benefited from increased fodder availability (grass seeds).

- vii Of the 3 target bird species for the Grazed Zone - Grey-headed Lapwing *Vanellus cinereus*, Cattle Egret *Bubulcus ibis* and Greater Painted Snipe *Rostratula benghalensis* – only Cattle Egret was present, but at a low abundance. Results suggest this species was slightly more associated with the Grazed Zone than others.
- viii Following the introduction of livestock, grazing maintained a shorter mean grass sward height compared to other treatments; mean grass height did not exceed ~30cm and remained below ~20cm during winter months. In contrast, mean grass height exceeded 70cm in the Managed Zone, however during winter months a mean height similar to the Grazed Zone was maintained (~20cm). The diversity of sward structure was considerably greater in actively managed zones (Grazed and Managed), but slightly more diverse in the Managed Zone.
- ix Data suggested that the buffalo created and maintained ~10% bare ground. Results imply that upon introduction, the buffalo rapidly reduced grass cover but then maintained a fairly constant cover throughout the study of ~47%. In the Managed Zone individual cutting events typically caused a short-term reduction in herb cover and increase in bare ground area. In the Unmanaged Zone bare ground was eventually eliminated in the absence of active management, but outright sward dominance by grasses was not observed within the study period.
- x The study did not find significant differences caused by treatment to the target grasses *Paspalum conjugatum* or *Phragmites australis* on bund areas. However the growth rate of *P. australis* stands located in centralised pond areas, was considerably less in the Grazed Zone than other zones within the initial 12-month period. This suggests the buffalo had a controlling effect on *P. australis*, but localised factors such as small variation in water depth may be responsible. The lateral growth rate (or spread) of grasses from bankside locations into open water areas did not differ significantly between treatments and was influenced predominantly by season.
- xi An economic comparison of project expenditure within this 18-month study showed grazing costs to be 30 times more expensive than manual cutting methods. However an economy of scale over a longer time period (i.e. 10 years) clearly favours grazing methods. Grazing also has intangible gains such as environmental and educational benefits.
- xii Within this study, the grazing pressure of 1 buffalo per 1.8 ha freshwater pond area did not create a shorter grass sward in winter months compared to manual methods and therefore the identified problem of unfavourable sward conditions for wintering Anatidae was not overcome. In this respect a slightly higher grazing pressure could be more effective on freshwater ponds i.e. 1 Livestock Unit (LSU) per 1.4ha.
- xiii The study provided valuable insight into the effects of buffalo grazing upon birds and vegetation at freshwater ponds and thus objectives no. 1 and no. 2 were considered achieved. Because benefits of each active management type to flora and avifauna are not distinguishable in this study, Objective no. 3 could only be completed if such benefits were considered equal. The study had limited achievement of the 3 chosen Indicators of Success. Indicators no. 1 and no. 2 concerning the buffalo's ability to control or diversify vegetation/plant types were deemed partially achieved either due to a lack of comparative data or unproven differences to both treatments. Indicator no. 3 was marginally achieved because bird data did not reveal significant differences between the stated attributes.
- xiv Further research study upon buffalo as a potential management tool for the conservation and enhancement of freshwater ponds is recommended including experimentation using a variety of LSU rates, larger pond areas, seasonal grazing, and a combination of cutting with grazing (aftermath grazing). To better understand the ecological requirements of the target bird species, a baseline survey to quantify the general conditions at Kam Tin would be useful. Within the existing study area it is recommended to continue grazing with a reduced monitoring effort to investigate longer-term bird and vegetation trends.

1. INTRODUCTION

1.1 Background

- 1.1.1 In the mid-1990s, WWF Hong Kong converted a number of commercially operated fishponds to rain-fed freshwater ponds in the southern portion of Mai Po Nature Reserve (MPNR). To date three main series of freshwater ponds are established; 6 sub-ponds at Pond #20, 8 sub-ponds at Pond #24, and 4 in close proximity to the WWF Education Centre.
- 1.1.2 Following their conversion, the ponds became favoured roost areas for wintering waterbirds inside the Reserve attracting over 6,000 Anatidae (12-Jan-07 : WWF-HK, 2007) and provide important habitat to freshwater biodiversity, in particular odonates and amphibians. Their success is attributed to a combination of factors; vegetation management and control, water-level management, water quality maintenance, predatory fish control measures and their location.
- 1.1.3 Of these factors, the control of tall vegetation (particularly grasses) growing along bunds and pond margins is both time consuming and a heavy burden on management resources each year. This type of vegetation if left unchecked tends to dominate and create unfavourable conditions for roosting and foraging Ardeids and Anatidae in winter. The grass *Paspalum conjugatum* is considered a problematic species due to its aggressive growth and apparent unpalatable taste to Anatidae (Dr. Lew Young, pers. comm.). The amount of open water habitat available to waterbirds can also be reduced through unwanted encroachment of margin vegetation into centralised pond areas and an eventual choking of the waterbody. Common Reed *Phragmites australis* is notorious for this.
- 1.1.4 Some 90 man-days (2004/2005 management year data) are required to carry out a single cut-and-clearance of these vegetation types in the series of freshwater ponds at #20 and #24. Seasonal staff and contractors are often employed to operate backpack grasscutters and rake cuttings. Hand removal and herbicide spraying (Glyphosphate) is also employed on a needs basis to control encroachment of interior and bankside vegetation. The typical management cycle for bund vegetation at these freshwater ponds is :
- November – April:** No cutting.
May – August: Single cut during the May/June period and another in the July/August period (resource dependant).
September – October: Single cut.
- 1.1.5 In any given management year substantial vegetation growth often occurs after the October cut and by mid-winter when peak numbers of Anatidae are present in Deep Bay, vegetation is structurally unfavourable. To avoid disturbance to these birds no additional cutting is carried out between November to April. In addition, regular cutting is purported to create a homogenous sward structure along the bunds which is believed to support lower invertebrate species diversity and reduce plant diversity in the longer-term.
- 1.1.6 The conservation management of freshwater vegetation is under-researched in the region with most prescriptions based on field observations. Related Hong Kong reports include field trials on wetland compensation methods (Anon, 2004), and a study of Anatidae response to vegetation cutting (WWF-HK, 2006). Burning was a common control practice employed by fish pond operators; however this method is now considered unacceptable and prohibited.
- 1.1.7 Overseas conservation experience has shown that ecological and management benefits (including the control of vegetation) can be brought to freshwater habitat ecosystems through the introduction of large herbivores (van Wieren, 1991; Ausden & Treweek, 1995). Certain breeds of hardy livestock are known to create an uneven sward of short and tall vegetation,

and poach ground to produce a diversity of wetland micro-habitats beneficial to a greater variety of wildlife.

- 1.1.8 Livestock grazing for conservation gain is not common practice in Hong Kong. However locally, grazing animals are found in a number of important bird sites. One of the best known is the now abandoned wet agricultural fields at Kam Tin (near Yuen Long, N.T.) that supports around 30 feral Water Buffalo. The fields are the main wintering-site for Grey-headed Lapwing *Vanellus cinereus* in Hong Kong (Carey *et al.* 2001) and support other waterbirds of note including Cattle Egret *Bubulcus ibis* and the declining Greater Painted Snipe *Rostratula benghalensis*. At that site, the buffalo herd maintain a fairly open landscape by consuming and trampling scrubby and rank vegetation.
- 1.1.9 Based upon the management requirements of freshwater ponds at MPNR, international knowledge, and local experience, Water Buffalo clearly has potential to bring a range of benefits to the Nature Reserve and WWF. The level of grazing pressure is a critical factor to determine the scale of impact upon wildlife; too low and no effect is observed, too high and a site can quickly lose its conservation value. European studies show that optimum bird numbers are supported at a LSU (Livestock Units) range of 1.4-1.6 ha⁻¹ in saltmarsh habitat. Another study on a coastal grassland showed that a LSU of 2.5 ha⁻¹ provided suitable habitat for wintering waterfowl (van Wieren, 1991). Due to a lack of knowledge in this field on a local/regional scale, and uncertainty over the appropriate LSU rate for freshwater pond habitat, a cautious approach is taken in this study.

1.2 Study Objectives

- 1.2.1
1. To investigate the impact of buffalo grazing upon the composition and structure of freshwater pond vegetation;
 2. To investigate the impact of buffalo grazing upon avifauna; and
 3. To undertake a comparison of the cost effectiveness of habitat management between buffalo and human methods.

1.3 Approach

- 1.3.1 The project operated four work phases:
- *Phase I.* Site preparation works:
 - (1) Infrastructure construction - a 510m livestock fence and simple wooden buffalo shelter (Appendix VI – Infrastructure Photographs).
 - (2) Mark out and set survey post markers.
 - *Phase II.* Commencement of field survey work:
 - (1) Collect avifauna, water-level and vegetation data.
 - (2) Photographic sets of the study area from fixed locations.
 - *Phase III.* Application of treatment methods:
 - (1) Cut vegetation along pond bund and bankside areas according to the typical WWF management prescription (para 1.1.4).
 - (2) Introduction of a single buffalo.
 - *Phase IV.* Production of a Final Project Report.

2. METHODS

2.1 Study Area

2.1.1 The series of freshwater sub-ponds at Pond #24 was selected to (1) provide livestock with an all-year-round source of natural fodder and drinking water, and (2) provide an undisturbed area to facilitate avifauna surveys. Concern over potential disturbance to large numbers of wintering waterbirds in Pond #20 led to its deselection.

2.2 Zonation

2.2.1 To survey different treatments, Sub-ponds #24c and #24e were divided into 3 surveying zones (Fig. 1). Each zone contained an open water area surrounded by a 'U' shaped length of bund. The 3 zones ranged in area from 1.04-1.83 ha and total bund length in each zone ranged between 286-414m (Table 1). Their environmental and physical attributes - aspect, vegetation type and slope - and previous management history are generally similar. The proportion of internal habitat types within each zone was also similar; ~15% bund area, ~20% stand of Common Reed *P. australis*, and ~65% open water.

Figure 1. Study area – Location, zones, transect locations, and photography points.

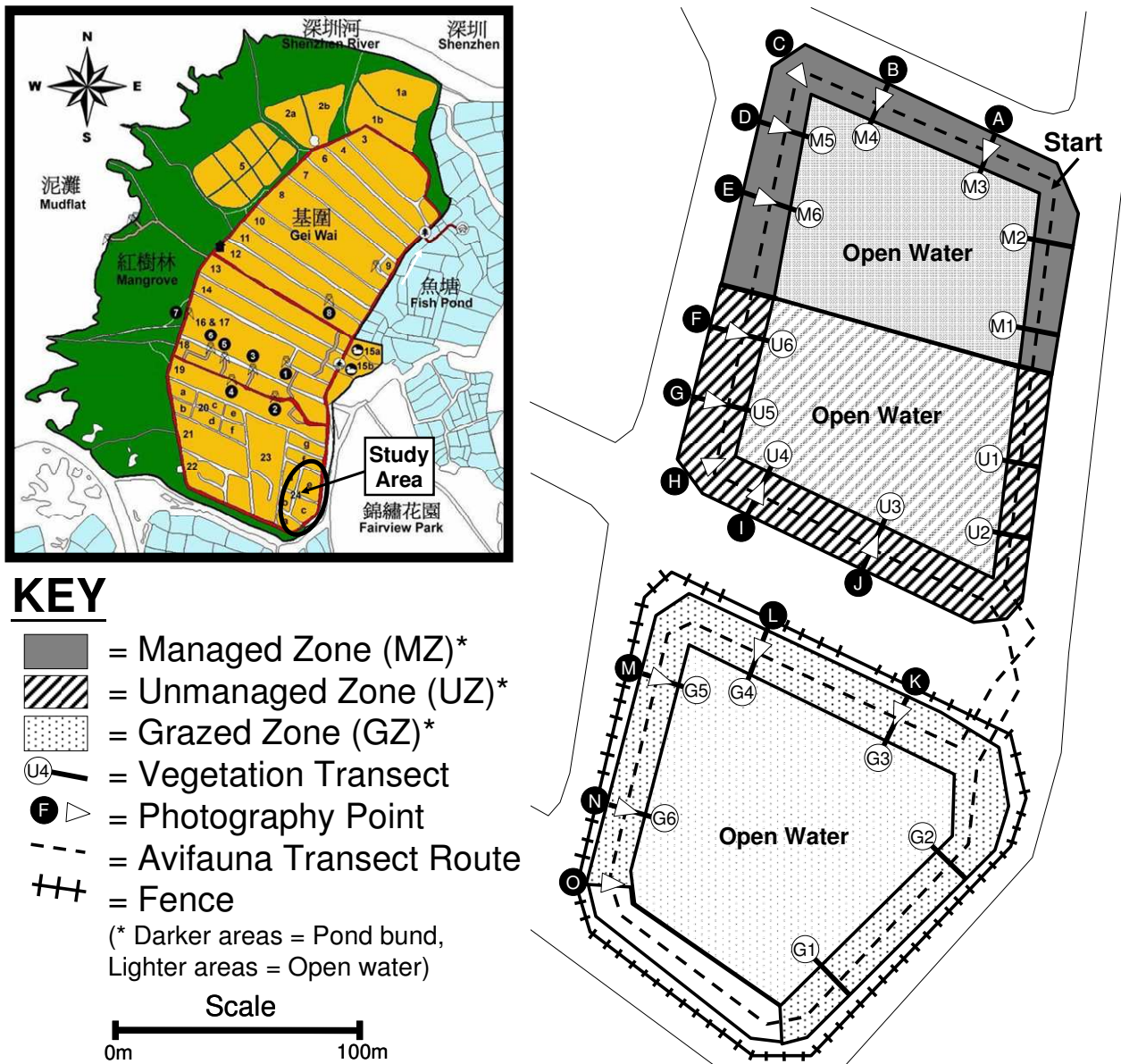


Table 1. Areas and lengths within the study site.

Zone	Area	Bund Length
Grazed (GZ)	1.83 ha	414 m
Managed (MZ)	1.04 ha	286 m
Unmanaged (UZ)	1.26 ha	307 m
All	4.13 ha	1007 m

2.3 Treatment Methods

2.3.1 *Grazed Zone (GZ)*. A 535m perimeter livestock fence was constructed around Sub-pond #24c to enclose the 1.83ha zone, and a female buffalo introduced on 09 May 2006. The buffalo generally roamed freely within the zone but was tethered on occasion (health checks, fence repairs, etc.).

Managed Zone (MZ). Vegetation was cut to ground level on the bund and margin areas according to the normal WWF cutting regime (para 1.1.4). Treatments dates were: (1) 20-23 April 2006, (2) 10-14 July 2006, (3) 30-31 October 2006, (4) 25-30 April 2007, and (5) 10-12 September 2007. The majority of emergent bankside vegetation away from the bund edge could not be cut due to inaccessibility and presence of deep water. Within the study period no internal vegetation in open water areas of the Managed zone received management as it was not deemed necessary.

Unmanaged Zone (UZ). A non-intervention zone with no active management throughout the study period.

2.4 Water-level Measurements

2.4.1 Two wooden gauge boards were installed - one in Sub-pond #24c and one in Sub-pond #24e - and water-level readings taken twice monthly. A small connecting ditch linked the zones during periods of high water.

2.5 Avifauna Counts

2.5.1 Birds in each zone were counted and identified to species level twice each month using a fixed transect route through the study area (Figure 1). A count consisted of the combined bird observations from a morning transect and an evening transect walk. Morning transects being conducted in the 60-120 minute period after sunrise, and evening transects in the period between 120-60 minutes before sunset. These are active foraging periods for birds.

2.6 Vegetation Surveys

Transect

2.6.1 Within each zone 6 random belt transects were located along bund lengths then marked with wooden posts to survey vegetation (Figure 1). Each transect was aligned perpendicular to the bund length to include both bund and bankside vegetation. The first survey was carried out at the very beginning of May 2006 (prior to treatment) and thereafter repeated every 2 months throughout the study period. Surveys employed conventional 1m x 1m quadrats placed at 2m intervals along each transect and recorded:

- Ground cover of plant species/bare ground using Domin scale categories within each quadrat.
- Three grass height readings from each of the first 2 quadrats along individual transects.

- 2.6.2 To assess the extent of grass encroachment (or spread) from bankside areas into open water habitat, measurements were taken of the lateral distance between the furthest living grass plant and the transect start marker post along each belt transect every 2 months.

Phragmites australis

- 2.6.3 Four permanent marker posts were placed at the terminus of large stands of the target species Common Reed *P. australis* in centralised areas of each of the three survey zones in May 2006 and a distance measurement taken of stand growth (encroachment) beyond each marker at the 12-month stage of the study.

2.7 Habitat Condition

- 2.7.1 A visual record of the general habitat condition within each zone was kept by taking a set of 15 photographs from fixed locations prior to treatment application and thereafter every 2 months throughout the study period. Fixed locations included 4 of the transect markers from each zone and one pond corner location to provide a panorama into each zone (Fig. 1).

2.8 Project Expenditure Tracking

- 2.8.1 An accurate record of all capital and revenue project expenditure was kept throughout the project and assigned to a particular treatment method. This included the actual cost of items/services donated to the project.

2.9 Indicators of Success

- 2.9.1
1. The water buffalo is able to create a more diverse (a) grass sward structure and (b) plant composition in comparison to ungrazed and managed areas.
 2. The water buffalo is able to control^a the coverage of target grasses, e.g. Common Reed *Phragmites australis* and *Paspalum conjugatum* in areas where it grazes.
 3. The water buffalo is able to attract a greater number and diversity of birds in comparison to ungrazed and managed areas.

(^a – ‘Control’ is defined as that achieved through normal WWF management practices)

2.10 Statistical Analysis

- 2.10.1 *Bird Species Composition/Vegetation Composition*
- Unconstrained non-metric multidimensional scaling (nMDS) was used to visualise overall dispersion and potential differences between and within each of the 3 treated zones.
 - One-way ANOSIM (Analysis of Similarities) was used to test the null hypothesis that bird species composition and vegetation species composition did not differ between treated zones. Pair-wise tests were carried out to compare specific pairs of sampling units when the global ANOSIM test for overall differences between sampling units showed significant results. The significance of similarities was tested by the *R*-statistic (Clarke, 1993). The SIMPER (Similarity Percentage) procedure was employed where necessary to identify important species contributing to the differences within and between sampling units using Bray-Curtis dissimilarities (PRIMER v6, Clarke & Gorley, 2001).

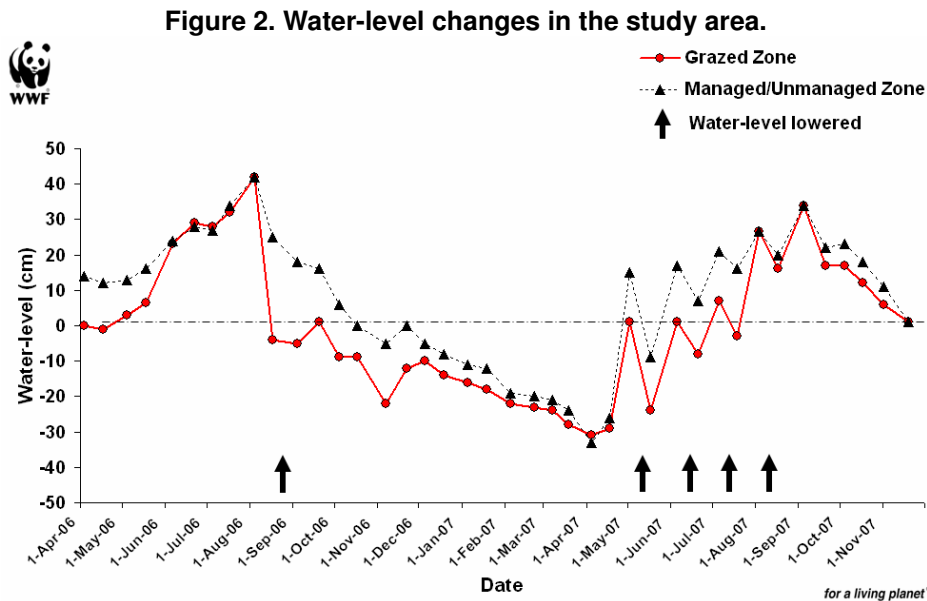
Bird Density and Bird Species Density

- Non-parametric Friedman's Repeated Measures Analysis of Variance (RM ANOVA) on Ranks, with time as a repeated factor, was used to test the null hypothesis that bird density or bird species density did not differ between treated zones. To isolate the group or groups that differ from the others, Dunn's multiple comparison procedure was then used to pairwise compare the differences. All statistical procedures were carried out using SigmaStat 3.0 statistical software and the significance level of $p < 0.05$ was adopted (Zar, 1999).

3. RESULTS

3.1 Water-levels

3.1.1 Water-levels varied by 75cm throughout the study period, being lowest prior to commencement of the wet season (April) and greatest in the latter half of the wet season (August/September) (Figure 2 and Appendix I). On 5 occasions water-levels had to be manipulated to prevent submersion of bund areas and as a precautionary measure to prevent livestock escape. Generally, MZ/UZ (Sub-pond #24e) retained water better than GZ (Sub-pond #24c), but levels remained similar throughout.



3.2 Avifauna

Bird Density

3.2.1 Generally, the highest bird densities occurred during winter months in all zones (Fig. 3) with peak counts for GZ (= 187.2/ha) and UZ (= 29.3/ha), both recorded in January 2007. Within MZ, the peak count (67.3 ha⁻¹) occurred in 04-Apr-07 and 03-Aug-07. The highest mean bird density was recorded in MZ (= 19.3 ha⁻¹) (Table 2), being 102.5% and 14.3% greater than UZ and GZ respectively. Of the 10 peak densities, 8 (80%) are recorded from MZ; these mostly occurred prior to treatment dates. [Raw avifauna data set in Appendix II]

3.2.2 The RM ANOVA on Ranks and Dunn's pairwise comparison showed significant differences in median values of bird density between MZ vs UZ, and GZ vs UZ greater than would be expected by chance (Table 3).

Table 2. Summary of bird count data per zone.

	Grazed	Managed	Unmanaged
Bird density (/ha)	Mean = 16.9 S.E = ±4.5	Mean = 19.3 S.E = ±2.6	Mean = 9.5 S.E = ±0.9
Species density (/ha)	Mean = 4.6 S.E = ±0.3	Mean = 5.7 S.E = ±0.4	Mean = 4.5 S.E = ±0.3
Cumulative no. of species recorded	46	40	36

Bird Species Density

- 3.2.3 Similar to bird density, bird species densities were generally higher in winter months across all zones (Fig. 4). The highest mean species density ($= 5.7 \text{ ha}^{-1}$) was associated with MZ; being 25.8% and 22.8% greater than UZ and GZ respectively (Table 2).
- 3.2.4 The RM ANOVA on Ranks and Dunn's pairwise comparison showed significant differences in median values of bird species density between MZ vs UZ greater than would be expected by chance (Table 4).

Bird Species/Composition

- 3.2.5 A total of 57 bird species were observed within the study area. GZ attracted the highest cumulative number of species (Table 2). The most commonly recorded species in all zones throughout the study period (Table 5 and Fig. 5) are waterbird and terrestrial species abundant in the Deep Bay area. Of the target species only Cattle Egret *B. ibis* was present being recorded from GZ and UZ (Fig. 5) with no more than 2 individuals recorded during any single count.

Table 3. RM ANOVA on ranks (Friedman) and pairwise multiple comparison (Dunn's Method) for bird density.

Zone	n	Median	25%	75%	Pairwise Tests - Groups	Diff of Ranks	Q	p < 0.05
Grazed	40	10.339	7.662	15.325	Grazed vs Managed	0.075	0.335	No
Managed	40	12.496	8.171	27.396	Managed vs Unmanaged	0.675	3.019	Yes
Unmanaged	40	7.909	5.932	11.468	Unmanaged vs Grazed	0.600	2.683	Yes

Chi-square= 10.950 with 2 degrees of freedom. ($p = 0.004$)

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Table 4. RM ANOVA on ranks (Friedman) and pairwise multiple comparison (Dunn's Method) for bird species density.

Zone	n	Median	25%	75%	Pairwise Tests - Zones	Diff of Ranks	Q	p < 0.05
Grazed	40	4.379	3.284	5.473	Grazed vs Managed	0.350	1.565	No
Managed	40	5.768	3.845	7.209	Managed vs Unmanaged	0.625	2.795	Yes
Unmanaged	40	3.954	3.164	5.536	Unmanaged vs Grazed	0.275	1.230	No

Chi-square= 7.850 with 2 degrees of freedom. ($p = 0.020$)

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Table 5. Ranked species density for the five most commonly recorded bird species per zone.

Species	Grazed	Managed	Unmanaged
Chinese Bulbul <i>Pycnonotus sinensis</i>	1 (1.68)	-	-
Yellow-bellied Prinia <i>Prinia flaviventris</i>	2 (1.41)	5 (1.08)	1 (1.29)
Scaly-breasted Munia <i>Lonchura punctulata</i>	3 (1.31)	1 (8.15)	2 (1.19)
Plain Prinia <i>Prinia inornata</i>	4 (1.19)	2 (1.59)	-
White-breasted Waterhen <i>Amaurornis phoenicurus</i>	5 (0.97)	4 (1.44)	5 (0.63)
Common Moorhen <i>Gallinula chloropus</i>	-	-	4 (0.69)
Tufted Duck <i>Aythya fuligula</i>	-	3 (1.51)	3 (0.87)

[Mean density - ha^{-1} - in parentheses]

Figure 3. Graphs showing changes in bird density and bird species density.

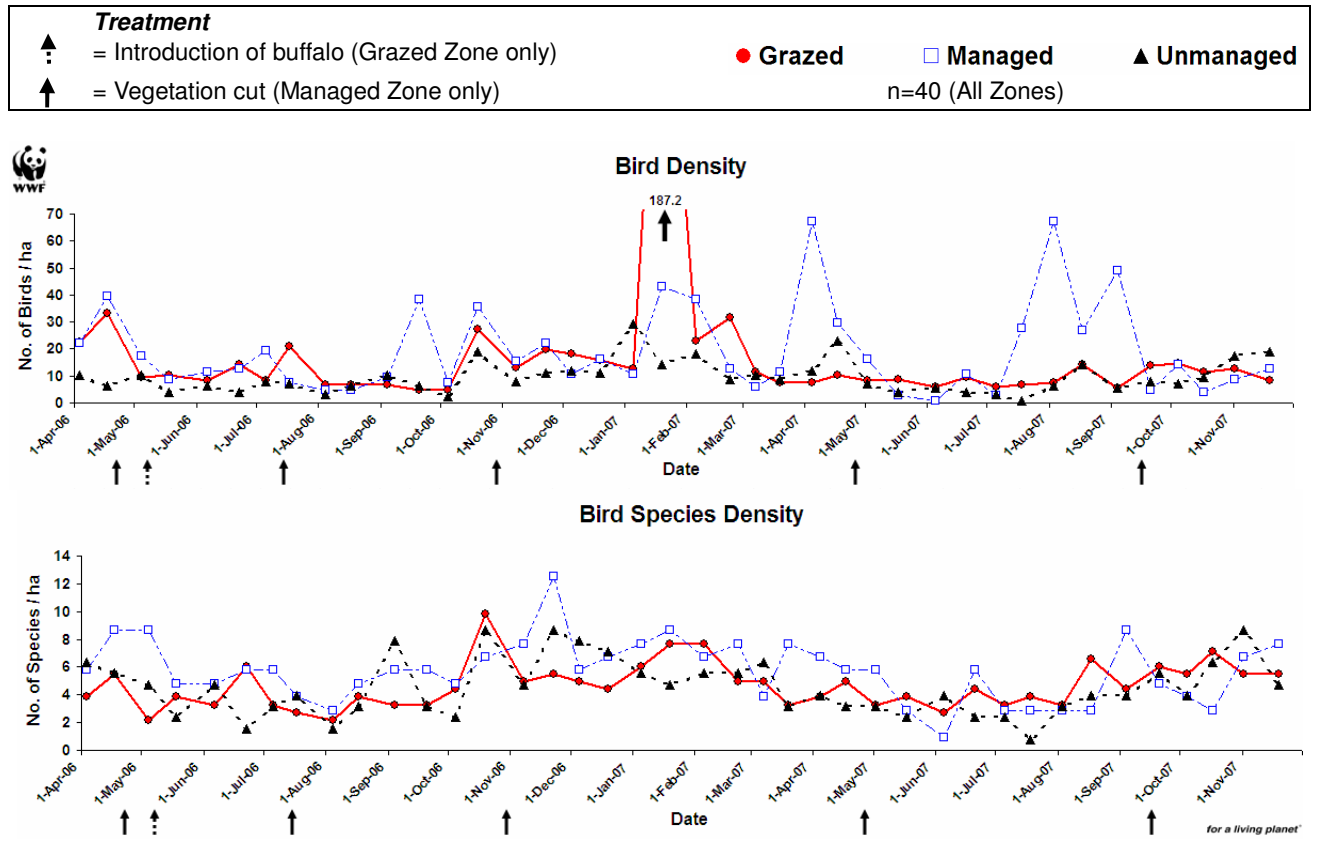
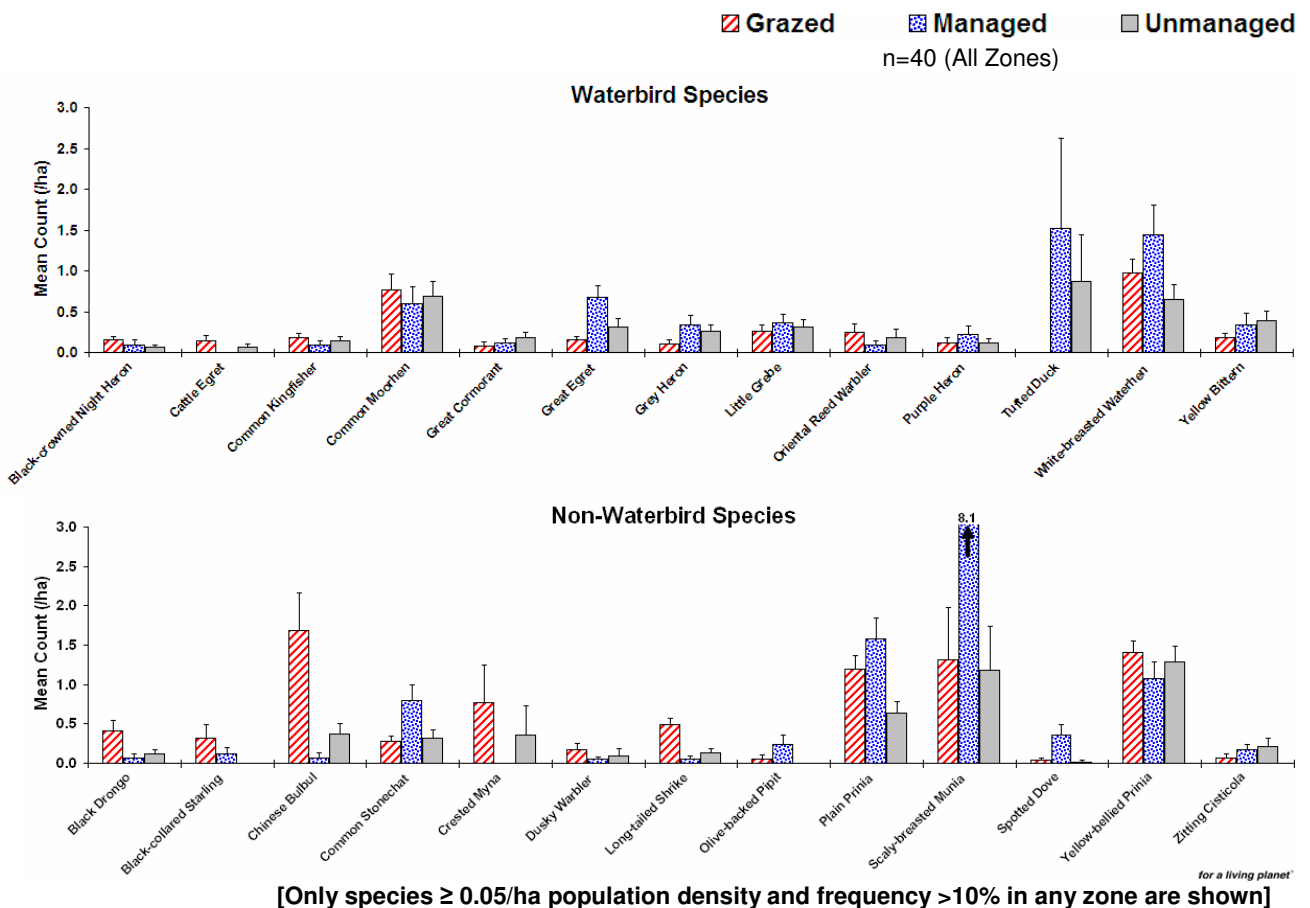


Figure 4. Graphs showing differences in bird density for selected species.



- 3.2.6 Single species flocks generally accounted for the majority of observed peak density counts within each zone. These included (peak count in parentheses):
- GZ: Red-billed Starling *Sturnus sericeus* (310), Scaly-breasted Munia *Lonchura punctulata* (44) & Crested Myna *Acridotheres cristatellus* (32),
 - MZ: Scaly-breasted Munia *L. punctulata* (64) & Tufted Duck *Aythya fuligula* (32),
 - UZ: Tufted Duck *A. fuligula* (26), Scaly-breasted Munia *L. punctulata* (22) & Crested Myna *A. cristatellus* (18).
- 3.2.7 Bird species showing an association to a particular treatment or treatment methods (based on differences in the Standard Error of Mean – Fig 4.) include :
- GZ: Black Drongo *Dicrurus macrocercus*, Chinese Bulbul *Pycnonotus sinensis* & Long-tailed Shrike *Lanius schach*,
 - MZ: Great Egret *Casmerodius albus*, Common Stonechat *Saxicola torquata*, Scaly-breasted Munia *Lonchura punctulata* & Spotted Dove *Streptopelia chinensis*,
 - GZ/MZ: Plain Prinia *Prinia inornata* & Black-collared Starling *Sturnus nigricollis*.
- 3.2.8 A nMDS plot of bird species composition does not show any clear separation between treatments (Fig. 5); the stress value of the nMDS plot was > 0.2. A cluster analysis similarly showed no clear separation. ANOSIM revealed a significant overall difference between treatments (Table 6), however, R values were low (<0.3) which agrees with the unclear separation in the nMDS plots.

Figure 5. Unconstrained non-metric multidimensional scaling (nMDS) of bird species composition between treated zones.

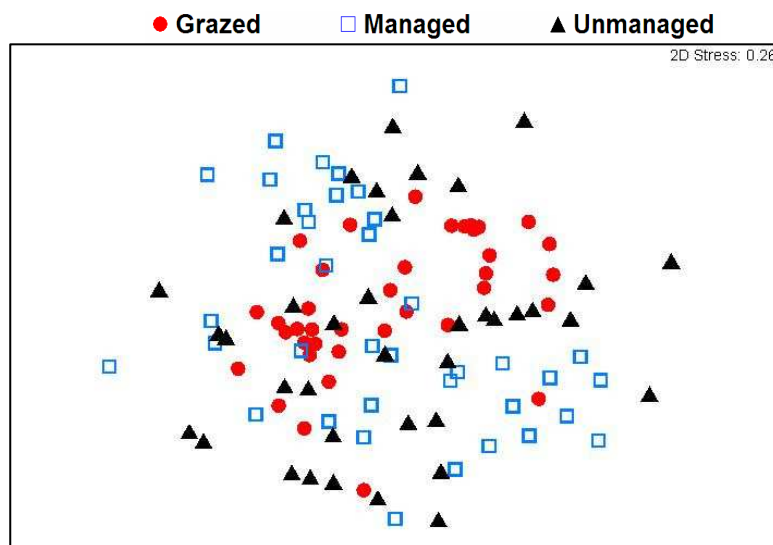


Table 6. ANOSIM results - Bird species composition.

Factors	R	p	Pairwise Tests - Groups	R	p
Treatment	0.117	0.001	Grazed vs Managed	0.195	0.001
			Managed vs Unmanaged	0.075	0.003
			Unmanaged vs Grazed	0.090	0.003

3.3 Vegetation

Grass Structure (Bund areas)

- 3.3.1 Mean bund grass height generally peaked during the warmer wet season months, the maximum being over 70cm from UZ (July-2007) (Fig. 6). In GZ, treatment reduced mean

height by 25.8% within 2 months, 50.5% after 12 months and varied between 14.3-30.2cm (mean = 19.8cm) following treatment. In MZ grass height ranged between 7.0-71.8cm (mean = 30.8cm) with individual applications of treatment impacting upon height readings in the following survey. In UZ grass height ranged between 33.9-60.3cm (mean = 46.3cm) and had increased by 46.4% after 12 months. [Raw data in Appendix III]

- 3.3.2 A greater variation in grass height was observed in MZ (Mean Coefficient of Variation = 100.3%) and GZ (Mean Coefficient of Variation = 91.2%) from data sets after treatment commenced (Table 7). Both show considerably more variation than UZ.

Table 7. Summary of bund grass height data per zone after treatment commenced.

Zone	Mean (cm)	Mean CV ¹ (%)
Grazed	19.8	91.2%
Managed	30.8	100.3%
Unmanaged	46.3	47.0%

Raw data in Appendix III

¹ – Mean Coefficient of Variation calculated from individual survey sets

Bankside Grass Encroachment

- 3.3.3 The spread of bankside grass vegetation was predominantly affected by season (Fig. 6), i.e. extension in the wet season and retraction in the cooler dry season. In general, all 3 zones witnessed a decrease in length throughout the study period. [Raw data in Appendix IV]

Vegetation Cover

- 3.3.4 Grasses dominated the bund and bankside cover accounting for 60.7% of the 18-month data set. Mean cover throughout the study was similar between GZ (48.8%) and MZ (47.0%), but notably greater in UZ (62.6%) (Fig. 7). Herbs accounted for 8.4% of the study data set, sedges 4.7% and generally their cover remained stable through the study period (Fig. 7). Results suggest treatment in Nov-06 and May-07 caused a temporary reduction in herb cover. Bare ground cover was more extensive in GZ and MZ than UZ (Fig. 7). Results suggest the treatment in GZ created and maintained a small area of bare ground (<10%) especially in winter months. Treatment (Nov-06 and May-07) in MZ appeared to temporarily increase bare ground cover. [Full data set in Appendix V]

Plant Species/Composition

- 3.3.5 Within the 18-month study period a total of 8 grass species, 21 herbaceous species and 2 sedge species were recorded. Change in the total number of species recorded between surveys was greatest in MZ (Fig. 8) where treatment caused a temporary reduction in the number recorded. Over the course of the the study period there was no obvious net change to the number of species in GZ, but in UZ the results mildly suggest a gradual loss of species diversity.
- 3.3.6 The nMDS plot of species composition shows a clear separation between treatments (Fig. 9); the stress value was <0.1 which is acceptable (Clarke & Gorley, 2001). ANOSIM showed significant overall differences between treatments (Table 8), and high R values agree with the clear separation in the nMDS plots. Three distinct groupings are apparent. Results of the one-way SIMPER show large differences in plant species composition between treatments (Table 9). In GZ, the dominant species included *Paspalum paspoides*, *Paspalum orbiculare* and *Eliocharis* sp.. In MZ, the dominant species were *P. paspoides*, *Leersia hexandra* and *Panicum maximum*, whereas in UZ, *P. repens*, *P. paspoides* and *P. orbiculare* were abundant. There were many species present in the study area hence the mean cover of the more abundant species is low.

- 3.3.7 These separations in the composition of vegetation between zones may be due to natural differences at the start of the study. This limits data inference and the validity of comparisons between treatments. Under such conditions, results should be interpreted with caution.

Table 8. ANOSIM results - Plant species composition.

Factors	R	p	Pairwise Tests - Zones	R	p
Treatment	0.982	0.001	Grazed vs Managed	0.999	0.001
			Managed vs Unmanaged	0.999	0.001
			Unmanaged vs Grazed	1.000	0.001

Table 9. One-way SIMPER - Species contribution to treatment zones.

Species	Mean Cover (%)	% Contribution to Vegetation Similarity Within Zone	Cumulative % Contribution to Vegetation Similarity Within Zone
Grazed Zone			
<i>Paspalum pasploides</i>	5.9	22.8	22.8
<i>Paspalum orbiculare</i>	4.5	17.6	40.4
<i>Eliocharis sp.</i>	4.0	14.9	55.3
Managed Zone			
<i>Paspalum pasploides</i>	6.5	29.0	29.0
<i>Leersia hexandra</i>	4.3	16.9	45.9
<i>Panicum maximum</i>	2.7	10.0	55.9
Unmanaged Zone			
<i>Panicum repens</i>	6.4	26.3	26.3
<i>Paspalum pasploides</i>	4.9	19.9	46.1
<i>Paspalum orbiculare</i>	2.9	11.2	57.4

(only species with cumulative % contribution to vegetation similarity \geq 50% are included)

Target Plant Species

- 3.3.8 The cover of *Paspalum conjugatum* generally increased in all zones within the study period, being more abundant in the second wet season period (May-07 to Sep-07) than the first (Fig. 10). No clear trend was observed within the study period.
- 3.3.9 *Phragmites australis* was present in low abundance in the belt transects within all 3 zones (Appendix V). Cover showed no significant trend differences between UZ and GZ (Fig. 10). Within MZ transects, *P. australis* became established from May-06 onwards. Stand growth measurements from the four permanent marker posts showed that the centralised stands of *P. australis* had increased the least inside GZ (Table 10).

Table 10. *Phragmites australis* stand growth measurements (cm).

Zone	Mean Growth	s.d	n
Grazed	5.8	3.8	4
Managed	69.5	13.9	4
Unmanaged	26.0	19.3	4

3.4 Habitat Condition

- 3.4.1 Photographic sets from the fixed marker posts clearly show the general impact of each treatment upon habitat condition. A selection of images from 2 markers in each zone is presented in Appendix VII (full photographic sets from the study are available on the Project CDrom).

3.5 Economic Comparison of Treatment Methods

3.5.1 Over the 18-month study period, project costs were approximately 30 times greater to complete the necessary management in GZ compared to MZ (Table 11). A substantial proportion (70%) of the total GZ costs is however infrastructure related.

Table 11. Management costs associated with the Grazed and Managed Zones.

Project Stage	Grazed Zone (1.83 ha)		Managed Zone (1.04 ha)	
Setting up	Buffalo (x 1)	\$1,000*	Grass cutter	\$2,000
	Sterilisation (x 1)	\$2,000*		
	Micro chip (x 1)	\$50*		
	Transportation	\$1,000*		
	Fence materials	\$59,000		
	Shelter materials	\$5,000		
	Construction labour	\$40,000		
	Sub-total	\$107,050		\$2,000
Operation	Husbandry (daily)	\$37,000	Labour (x 4)	\$2,100
	Veterinary animal check-up (x 3)	\$4,500*	Fuel (x 4)	\$500
	Repair - materials	\$500	Parts	\$200
	Repair - labour	\$2,000		
	Sub-total	\$45,000		\$2,800
TOTAL	\$152,050		\$4,800	

* - Items donated to the project, but included in the TOTAL

Figure 6. Graphs showing changes in grass height and grass encroachment along transects.

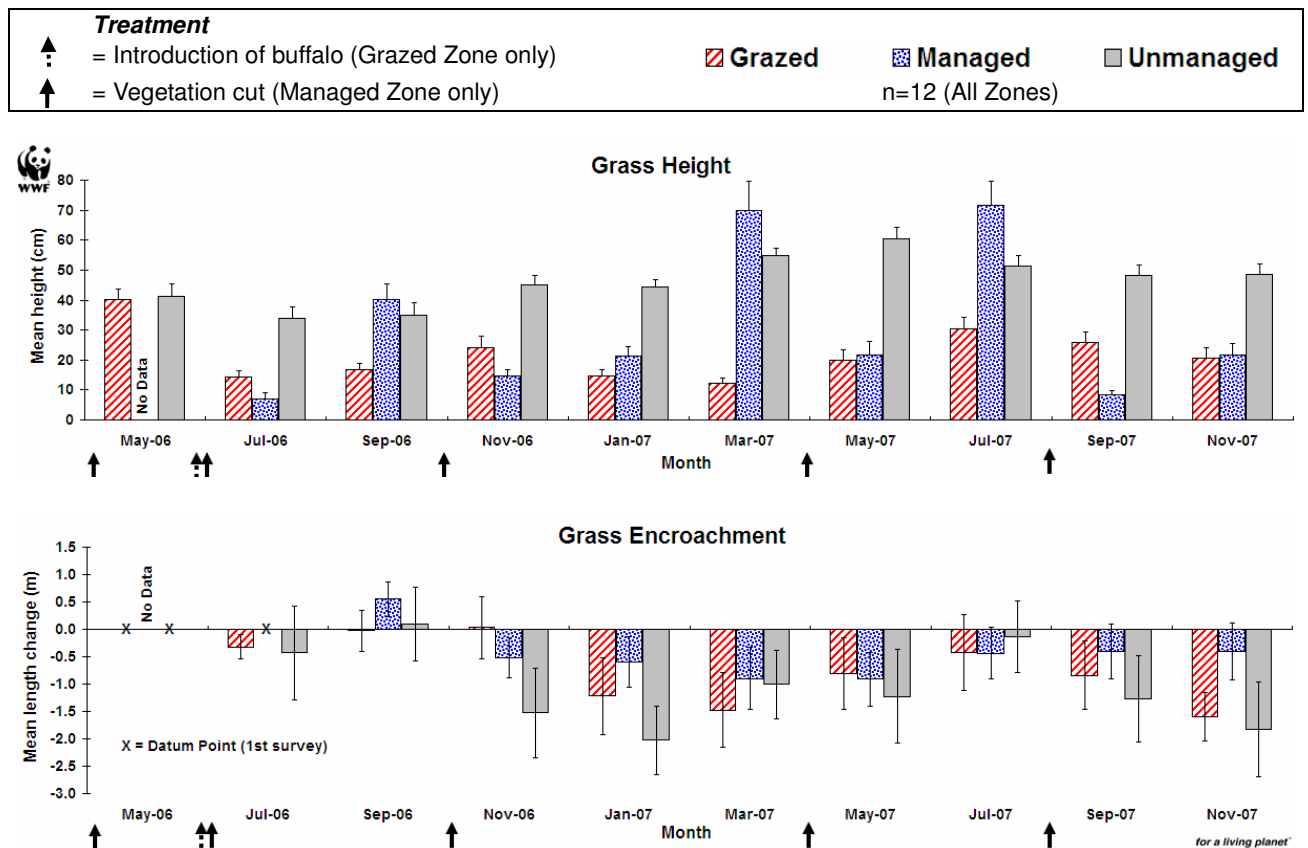


Figure 7. Graphs showing cover changes within vegetation groups.

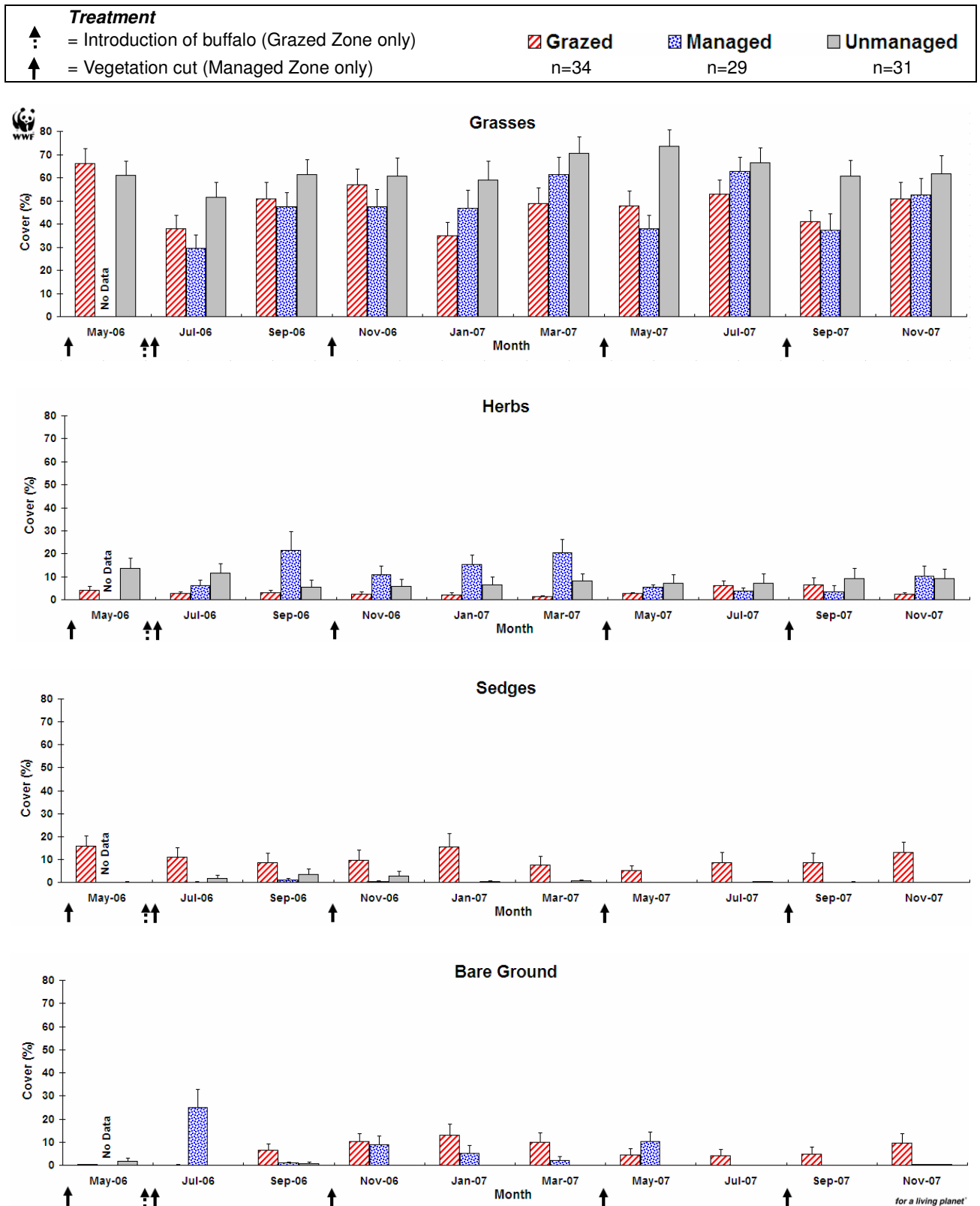


Figure 8. Graphs showing changes in the number of plant species within zones.

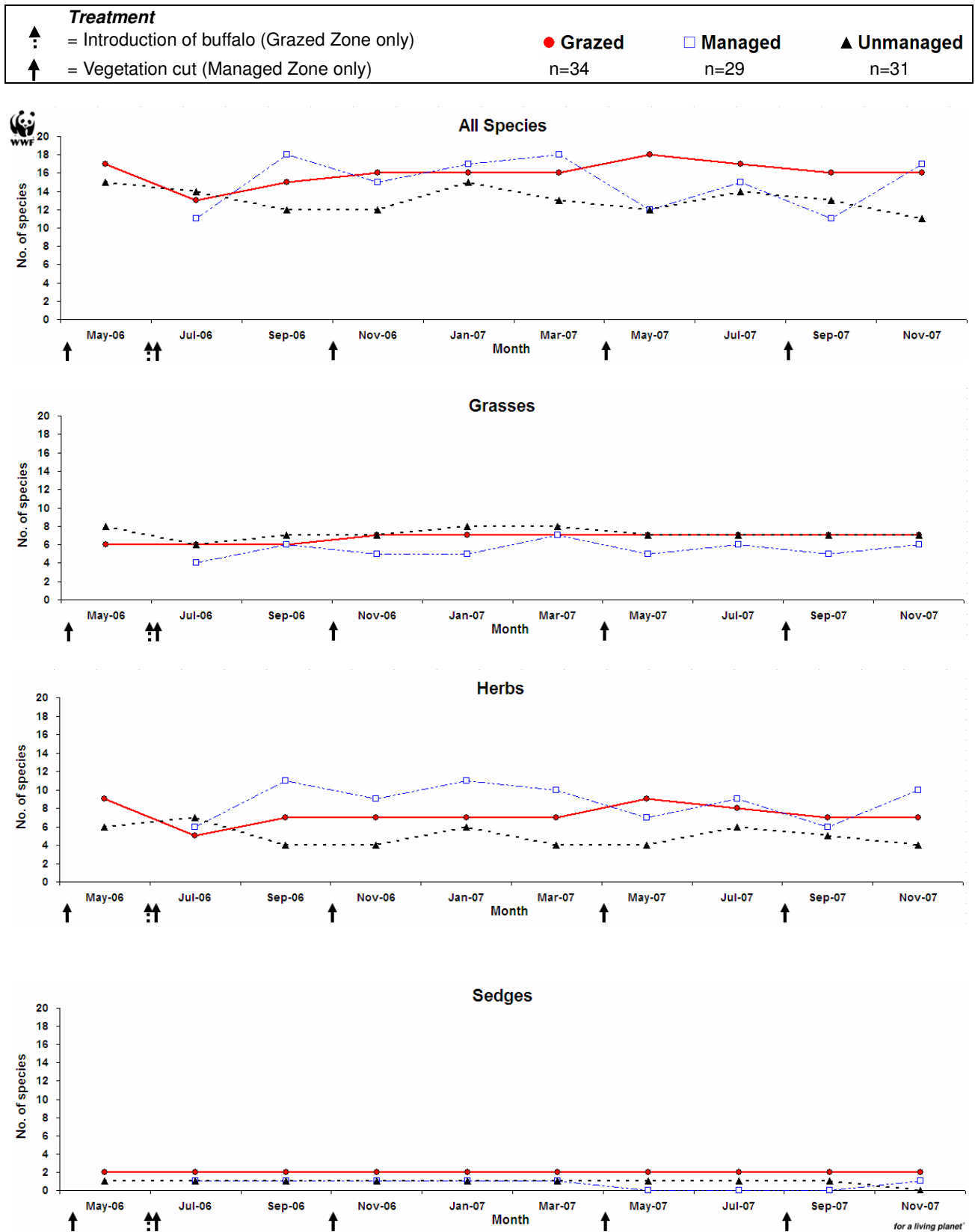


Figure 9. Unconstrained non-metric multidimensional scaling (nMDS) of plant species composition between treated zones.

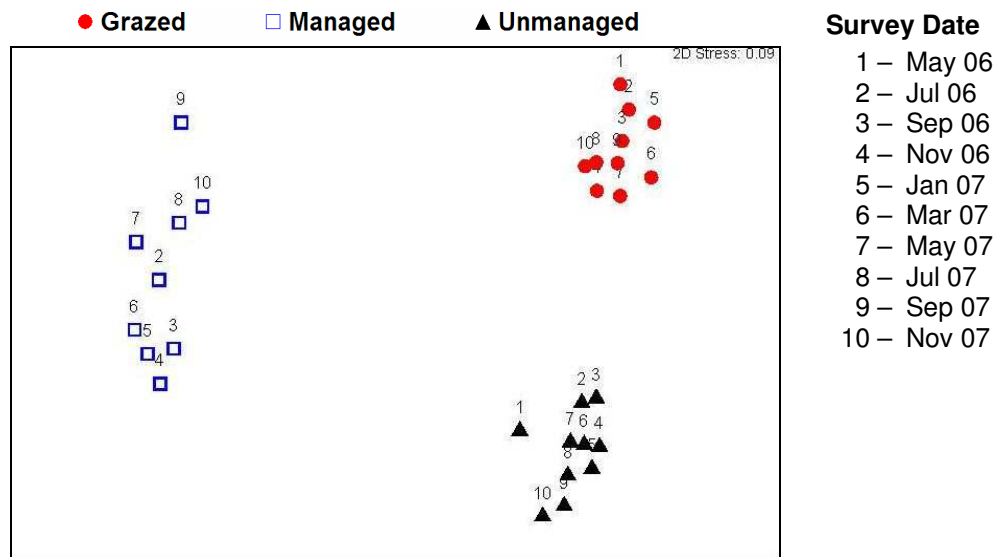
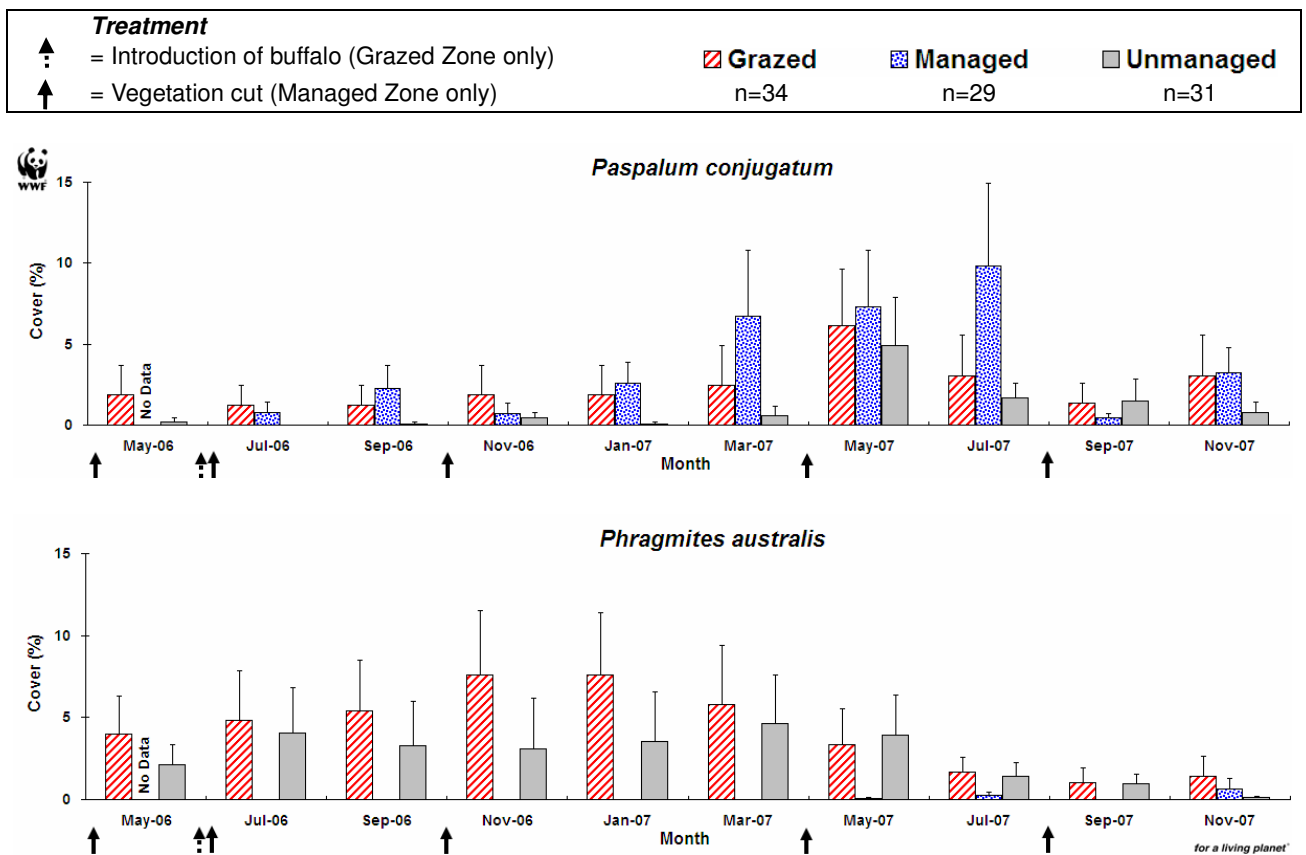


Figure 10. Cover changes in *Paspalum conjugatum* and *Phragmites australis*.



4. DISCUSSION

4.1 Objective 1

Grass structure

4.1.1 Grazing maintained a shorter mean grass sward height throughout the study period compared to other treatments. Following the introduction of livestock, mean grass height did not exceed ~30cm and remained below ~20cm during winter months (November and January data). In contrast, mean grass height exceeded 70cm in MZ, however during winter months a mean height similar to GZ was maintained ~20cm. The diversity of sward structure heights (as shown by Coefficients of Variation) was considerably greater in actively managed zones (GZ and MZ), but interestingly slightly more diverse (less homogenous) in MZ. Although grass sward structure was found to be more diverse in GZ than UZ, it was not shown for GZ against MZ. Therefore, Indicator of Success no. 1 is only partially achieved.

Bankside grass encroachment

4.1.2 The lateral growth rate (or spread) of bankside grasses into open water areas did not differ significantly between treatments and was influenced predominantly by season i.e. an extension in the warmer months and a retraction in the colder winter period. Longer-term data sets or higher treatment application rates may reveal differences.

Vegetation cover

4.1.3 The 18-month study period is considered too short to expose any significant changes to the cover of plant species or vegetation groups. Data suggested that the buffalo created and maintained ~10% bare ground in GZ. Field observations of poached areas and wallows (Appendix VIII) in the zone support this. Results imply grazing rapidly reduced grass cover but then maintained a fairly constant cover throughout the study of ~47% (Table 12). In other zones, individual cutting events in MZ had a short-term impact by decreasing herb cover and increasing bare ground, but this is influenced by the time interval between treatment and survey date. In UZ, bare ground was eventually eliminated in the absence of active management, but outright sward dominance by grasses was not observed within the study period.

Table 12. Summary of changes in grass cover (%).

Zone	Start	12-month	18-month	Mean*	s.d*
Grazed	66.0	47.8	50.7	46.9	7.3
Managed	29.3	38.0	52.4	47.0	11.0
Unmanaged	60.9	73.6	61.8	62.6	6.2

* - Relate to data after treatment commenced
Full data set in Appendix V

Plant species/composition

4.1.4 Data analysis showed that at the start of the study zones had differing plant composition. Therefore changes observed in each zone following the commencement of treatment are not directly comparable and, in the absence of replicates, are interpreted with caution. It is also noted that an 18-month study period may be insufficient to reveal trends.

4.1.5 In UZ, results mildly suggest a gradual reduction in the number of plant species, in particular herbs such as *Alternanthera sessilis* (as shown in Appendix VII – Post H). In GZ, *Mikania micrantha* established at the study mid-point, but this is most likely due to the fence structure providing suitable habitat for establishment.

Target plant species

4.1.6 *Paspalum conjugatum* was recorded in all zones with no clear difference observed between the 3 treatments within the study period. There is suggestion that individual cutting events in MZ had a short-term reduction impact on cover.

- 4.1.7 The cover of *Phragmites australis* similarly showed no significant differences between zones. Some variation is observed, but this may be due to localised conditions. The growth rate of *P. australis* stands in GZ was considerably less than other zones within the initial 12-month period. This suggests the buffalo had a controlling effect on *P. australis*, but localised factors, such as variations in water depth, may be responsible. Results from this study's quantitative data are inconclusive, but the notion that the buffalo controls/checks the growth of *P. australis* is supported by field observations. At several locations within GZ, the buffalo had a clear impact on established stands of *P. australis* growing on bund areas (Appendix VIII – Photos 2 and 3). Direct evidence of grazed *P. australis* stems and leaves was observed during field surveys.
- 4.1.8 Active management of bund vegetation had a positive effect upon the abundance and diversity of birds. Although not clearly shown by the study data, perhaps due to the short study period, non-intervention in the long-term may lead to a more scrubby vegetation community with small shrubs and possible invasion by *Mikania micrantha*. This is an observed trend on infrequently managed bunds within MPNR (pers. obs.). Conversely, intensive management can lead to plant species loss; this is observed on commercial fishponds in Deep Bay where frequent cutting, burning and planting activities allow grasses such as *Panicum maximum* to dominate (pers. obs.). An appropriate level of active management can therefore benefit plant diversity and composition.
- 4.1.9 Although results from GZ and MZ show temporal differences in the cover of *P. conjugatum* throughout the study period, both appeared to maintain the grass at a low cover level. An exceptionally low abundance of *P. australis* from transect data in MZ prevents a meaningful comparison with GZ. Therefore, Indicator of Success no. 2 is partially achieved.

4.2 Objective 2

Bird density

- 4.2.1 Mean bird density is proven to be greater in the actively managed areas (GZ and MZ) compared to the non intervention area (UZ) which strongly suggests that these forms of management attracted greater numbers of birds. There was no valid statistical difference in bird composition between GZ and MZ.
- 4.2.2 Within MZ, cutting events had a clear and immediate impact upon bird density. In most instances bird density peaked prior to cutting, with Scaly-breasted Munia *L. punctulata* identified as the most sensitive species. It is speculated that these Munias responded to fodder availability (grass seeds) as grasses, particularly *P. maximum*, matured and flowered. After treatment, species such as Spotted Dove *S. chinensis* were noted to utilise newly created bare ground areas presumably to feed on grain both fallen and from cut flowering plants. A higher Great Egret *C. albus* density suggests regular cutting maintained better foraging habitat along pond margins for this species. Common Stonechat *S. torquata* (a winter migrant) appeared to favour MZ, but the reason is unknown. Within GZ, the observed higher density of Long-tailed Shrike *L. schach* and Black Drongo *D. macrocercus* is probably related to the presence of infrastructure facilities such as fence posts providing suitable perches.

Bird species density/composition

- 4.2.3 MZ was shown to have the highest mean species density of all 3 zones; the difference to UZ was statistically valid. Although GZ recorded a greater cumulative number of species than other zones, this may be due to differences in area or vegetation type.
- 4.2.4 Of the target species only Cattle Egret *B. ibis* was recorded in GZ and UZ. Data mildly suggests Cattle Egret was more associated with GZ. The failure of GZ to attract Grey-headed Lapwing *V. cinereus* may be due to this species low over-wintering population in Hong Kong (peak count 23 individuals in 2006/07 winter, John Allcock pers.com), or simply that the area of grazed marsh grassland was too small or not suitable. It is noted that within GZ the maximum area of grazed grassland created by the buffalo is

only 0.25 ha, i.e. the pond bund area (~6m wide). In addition, the pond bunds are sloped, a noticeable physical difference from habitat used by Grey-headed Lapwing on the abandoned agricultural fields at Kam Tin. These factors may also partly explain the absence of Greater Painted Snipe *R. benghalensis*.

- 4.2.5 The study duration period is another factor such that suitable habitat conditions, particularly in GZ, may take longer than 18-months to establish or the bird species concerned may only utilise/colonise the habitats after several years of management.
- 4.2.6 Although bird density was statistically greater in GZ than UZ, it was not proven against MZ. Bird species density was not significantly different between GZ and other zones, and bird composition did not differ between zones. Therefore, Indicator of Success no. 3 is marginally achieved.

4.3 Objective 3

- 4.3.1 It is not practicable to assess the ‘cost effectiveness’ of GZ against MZ because benefits of each treatment type to flora and avifauna are not distinguishable in this study. Although the study data showed differences, results are mixed and it would be unwise to base a comparison upon them. If the benefits are considered equal then a comparative cost analysis based on this 18-month study strongly favours manual management methods over livestock grazing. However 70% of GZ costs are infrastructure related and an economy of scale is apparent such that a longer-term project could reduce MZ’s economic advantage. For example if the entire 13.8 ha area of Pond #24, including all 8 sub-ponds, was subjected to either grazing at 10 LSU or manual treatment over a 10-year period, the total running costs favour grazing in the fifth year with the final cost estimated to be ~52% lower (Table 13). Grazing also has the advantage of being an environmentally sound management tool in comparison to mechanised cutting, and has potential education benefits to the public. These are intangible gains which cannot be easily expressed in monetary terms.

Table 13. Projected costs associated with the 10-year vegetation management of Pond #24 (13.8 ha) using grazed and manual management methods.

Project Stage	Grazed		Manual	
Setting up	Buffalo (x 10)	\$10,250	Grass cutter (x 5)	10,415
	Sterilisation (x 10)	\$15,375		
	Micro chip (x 10)	\$5,125		
	Transportation	\$5,125		
	Perimeter fence materials	\$149,000		
	Shelter materials	\$10,250		
	Construction labour	\$149,000		
	Sub-total	\$344,125		\$10,415
Operation	Husbandry (one day per week)	\$39,650	Labour (x 30)	\$858,180
	6 monthly veterinary animal check-up	\$33,610	Fuel (x 30)	\$28,570
	Repair - materials	\$3,360	Parts	\$2,240
	Repair - labour	\$14,565		
	Sub-total	\$91,185		\$888,990
TOTAL	\$435,310		\$899,405	

Annual inflation rate of 2.5% included in all calculations

4.4 Livestock Units

- 4.4.1 Within this study, grazing pressure was set at 1 LSU for the 1.8 ha freshwater pond area. Whether or not this is a key factor behind the failure of GZ to attract target bird species is unclear, but the small zone size (1.8 ha), restricted area of grassland (0.25 ha) and enclosed nature of the zone may be contributing factors. The chosen LSU rate was insufficient to create a shorter grass sward in winter months compared to manual methods, and therefore an unfavourable sward height for Anatidae remained in winter (para 1.1.5). In this respect a slightly higher grazing pressure of 1 LSU per 1.4ha could be more effective.

5. RECOMMENDATIONS

- 5.1.1 Further research study upon buffalo as a potential management tool for the conservation and enhancement of freshwater ponds is recommended. This should include experimentation using a variety of LSU rates, larger pond areas, seasonal grazing, and a combination of cutting with grazing. This latter technique is commonly used in the UK by conservation managers and typically involves a grass cut in autumn followed by ‘aftermath’ grazing. To better understand the ecological requirements of the target bird species, a baseline survey to quantify the general conditions at Kam Tin such as the no. of buffalo, ground water levels, vegetation structure, invertebrate abundance, etc. would be useful. This information may generate further study work.
- 5.1.2 Within the existing study area it is recommended to continue grazing and, at a reduced sample effort i.e. in January and July only, monitor the impact to vegetation and avifauna. In the absence of new research studies this continuation would allow for longer-term trends to be investigated using minimal resources (in kind support may be necessary). Other options to consider include an increased LSU rate, a substantial lowering of water-levels to enlarge the wet grassland area, and an extension of the grazed area into neighbouring sub-ponds.
- 5.1.3 Based upon the experiences gained from this project, several practical recommendations are suggested for new livestock enclosures at MPNR.
- In areas frequently inundated with water, the structural integrity of fences can be improved by:
 - Setting fence posts to a depth of at least 1.5m (compared to 1.0m in elevated drier areas),
 - Fixing wooden railings (10cm x 5cm) between fence posts at ground level.
 - Good quality high tensile galvanised steel wire is not readily available in Hong Kong and therefore should be sourced from overseas. An acceptable alternative is high grade 2mm steel cable wire, commonly sold in local hardware outlets.
 - In-line fence tensioners (sourced from overseas) are necessary to keep wires taught and stock proof.

6. CONCLUSION

- 6.1.1 Study objectives no. 1 and no. 2 are achieved. A comparison of the cost effectiveness of buffalo and human methods under objective no. 3 could not be fully completed because wildlife benefits are not distinguishable between the methods. However, based on a hypothetical equal benefit assumption, an economy of scale is apparent such that a comparison of methods on a 13.8 ha area of freshwater ponds, shows grazing methods would have an economic advantage after 5 years with a ~52% total project cost saving after 10 years.
- 6.1.2 The study had limited achievement of the 3 chosen Indicators of Success. Indicators no. 1 and no. 2 concerning the buffalo’s ability to control or diversify vegetation/plant types were both deemed partially achieved either due to a lack of comparative data or unproven differences between grazed and manual treatments. Indicator no. 3 concerning the buffalo’s ability to attract a greater number of birds and diversity of bird species was marginally achieved because bird data did not reveal significant differences between the stated attributes.

- 6.1.3 Despite the study's short duration period, it provided a valuable insight into the effects of buffalo grazing at freshwater ponds. The main findings of interest being:
- Grazing (at 1 LSU per 1.8 ha area) and manual cutting of vegetation (2-3 times between April to November) created similar mean grass sward heights (~20cm in winter months) and mean grass cover (~47%). Both created a more diverse grass sward structure than unmanaged areas.
 - Grazing created and maintained a mean bare ground cover of ~10% and results suggest it may reduce *P. australis* stand growth.
 - In unmanaged areas there was a gradual elimination of bare ground cover and an apparent decline in herbaceous species diversity over time.
 - Both grazing and manual cutting methods attracted higher bird density and bird species density than unmanaged areas. The grazed area attracted the greatest total number of bird species.

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APPENDIX I – Water-level Readings : Raw Data

Date	Grazed Zone (cm)	Managed/Unmanaged Zone (cm)
03-Apr-06	0	14.0
17-Apr-06	-1.0	12.0
04-May-06	3.0	13.0
18-May-06	6.5	16.0
06-Jun-06	23.0	24.0
22-Jun-06	29.0	28.0
05-Jul-06	28.0	27.0
17-Jul-06	32.0	34.0
04-Aug-06	42.0	42.0
17-Aug-06	-4.0	25.0
04-Sep-06	-5.0	18.0
20-Sep-06	1.0	16.0
04-Oct-06	-9.0	6.0
17-Oct-06	-9.0	0.0
07-Nov-06	-22.0	-5.0
22-Nov-06	-12.0	0.0
05-Dec-06	-10.0	-5.0
19-Dec-06	-14.0	-8.0
05-Jan-07	-16.0	-11.0
19-Jan-07	-18.0	-12.0
05-Feb-07	-22.0	-19.0
22-Feb-07	-23.0	-20.0
07-Mar-07	-24.0	-21.0
19-Mar-07	-28.0	-24.0
04-Apr-07	-31.0	-33.0
17-Apr-07	-29.0	-26.0
02-May-07	1.0	15.0
17-May-07	-24.0	-9.0
05-Jun-07	1.0	17.0
20-Jun-07	-8.0	7.0
05-Jul-07	7.0	21.0
18-Jul-07	-3.0	16.0
03-Aug-07	26.5	26.5
17-Aug-07	16.0	20.0
04-Sep-07	34.0	34.0
20-Sep-07	17.0	22.0
04-Oct-07	17.0	23.0
17-Oct-07	12.0	18.0
01-Nov-07	6.0	11.0
19-Nov-07	1.0	1.0

APPENDIX II – Avifauna Raw Data (cont.)

Managed Zone

Date	Black-browed Reed Warbler	Black Drongo	Black-collared Starling	Black-crowned Night Heron	Cinnamon Bittern	Chinese Bulbul	Chinese Pond Heron	Common Blackbird	Common Kingfisher	Common Moorhen	Common Sandpiper	Common Stonechat	Dusky Warbler	Eurasian Tree Sparrow	Eurasian Wigeon	Great Bittern	Great Cormorant	Great Egret	Greater Coucal	Grey Heron	Little Grebe	Long-tailed Shrike	Olive-backed Pipit	Oriental Reed Warbler	Pallas Grasshopper Warbler	Plain Prinia	Purple Heron	Red-throated Pipit	Scaly-breasted Munia	Spotted Dove	Tufted Duck	Unidentified Rail	White Wagtail	White-breasted Waterhen	White-throated Kingfisher	Yellow-breasted Bunting	Yellow Bittern	Yellow-bellied Prinia	Yellow Wagtail	Zitting Cisticola								
03-Apr-06																		3		2						5	2		22	2							1											
17-Apr-06																		1																														
04-May-06						2				1	1							1	1								5														2	2						
18-May-06			2																																													
06-Jun-06																					1																											
22-Jun-06																						1						3	1		3																	
05-Jul-06																																																
17-Jul-06															2																																	
04-Aug-06																																																
17-Aug-06																																																
04-Sep-06							1																																									
20-Sep-06									1			1																																				
04-Oct-06		1								2																																						
19-Oct-06	1	1										1																																				
07-Nov-06										4		3																																				
22-Nov-06			1					1		4	4	1			1			2																														
05-Dec-06												2	1					1																														
19-Dec-06										5		3					1	3		2	1																											
05-Jan-07									1			2					1	2		1																												
19-Jan-07									1	1		5					2	1	1																													
05-Feb-07			2																1	3	1																											
22-Feb-07						1						1									1	1																										
07-Mar-07									1			3																																				
19-Mar-07												3					1	1		1	1																											
04-Apr-07										1		1																																				
17-Apr-07										2		1																																				
02-May-07																																																
17-May-07				1																																												
05-Jun-07																																																
20-Jun-07				1																																												
05-Jul-07																																																
18-Jul-07																																																
03-Aug-07																																																
17-Aug-07																																																
04-Sep-07				2	1																																											
20-Sep-07												1																																				
04-Oct-07		1																																														
17-Oct-07												1																																				
01-Nov-07										1																																						
19-Nov-07										1		1								2		1																										

APPENDIX II – Avifauna Raw Data (cont.)

Unmanaged Zone

	Black-browed Reed Warbler	Black Drongo	Black-crowned Night Heron	Black-faced Bunting	Cattle Egret	Chinese Bulbul	Common Kingfisher	Common Moorhen	Common Stonechat	Crested Myna	Dusky Warbler	Eastern Marsh Harrier	Great Bittern	Great Cormorant	Great Egret	Greater Coucal	Grey Heron	Lanceolated Warbler	Little Grebe	Long-tailed Shrike	Masked Laughingthrush	Northern Pintail	Oriental Reed Warbler	Pallas Grasshopper Warbler	Pheasant-tailed Jacana	Pied Kingfisher	Plain Prinia	Purple Heron	Scaly-breasted Munia	Spotted Dove	Tufted Duck	White-breasted Waterhen	White-throated Kingfisher	Yellow Bittern	Yellow-bellied Prinia	Zitting Cisticola		
03-Apr-06	3	.	.	.	.	.	.	1	1	.	.	1	.	1	.	.	.	.	.	3	.	.	.	1	.	.	1	2	.		
17-Apr-06	1	.	1	2	1	.	
04-May-06	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	3	2	.		
18-May-06	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	2	.	.	.	.	.	.	.	.
06-Jun-06	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
22-Jun-06	1	.	.	.	.	1	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.
05-Jul-06	2	3	1	.	
17-Jul-06	2	1	3	1	.	
04-Aug-06	2	
17-Aug-06	1	2	2	3	.
04-Sep-06	1	1	.	.	.	1	2	.	2	1	1	1	1	2	.	
20-Sep-06	.	1	
04-Oct-06	1	1	.	.	
19-Oct-06	1	.	.	.	1	.	1	.	1	.	.	.	.	.	2	.	1	1	.	1	.	.	.	5	.	.	.	.	5	.	.	.	.	.	5	.
07-Nov-06	.	1	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	3	1	.	.	3	.	.	.	.	.
22-Nov-06	1	1	1	1	1	.	.	2	.	.	1	.	.	.	1	1	2	2	.	
05-Dec-06	3	1	2	2	.	.	.	1	.	.	.	1	.	1	.	.	.	.	.	.	.	2	.	.	.	.	.	1	.	1	.		
19-Dec-06	.	.	.	2	.	1	1	2	3	.	.	.	.	1	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.
05-Jan-07	1	2	1	1	4	.	
19-Jan-07	2	2	1	.	.	1	26	4	.	
05-Feb-07	6	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	4	.	.	.	.	.	.	.	7	.	1	.	3	.		
22-Feb-07	2	.	.	.	.	.	1	1	1	.	.	.	2	.	.	.	.	.	.	.	2	.	.	.	.	.	.	2	.	.		
07-Mar-07	1	.	4	2	.	2	1	1	1	.	
19-Mar-07	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	.	.	.	.	.	.	1	.		
04-Apr-07	4	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	4	.	.	1	.		
17-Apr-07	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	22	.	.	1	.	.	4	.		
02-May-07	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	4	.	.	.	.	.	2	.		
17-May-07	2	.	.	.	.	1	.	.	2	.		
05-Jun-07	.	.	1	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	2	.
20-Jun-07	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	.
05-Jul-07	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	1	.
18-Jul-07	1	.		
03-Aug-07	1	.	.	.	.	.	.	.	2	.	4	.	.	1	.	.	.	.
17-Aug-07	2	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	12	.	.	.	.	.	2	.		
04-Sep-07	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1	3	.
20-Sep-07	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	1	.	.	.	1	3	.	.	.	.	2	.	.
04-Oct-07	.	1	.	.	.	3	.	.	.	.	.	.	.	.	3	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
17-Oct-07	.	1	.	.	.	.	1	.	2	.	1	.	.	.	.	.	.	.	1	.	.	.	.	2	.	2	.	.	2	.	.	.	.	.	.	.
01-Nov-07	2	2	.	4	.	.	1	.	.	1	.	.	.	.	.	1	.	.	.	3	1	.	.	.	1	.	.	5	1		
19-Nov-07	1	1	18	.	.	.	1	2	

APPENDIX III – Bund Grass Height Raw Data

Date	Grazed Zone (cm)			Managed Zone (cm)			Unmanaged Zone (cm)		
May-06	6.0	1.0	5.5	-	-	-	0.0	9.0	14.5
	10.5	14.5	16.5	-	-	-	16.5	10.5	7.0
	11.5	33.5	13.0	-	-	-	17.5	24.5	13.5
	35.5	38.5	20.5	-	-	-	28.0	41.0	51.0
	36.0	34.5	50.0	-	-	-	28.5	32.0	29.0
	37.5	38.5	43.0	-	-	-	29.0	20.5	47.5
	45.0	64.0	83.0	-	-	-	42.0	56.5	73.5
	48.5	33.0	32.5	-	-	-	44.0	21.0	42.5
	50.0	48.5	23.0	-	-	-	45.5	57.0	59.0
	50.5	66.0	78.0	-	-	-	62.0	46.5	20.0
	59.5	42.0	41.5	-	-	-	72.0	53.0	81.5
	74.0	74.0	81.5	-	-	-	83.0	105.5	99.0
	Jul-06	0.0	8.0	0.0	0.0	2.0	0.0	0.0	5.0	28.0
0.0		0.0	35.0	0.0	6.0	4.5	2.0	41.0	42.0
4.0		13.5	10.0	0.0	0.0	0.0	19.0	9.0	12.0
5.0		11.0	9.0	0.0	0.0	0.0	19.0	18.0	22.0
6.0		3.0	7.0	0.0	0.0	0.0	21.0	26.0	36.0
10.0		25.0	15.5	0.0	0.0	0.0	28.0	54.0	43.0
15.0		7.0	9.0	0.0	0.0	4.5	29.5	25.0	25.0
16.0		19.5	10.0	0.0	0.0	0.0	36.0	21.0	1.5
19.0		4.0	24.0	15.0	0.0	0.0	42.0	24.0	42.0
20.0		23.0	11.0	15.5	33.0	37.0	63.0	82.0	69.0
41.0		36.0	22.0	25.0	1.0	14.0	63.0	37.0	35.0
45.0		0.0	30.0	26.5	39.0	28.0	64.0	86.5	51.0
Sep-06		0.0	0.0	12.0	0.0	0.0	16.0	0.0	17.5	45.5
	5.0	6.0	2.0	14.0	15.5	22.0	13.0	15.5	12.0
	7.0	8.0	5.0	18.0	32.0	38.0	13.0	40.0	59.5
	9.0	0.0	0.0	22.0	43.0	37.0	13.5	39.0	23.5
	15.5	4.0	12.0	36.0	43.0	57.0	18.5	31.0	28.0
	17.0	0.0	2.0	38.0	55.0	36.0	19.0	127.0	65.0
	19.0	25.0	17.5	41.0	39.0	16.0	31.0	46.5	52.0
	20.0	13.0	28.5	41.5	52.0	63.5	37.0	20.0	0.0
	28.0	32.0	44.5	45.0	0.0	0.0	41.0	38.0	25.5
	29.0	52.0	32.0	67.5	24.5	8.0	47.0	44.5	44.5
	36.0	7.5	9.0	88.0	81.0	33.0	60.5	51.5	1.0
	41.0	31.0	28.5	128.0	104.0	94.0	63.0	55.0	21.0
	Nov-06	0.0	6.0	14.5	0.0	35.5	29.0	3.0	41.0	51.5
0.0		3.0	16.0	2.0	3.0	35.5	15.5	13.0	28.0
2.0		3.5	3.5	4.0	0.0	4.0	18.0	21.0	51.0
5.0		16.0	12.5	5.0	13.5	19.0	38.0	34.5	51.0
8.5		0.0	11.0	5.5	0.0	0.0	43.0	29.0	20.0
11.0		37.5	52.5	8.0	3.0	6.0	49.0	44.0	45.0
18.5		22.0	27.0	11.5	12.0	13.5	53.0	70.0	40.0
18.5		13.0	14.5	13.0	19.5	22.0	55.5	33.0	49.0
24.0		31.0	2.5	14.0	13.5	3.0	56.5	53.0	51.0
55.5		49.0	50.5	20.0	17.5	20.5	61.0	56.5	46.0
65.5		48.5	69.0	30.0	25.0	17.0	84.5	64.0	53.5
81.0		40.5	34.5	38.0	26.0	40.0	86.5	55.0	65.0
Jan-07		0.0	4.0	3.5	0.0	13.0	85.0	27.0	30.0	40.0
	0.0	0.0	0.0	5.5	12.0	9.5	27.5	24.0	14.0
	5.5	0.0	0.0	7.0	0.0	19.5	30.0	33.0	34.5
	6.5	25.5	19.5	9.5	12.0	12.5	34.0	36.0	39.5
	9.0	7.0	3.0	16.5	20.0	13.5	39.5	19.0	29.0
	11.0	0.0	24.0	16.5	13.0	14.0	44.5	54.0	44.0
	13.0	0.0	3.0	16.5	0.0	4.0	49.5	56.0	52.0
	19.5	25.0	27.5	18.5	2.0	16.0	57.5	55.5	53.0
	27.0	9.0	20.0	27.5	28.0	40.0	59.0	47.5	47.5
	28.0	11.0	4.5	30.0	26.5	19.0	60.0	60.0	71.0
	45.0	49.5	36.5	31.0	25.0	21.0	60.5	51.0	47.0
	46.0	10.5	29.0	64.5	65.0	54.0	67.0	55.0	48.0
	Mar-07	0.0	0.0	0.0	3.0	42.0	44.5	13.5	55.0	71.0
0.0		3.0	7.0	18.0	28.0	26.0	26.0	27.0	28.0
0.0		0.0	0.0	29.0	32.0	24.0	41.0	41.0	46.0
5.0		0.0	13.0	33.0	30.5	26.5	53.0	55.5	45.0
9.0		8.0	4.5	33.5	54.5	34.5	55.0	49.0	40.5
9.0		3.0	5.0	41.0	43.0	46.0	55.5	57.5	31.5
13.5		4.0	3.0	48.0	59.5	50.5	57.0	75.5	78.5
16.0		20.0	17.0	63.5	54.5	51.0	57.0	58.5	61.0
16.0		23.0	19.5	87.0	12.0	30.0	59.0	63.5	67.5
18.5		32.5	18.0	119.0	155.0	147.5	68.0	53.5	61.0
24.0		31.5	39.0	151.0	179.0	184.0	69.5	79.0	63.5
33.0		30.0	10.0	201.0	208.0	129.0	74.5	80.5	52.5

APPENDIX III – Bund Grass Height Raw Data (cont.)

	Grazed Zone (cm)			Managed Zone (cm)			Unmanaged Zone (cm)		
May-07	0.0	0.0	5.0	0.0	7.0	3.5	24.0	19.5	14.5
	0.0	2.0	0.0	0.0	19.0	16.5	42.5	44.5	45.0
	0.0	9.0	0.0	0.0	15.5	22.0	44.0	56.5	81.5
	0.0	0.0	0.0	0.0	2.0	5.0	47.5	28.0	32.0
	7.5	5.0	7.0	0.0	20.5	25.0	51.0	76.0	72.5
	13.0	9.0	6.5	20.0	10.0	0.0	56.0	50.5	47.5
	14.0	13.0	0.0	22.5	13.0	3.0	62.0	84.5	73.0
	15.0	34.5	14.0	23.0	26.0	37.5	67.0	57.5	62.0
	25.0	52.0	63.0	24.5	0.0	3.0	76.0	69.5	93.0
	28.0	27.0	21.0	29.0	6.0	2.0	87.0	78.0	29.5
	55.0	55.5	53.0	82.0	73.0	53.5	95.5	72.5	34.0
	71.0	59.0	48.5	91.0	74.5	56.0	103.5	115.0	78.5
	Jul-07	0.0	47.0	85.0	30.0	19.0	20.0	15.0	66.0	59.0
0.0		0.0	9.5	31.0	55.0	72.0	36.0	35.0	35.0
7.0		10.5	4.5	41.0	20.0	63.0	41.0	22.0	28.0
8.0		4.0	7.0	44.0	9.0	16.0	43.0	0.0	9.0
18.0		17.0	13.5	49.0	49.0	67.0	43.0	54.0	42.0
29.5		31.5	34.0	52.0	53.0	59.0	51.0	39.0	61.0
34.5		28.0	0.0	67.0	74.0	71.0	51.0	55.0	42.0
40.0		44.0	2.0	72.0	43.0	57.0	53.0	67.0	63.0
44.0		56.0	33.0	84.0	89.0	62.0	60.0	90.0	60.0
44.0		53.0	69.0	108.0	102.0	100.0	70.0	54.0	59.0
49.0		48.0	53.0	154.0	137.0	153.0	73.0	64.0	78.0
64.0		64.0	37.0	203.5	205.0	53.0	99.0	64.0	63.0
Sep-07		0.0	0.0	10.0	0.0	29.5	10.0	15.0	12.5	25.0
	5.0	21.5	29.5	1.0	9.0	22.5	28.0	19.5	21.0
	10.0	0.0	23.5	1.0	3.0	0.0	37.0	29.5	39.5
	15.5	25.0	0.0	3.0	8.0	0.0	43.0	21.0	28.0
	18.0	22.0	0.0	3.0	0.0	3.0	44.5	35.0	58.0
	19.0	13.0	19.0	3.5	0.0	11.0	51.5	53.0	55.0
	22.0	17.5	26.0	5.0	0.0	2.5	60.0	67.0	44.0
	24.0	17.0	21.5	5.0	15.0	3.0	61.0	71.5	30.0
	28.0	36.0	9.0	6.0	18.0	13.0	64.5	49.5	32.0
	30.5	53.0	75.5	9.0	9.5	6.0	70.0	71.5	53.5
	51.5	36.5	41.0	21.0	32.0	4.0	70.0	45.0	51.5
	78.0	68.5	66.5	30.0	13.0	0.0	98.0	98.0	80.5
	Nov-07	0.0	38.0	36.0	2.0	8.0	9.0	19.0	29.5	30.0
0.0		10.0	7.0	2.0	6.5	13.0	20.0	16.0	21.5
0.0		4.0	0.0	5.0	1.0	12.5	24.5	29.0	49.5
9.0		23.0	4.0	7.5	16.0	17.0	33.5	48.5	54.0
14.0		38.0	17.0	8.0	35.0	3.0	33.5	38.0	59.0
14.0		13.0	13.0	8.0	22.5	4.0	39.0	30.5	24.0
15.0		9.5	15.0	11.0	24.0	15.5	41.0	46.0	49.0
18.0		13.0	0.0	13.0	18.5	20.0	47.0	55.5	72.0
20.0		18.0	22.5	20.0	6.5	21.5	53.0	56.5	66.0
20.5		46.0	76.0	25.0	29.0	23.0	65.5	71.0	60.0
29.0		11.0	13.0	51.0	60.0	17.0	71.0	44.0	61.0
53.5		62.0	65.0	99.0	98.0	50.5	93.5	96.0	97.0

APPENDIX IV – Grass Encroachment Raw Data

	Grazed Zone (m)						Managed Zone (m)						Unmanaged Zone (m)					
	G1	G2	G3	G4	G5	G6	M1	M2	M3	M4	M5	M6	U1	U2	U3	U4	U5	U6
May-06	7.54	8.97	13.43	15.56	15.21	9.29	-	-	-	-	-	-	12.07	11.19	11.65	15.11	11.20	9.89
Jul-06	7.61	8.87	12.22	14.80	15.41	9.14	12.24	11.06	10.59	10.25	10.58	7.78	8.59	12.84	11.64	15.80	8.67	11.00
Sep-06	8.00	9.11	11.99	15.16	15.01	10.56	13.15	13.00	10.56	10.52	10.98	7.60	11.25	13.30	12.05	16.05	8.52	10.47
Nov-06	8.04	8.22	11.75	14.62	16.31	11.27	11.32	11.15	8.65	10.91	9.95	7.45	9.10	12.78	8.94	12.31	8.51	10.31
Jan-07	7.38	8.26	9.81	12.36	15.47	9.40	12.39	11.08	7.96	10.60	9.46	7.40	10.40	10.03	8.54	11.42	8.27	10.32
Mar-07	3.91	7.63	11.22	12.99	15.33	10.07	12.05	10.08	7.41	10.77	8.86	7.95	9.73	12.05	11.39	13.34	8.33	10.26
May-07	3.66	8.34	13.29	14.66	15.48	9.74	9.72	10.58	8.74	10.47	9.21	8.33	9.33	12.95	11.36	11.42	8.70	10.01
Jul-07	4.13	8.48	13.04	15.10	15.80	10.95	10.66	11.00	8.83	10.32	9.96	9.10	11.08	12.30	10.30	17.15	9.04	10.45
Sep-07	3.92	7.78	13.11	14.71	16.01	9.42	10.74	11.28	8.59	10.53	9.95	8.99	8.54	12.53	10.07	13.05	8.66	10.64
Nov-07	4.08	8.38	12.68	14.64	13.20	7.43	10.78	11.41	8.82	10.65	9.28	9.11	9.08	12.23	6.97	13.36	8.47	10.07

APPENDIX V – Vegetation Transect Data

	Bare Ground	Open Water	<i>Ageratum conyzoides</i>	<i>Alternanthera sessilis</i>	<i>Bidens alba</i>	<i>Centella asiatica</i>	<i>Cyrtococcum patens</i>	<i>Echinochloa crusgalli</i>	<i>Eclipta prostrata</i>	<i>Eleocharis</i> sp.	<i>Emilia sonchifolia</i>	<i>Euphorbia hirta</i>	<i>Ipomoea aquatica</i>	<i>Ipomoea triloba</i>	<i>Leersia hexandra</i>	<i>Lemna minor</i>	<i>Ludwigia adscendens</i>	<i>Macropitium lathyroides</i>	<i>Marriscus umbellatus</i>	<i>Mikania micrantha</i>	<i>Murdannia nudiflora</i>	<i>Paederia scandens</i>	<i>Panicum maximum</i>	<i>Panicum repens</i>	<i>Paspalum conjugatum</i>	<i>Paspalum orbiculare</i>	<i>Paspalum paspaloides</i>	<i>Passiflora foetida</i>	<i>Phragmites australis</i>	<i>Rumex dentatus</i>	<i>Sesbania javanica</i>	<i>Solanum nigrum</i>	<i>Vernonia cinerea</i>	
Grazed Zone																																		
May-06	0.3%	2.7%	0.0%	0.5%	0.2%	0.1%	0.0%	0.0%	0.3%	14.3%	0.0%	0.0%	0.1%	0.0%	0.9%	0.3%	2.5%	0.0%	1.2%	0.0%	0.0%	0.0%	0.0%	2.4%	1.8%	16.4%	39.1%	2.5%	4.0%	trace	0.0%	0.0%	0.0%	
Jul-06	0.1%	40.8%	0.0%	0.9%	0.0%	0.0%	0.0%	0.0%	0.2%	10.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.6%	0.0%	0.4%	0.0%	0.3%	0.0%	0.0%	1.8%	1.2%	11.6%	18.4%	0.0%	4.8%	0.0%	0.0%	0.0%	0.0%	
Sep-06	6.3%	31.5%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.7%	8.6%	0.0%	0.0%	0.0%	0.0%	0.9%	0.4%	1.4%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	3.3%	1.2%	12.2%	27.4%	0.1%	5.4%	0.0%	0.0%	0.0%	0.0%	
Nov-06	10.1%	17.2%	0.0%	0.1%	0.0%	0.0%	0.0%	1.9%	0.2%	9.4%	0.0%	0.0%	0.0%	0.0%	4.6%	0.9%	0.1%	0.0%	0.1%	0.0%	1.1%	0.0%	0.0%	6.1%	1.8%	12.2%	21.5%	0.0%	7.6%	0.0%	0.0%	0.0%	0.0%	
Jan-07	12.6%	5.4%	0.0%	0.2%	0.0%	0.1%	0.0%	2.6%	0.1%	15.2%	0.0%	0.0%	0.0%	0.0%	2.4%	1.5%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	1.9%	1.8%	7.4%	11.0%	0.0%	7.6%	0.0%	0.0%	0.0%	0.0%	
Mar-07	14.0%	9.9%	0.0%	0.4%	0.0%	0.3%	0.0%	0.1%	0.1%	7.4%	0.0%	0.0%	0.0%	0.0%	0.2%	0.3%	0.1%	0.0%	0.1%	0.2%	0.0%	0.0%	0.0%	6.3%	2.4%	13.8%	19.9%	0.0%	5.8%	0.0%	0.0%	0.0%	0.0%	
May-07	4.4%	26.0%	0.0%	0.4%	0.1%	0.2%	0.0%	0.2%	0.4%	5.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.9%	0.4%	0.0%	0.1%	0.1%	0.4%	0.0%	0.0%	7.9%	6.1%	9.7%	20.2%	0.0%	3.4%	0.0%	0.0%	0.0%	0.0%	
Jul-07	4.1%	24.3%	0.0%	0.7%	0.0%	0.3%	0.0%	1.4%	0.7%	8.4%	0.0%	0.0%	0.0%	0.1%	1.3%	3.1%	0.4%	0.0%	0.2%	0.1%	0.8%	0.0%	0.0%	6.8%	3.1%	15.4%	22.9%	0.0%	1.7%	0.0%	0.0%	0.0%	0.0%	
Sep-07	4.6%	29.9%	0.0%	0.8%	0.0%	0.1%	0.0%	0.8%	0.4%	8.4%	0.0%	0.0%	0.0%	0.0%	1.2%	4.4%	0.1%	0.0%	0.0%	0.0%	0.5%	0.0%	0.0%	7.2%	1.4%	12.8%	16.2%	0.0%	1.0%	0.0%	0.0%	0.0%	0.0%	
Nov-07	9.5%	11.6%	0.2%	0.4%	0.0%	0.0%	0.0%	0.7%	0.1%	12.7%	0.0%	0.0%	0.0%	0.0%	2.4%	1.1%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	6.7%	3.1%	13.5%	22.0%	0.0%	1.4%	0.0%	0.0%	0.0%	0.0%	
Managed Zone																																		
May-06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jul-06	24.1%	36.6%	0.0%	0.8%	0.7%	0.0%	0.0%	0.0%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	5.2%	0.0%	0.0%	0.0%	0.1%	0.2%	2.7%	0.0%	0.2%	0.0%	0.8%	0.0%	23.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Sep-06	1.0%	41.5%	3.3%	2.4%	1.0%	0.0%	5.5%	0.0%	1.7%	0.0%	trace	0.0%	0.0%	0.0%	8.1%	0.4%	0.0%	0.0%	1.0%	3.3%	2.6%	0.0%	5.5%	1.7%	2.3%	0.0%	29.5%	0.0%	0.0%	trace	trace	0.0%	0.3%	
Nov-06	11.1%	8.6%	0.0%	0.8%	0.2%	0.0%	3.7%	0.0%	0.3%	0.0%	0.0%	trace	0.0%	0.1%	6.8%	1.3%	0.0%	0.0%	0.3%	2.2%	2.1%	0.0%	2.9%	0.0%	0.7%	0.0%	36.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Jan-07	5.1%	7.6%	0.1%	1.6%	0.8%	0.0%	5.9%	0.0%	0.4%	0.0%	trace	0.0%	0.0%	0.1%	3.3%	2.8%	0.0%	0.0%	0.1%	1.0%	2.3%	0.0%	5.7%	0.0%	2.6%	0.0%	33.7%	0.0%	0.0%	0.0%	0.0%	trace	0.2%	
Mar-07	2.2%	3.6%	1.4%	3.3%	5.6%	0.0%	0.1%	trace	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	6.3%	2.1%	0.0%	0.0%	0.1%	2.8%	3.6%	trace	8.7%	0.9%	6.7%	0.0%	37.2%	0.0%	0.0%	0.0%	0.0%	trace	0.1%	
May-07	10.4%	19.0%	0.0%	1.6%	0.4%	0.0%	0.0%	0.0%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	10.7%	0.8%	0.0%	0.0%	0.0%	0.2%	1.5%	0.0%	6.8%	0.0%	7.2%	0.0%	12.9%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	
Jul-07	0.0%	15.0%	0.1%	1.4%	0.6%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	16.5%	0.2%	0.0%	0.0%	0.0%	0.3%	1.1%	trace	10.5%	2.5%	9.7%	0.0%	22.6%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	
Sep-07	0.0%	15.9%	0.0%	1.5%	1.4%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	21.7%	0.1%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	1.3%	2.8%	0.4%	0.0%	10.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Nov-07	0.2%	6.3%	3.3%	1.3%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	trace	0.0%	0.0%	1.4%	20.8%	0.2%	0.0%	0.0%	0.1%	0.0%	2.3%	0.0%	3.7%	3.9%	3.2%	0.0%	19.4%	0.0%	0.7%	0.0%	0.0%	0.0%	0.1%	
Unmanaged Zone																																		
May-06	1.6%	16.9%	trace	2.0%	6.0%	1.0%	2.2%	0.0%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.2%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	2.1%	20.3%	0.2%	9.3%	25.2%	0.0%	2.1%	0.0%	0.0%	0.0%	0.0%	
Jul-06	0.0%	33.9%	trace	1.1%	1.4%	0.3%	3.3%	0.0%	4.1%	0.0%	0.0%	0.0%	0.0%	0.0%	2.8%	0.9%	0.0%	trace	1.6%	0.0%	0.0%	0.0%	0.0%	15.6%	0.0%	8.9%	19.4%	0.0%	4.0%	0.0%	0.0%	0.0%	0.0%	
Sep-06	0.8%	36.8%	0.0%	0.5%	0.0%	0.1%	3.1%	0.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.3%	0.6%	0.0%	0.0%	3.4%	0.0%	0.0%	0.0%	0.0%	23.0%	0.1%	6.7%	23.2%	0.0%	3.3%	0.0%	0.0%	0.0%	0.0%	
Nov-06	0.0%	11.1%	0.0%	0.0%	0.1%	0.0%	3.6%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	6.5%	1.3%	0.0%	0.0%	2.6%	0.0%	0.0%	0.0%	0.0%	29.2%	0.5%	6.7%	13.0%	0.0%	3.1%	0.0%	0.0%	0.0%	0.0%	
Jan-07	0.0%	6.6%	0.0%	0.1%	0.3%	0.0%	4.4%	trace	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	6.4%	1.2%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	32.3%	0.1%	3.9%	11.3%	0.0%	3.5%	0.0%	0.0%	0.0%	0.0%	
Mar-07	0.0%	8.2%	0.0%	0.0%	1.6%	0.1%	4.0%	trace	1.4%	0.0%	0.0%	0.0%	0.0%	0.0%	7.2%	1.0%	0.0%	0.0%	0.6%	0.0%	0.0%	0.0%	0.0%	35.3%	0.6%	6.4%	14.2%	0.0%	4.6%	0.0%	0.0%	0.0%	0.0%	
May-07	0.0%	7.2%	0.0%	0.0%	1.6%	0.7%	4.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	6.5%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	34.9%	4.9%	5.3%	16.0%	0.0%	3.9%	0.0%	0.0%	0.0%	0.0%	
Jul-07	0.0%	19.6%	0.0%	0.0%	0.7%	2.7%	2.9%	0.0%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	5.8%	0.1%	0.0%	0.0%	0.2%	0.0%	0.0%	trace	0.0%	35.2%	1.7%	5.7%	15.0%	0.0%	1.4%	0.0%	0.0%	0.0%	0.0%	
Sep-07	0.0%	21.5%	0.0%	0.1%	0.8%	2.8%	3.6%	0.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.6%	3.5%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	35.1%	1.5%	3.1%	15.3%	0.0%	0.9%	0.0%	0.0%	0.0%	0.0%	
Nov-07	0.2%	10.7%	0.0%	0.0%	1.9%	3.0%	3.3%	0.0%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	6.3%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	31.5%	0.8%	3.7%	17.7%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	



APPENDIX VI – Photographs : Infrastructure

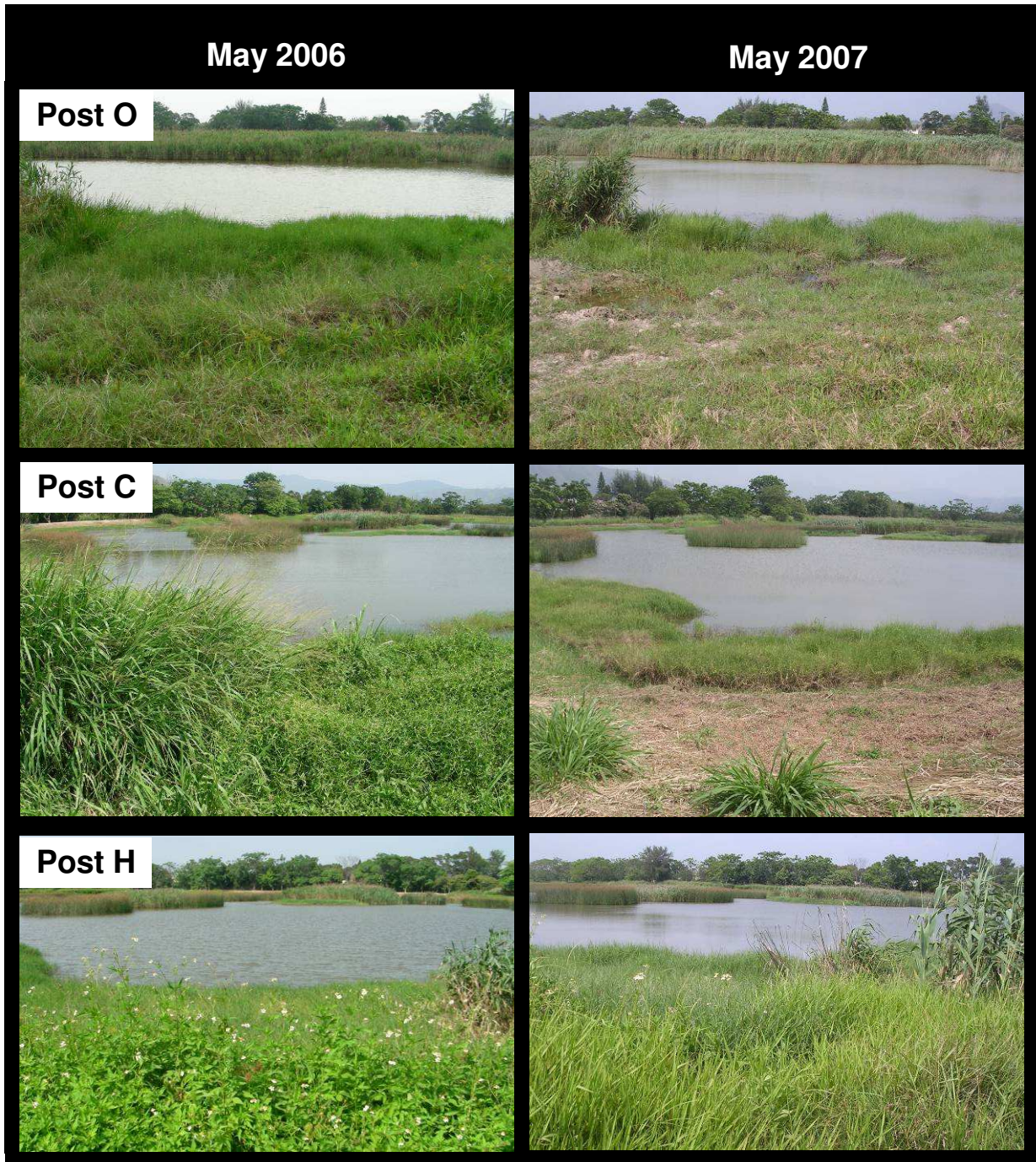


1. Fence construction.

2. Completed fence enclosure.

3. Buffalo shelter.

APPENDIX VII – Photographs : Habitat Condition Page 1 of 2



Post O – Grazed Zone

Post C – Managed Zone

Post H – Unmanaged Zone

APPENDIX VII – Photographs : Habitat Condition



1. Grazed Zone - Post N (May-07)



2. Managed Zone – Post A (May-07)



3. Unmanaged Zone – Post I (May-07)



APPENDIX VIII – Photographs : Grazed Zone



1. Typical grazed marsh habitat showing poached ground and a wallow (08-Feb-2007).
2. Area of Common Reed grazed and trampled by the buffalo (08-Feb-2007).
3. Comparison of a Common Reed stand along a shared bund between the Grazed zone and a neighbouring pond (06-Dec-2006).