Chapter 1: Introduction

1.1. Introduction

Section 1.1 will give a general background on the following six aspects, providing the motivational basis for this study in Section 1.2. The objectives and hypothesis in Section 1.3, and the research framework in Section 1.4 will then follow.

1. Riparian ecosystems
2. Urban environments and their affects on riparian ecosystems
3. Biodiversity
4. General, ecological and scientific importance of birds
5. Habitat selection
6. Community ecology

1.1.1. Riparian ecosystems

The term 'riparian' is derived form the Latin *riparius* meaning "belonging to the bank of a river", and riparian communities therefore refer to biotic communities living on the shores of wetlands (Naiman *et al.* 2000). Riparian ecosystems are characteristic of many landscapes throughout the world and are increasingly recognised as key areas for biodiversity conservation (Palmer & Bennett 2006).

Broadly stated, a riparian ecosystem is the area between the aquatic and terrestrial setting (Naiman *et al*. 1993). This area includes the stream channel from the high water mark towards the terrestrial setting where vegetation is influenced by elevated water tables, flooding, and by the ability of soils to hold water (Naiman *et al*. 1993). Riparian ecosystems can also be described as water ecotones, since they are the interface or transition zone between the terrestrial and aquatic ecosystems (Gregory *et al.* 1991;Naiman *et al.* 1993).

The boundaries of riparian ecosystems extend outwards to the limits of flooding and upwards into the canopy of streamside vegetation (Gregory *et al*. 1991). A combination of aquatic and terrestrial fauna and flora along riparian ecosystems contributes towards its complexity and heterogeneity.

Riparian ecosystems are often more dynamic, diverse, and complex than the surrounding landscapes and encompass sharp environmental gradients in ecological processes and communities (Naiman *et al*. 1993). These ecosystems are often surrounded either by natural, urban, industrial, or agricultural landscapes. These surrounding landscapes may influence avian diversity, populations and communities, as well as dynamic patterns of riparian ecosystems. Avian assemblages of riparian ecosystems and surrounding landscapes are not independent, as bird communities in such surrounding uplands can influence species assemblages within the riparian ecosystems and *vice versa* (Knopf & Samson 1994). Since birds in riparian ecosystems were the focus point of this study, no comparisons were made with birds in the surrounding landscapes.

Birds and other fauna make use of riparian ecosystems, both as corridors and habitats. A corridor is a linear landscape element that provides a passageway for animals between habitat patches (Rosenberg *et al*. 1997). Birds use corridors for movement between habitats where they live and reproduce, but the corridors themselves are not necessarily used for reproduction (Rosenberg *et al*. 1997). Therefore, not all requirements for residency and breeding may be met in a corridor, whereas all survivor requirements must be present in a habitat (Rosenberg et al. 1997). Corridors are therefore critically important within urban environments due the fragmented nature of the surrounding landscapes, as many species need to move within these corridors to locate less fragmented habitat patches where they can breed.

Riparian ecosystems consist of a variety of different habitat types, which are favoured by many birds. The formation and stability of these habitats are greatly influenced by the riparian ecosystem itself (Naiman *et al*. 1993). The influences of riparian ecosystems on riparian habitats will be described in Section 2.2.1.

An ecological profile of a riparian habitat is shown in Figure 1.1 (Dunajewski 1938;Lachavanne & Juge 1997), illustrating the characteristics of an ecotone. It illustrates the high diversity, complexity, heterogeneity, and quality of a natural riparian habitat (to be described in Section 2.1.3). It also shows the variety of breeding and feeding places for birds and the wide range of bird species that can occur along riparian ecosystems, emphasising its conservation importance.

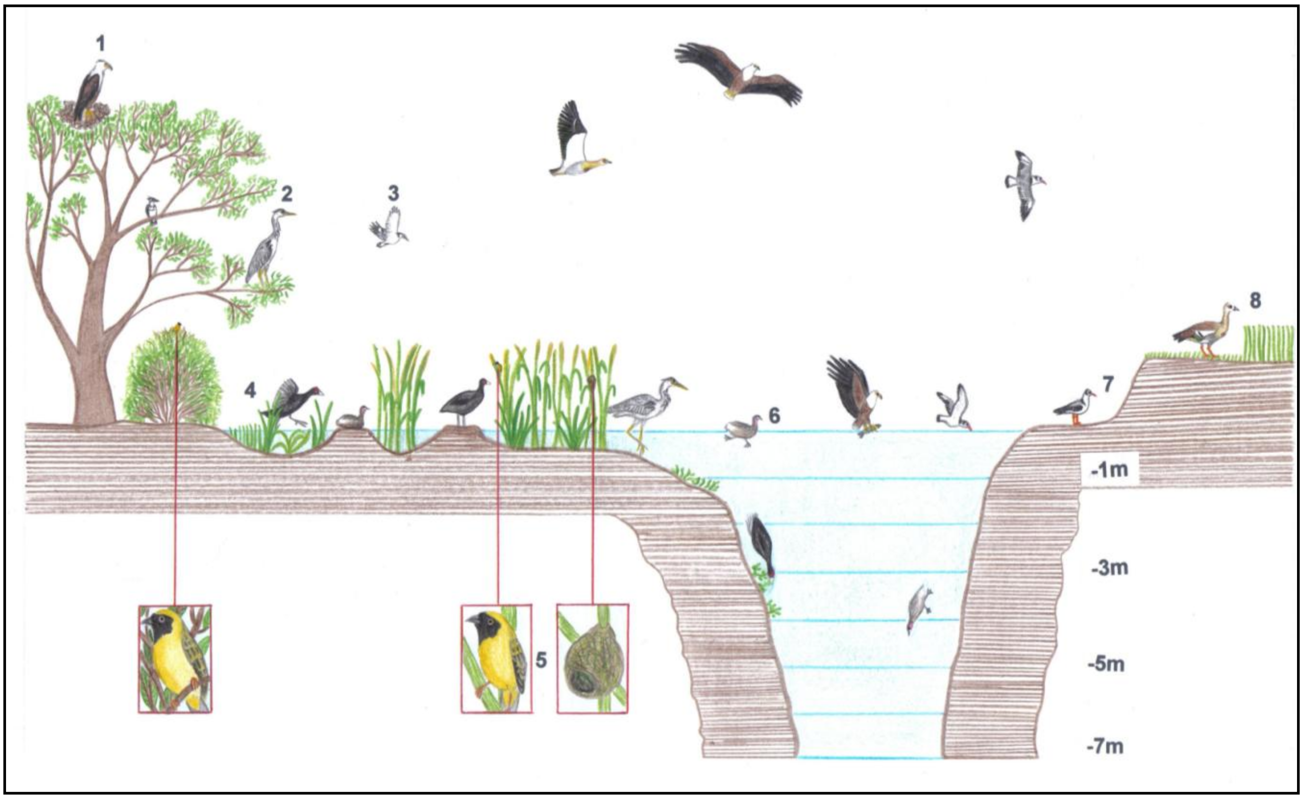

Figure 1.1 River ecological profile of a riparian habitat adapted from Dunajewski (1938) and Lachavanne and Juge (1997).

1. African Fish-Eagle, *Haliaeetus vocifer*, 2. Grey Heron (Juvenile), *Ardea cinerea*, 3. Pied Kingfisher, *Ceryle rudis*, 4. Red-knobbed Coot, *Fulica cristata*, 5. Southern Masked-Weaver, *Ploceus velatus*, 6. Little Grebe, *Tachybaptus ruficollis*, 7. Grey-headed Gull, *Larus cirrocephalus*, 8. Egyptian Goose, *Alopochen aegyptiaca* etc.

1.1.2. Urban environments and their affect on riparian ecosystems

Due to human population growth, intensified developments, and increased anthropogenic activities, there is an inevitable expansion of urbanisation. Urbanisation is characterised by dramatic land use transformation and leads to the conversion of land cover from a natural to an urban environment (Walker *et al*. 2008). Urbanisation is a dominant process, which affects ecological community structures and population dynamics, and generates unique assemblages of organisms (Hostetler 1999). For this reason, urbanisation is regarded to have some of the most severe impacts on the environment. The influences of urbanisation on avian communities have been examined in a number of studies (Beissinger & Osborne 1982;Chace & Walsh 2006;Chamberlain *et al.* 2009;DeGraaf & Wentworth 1981;Kelcey & Rheinwald 2005), yet little attention has been given to the impacts of urbanisation on riparian ecosystems and associated avian communities (Rottenborn 1999). Rottenborn (1999) (supported by others) gave three reasons why the urban impacts on riparian ecosystems is a noteworthy subject for future studies.

1. Riparian ecosystems support relatively high numbers of plant and animal species (Knopf *et al*. 1988;Naiman *et al*. 1993).
2. Riparian ecosystems play an important part in maintaining high biodiversity on a regional scale, especially in drier or arid regions.
3. Despite the importance of riparian ecosystems to biodiversity, anthropogenic activities have severely degraded these ecosystems.

These reasons motivate the importance of riparian ecosystem studies in urban landscapes. Miller and Hobbs (2000) also stated that lands bordering creeks and rivers are usually among the last available land for conservation purposes in settled and urban landscapes. Therefore, studies on riparian ecosystems are vital for the preservation of existing riparian ecosystems and associated wetland areas in urban environments.

Several anthropogenic factors and activities, due to urbanisation, increase habitat fragmentation along the riparian landscapes. Examples of such factors are disturbance, litter, pollution, reduction of vegetation, agriculture and grazing, and flood control such as canalisation (Mensing *et al*. 1998). The human impacts also illustrate that studies and conservation management strategies in urban environments need to be a multidisciplinary field, in which biologists collaborate with anthropologists, sociologists, and geographers (Alberti *et al*. 2003;Shochat *et al*. 2006).

1.1.3. Biodiversity

Primack (2002), and Meffe and Carroll (1997) stressed that the protection of biodiversity is the central theme to conservation biology. As stated earlier, riparian ecosystems are increasingly recognised as key areas for biodiversity conservation, especially in urban environments (Palmer & Bennett 2006). To conserve biodiversity effectively, an understanding of how biological communities respond to habitat loss and anthropogenic disturbances is needed (Posa & Sodhi 2006). This section includes concepts of biodiversity, and measures to identify these biodiversity concepts in a study area.

Biodiversity refers to a broad spectrum of levels and types of biological variation (Doherty *et al*. 2000;Meffe & Carroll 1997;Primack 2002). According to Primack (2002), it is generally divided into three different levels; species diversity, genetic diversity, and community diversity. Species diversity includes the entire range of species, genetic diversity is genetic variation within species, and community diversity comprises of different biological communities as well as their associations with the physical environment (Primack 2002). In addition, Doherty *et al.* (2000) discussed habitat diversity to evaluate the benefit and firmness of the first three levels of biodiversity.

As a result, biodiversity conservation must reach beyond species level; communities as well as ecosystems need to be considered (Meffe & Carroll 1997). Therefore, the characterising of habitats is useful for managing and conserving faunal diversity along riparian ecosystems. In other words, when managing and conserving different habitats, the species occupying these habitats can be managed and conserved indirectly.

Two clear approaches exist for characterising occupied habitats within landscapes (Chen *et al*. 2005). The first is the single species approach and the second is the multispecies approach.

1. The single species approach includes the characterising of occupied habitats for the conservation of rare, special concern or threatened species (Chen *et al*. 2005). However, most of these studies describe species habitats by using a reductionist approach, and are helpful for the conservation of specific species by protecting their sources of food, water and other environmental factors necessary for their survival (Chen *et al*. 2005).
2. The multispecies approach gives additional information that a single species approach cannot provide. This approach provides general information about habitat clusters, community structures, species interactions, and their spatio-temporal scales for creating habitat conservation and management strategies. The multispecies approach

can also explain critical resource needs of overall diversity (Chen *et al*. 2005). Spatial characteristics of habitats at the regional level for multispecies aggregation provide information such as distribution of habitat loss, habitat overlaps, and ecosystem associations (Chen *et al*. 2005). Therefore, a multispecies approach is more reliable for assessing the integrity of a natural environment (Idzelis *et al*. 2008).

The above illustrates the difference between a single- and a multispecies approach, indicating that the multispecies approach is more suitable than the single species approach to identify species-, genetic-, community-, and habitat diversity within a landscape. Therefore, these components (levels) of biodiversity can be identified within a study that is based on a multispecies approach.

In addition, abundance within species is useful to conclude a greater significance of diversity and numerical community structures within a study area (Section 1.1.6). Therefore, a diversity index can be used to calculate the avian diversity in the study area (Section 3.4). A diversity index takes two factors into account; species richness (number of species) and abundance (number of individuals per species) (Magurran 2008). Species richness and abundance is a dual concept concerning biodiversity. For instance, if species richness is constant along a spatial scale and the abundance of these species varies, the diversity will then vary along this spatial scale. If both the species richness and abundance vary along the spatial scale, the variations in diversity would be greater. Therefore, a diversity index quantifies biodiversity within an area (Magurran 2008).

Different species are associated with different habitats; therefore, different combinations of habitat types can influence the diversity and community structures. Hence, a greater variety of habitats in a landscape would support greater species diversity. Additionally, not only vegetation structure, but also anthropogenic factors (where present) influence habitat diversity (Posa & Sodhi 2006;Vidaurre *et al*. 2006). Therefore, vegetation structure and anthropogenic factors are needed to characterise habitats adequately, especially in areas where anthropogenic activities are present. Ordination of the biological communities with these habitats characterised according to vegetation structure and anthropogenic factors, should illustrate how biological communities interact with these factors. Conservation strategies can then be implemented by using such knowledge (Posa & Sodhi 2006).

1.1.4. General, ecological, and scientific importance of wild birds

General aspects highlighting the importance of wild birds:

- The public notices birds more often than other smaller types of fauna and they are also concerned when birds die or disappear (Adamus 2002).
- Birds are economically important, for example game birds (Adamus 2002). Birds also attract tourists to bird sanctuaries and game reserves, which may promote job creation and economic growth.
- Some bird species are seen as “flagship” species. They have a high public profile whose conservation is seen as high priority, such as raptors, cranes, or birds compared to less remarkable animals (O'Halloran *et al*. 2002).
- Some bird species are useful pest controllers, such as insectivores and raptors. For instance, oxpeckers (genus: *Bubhagus*) reduce the abundance of ticks on cattle and antelope. The Barn Owl, *Tyto alba* and the Black-shouldered Kite, *Elanus caeruleus* reduce mice and rat impacts on crops (Hockey *et al*. 2005).

Scientific importance of birds:

- Birds are relatively easy to survey because there is no need to collect and analyse samples or to struggle with complex taxonomic keys (Adamus 2002).
- Large number of data collectors exist that are proficient at bird identification and people can be trained for bird counting and surveys. People are often eager to volunteer for surveys (Adamus 2002).
- Birds can be relatively easily identified by their plumage and their calls.
- Birds are often abundant and varied (species) resulting in large amounts of data. Data treatment and statistics can be used to identify ecological patterns, processes, community structures, occupied

habitats, and species interactions along spatio-temporal scales (Adamus 2002;Cody 1985;Wiens 1989a;Wiens 1989b).

- Birds can indicate integrity (health, condition, or state) of a landscape. The integrity assessment along landscapes is vital for evaluating the cumulative effects of human activities (Adamus 2002).
- Idzelis *et al.* (2008) found that different bird species can characterise the state of different urbanised areas in Vilnius (capital of Lithuania) (Idzelis *et al*. 2008).
- The majority of bird species exhibit high adaptive ability in relation to both breeding and feeding (Lachavanne & Juge 1997).
- Birds are highly mobile allowing them to move from unsuitable towards suitable habitats (Adamus 2002).
- Presumably no other taxonomic group has exercised the potential for habitat selection that birds do (Cody 1985).

Ecological importance of birds:

- Factors that benefit birds may also have a positive influence on other living organisms (O'Halloran *et al*. 2002).
- Some species of birds can be seen as “umbrella” and “keystone” species. Umbrella species can be used to make conservation related decisions. By protecting umbrella species, many other species that make up the ecological community in a habitat are protected indirectly. Keystone species are species that if removed from an ecosystem, would result in the complete re-ordering or re-structuring of an ecosystem due to the many other species that depend on the keystone species for their survival (Begon *et al*. 1996).
- Birds play an important role in the food web. Certain bird species are primary consumers (such as ducks, geese, doves, finches etc). Others are secondary consumers (such as cisticolas, shrikes, flycatchers, falcons, owls, etc) and some are tertiary consumers (such as falcons, kites, eagles etc) (Begon *et al*. 1996;Cody 1985;Hockey *et al*. 2005;Maclean 1993;Wiens 1989a;Wiens 1989b).

- Some birds such as scavengers (vultures and crows) eat dead animal material (Begon *et al*. 1996;Hockey *et al*. 2005;Maclean 1993).
- Birds are natural dispersers of seeds, especially the granivores, frugivores, and omnivores (O'Halloran *et al*. 2002). Frugivores disperse pioneer plants for reforestation, and play a vital role in maintaining and restoring plant communities (Pejchar *et al*. 2008).

1.1.5. Habitat selection

Most birds are flying animals that are highly mobile, wide ranging, and selective regarding their habitat. Birds pass over and through a range of habitats, but only some habitats are used for breeding, foraging or over-wintering (Cody 1985). Birds select their habitats according to the physical and biotic properties (Cody 1985). Physical and biotic properties include all the resources needed for survival such as habitat structure, microclimate, edges, floristics, food and water availability, nesting suitability, shelter, breeding mates, and other species (Begon *et al*. 1996). Birds use these factors for selecting suitable habitats during winter, breeding seasons, and migration (Cody 1985). For instance, migrating birds may select wintering grounds independent of reproductive considerations, but not if they spend the non-breeding season in flocks in which social status is defined, and later bears on securing prime territory and attracting mates (Cody 1985). Therefore, at different periods, particular but different qualities of a habitat may be predominating.

Birds make decisions to select an appropriate habitat for breeding, foraging or wintering, and this leads to distinct bird distribution patterns (Cody 1985). A conceptual model was illustrated by Wiens (1985b), who proposed a basic habitat-selection procedure (decision-making) used by individual birds when selecting their habitats. This model may specify habitat requirements quite narrowly, although in most other species it seems rather broad (Wiens 1989b). However, the basics of this model should be mentioned briefly to give a better understanding of habitat selection.

Birds have an internal image or template that is genetically determined or learned of what constitutes a suitable habitat (Wiens 1989b). The following environmental variations fit into the template and complicate the realised habitat selection. These variations are mentioned in sequence from basic determinations to more complicated determinations:

1. Habitat aspects such as habitat structure, microclimate, edges, floristics, food and water availability, nesting suitability, shelter, breeding mates and other species.
2. Population density may influence the occupancy of the individual in the specific area.
3. Interspecific interactions such as competition, predators, and mutualisms.
4. Time lags also complicate the template, as individuals and populations may not respond immediately to changes in habitat aspects, population densities or the abundance and presence of other species (Wiens 1989b).

The above factors influence the realised habitat selection of an individual bird. This concept varies according to time and space, often in different ways on different scales. The result is that the realised habitat selection expressed by individuals is dynamic and an ongoing process (Wiens 1989b).

Animal size has been proposed as predictors of the scales at which animals respond to features in the environment for selecting the appropriate habitat (Hostetler 1999;Wiens 1989b). For instance, locally, a hawk needs and selects much larger areas and objects than for instance a cisticola. However, both of them have a similar set of hierarchical decisions that need to be made for selecting nesting sites, food, and overall habitat patches (Hostetler 1999). The hawk needs a much larger home range for selecting habitat patches than the cisticola. However, when considering human impact, the scale of anthropogenic disturbances will affect these two species differently. The changing of a reedbed section along a riparian ecosystem would affect the cisticola directly but may have little effect on the hawk. On the other hand, the construction of an industrial or a residential area near the riparian ecosystem may have a greater effect on the hawk than the cisticola due to their different home range sizes.

Different species can be associated with similar environmental factors, or they utilise similar resources found in a habitat. These species may look different, but have similar ecological functions; therefore, they are classified into similar guilds (Begon *et al*. 1996). Species that may look similar but with different ecological functions are normally found within different habitat types with different environmental factors (Begon *et al*. 1996). These species are then classified into different guilds. Consequently, due to habitat selection, definite species assemblages co-occupy specific habitat types according to their resource needs (ecological functions). Therefore, habitat selection can influence community assemblages within habitats.

1.1.6. Community ecology

A community is the co-occurring of individuals of several species, where the individuals of the species interact with one another to create a certain structure in an ecosystem (Wiens 1989a). Community ecology is concerned with identifying patterns that characterise natural assemblages of species, understanding what has caused these patterns, and determining how common they occur (Wiens 1989a). The challenge of studying community ecology is to identify patterns from several observations and to explain the cause (process) of these patterns. Community patterns can be determined by composition, distribution, abundance, morphological and behavioural characteristics of the species in a community. Therefore, for the purpose of this study, composition or assemblages, distribution, abundance, and behavioural characteristics such as nesting and feeding behaviours, will be useful in order to identify community patterns within space and time.

The most basic pattern of a community is the number of species it consist of (Wiens 1989a). This may reveal interesting and general patterns, but it misses the concept that some species are rare and others are common, and that species between areas vary in their abundance (Begon *et al*. 1996;Wiens 1989a). Therefore, numerical structures of communities are ignored when the compositions of communities are described simply in terms of the number of species (Begon *et al*. 1996).

Data of species and their abundance within communities can be fitted to various statistical distributions to gain a better understanding of the communities (Wiens 1989a). The data can also reveal diversity levels of communities between study areas (Begon *et al*. 1996;Magurran 2008;Wiens 1989a). According to Wiens (1989a), three species abundance models are popular. These models are accompanied by a biological mechanism, and a fit of data to a given model often leads directly to the conclusion that the mechanism associated with that model had in fact produced the pattern. These models, together with their biological mechanisms, can be used to describe the abundance patterns within communities (Wiens 1989a).

- A niche space may randomly be divided by a set of species, so that the occupied niches are non-overlapping. If the abundance is proportional to the niche size, the distribution of abundance will then be relatively even, with little numerical dominance by one or a few species (Wiens 1989a).
- If the numerical dominance of a few species in a community is strong, then the abundance of all the species will be quite uneven. These few dominant species occupy a certain proportion of the community niche space and the remaining species will only utilise a fraction of remaining niche space (Wiens 1989a).
- When the community contains a large number of species, it often coincides with a "lognormal" distribution. The biological mechanism for this model is that the distribution of niche sizes among species should be normal if large numbers of independent factors determine the niche occupancy of different species. As a result, the community consists of few common and rare species and many species that have moderate abundance (Wiens 1989a).

The above illustrates how important it is to calculate species abundance when describing communities within a study area. Bird communities can also be defined in terms of different habitat types or life-form categories (Wiens 1989a), because vegetation structure and floristic composition can strongly influence the structures of bird communities (Powell & Steidl 2000). It was stated in Section 1.1.5 that birds select their habitats according to their specific resource needs (ecological function). Therefore, the measures taken by species in selecting appropriate habitats according to species-specific behaviours influence the community structure in an area. Habitat selection therefore, can influence the community structures within landscapes (Section 1.1.5).

1.2. Motivation

Three main riparian corridors are located in Potchefstroom that are described in detail in Chapter 3. These riparian ecosystems serve as a corridor as well as a habitat for birds (Section 1.1.1), and may be critically important for sustaining avian diversity, especially when located in an urban environment such as Potchefstroom. Urbanisation along these streams may cause substantial declines in populations of many riparian-associated birds by not only fragmenting and damaging riparian habitats, but also hindering their function as corridors. This emphasises the importance of studying avian diversity, community patterns, and governing factors along urban streams (riparian corridors) to develop strategies for managing avian diversity.

The concepts of habitat selection (Section 1.1.5) and community ecology (Section 1.1.6) will help to explain and clarify these identified patterns. Additionally, the state of the different habitats and different sections of the streams will be determined and compared with the bird variables.

A literature review is in Chapter 2 to illustrate the factors that influence avian diversity and communities among riparian ecosystems. Based on this general introduction (Chapter 1) and the literature review (Chapter 2), a number of objectives and a hypothesis, which will be tested by this study, are formulated in Section 1.3.

1.3. Objectives and hypothesis

From the general introduction (Chapter 1), and the literature review (Chapter 2) that follows, the following hypothesis was formulated for this study: Bird variables along the riparian corridors in Potchefstroom are affected by vegetation, anthropogenic, and seasonal influences.

Bird variables include relative avian density, species richness, diversity index, and biomass, species assemblages (communities), habitat preferences, and traits such as feeding and nesting guilds.

The following objectives were formulated:

- Characterise riparian avian habitats according to:
    - Vegetation structure
    - Anthropogenic structures
    - Informal settlers
- Identify temporal and spatial changes in avian variables.

By achieving these objectives, the hypothesis will be verified.

1.4. Research framework

Based on the motivation (Section 1.2), objectives and the hypothesis (Section 1.3), the following research framework was used for this study:

Planning

- Introduction and literature review (Chapters 1 and 2)
- Develop hypothesis and objectives (Chapter 1)
- Information about the study area (Chapter 3)

Data collection

- Bird surveys (Chapter 3)
- Environmental factors survey (Chapter 3)

Data analyses

- Changes on a spatio-temporal scale (Chapter 4) (Transect-time profiles)
- Characterising different habitats into Characterised Avian Habitats (CAHs) using multivariate analyses: (NMS bi-plot and cluster analyses) (Chapter 4)
- Ordinating avian data with the CAHs over time using multivariate analyses. (NMS successional vector graphs, and indicator species analysis) (Chapter 4)
- Ordinating the species classified into the different nesting and feeding guilds over time using multivariate analyses. (NMS successional vector graphs) (Chapter 4)

Interpretations and discussions

- Avian variables change on a spatio-temporal scale (Chapters 4 and 5)
- Avian variables fluctuate among CAHs and fluctuate over time (avian community trajectories) (Chapters 4 and 5)

Discussions and conclusions

- Describe how the results confirm the hypothesis (Chapter 5)
- Develop conclusions (Chapter 5)