WWF for a living planet®

The Hong Kong Bird Ringing Group

STUDY INTO THE AVIAN VALUE OF DIFFERENT AGED STANDS OF *PHRAGMITES AUSTRALIS* AT MAI PO NATURE RESERVE

FINAL REPORT : 2009

CONTENTS

This publication should be cited as:
WWF-HK & HKBRG, 2008. **Study into the Avian Value of Different Aged Stands of *Phragmites Australis* at Mai Po Nature Reserve**. Joint report by the World Wide Fund For Nature Hong Kong and the Hong Kong Bird Ringing Group.

Report Authors:
Mr. Bena Smith, WWF Hong Kong.
Mr John Allcock, Hong Kong Bird Ringing Group.

Principal Field Surveyors:
WWF-HK – Mr. Bena Smith, Ms. Katherine Leung, Dr. Judy Wan.
HKBRG – Dr. Mike Leven, Mr. Paul Leader, Mr. John Allcock.

[Cover photo: The Reedbed in *Gei wai* #8 – Bena Smith]

EXECUTIVE SUMMARY

i In January 2001, WWF Hong Kong and the Hong Kong Bird Ringing Group partnered to study the avian value of different aged stands of Reed Grass *Phragmites australis* at the Mai Po Nature Reserve (MPNR). The 5-year study is expected to contribute to the formulation of an overall management strategy for the large areas of Reed Grass (often called “reedbed”) which have established inside the Reserve over the past 20 years.

ii The primary study objective is to investigate the influence of reed age and structure on the diversity and abundance of bird species present within the Mai Po reedbeds. A secondary objective is to investigate the impact of manual management upon the structure of reed stands.

iii The large stand of reed in *gei wai* #8 was selected for the study in which five 1 ha plots were established. One plot acted as a control area, the other four received treatment; burning (Plot #2 only), or manually cutting and removing of reed. Treatment was applied on an annual rotation with each of the four plots being treated once within the 5-year study period. To investigate reed structure, various key parameters in each plot were assessed in January of each study year (prior to receiving treatment). Avifauna data was collected in spring (January to May) and autumn seasons (August to December) by trapping birds in mist nets from each plot using constant effort.

iv A total of 7,414 birds comprising 71 species were trapped. The five most abundant species being Oriental Reed Warbler *Acrocephalus orientalis*, Dusky Warbler *Phylloscopus fuscatus*, Black-browed Reed Warbler *Acrocephalus bistrigiceps*, Japanese White-eye *Zosterops japonicus* and Yellow-bellied Prinia *Prinia flaviventris*. Three globally-threatened species were also trapped: Styan’s Grasshopper Warbler *Locustella pleskei*, Manchurian Reed Warbler *Acrocephalus tangorum* and Yellow-breasted Bunting *Emberiza aureola*.

v Variations in bird abundance were significant between years in autumn (August to December) for most species, but only apparent in spring (January to May) for three species. There was no variation in the abundance of any bird species, or the total bird abundance, between the different treatment plots during either spring or autumn.

vi No significant differences were observed in the abundance of any bird species between reed stands of different age in autumn. This indicates that reed stands cut in mid-winter have regrown sufficiently to provide suitable habitat for reed-dependent species by the time of autumn migration. In spring, newly-cut reed stands did show an immediate decline in bird abundance, particularly for resident prinias (*P. flaviventris* and *Prinia inornata*). Spring migrants did not differ significantly, which suggests that following treatment, reeds are sufficiently regrown by the time of spring migration.

vii The relationships between bird abundance and reed stand structure were relatively complex, with results differing for each species. The most frequent relationship was between bird species and leaf litter depth; being significant in autumn for six of the top ten bird species (Dusky Warbler, Japanese White-eye, Yellow-bellied Prinia, Plain Prinia, Scaly-breasted Munia and Siberian Rubythroat). A significant relationship between total bird abundance and leaf litter depth was also observed. Both may be explained by a higher abundance of invertebrates in reed stands with deeper leaf litter. There was a significant relationship between total bird abundance and basal stem density, which was also significant for Dusky Warbler and Plain Prinia. A high density of reed stems may either increase invertebrate abundance, or may assist with movement of birds through the reed stand.

ix Fewer relationships were found between bird abundance and reed stand structure in spring, although overall bird abundance was correlated to basal stem density and inversely correlated to the number of flowering stems. There was a strong correlation in spring between Siberian Rubythroat abundance and the ratio of old to new reed stems (probably related to food availability – a higher density of ant (*Polyrachis* sp.) nests in older reed stands).

x Trend analysis of the reed structure data mildly suggests treatment increased reed density and the percentage of flower-bearing stems in the first year post-treatment, and also decreased reed length and diameter in the few years following treatment. Data from the only burned plot (Plot #2) showed the post-treatment response differed from manual clearance methods such that reed stem length, diameter and the percentage of flower-bearing stems may take longer to recover. Several of these findings concur with those from European studies. Data was however affected by annual climatic variation.

xi A number of factors affected the quality of field data. Climatic variations between years, water-level fluctuations and changes in recorder personnel from one year to the next all affected reed structure data. Annual variation and the use of non-independent plot areas affected bird data. Data interpretation suffered from the rejection of data from the control area (due mainly to concerns over structural differences from the main study plots) and the use of two different treatment methods.

xii There are no major implications for the future management of the MPNR reed stands arising from this study. It has however shown that:

- Regular cutting or burning does not significantly impact upon bird abundance or diversity.
- Annual climatic variation influenced reed stand structure greater than burning or cutting management methods.
- Post-treatment, changes to reed structure (reed stem length and diameter, and percentage of flower-bearing stems) in burned stands and manually cut stands may differ.
- The MPNR reed stands continue to support a variety of birds including three globally-threatened species: Styan's Grasshopper Warbler, Manchurian Reed Warbler and Yellow-breasted Bunting.

xiii Although not an objective of this study, regular management activities such as cutting or burning can prevent reed stands drying out and thus maintain their health by suppressing mangrove shrubs, ferns and unwanted grasses (particularly *Echinochloa* sp.). Drying out would significantly impact those bird species which are dependent on this habitat at MPNR, in which case the cutting of reed stands may assist in maintaining suitable habitat for them. This deliberate interruption of the ecological succession process is common practice in European and North American conservation managed reed stand areas to reduce long-term management costs and the frequency of expensive de-silting operations (Hawke & Vose, 1996).

xiv Further study such as an investigation into the avian and invertebrate values of wet and mature reed stands is recommended to aid the formulation of the reedbed management strategy. Based upon experiences within this study, it is recommended that future studies collect structure data upon reed density, ratio old:new stems, percentage of flowering stems, reed stem length, and reed stem diameter only.

1. INTRODUCTION

1.1 Background

1.1.1 The Mai Po Nature Reserve (MPNR), located at the eastern side of the Mai Po Inner Deep Bay Ramsar Site, has been managed by the World Wide Fund For Nature Hong Kong since 1983 and at present contains over thirty independent waterbodies; traditionally operated brackish *gei wai*, high-tide roosts and rain-fed freshwater ponds. Following the onset of nature conservation management and the cessation of intense aquaculture practices upon these waterbodies, natural succession led to the establishment of large areas of aquatic vegetation, particularly Reed Grass *Phragmites australis*. Between 1973 and 2001, stands of Reed Grass (often called 'reedbed') increased by ~70% mainly at the expense of open water areas inside MPNR (WWF-HK, 2006).

1.1.2 The 46ha area of reed inside MPNR is an important habitat for a diversity of insects - known to support nearly four hundred species of invertebrate with at least four species probably being undescribed previously (Reels, 1994) – and a total of 88 bird species. Reedbeds within the Reserve provide an important habitat for a number of migrant and overwintering passerine species, some of which are found almost exclusively in this habitat. Among the bird species, Styan's Grasshopper Warbler *Locustella pleskei*, Manchurian Reed Warbler *Acrocephalus tangorum* and Yellow-breasted Bunting *Emberiza aureola*, are all listed as globally threatened (Vulnerable) (Birdlife International, 2008).

1.1.3 Despite their intrinsic wildlife value and contribution to the biodiversity of MPNR, a continued expansion of reed inside the Reserve could negatively affect other wildlife, particularly species which rely on open water areas or other aquatic vegetation types. The older mature stands of reed are also drying out and thus becoming invaded by terrestrial vegetation; this reduces reed quality and density and their attractiveness to certain bird species. A conservation management strategy, based upon field trials, is therefore required for the MPNR reedbeds to guide future management decisions.

1.1.4 European studies indicate there is a relationship between the age of the reeds and the abundance and diversity of birds found within them, particularly so for breeding species (White, 2005a). It is noted the relationship differs for 'interior' and 'exterior' species. Because the environment, climate and bird species differ between South China and Europe, an independent study is required to investigate whether the same results hold true in Hong Kong. As a result, a joint study was initiated in 2001 between the World Wide Fund for Nature Hong Kong and the Hong Kong Bird Ringing Group to investigate this topic and to facilitate the formulation of a suitable management strategy for the MPNR reedbeds.

1.2 Study Objectives

1.2.1 The objectives of the study are:

Primary – To investigate the influence of reed age and structure on the diversity and abundance of bird species present within the stands of reed.
Secondary – To investigate the impact of manual management upon the structure of reed stands.

2. METHODS

2.1 Study Area

2.1.1 The stand of reed inside *gei wai* #8 (Fig. 1) was deemed suitable for study purposes, being the largest single contiguous stand of reed inside MPNR. It is also located in an area not accessible to public visitor groups. For the purposes of the study, the centralised area of reed inside *gei wai* #8 was divided into five 1ha plots (Fig. 2) with an internal network of boardwalks providing access between plots.

Figure 1. Location of *Gei wai* #8 and Study Area inside Mai Po Nature Reserve.

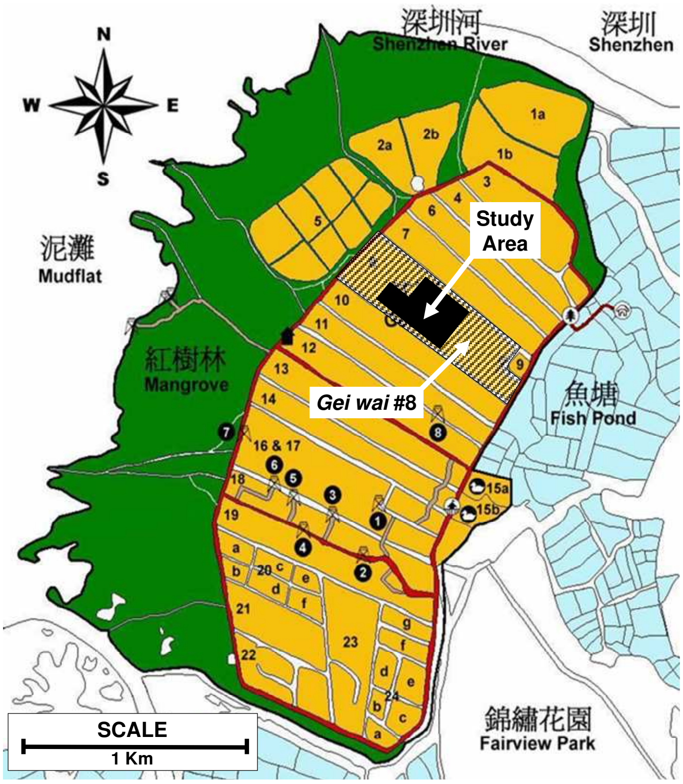
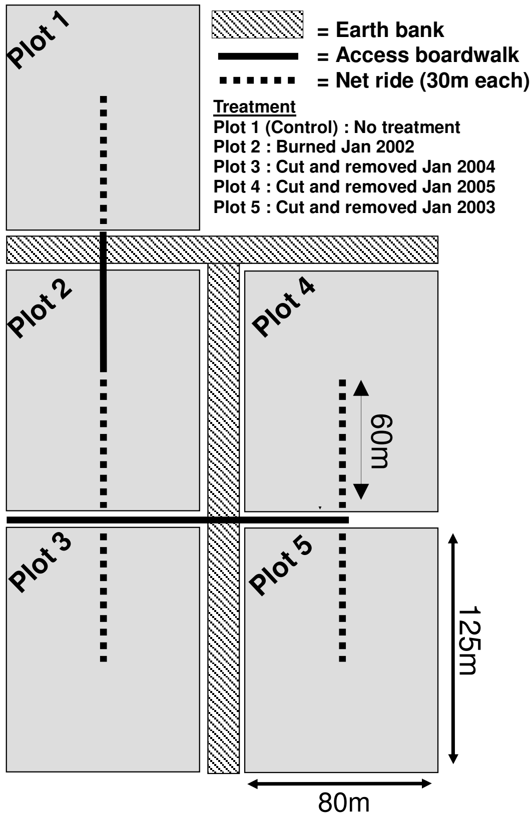


Figure 2. Layout and Treatment of the Five 1-ha Study Plots inside *Gei wai* #8.



2.2 Reed Stand Treatment

2.2.1 In late January, the reeds in Plots #2, #3, #4 and #5 were treated on a rotational basis between 2002 and 2005 (Fig. 2). Burning was the preferred treatment method and applied to Plot #2 in January 2002, but due to unexpected circumstances it could not be used thereafter. For the remaining plots (#3, #4 and #5) cutting and removal was employed. Plot #1 remained as a control area without treatment.

2.3 Reed Stand Structure Data

2.3.1 In early January of each year (prior to receiving treatment), six 2m x 2m quadrats were randomly located in each of the five plots to sample the relative structure of the reed. Within this large quadrat, a smaller 0.5m x 0.5m quadrat was randomly placed. The following parameters were measured:

Within the 2m x 2m quadrat:

- *Basal vegetation density*
  A 35cm x 35cm board painted with a 5 x 5 checkered pattern was inserted vertically into the reed base. At a distance of 50cm from the board, the observer counted the number of obscured squares (i.e. 50% or more of the square not visible through the reed). The basal density equaled the overall percentage of obscured squares.

- *Leaf litter depth*
  Four measurements of the depth of the leaf litter layer at the base of the reed were taken using a meter ruler to the nearest 0.5cm.

- *Reed stem length and reed stem diameter*
  Twenty flowering stems were cut just above ground-level and removed for stem length and diameter measurements. The stem length - the distance from the substrate surface

(the cut end) to the top of the extended flower - was measured to the nearest centimeter. In addition, the diameter of the same twenty flowering stems was measured to the nearest 0.1mm using a Vernier caliper. Measurements were taken about 3cm above the cut and avoided obvious knots.

- *Percentage of flower-bearing stems*
  Fifty randomly selected reeds were examined for the presence of flowering heads to calculate the percentage of flower-bearing stems.

Within the 0.5m x 0.5m quadrat

- *Reed density*
  All reed stems rooted in the quadrat with a height greater than 1m above ground-level were counted.

- *Ratio of old:new stems*
  The numbers of old reed stems (not green at base) and new stems (green at base) rooted in the quadrat with a height greater than 1m above ground-level were counted, and the ratio of old to new stems calculated.

2.3.2 To overcome bias towards the number of samples collected from certain aged plots within the study, and to facilitate a a more meaningful comparison of structural changes, the number of quadrats surveyed in the most affected age stands was increased. For example, reed stands aged 4 years were only available for survey in the final study year (2006), so the sample effort in aged 4 reed stands was substantially increased in that year to obtain a data set comparable in size to other aged stands. Although not ideal, this was deemed necessary.

2.4 Bird Data

2.4.1 Bird trapping was conducted by the Hong Kong Bird Ringing Group between January 2001 and December 2005 using mist nets set in the centre of each of the five plots (Fig. 2). During this time, three trapping sessions were carried out per month during the period January – May and August – December; no surveys were conducted during June and July, when the density of birds is low and trapping could negatively impact on breeding activity. During each trapping session, a standard set-up of mist-nets (totally 60m per plot) was erected for a period of four hours, starting at dawn. All birds trapped were ringed and released back into the reed stand.

2.5 Control Plot

2.5.1 In January 2005, after collection of the fourth reed stand structure data set, Plot #1 was deemed too dissimilar to other plots to be an effective control for the study. Vegetation such as small mangrove shrubs and ferns, and terrestrial grasses had invaded the plot. Differences in vegetation structure were also reflected in the bird community, which supported fewer reed-associated species, the focus of this study. In view of these differences from other plots, it was decided to omit all control plot data from statistical data analysis and be used only for reference purposes.

2.6 Statistical Methods

2.6.1 Statistical analyses of bird distribution were conducted on a seasonal basis, based on the mean number of individuals trapped per session in each season (January – May for spring, and August – December for autumn). This corresponds with the period before and after treatment of the reed. The data used for analysis includes all captures (including original captures and recaptures of individuals previously trapped). Unfortunately, some trapping sessions were cancelled as a result of poor weather, therefore the number of trapping sessions varied in different years, although the seasonality of the trapping within each year was not affected. To compensate for this difference, analysis has been conducted on the mean number of individuals trapped during each trapping session.

2.6.2 Separate analyses of the impacts of reed stand age and structure on the bird community have been conducted for the abundance of each of the ten commonest bird species, as well as for the total abundance of birds in the reed stands.

2.6.3 Differences in bird species abundance between years and differences between reed stand ages were compared by One-way ANOVA. Relationships between reed stand structure and bird abundance were assessed by use of non-parametric correlations (Spearman's Rank correlation).

3. RESULTS

3.1 Reed Stand Structure

Results are summarised per reed stand age (Table 1 and Fig. 3), and per plot (Table 2 and Fig. 4).

3.1.1 *Reed density* (Figs. 3a & 4a)
Reed stand age data suggests that reed density generally increased in the two years following treatment by ~14-15% from pre-treatment levels. However individual study plot data is inconclusive and annual variation appeared to be a dominant factor.

3.1.2 *Ratio of old:new stems* (Figs. 3b & 4b)
Treatment appeared to not have an immediate impact on the ratio of old:new stems in plots, but in the following few years increased dramatically. The ratio peaked in plots aged 3 years showing a ~400% increase from pre-treatment levels. Annual variation appeared to be a dominant factor.

3.1.3 *Basal vegetation density* (Figs. 3c & 4c)
Treatment reduced basal density by ~27% in the first year after application with a general recovery thereafter. Annual variation appeared to influence the data as is illustrated by the 2004 data set.

3.1.4 *Leaf litter depth* (Figs. 3d & 4d)
The depth of leaf litter generally increased after treatment and continued to increase each year thereafter, being ~115% greater 4 years post-treatment.

3.1.5 *Percentage of flower-bearing stems* (Figs. 3e & 4e)
The number of flowering stems increased from ~36% in untreated stands to ~51% one year post-treatment, with a sharp decline thereafter to a percentage below pre-treatment levels. Annual variation appeared to be a dominant factor.

3.1.6 *Reed stem length* (Figs. 3f-3g)
Treatment generally reduced reed stem length in the first year after treatment (~5%) with a gradual recovery thereafter. Plot #2 (burned plot) was the only plot where reed stem length decreased for two consecutive years post-treatment before showing recovery.

3.1.7 *Reed stem diameter* (Figs. 4f-4g)
Reed stem diameter generally reduced in the first year following treatment (~8%), the only exception being Plot #5. Stem diameter in Plot #2 (burned plot) showed a continued reduction within the study period. Annual variation appeared to influence the data.

Table 1. Summary of Reed Structure Data for Different Aged Stands of Reed.

	Age of Reed Stand (years)				
	1	2	3	4	>4
Reed Density (/m^2)	102.8	103.4	93.9	54.9	90.0
Ratio of Old/New Stems	3.6	9.3	14.3	12.2	3.6
Basal Vegetation Density (%)	55.5	70.8	60.8	62.3	75.6
Leaf Litter Depth (cm)	9.2	10.7	17.0	18.6	8.6
% of Flowering-bearing Stems	50.9	27.2	19.9	33.4	36.4
Stem Length (cm)	198.8	204.3	202.3	195.5	209.3
Stem Diameter (mm)	6.6	7.1	6.3	6.2	7.2
Total No. of Plots Surveyed	**4**	**3**	**2**	**1**	**10**
Total No. of Samples	**26**	**26**	**26**	**26**	**32**

Table 2. Summary of Reed Structure Data from Each Plot.

	Survey Year	Reed Density (/m^2)	Ratio of Old/New Stems	Basal Vegetation Density (%)	Leaf Litter Depth (cm)	% of Flowering-bearing Stems	Reed Stem Length (cm)	Reed Stem Diameter (mm)	Age of Reed Stand (years)
Plot 2	2002	78.0	2.3	48.0	5.0	66.0	226.2	7.8	>4
	2003	68.0	1.8	30.0	2.0	75.0	217.2	7.1	1
	2004	110.7	14.1	98.0	5.6	46.0	194.2	7.3	2
	2005	96.7	8.1	70.0	8.9	27.3	204.0	6.7	3
	2006	54.9	12.2	62.3	18.6	33.4	195.5	6.2	4
Plot 3	2002	102.0	6.3	54.0	6.0	28.0	199.3	7.1	>4
	2003	40.0	1.0	76.0	5.8	60.0	197.1	7.1	>4
	2004	80.7	7.1	98.0	4.7	52.7	204.8	7.3	>4
	2005	99.3	3.7	37.3	7.5	36.3	183.9	5.7	1
	2006	101.1	10.1	61.1	10.2	29.4	211.1	7.1	2
Plot 4	2002	86.0	3.3	44.0	4.8	21.0	209.6	7.4	>4
	2003	60.0	2.0	52.0	5.8	44.0	212.9	6.9	>4
	2004	103.3	3.7	86.0	11.0	30.0	207.4	7.0	>4
	2005	135.3	3.1	79.3	13.5	5.0	212.6	7.1	>4
	2006	106.0	2.3	49.0	10.7	54.3	212.5	6.7	1
Plot 5	2002	62.0	30.0	58.0	4.3	31.0	211.1	7.4	>4
	2003	54.0	2.4	68.0	4.0	62.0	218.0	7.1	>4
	2004	111.3	26.8	95.3	6.3	50.3	180.2	7.4	1
	2005	101.3	5.9	66.0	13.0	3.3	195.9	6.5	2
	2006	93.0	18.4	58.0	19.5	17.7	201.8	6.1	3

Figure 3. Graphs Showing Changes in Reed Stand Structure Attributes by Reed Stand Age.

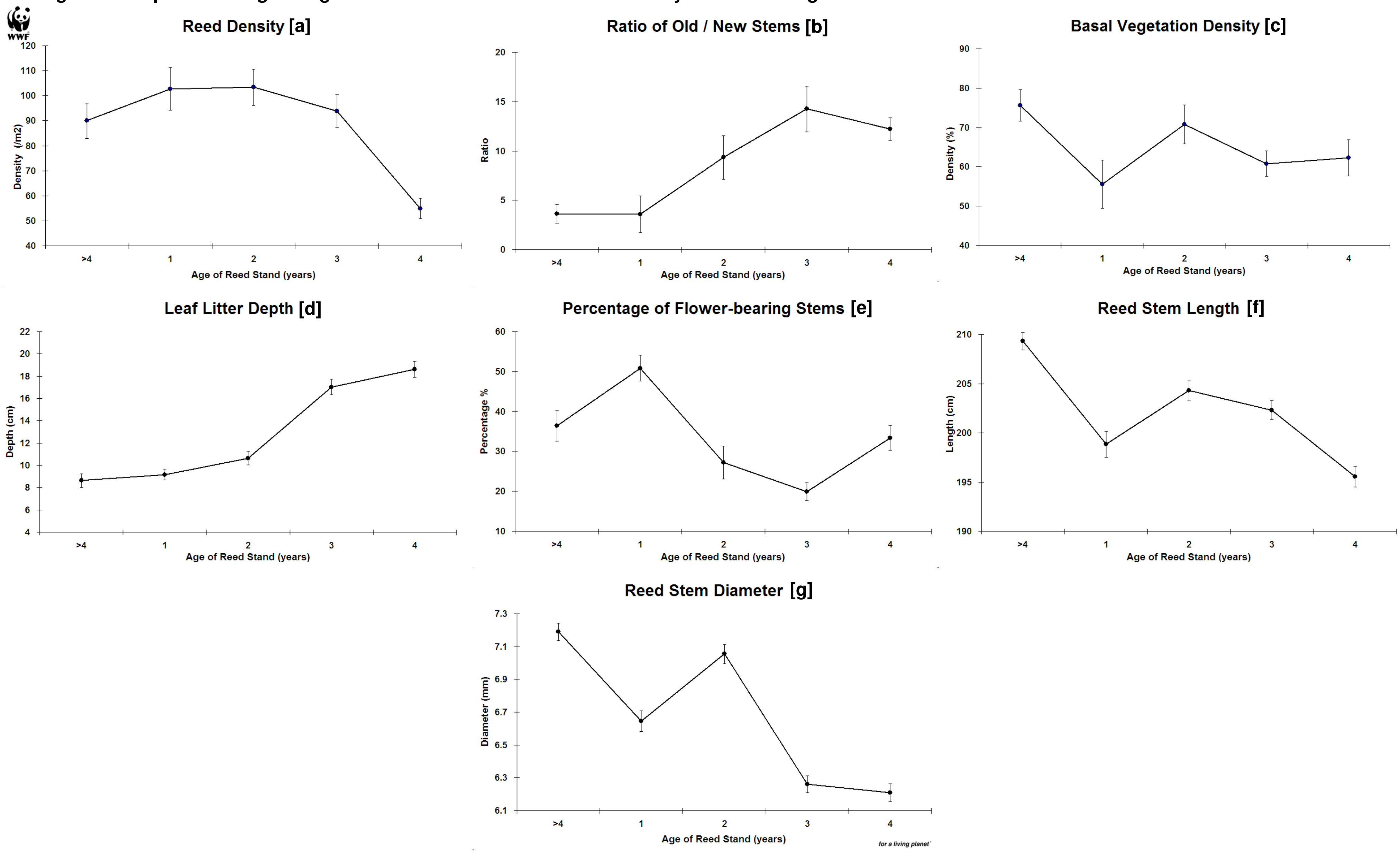
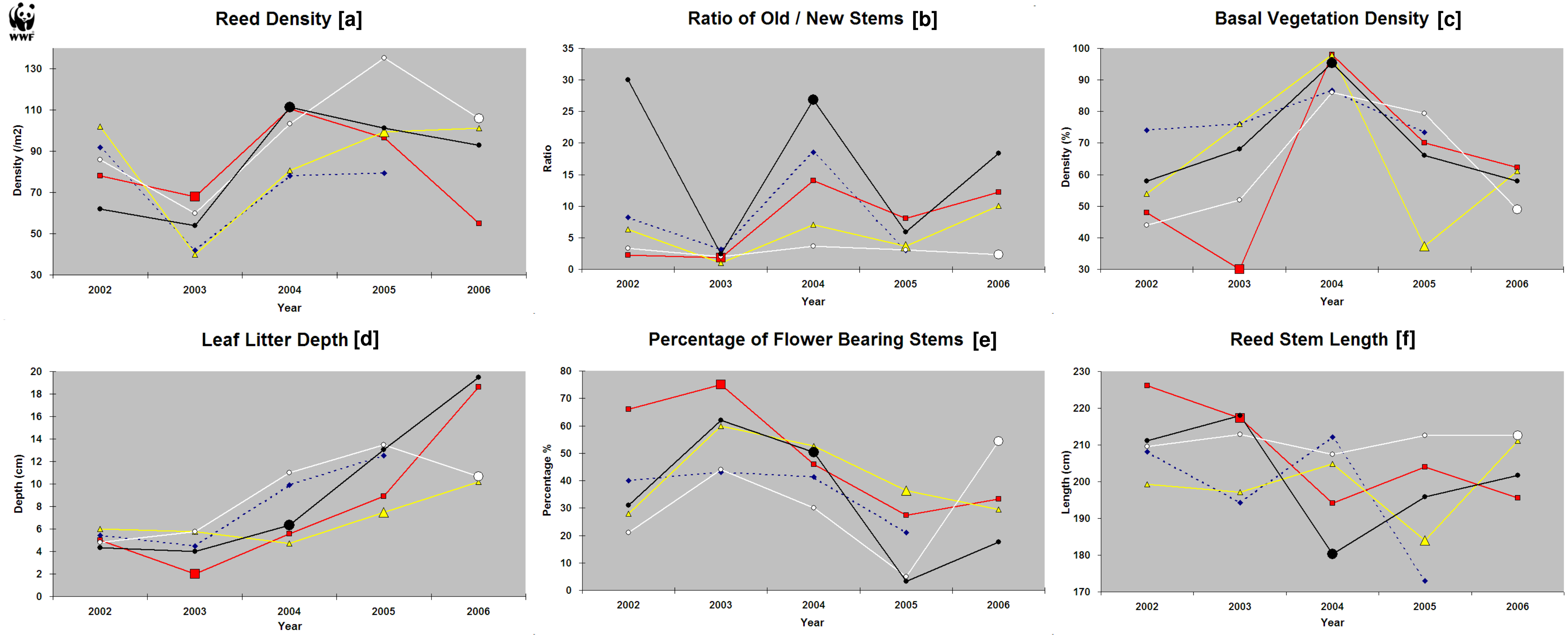
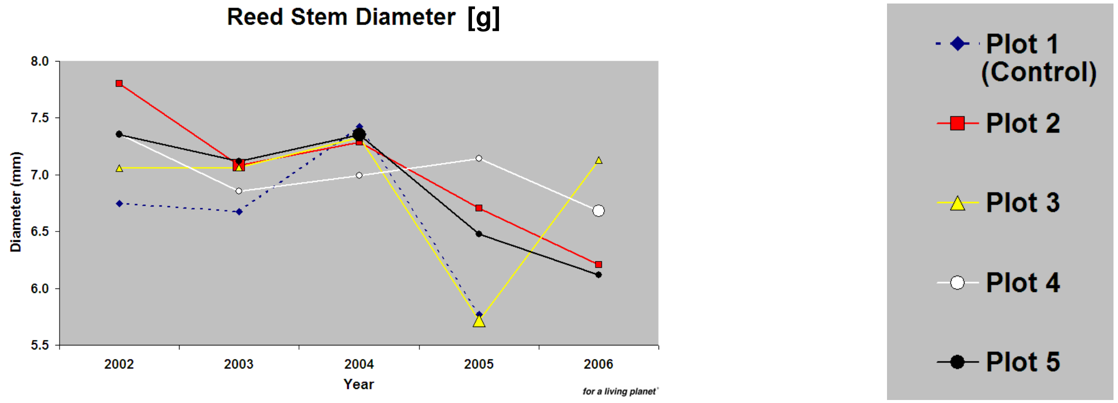


Figure 4. Graphs Showing Changes in Reed Stand Structure Attributes by Year.



Within each trend line, large symbols refer to the first data set collected after treatment for that plot



3.2 Bird Survey

General Bird Trapping Results

3.2.1 Within the 5-year study period a total of 7,414 birds were trapped (including recaptures of birds previously ringed) comprising 71 species (Appendix I). Of the top ten species trapped (Table 3), six are migrant species (Oriental Reed Warbler *Acrocephalus orientalis*, Black-browed Reed Warbler *Acrocephalus bistrigiceps*, Dusky Warbler *Phylloscopus fuscatus*, Chinese Penduline Tit *Remiz consobrinus*, Siberian Rubythroat *Luscinia calliope* and Black-faced Bunting *Emeriza spodocephala*), three species are resident in the reed stands (Yellow-bellied Prinia *Prinia flaviventris*, Plain Prinia *Prinia inornata* and Scaly-breasted Munia *Lonchura punctulata*) and one species is resident in Hong Kong but only uses reed habitats in winter (Japanese White-eye *Zosterops japonicus*).

3.2.2 The five most abundant species were Oriental Reed Warbler (1,598 captures), Dusky Warbler (1,280 captures), Black-browed Reed Warbler (802 captures), Japanese White-eye (788 captures) and Yellow-bellied Prinia (658 captures). Three globally threatened species were trapped: Styan's Grasshopper Warbler *Locustella pleskei* (2 captures), Manchurian Reed Warbler *Acrocephalus tangorum* (17 captures) and Yellow-breasted Bunting *Emberiza aureola* (11 captures).

Variation in Bird Abundance (Tables 3 & 4, Fig. 5)

<u>*Variation in abundance between years*</u>

3.2.3 Bird abundance differed significantly between years in autumn for most species (Oriental Reed Warbler p=0.044; Dusky Warbler p<0.001; Black-browed Reed Warbler p=0.001; Japanese White-eye p<0.001; Chinese Penduline Tit p=0.050; Siberian Rubythroat p=0.020). Yellow-bellied and Plain Prinias, both of which are resident species in the reed stand, did not differ significantly in abundance between years (Yellow-bellied Prinia p=0.651; Plain Prinia p=0.072). Scaly-breasted Munia was significantly more abundant in 2005 (p=0.018), when large flocks were present in the reed stand, possibly roosting or feeding on the seeds of grasses present among the reeds. Black-faced Bunting was the only migratory species not to show any inter-annual variation in abundance in autumn (p=0.119).

3.2.4 Variation between years was only apparent in spring for three species: Oriental Reed Warbler (p=0.003), Black-browed Reed Warbler (p=0.012) and Plain Prinia (p=0.049).

<u>*Variation in abundance between plots*</u>

3.2.5 There was no variation in the abundance of any bird species, or the total bird abundance, between the different treatment plots during either spring or autumn.

Bird Abundance in Relation to Reed Stand Age (Tables 3 & 4, Fig. 6)

3.2.6 Despite a slight increase in total autumn bird abundance as reed stands aged after cutting (Fig. 6), this was not significant and reed stand age had no impact on total bird abundance in the individual plots.

3.2.7 There were, however, significant differences in spring: total bird abundance was lower in reed stands which had been recently cut (p=0.005). This was also apparent in both prinia species (Yellow-bellied Prinia p=0.004; Plain Prinia p=0.046). Siberian Rubythroats were more abundant in old reed stands (>4 years) than in newly-cut reed stands (p=0.021), although the differences were not significant between other age categories.

Bird Abundance in Relation to Reed Stand Structure (Figs. 7 & 8).

<u>*Relationship between total bird abundance and reed stand structure*</u>

3.2.8 Autumn bird abundance within the plots was significantly correlated to reed density (p=0.043) and leaf litter depth (p=0.011). Spring bird abundance was correlated to reed density (p=0.016) and negatively correlated to the number of flowering stems (p=0.027).

Relationship between individual species and reed stand structure

3.2.9 Several species showed significant correlations between abundance in autumn and the reed stand structure in the following January (i.e. during the same winter). Oriental Reed Warbler preferred reed stands with a high ratio of old to new stems (p=0.014). Dusky Warbler preferred reed stands with a high density of reeds (p=0.024) and deeper leaf litter (p=0.018). Japanese White-eye occurred mostly in reed stands with thicker stems (p=0.007), a greater basal density (p=0.008) and deeper leaf litter (p=0.046). Yellow-bellied and Plain Prinias tended to occur in reed stands with deeper leaf litter (p=0.011 and p=0.006) and less flowering stems (p=0.002 and p=0.028); Plain Prinia also preferred thinner reed stems (p=0.043). Scaly-breasted Munia similarly showed a strong correlation to plots with deep leaf litter (p<0.001) and thin reed stems (p=0.026). Siberian Rubythroat preferred reed stands with deeper leaf litter (p=0.034). No significant correlations between abundance and reed stand structure were observed for Black-browed Reed Warbler, Chinese Penduline Tit or Black-faced Bunting. Overall bird abundance showed significant correlations to basal reed density (p=0.043) and leaf litter depth (p=0.011).

3.2.10 In spring, only four species were significantly affected by reed stand structure. Chinese Penduline Tit occurred in larger numbers in plots with a high density of reeds (p=0.031) and a high basal stem density (p=0.047). Plain Prinia preferred plots with a higher ratio of old to new stems (p=0.011) and with deeper leaf litter (p=0.014). Siberian Rubythroat also preferred a high ratio of old to new stems (p=0.002). Black-faced Buntings tended to occur in reed stands with a higher basal stem density (p=0.023).

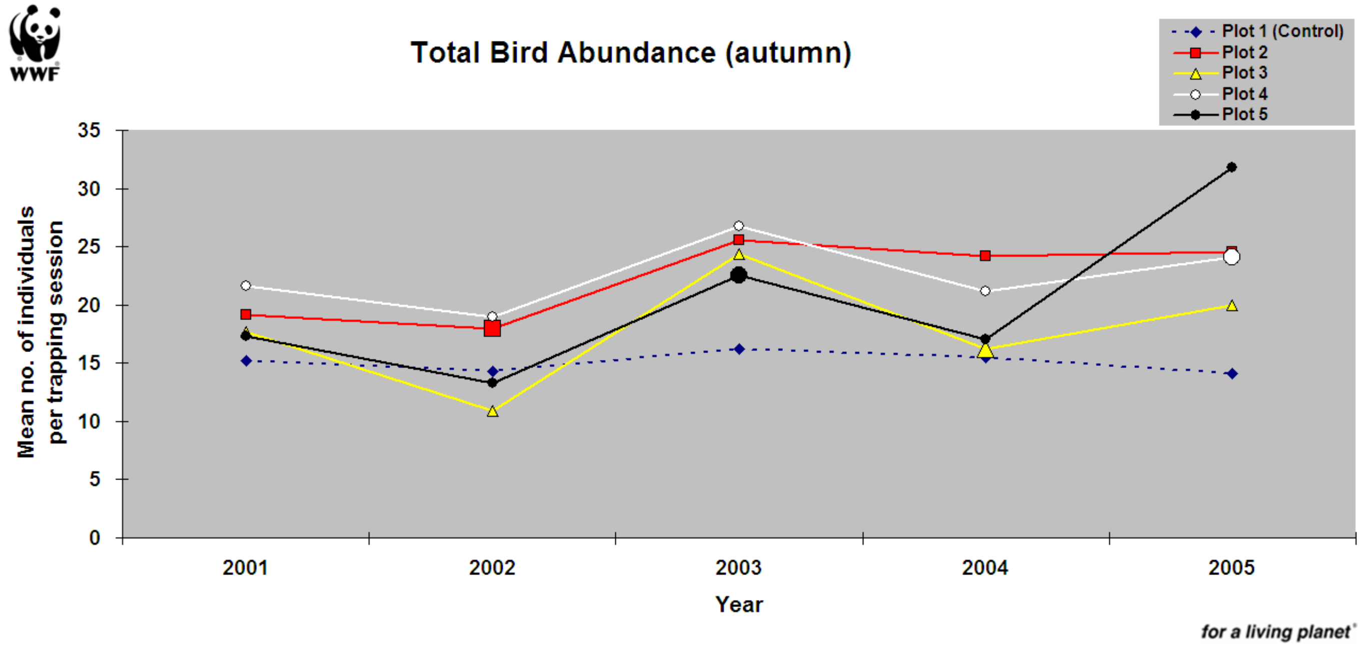
Table 3. Mean Abundance per Trapping Session in Autumn (August – December) of the Ten Most Numerous Birds.

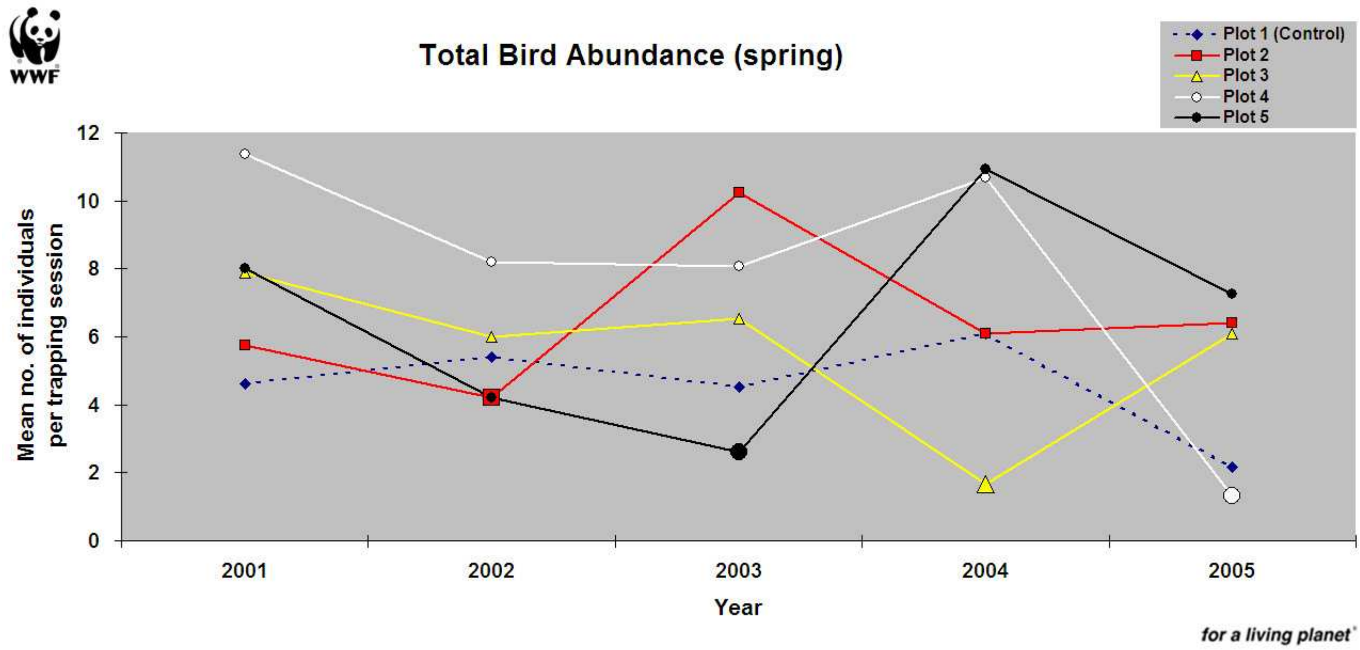
	Survey Year	Oriental Reed Warbler	Dusky Warbler	Black-browed Reed Warbler	Japanese White-eye	Yellow-bellied Prinia	Chinese Penduline Tit	Plain Prinia	Scaly-breasted Munia	Siberian Rubythroat	Black-faced Bunting	Age of Reed Stand (years)
Plot 1	2001	5.8	2.5	2.2	0.7	1.0	0.0	0.3	0.0	0.2	0.2	>4
	2002	3.8	1.3	1.4	2.6	1.2	0.1	0.9	0.8	0.2	0.1	>4
	2003	4.5	4.6	1.9	0.7	0.6	0.5	0.1	0.1	0.2	0.3	>4
	2004	4.5	3.2	2.5	1.2	1.1	0.1	0.4	0.0	0.1	0.1	>4
	2005	5.3	3.6	1.8	0.3	1.3	0.0	0.8	0.1	0.3	0.0	>4
Plot 2	2001	6.0	2.3	4.2	3.8	0.3	0.7	0.0	0.0	0.2	0.2	>4
	2002	5.2	2.2	1.6	2.8	0.5	1.8	1.0	0.1	0.5	1.1	1
	2003	6.6	4.3	2.5	5.8	1.4	1.2	0.2	0.5	0.5	0.5	2
	2004	7.3	4.4	3.3	3.1	1.5	0.1	1.2	0.0	0.3	0.3	3
	2005	6.7	4.8	3.0	0.4	1.7	0.2	1.8	3.3	0.8	0.3	4
Plot 3	2001	5.7	2.0	3.5	1.7	1.0	0.2	1.8	0.2	0.0	0.0	>4
	2002	2.3	1.8	1.2	2.0	1.3	0.2	0.5	0.4	0.3	0.4	>4
	2003	4.8	6.5	3.5	5.5	0.9	0.2	0.8	0.2	0.2	0.0	>4
	2004	4.4	4.1	2.9	0.4	0.9	0.4	1.1	0.4	0.0	0.1	1
	2005	4.6	4.2	2.9	0.6	1.4	0.1	1.2	2.3	0.3	0.3	2
Plot 4	2001	5.8	3.7	3.3	1.3	2.3	2.0	1.2	0.2	0.0	0.0	>4
	2002	4.6	1.7	1.2	3.2	1.5	3.6	0.1	0.2	0.2	0.5	>4
	2003	4.8	5.4	3.0	5.5	1.7	1.7	1.3	0.5	0.7	0.5	>4
	2004	5.4	3.8	2.7	2.1	2.4	0.4	1.9	0.1	0.3	0.2	>4
	2005	6.8	5.8	4.3	0.5	1.3	0.3	1.9	0.3	0.3	0.3	1
Plot 5	2001	6.5	2.8	2.7	3.2	1.3	0.2	0.0	0.0	0.0	0.0	>4
	2002	3.2	1.5	1.3	1.7	1.0	2.2	0.5	0.2	0.3	0.1	>4
	2003	6.6	6.7	1.4	3.0	1.7	0.2	1.1	0.2	0.2	0.2	1
	2004	4.7	3.9	2.7	0.8	1.1	0.2	1.5	0.4	0.2	0.2	2
	2005	7.3	6.8	3.6	0.6	2.3	0.0	1.3	7.5	0.4	0.0	3

Table 4. Mean Abundance per Trapping Session in Spring (January – May) of the Ten Most Numerous Birds.

	Survey Year	Oriental Reed Warbler	Dusky Warbler	Black-browed Reed Warbler	Japanese White-eye	Yellow-bellied Prinia	Chinese Penduline Tit	Plain Prinia	Scaly-breasted Munia	Siberian Rubythroat	Black-faced Bunting	Age of Reed Stand (years)
Plot 1	2001	0.1	0.5	0.0	0.3	2.1	0.5	0.4	0.0	0.3	0.1	>4
	2002	0.5	1.1	0.6	0.3	0.7	0.2	0.5	0.0	0.6	0.0	>4
	2003	0.5	0.8	0.3	0.4	0.5	0.1	0.3	0.0	0.3	0.2	>4
	2004	0.6	0.6	0.5	0.9	0.8	0.5	0.8	0.0	0.7	0.0	>4
	2005	0.1	0.2	0.1	0.3	0.5	0.0	0.7	0.0	0.2	0.0	>4
Plot 2	2001	0.1	0.8	0.1	0.3	1.3	1.6	0.5	0.0	0.5	0.0	>4
	2002	0.2	0.7	0.6	0.8	0.6	0.2	0.4	0.1	0.1	0.0	1
	2003	0.3	0.5	0.3	1.8	1.0	3.5	0.9	0.3	0.2	0.8	2
	2004	0.9	0.4	0.8	0.3	0.9	1.3	0.6	0.0	0.5	0.1	3
	2005	0.4	0.5	0.3	0.1	0.7	2.0	1.8	0.0	0.3	0.0	4
Plot 3	2001	0.0	0.0	0.0	0.6	1.8	3.1	1.3	0.0	0.4	0.0	>4
	2002	0.2	0.7	0.4	0.1	1.8	0.9	0.9	0.0	0.5	0.0	>4
	2003	0.4	0.7	0.0	0.3	1.0	1.7	0.9	0.2	0.4	0.5	>4
	2004	0.3	0.1	0.2	0.0	0.0	0.1	0.7	0.0	0.0	0.0	1
	2005	0.3	0.3	0.3	0.0	1.2	0.4	2.8	0.1	0.3	0.1	2
Plot 4	2001	0.0	0.5	0.0	3.5	1.4	3.6	1.0	0.0	0.9	0.0	>4
	2002	0.3	1.0	0.1	0.3	1.2	1.2	0.6	0.0	0.6	0.1	>4
	2003	0.2	0.9	0.2	0.2	1.4	3.5	0.7	0.0	0.2	0.2	>4
	2004	0.5	1.1	0.7	0.3	0.8	4.7	1.0	0.0	0.5	0.1	>4
	2005	0.1	0.1	0.2	0.0	0.3	0.1	0.4	0.0	0.0	0.0	1
Plot 5	2001	0.0	1.0	0.0	0.8	1.5	2.6	1.4	0.0	0.1	0.5	>4
	2002	0.1	0.4	0.2	0.1	0.8	0.8	0.5	0.1	0.6	0.0	>4
	2003	0.1	0.2	0.0	0.5	0.3	0.2	0.5	0.0	0.1	0.1	1
	2004	0.5	1.2	0.5	3.0	1.8	1.3	1.8	0.0	0.3	0.5	2
	2005	0.1	0.6	0.2	0.2	1.5	1.0	3.3	0.1	0.0	0.0	3

Figure 5. Graphs Showing Changes in Bird Abundance by Year.





Within each trend line, large symbols refer to the first data set collected after treatment for that plot

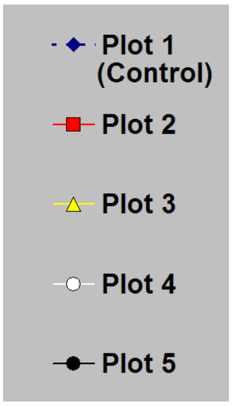
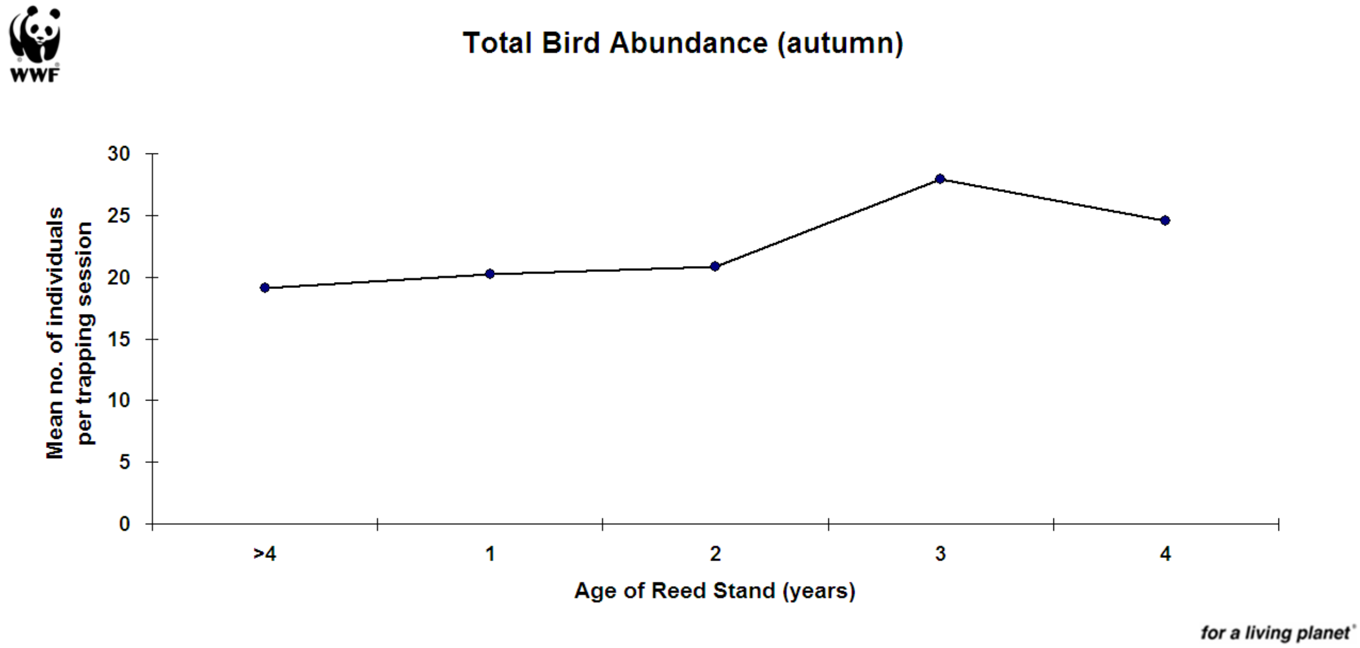


Figure 6. Graphs Showing Changes in Bird Abundance by Reed Stand Age.



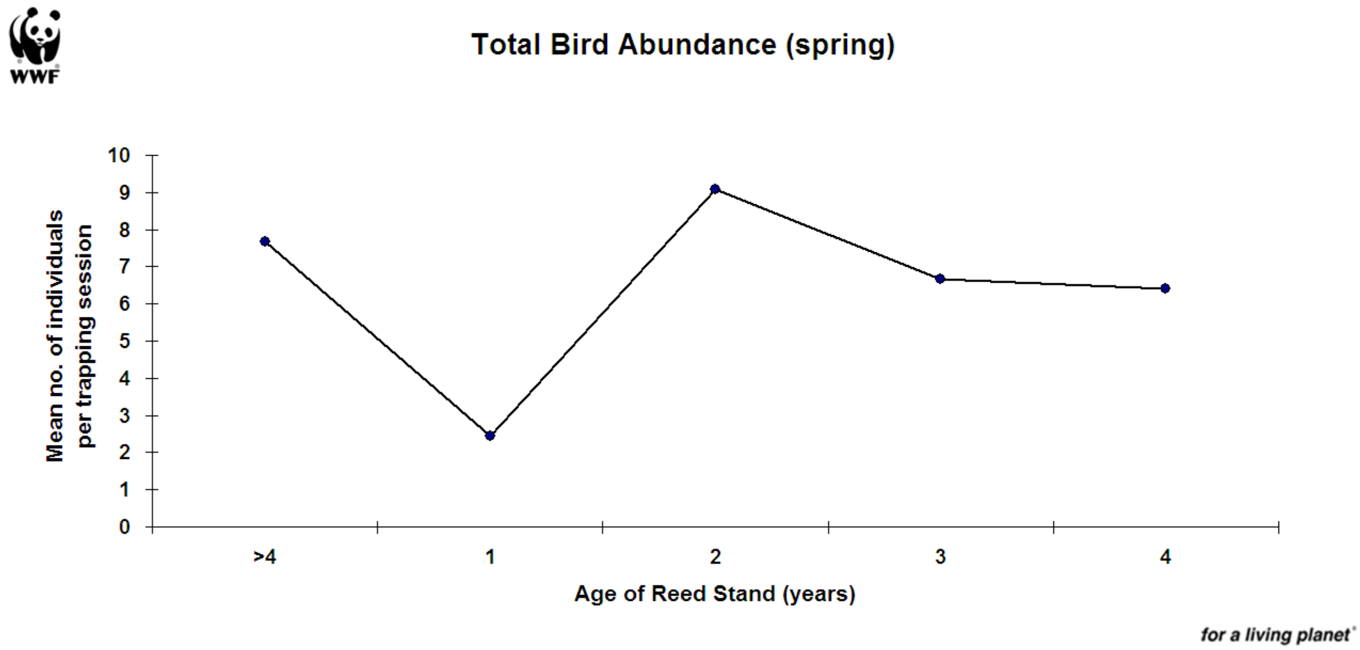


Figure 7. Graphs Showing Influence of Reed Stand Structure on Bird Abundance (Autumn).

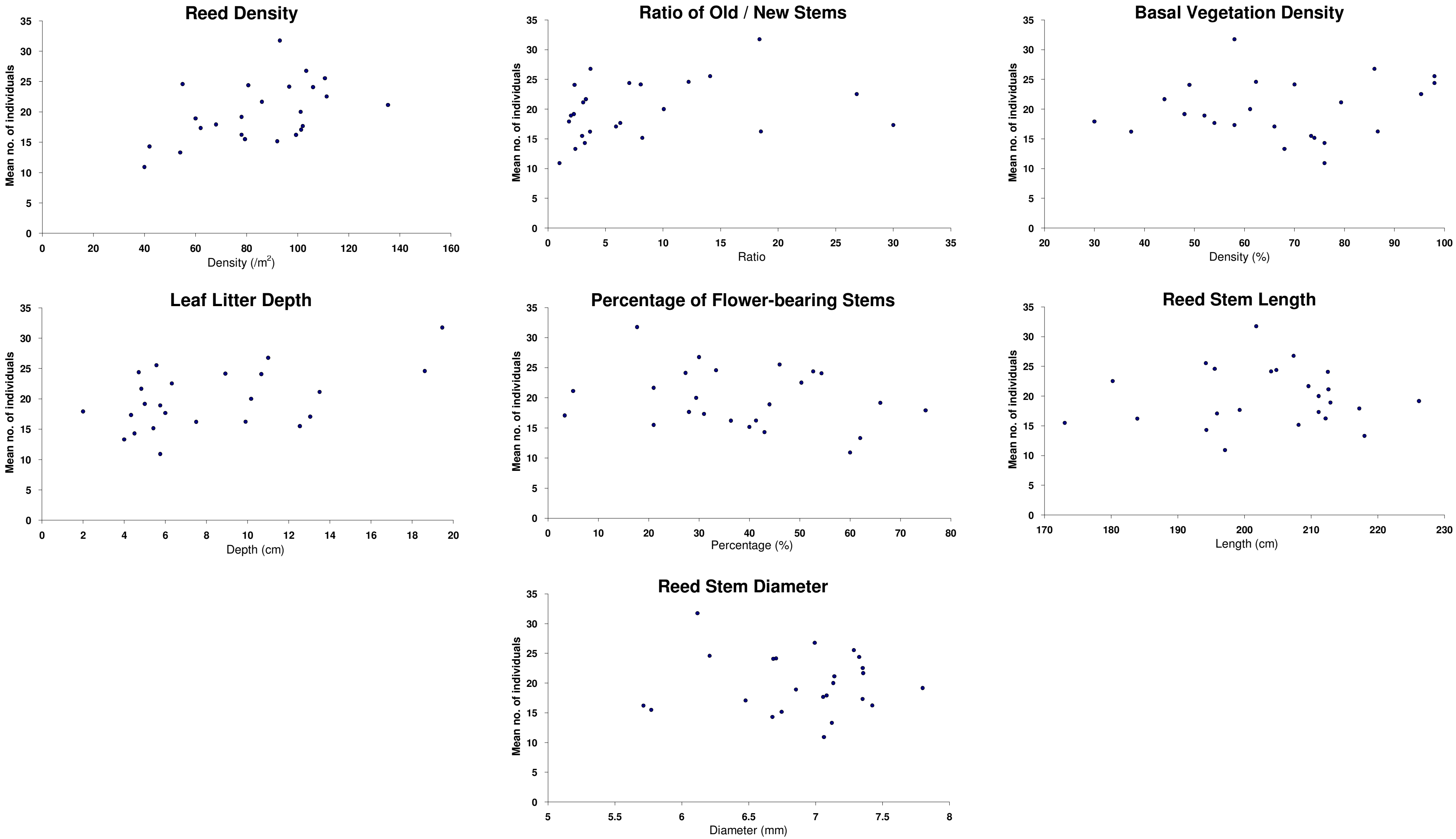
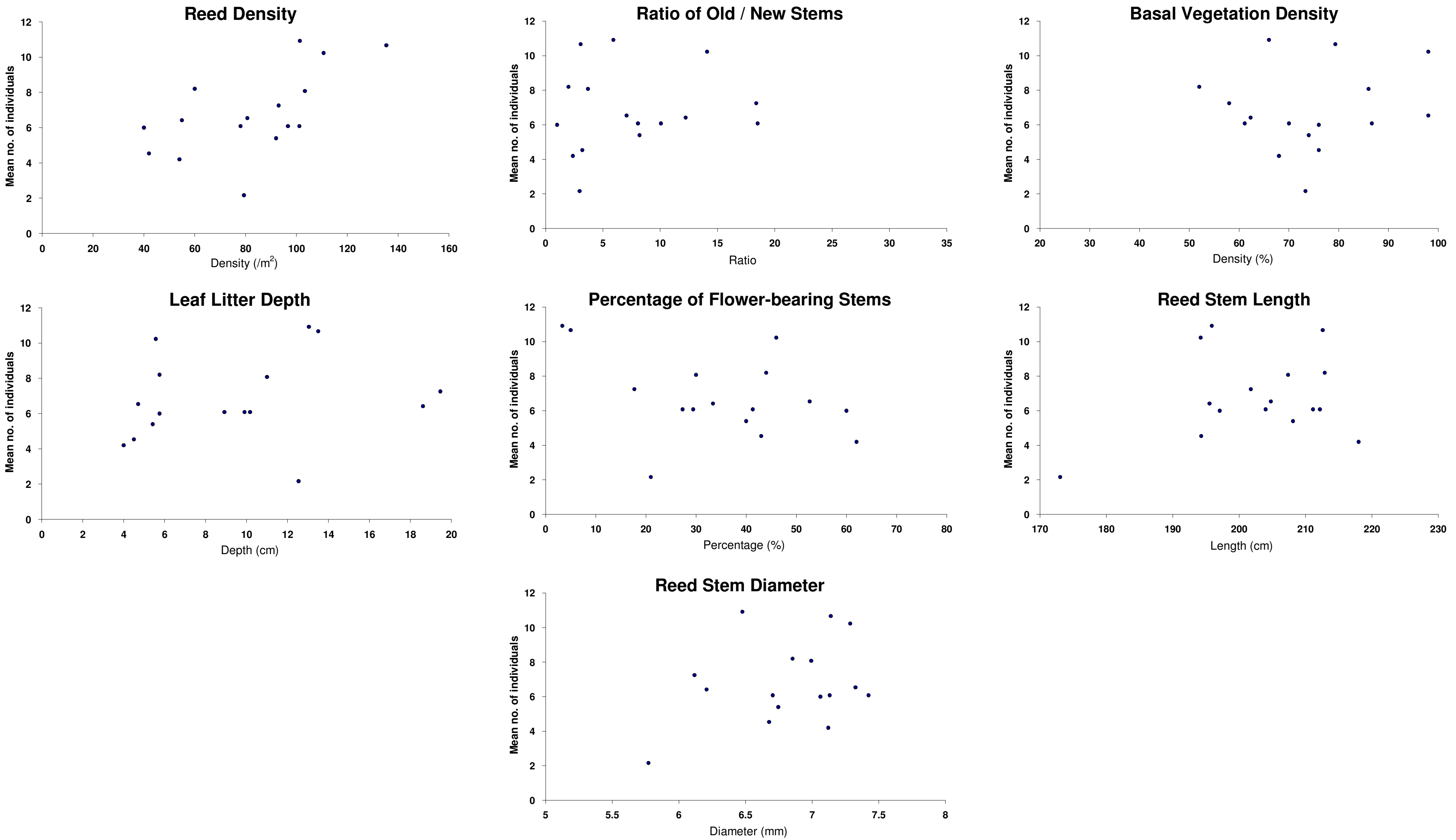


Figure 8. Graphs Showing Influence of Reed Stand Structure on Bird Abundance (Spring).



4. DISCUSSION

4.1.1 A number of factors directly influenced the study data and its interpretation, hence caution is necessary. The most influential factors being:

- *Reed Structure Data* - Climatic variations between years, water-level fluctuations (i.e. drain-downs) for management works in other parts of the *gei wai*, and changes in recorder personnel from one year to the next.
- *Birds* - Annual variation and non-independent plot areas.
- *General* - The rejection of data from the control area (para. 2.5.1), and the use of two different treatment methods (para 2.2.1).

Primary Objective

4.1.2 In autumn there were no significant differences in the abundance of any bird species between reed stands of different age. This indicates that reed stands cut in mid-winter have regrown sufficiently to provide suitable habitat for reed-dependent species by the time of autumn migration. In spring, newly-cut reed stands did show an immediate decline in bird abundance, particularly for resident prinias; this would be expected because the newly-cut reed stands do not provide sufficient cover for most birds. There is no significant difference in spring migrants however, suggesting that reeds are sufficiently regrown by the time of spring migration.

4.1.3 Although the cutting of reed stands results in immediate loss of habitat for resident and overwintering species, especially prinias, ringing recoveries have shown that individuals present in a particular plot prior to cutting have also been retrapped on later dates. This indicates that the cutting of reed stands does not result in the mortality of these species from habitat loss, rather that individuals move to another part of the reedbed and that the cut plot is recolonised after suitable conditions return.

4.1.4 The relationships between bird abundance and reed stand structure were relatively complex, with results differing for each species. The most frequent relationship was between bird species and leaf litter depth; this relationship was significant in autumn for six of the top ten bird species (Dusky Warbler, Japanese White-eye, Yellow-bellied Prinia, Plain Prinia, Scaly-breasted Munia and Siberian Rubythroat). This is reflected in a significant relationship between total bird abundance and leaf litter depth. This relationship is likely to result from a higher abundance of invertebrates in reed stands with deeper leaf litter. There was also a significant relationship between total bird abundance and basal stem density, which was also significant for Dusky Warbler and Plain Prinia. A high density of reed stems may either increase invertebrate abundance, or may assist with movement of birds through the reed stand.

4.1.5 There were fewer relationships between bird abundance and reed stand structure in spring, although overall bird abundance was correlated to basal stem density and inversely correlated to the number of flowering stems. The strongest correlation in spring was between Siberian Rubythroat abundance and the ratio of old to new reed stems. This is similar to the finding that this species was more abundant in old reed stands, which may be due to the distribution of ants, a favoured food for this species which is rarely consumed by other reed bird species. Older reed stands contained a large number of ant (*Polyrachis* sp.) nests throughout the study period and these ants were often abundant on the boardwalks within net rides.

Secondary Objective

4.1.6 The response to treatment for most reed structure data attributes is unclear due to notable influences from annual variations. Despite this, trend analysis mildly suggests that treatment increased reed density and percentage of flower-bearing stems in the first year post-treatment, and also decreased reed length and diameter in the few years following treatment.

From the limited "burned" data set (Plot #2 only), post-treatment response appeared to differ from manual clearance methods such that reed stem length, diameter and percentage of flower-bearing stems may take longer to recover.

4.1.7 Several of these findings concur with those from European studies where manual harvesting was shown to decrease reed length and increase reed density (Valkama, *et al.*, 2008), and burning had a significant impact upon reed height (Valkama, *et al.*, 2008). It is speculated that Hong Kong's sub-tropical climate may partly explain why the data is influenced predominantly by climatic factors rather than treatment.

5. RECOMMENDATIONS

5.1.1 Further study is required. In particular an investigation into the avian and invertebrate values of wet and mature reed stands is recommended. Studies in central Europe (France) suggest that maximum invertebrate food for reedbed passerine birds is available in wetter reedbed areas (Poulin *et al.*, 2002) and if proven in Hong Kong, this could have significant management implications for the MPNR reedbeds.

5.1.2 The more subjective reed stand structure parameters chosen for this study succumbed to recorder bias mainly because of personnel changes in field surveyors and volunteers. Based upon experiences within this study, it is recommended that future studies collect data upon reed density, ratio old:new stems, percentage of flowering stems, reed stem length, and reed stem diameter only.

6. CONCLUSION

6.1.1 There are no major implications for the future management of reed stands generated from this study. It has however shown that:

- Regular cutting or burning does not significantly impact upon bird abundance or diversity.
- Annual climatic variation influenced reed stand structure greater than burning or cutting management methods.
- Post-treatment, changes to reed structure (reed stem length and diameter, and percentage of flower-bearing stems) in burned stands and manually cut stands may differ.
- The MPNR reedbeds continue to support a variety of birds including three globally vulnerable species: Styan's Grasshopper Warbler, Manchurian Reed Warbler and Yellow-breasted Bunting.

6.1.2 Although not an objective of this study, regular management activities such as cutting or burning can prevent reed stands drying out and thus maintain their health by discouraging mangrove shrubs, ferns and grasses (particularly *Echinochloa* sp.) from colonising. Drying out of reed stands would have significant impact on those bird species which are dependent on this habitat at MPNR, in which case the cutting of reed stands may assist in maintaining the habitat for use by these reed-dependent species. This deliberate interruption of the ecological succession process is common practice in European and North American conservation managed reed areas to reduce long-term management costs and the frequency of expensive de-silting operations (Hawke & Vose, 1996).

7. REFERENCES (*) & BIBLIOGRAPHY

* BirdLife International. 2008. **Threatened Birds of the World**. Lynx Editions and BirdLife International, Barcelona and Cambridge.

Carey, G.J., Chalmers, M.L., Diskin, D.A., Kennerley, P.R., Leader, P.J., Leven, M.R., Lewthwaite, R.W., Melville, D.S., Turnbull, M. and Young, L. 2001. **The Avifauna of Hong Kong**. Hong Kong Birdwatching Society, Hong Kong.

Fellowes, *et al.* 2002. **Wild Animals to Watch: Terrestrial and Freshwater Fauna of Conservation Concern in Hong Kong**. *Memoirs of the Hong Kong Natural History Society* 25: 123-159.

Fowler, J., Cohen, L. and Jarvis, P. 1998. **Practical Statistics for Field Biology**. 2nd Ed. Wiley, Chichester.

* Hawke, C.J. and Vose, P.V. 1996. **Reedbed Management for Commercial and Wildlife Interests**. The Royal Society for Protection of Birds, Sandy, UK.

Lee, W.H. 1997. **Ecological Value of Reedbeds (*Phragmites australis*) at Mai Po Marshes Nature Reserve**. M.Phil. thesis. City University of Hong Kong.

* Poulin, B., Lefebvre, G. & Mauchamp, A. 2002. **Habitat Requirements of Passerines and Reedbed Management in Southern France**. *Biological Conservation* 107: 315-325.

* Reels, G.T. 1994. **Management Strategies for the Reed (*Phragmites australis*) (Cav.) Steud. At Mai Po Marshes Nature Reserve, Hong Kong, with Observations on the Associated Insect Fauna**. Unpub. M.Phil. thesis. University of Hong Kong, Hong Kong.

* Valkama, E., Lyytinen, S., & Koricheva, J., 2008. **The Impact of Reed Management on Wildlife: A Meta-analytical Review of European Studies**. *Biological Conservation* 141: 364 –374.

* White, G. 2005a. **The Future of Reedbed Management: Information and Advice Note.** The Royal Society for Protection of Birds, Sandy, UK.

White, G. 2005b. **Reedbed Design and Establishment: Information and Advice Note.** The Royal Society for Protection of Birds, Sandy, UK.

* WWF-HK. 2006. **Management Plan for Mai Po Marshes Wildlife Education Centre and Nature Reserve 2006-2010**. The World Wide Fund for Nature Hong Kong. Hong Kong.

WWF-HK, 2007. **Research and Monitoring Programme Plan for the Mai Po Nature Reserve : 2007 - 2011**. The World Wide Fund For Nature Hong Kong, Hong Kong.

Appendix I – Trapping Data for Individual Bird Species per Season (Spring and Autumn)

Species	Number of individuals trapped										
	Spr 01	Aut 01	Spr 02	Aut 02	Spr 03	Aut 03	Spr 04	Aut 04	Spr 05	Aut 05	TOTAL
Little Egret *Egretta garzetta*	0	0	0	0	0	0	0	1	0	0	1
Chinese Pond Heron *Ardeola bacchus*	0	0	0	0	1	0	0	1	0	0	2
Yellow Bittern *Ixobrychus sinensis*	0	0	1	2	1	6	0	9	0	3	22
Cinnamon Bittern *Ixobrychus cinnamomeus*	0	0	0	0	0	0	0	0	1	0	1
Great Bittern *Botaurus stellaris*	0	0	1	2	0	0	0	0	0	0	3
Japanese Sparrowhawk *Accipiter gularis*	0	0	0	0	0	1	0	1	0	0	2
Besra *Accipiter virgatus*	0	0	0	0	0	0	0	1	0	0	1
White-breasted Waterhen *Amaurornis phoenicurus*	0	1	0	0	0	3	0	3	1	1	9
Common Moorhen *Gallinula chloropus*	0	0	0	0	0	0	0	0	1	1	2
Common Sandpiper *Actitis hypoleucos*	0	0	0	0	0	0	1	0	0	0	1
Pintail Snipe *Gallinago stenura*	0	0	4	3	0	2	0	0	1	4	14
Common Snipe *Gallinago gallinago*	0	0	0	0	1	1	0	2	0	1	5
Oriental Turtle Dove *Streptopelia orientalis*	0	0	1	0	0	0	0	0	0	0	1
Plaintive Cuckoo *Cacomantis merulinus*	0	0	0	0	0	0	1	0	0	1	2
Common Koel *Eudynamis scolopaceus*	0	0	0	0	0	0	0	0	1	0	1
Greater Coucal *Centropus sinensis*	0	0	0	0	1	1	0	1	1	1	5
Common Kingfisher *Alcedo atthis*	0	0	0	6	1	3	1	9	0	0	20
White-throated Kingfisher *Halcyon smyrnensis*	0	0	0	0	1	1	0	2	0	1	5
Black-capped Kingfisher *Halcyon pileata*	0	0	0	0	0	0	0	1	0	0	1
Eurasian Wryneck *Jynx torquilla*	0	2	0	5	6	2	0	2	0	4	21

Species	Number of individuals trapped										
	Spr 01	Aut 01	Spr 02	Aut 02	Spr 03	Aut 03	Spr 04	Aut 04	Spr 05	Aut 05	TOTAL
Barn Swallow *Hirundo rustica*	0	0	0	0	0	0	2	0	1	0	3
Yellow Wagtail *Motacilla flava*	0	0	0	0	1	3	1	1	0	3	9
White Wagtail *Motacilla alba*	0	0	0	0	0	0	0	1	1	0	2
Red-throated Pipit *Anthus cervinus*	0	0	0	0	0	1	0	0	0	0	1
Pechora Pipit *Anthus gustavi*	0	0	0	0	3	1	3	0	1	0	8
Red-whiskered Bulbul *Pycnonotus jocosus*	0	2	0	5	0	0	0	0	0	0	7
Chinese Bulbul *Pycnonotus sinensis*	7	12	33	33	7	12	4	2	2	9	121
Brown Shrike *Lanius cristatus*	0	0	0	0	0	1	0	1	0	0	2
Long-tailed Shrike *Lanius schach*	1	0	1	0	1	0	3	0	2	1	9
Siberian Rubythroat *Luscinia calliope*	17	2	24	20	15	24	23	13	9	25	172
Bluethroat *Luscinia svecica*	1	1	1	2	0	1	0	4	2	5	17
Oriental Magpie Robin *Copsychus saularis*	0	0	1	0	0	1	0	0	1	0	3
Daurian Redstart *Phoenicurus auroreus*	0	0	0	0	1	1	0	0	0	0	2
Common Stonechat *Saxicola torquata*	1	7	1	2	1	11	2	8	1	16	50
Japanese Bush Warbler *Cettia diphone*	4	4	4	4	3	4	3	5	0	6	37
Spotted Bush Warbler *Bradypterus thoracicus*	0	0	0	0	0	0	2	0	0	1	3
Lanceolated Warbler *Locustella lanceolata*	0	1	1	1	1	2	0	7	0	3	16
Pallas's Grasshopper Warbler *Locustella certhiola*	0	5	0	8	2	9	0	22	0	9	55
Middendorff's Grasshopper Warbler *Locustella ochotensis*	0	1	0	1	0	0	0	0	0	0	2
Styan's Grasshopper Warbler *Locustella pleskei*	0	0	0	1	0	1	0	0	0	0	2
Black-browed Reed Warbler *Acrocephalus bistrigiceps*	1	95	19	88	11	161	31	197	12	187	802
Manchurian Reed Warbler *Acrocephalus tangorum*	2	0	1	0	1	3	0	5	0	5	17

Species	Number of individuals trapped										
	Spr 01	Aut 01	Spr 02	Aut 02	Spr 03	Aut 03	Spr 04	Aut 04	Spr 05	Aut 05	TOTAL
Paddyfield Warbler *Acrocephalus agricola*	0	0	0	0	4	0	0	0	0	1	5
Blunt-winged Warbler *Acrocephalus concinens*	3	0	0	1	0	0	0	2	0	3	9
Oriental Reed Warbler *Acrocephalus orientalis*	2	179	13	248	19	356	34	369	11	367	1598
Thick-billed Warbler *Acrocephalus aedon*	0	1	0	0	0	0	0	0	0	0	1
Zitting Cisticola *Cisticola juncidis*	0	0	0	3	0	11	1	10	0	2	27
Yellow-bellied Prinia *Prinia flaviventris*	64	36	51	73	55	82	52	99	50	96	658
Plain Prinia *Prinia inornata*	36	20	29	39	44	46	58	83	108	84	547
Dusky Warbler *Phylloscopus fuscatus*	22	80	39	111	40	357	41	270	19	301	1280
Radde's Warbler *Phylloscopus schwarzii*	0	1	0	1	0	0	0	0	0	0	2
Yellow-browed Warbler *Phylloscopus inornatus*	0	1	0	5	3	6	1	4	0	3	23
Arctic Warbler *Phylloscopus borealis*	0	4	0	0	0	16	0	7	0	5	32
Greenish Warbler *Phylloscopus trochiloides*	0	0	0	0	0	1	0	0	0	0	1
Red-throated Flycatcher *Ficedula albicilla*	0	0	0	0	0	1	0	0	0	0	1
Chinese Penduline Tit *Remiz consobrinus*	92	18	33	103	117	48	93	16	42	7	569
Japanese White-eye *Zosterops japonicus*	43	64	16	160	43	266	54	106	7	29	788
Chestnut-eared Bunting *Emberiza fucata*	0	0	0	0	0	0	0	4	0	0	4
Little Bunting *Emberiza pusilla*	0	2	0	0	2	6	0	0	0	3	13
Yellow-breasted Bunting *Emberiza aureola*	0	0	0	1	0	0	1	6	0	3	11
Chestnut Bunting *Emberiza rutila*	0	0	0	0	0	4	0	0	0	0	4
Black-faced Bunting *Emberiza spodocephala*	5	2	1	27	22	20	8	14	1	9	109
Reed Bunting *Emberiza schoeniclus*	0	0	0	0	0	0	2	1	1	0	4
Scaly-breasted Munia *Lonchura punculata*	0	2	2	23	6	20	0	13	2	161	229

Species	Number of individuals trapped										
	Spr 01	Aut 01	Spr 02	Aut 02	Spr 03	Aut 03	Spr 04	Aut 04	Spr 05	Aut 05	TOTAL
Eurasian Tree Sparrow *Passer montanus*	0	1	0	0	0	0	0	0	0	2	3
Baya Weaver *Ploceus philippensis*	0	2	2	1	2	0	1	3	0	0	11
Red-billed Starling *Sturnus sericeus*	0	0	0	0	0	2	2	2	0	0	6
Bearded Tit *Panurus biarmicus*	0	0	0	1	0	0	0	4	0	0	5
Yellow-fronted Canary *Serinus mozambicus*	0	0	0	0	0	0	0	1	0	0	1
Red Avadavat *Amandava amandava*	0	0	0	0	0	0	0	1	0	10	11
Red Bishop *Euplectes orix*	0	0	0	0	0	0	0	2	0	1	3
Total Birds Captured	**301**	**546**	**279**	**980**	**416**	**1498**	**425**	**1316**	**279**	**1374**	**7414**