Abundance, impacts and resident perceptions of non-native common pheasants (*Phasianus colchicus*) in Jersey, UK Channel Islands.

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Thesis submitted for the degree of Master of Science by Research in Biodiversity Management

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November 2016

Abstract

Few species are able to establish themselves in a non-native range and expand their population to become a wide-ranging invasive. However, for those that are able to, their negative environmental impacts include widespread predation of native flora and fauna, competition and spread of parasites and disease. The common pheasant (*Phasianus colchicus*), a native of central Asia, has been the subject of introductions for recreational hunting across the globe for hundreds of years. Today, millions of birds are released annually and rural habitats managed to better accommodate them. These mass introductions have prompted much research regarding the effects of pheasant populations in areas where they are released at high densities. However, little is known about the effects of naturalised populations of pheasants in areas where they are neither released nor their habitat managed. To fill this knowledge gap and to aid management, this study seeks to investigate the naturalised population of common pheasants on the Bailiwick of Jersey, UK Channel Islands. Through an extensive programme of field surveys, this research enables a better understanding of the impacts of this non-native species on native wildlife and agriculture. Distance sampling was used to provide density and abundance estimates of Jersey's pheasant population and Breeding Bird Survey data, provided by the British Trust for Ornithology, were also used to investigate population trends over time. Summer habitat preferences were also investigated and, to complement these findings and further inform management, an online questionnaire to analyse local perceptions of pheasants and their impacts was conducted. Pheasant density estimates ranged from 9.5 to 16.6 pheasants per km^2, with a total island-wide population of 1011-1780 pheasants. Highest concentrations were seen in the southeast (St. Clement) and northwest (St. Ouen) of the island and the lowest concentrations in the southwest (St. Brelade), with pheasants showing a preference for fields that contained shoots, mustard and bare ground. The long-term data revealed an overall decreasing but oscillating population trend since 2002. Residents of Jersey perceive pheasants as having negative impacts on farmland birds, herpetofauna and crops, with some respondents witnessing predation of reptiles and amphibians, all of which are protected species. Despite this, pheasants are generally well received by residents with the majority 'agreeing' or 'strongly agreeing' that pheasants add to the appeal of the countryside and that they enjoy having pheasants in Jersey. Pheasants are also considered to have a positive impact on birds of prey and are credited for the rise in marsh harrier (*Circus aeruginosus*) and buzzard (*Buteo buteo*) numbers. Arable farmers displayed the most adverse opinions of pheasants and were significantly more likely to view pheasants as negative for arable crops. The percentages of residents who believe pheasants should be protected by legislation and those who do not are almost equal. Specifically, arable farmers were generally in favour of removing pheasant protection, whereas

game shooters polarise this view. The successful management of any invasive species or their impacts relies on monitoring populations, examining their trends, and understanding their habitat use. To this end, this study provides the baseline data required for future decisions on pheasant management by policy makers in Jersey.

Keywords: Common pheasant, *Phasianus colchicus*, introduced, non-natural, distance sampling, density and abundance, ecological and economic impact, habitat preference, questionnaire, attitudes, perceptions.

Acknowledgements

Thank you to my supervisors Jim Groombridge, Jake Bicknell, Simon Tollington and Nina Cornish for their advice, encouraging words and support over the year. They were always willing to address any concerns I had and keep me on the right track. Their invaluable insight was fundamental for the creation of this thesis. I must also thank Stuart Newson, Rob Ward and Tristan Pett for taking the time to discuss ideas and methods with me.

I am grateful to all those at the Department of the Environment in Jersey for making me feel so welcome and for their enthusiasm and willingness to answer my many naive questions about their beautiful landscape, wildlife and agriculture. Thank you also to Claire Stanley and Ana Charalambous at the communications department for your help with the design and distribution of the questionnaire.

I am especially grateful to my survey volunteers: Neil Singleton, Christine Gill, Bob and Jill Thompkins, Liz Corry, Beatrice Clyde-Smith and Sophie Le Marquand, without whom I would have had much less sleep and much less data. Also, to Alberto Barbon at the Durrell Wildlife Conservation Trust for teaching me how to dissect pheasants and without whom my dissection attempts would probably have been more of a bloody mess.

Many thanks to the landowners and farmers who allowed us to traipse across their land and to those who provided pheasant carcasses for gastrointestinal analysis. Special thank you also to the people that took part in the questionnaire and got in touch to report live and dead pheasant sightings and to provide information.

To Lindsey Napton, Jo Alm and Alli Caldeira for providing places to stay while I was in Jersey and making me feel at home, for occasionally feeding me and for listening to my rants and offering advice. Having such gracious hosts made my time on Jersey all that more enjoyable. Thank you, also, to Rosie the dog for exploring Jersey with me and helping me with the initial stake out of transect routes.

I thank my family for their unconditional love and support through my years of travel, research and volunteering. My parents, Caroline and Michael Rice, for always lending an ear, always welcoming me home in-between moves and for whom counting pheasants in Jersey probably came as a welcome relief from my previous, more hazardous adventures. Thank you to my sister, Kirsty Rice, for letting me encroach into her room, giving up the drive, checking my thesis for spelling and grammar mistakes, and for pulling me back from the brink of despair. And thank you to my brother, Nicholas Rice, for the laughs and because it would be mean not to mention you.

This thesis was made possible by funding from the Countryside Enhancement Scheme, States of Jersey Department of the Environment, and I will be ever grateful for having been given the opportunity to further my studies and research experience. I must also express my gratitude to the British Trust for Ornithology, for providing and allowing the use of the raw Breeding Bird Survey data for pheasants in the Channel Islands, and to the BBS Jersey volunteers, many of whom also volunteered to help with data collection for this thesis.

Contents

Ethics Statement

All research adhered to the University of Kent's Code of Ethical Practice for Research and was approved by the Research Ethics Advisory Group (REAG).

Research involving animals was carried out with approval from the University of Kent's Named Animal Care and Welfare Officer (NACWO). Animals were disturbed as little as possible during surveys, the methods calling for such. Pheasants used for gastrointestinal analysis were either road kill or shot as pests and were not killed for the purpose of the research. Gastrointestinal and feather samples were imported into the UK under the general licence: IMP/GEN/2013/01 with a signed declaration by Jersey's State Veterinary Officer.

Research involving humans was carried out with the approval of the Head of the School of Anthropology and Conservation, University of Kent. The questionnaire was anonymous and collected no data that could identify individuals. Participants could pull out of the study at any time during completion of the questionnaire.

List of Figures

List of Tables

Chapter 1: Introduction

Conservation aims to protect and restore native biodiversity to maintain balance within ecosystems (Defra 2007). There is increasing emphasis on the need to address current extinction rates which are comparable to past mass extinction events (Scholes and Biggs 2005) with numerous anthropogenic threats to worldwide biodiversity including exploitation, habitat loss and change, climate change and invasive species (Defra 2007; WWF 2014).

The United Kingdom (UK), including its Crown Dependencies and Overseas Territories, has experienced biodiversity loss at rates higher than the global average and ranks as the 29th lowest country, of 218, in terms of its Biodiversity Intactness Index (BII) (Scholes and Biggs 2005; Hayhow *et al*. 2016). Forty percent of UK species have shown a strong or moderate decrease in population abundances since 1970, with 15% of species from Great Britain assessed as part of the States of Nature Report having gone extinct or currently being near extinction (Hayhow *et al*. 2016). These declines include 47% of vertebrate species, 59% of invertebrates and 50% of plants and lichens (Hayhow *et al*. 2016). Threats to terrestrial species within the European Union (EU), identified by the European Environment Agency (EEA 2015), include grazing by livestock, modification of cultivation practices, mowing or cutting of grassland and invasive species.

1.1 Non-native and Invasive species

Non-native species include any species that has been artificially introduced outside of its historic or current natural range with the potential to reproduce (Non-Native Species Secretariat [NNSS] 2016). The International Union for the Conservation of Nature (IUCN 2016) defines an invasive alien species (IAS) as one which has "established outside of its natural past or present distribution, whose introduction and/or spread threaten biological diversity". Identified as being the second greatest threat to global biodiversity (IUCN 2016; Department for Environment, Food and Rural Affairs 2008), negative effects of invasive species include predation of local fauna and flora, competition for resources, transmission of disease and changes to habitat structure (Rushton *et al*. 2006; Sage 2009; Reynolds *et al*. 2013; Tizanni *et al.* 2014; Hudina *et al.* 2016). Non-native species can also have economic impacts such as agricultural loss (Arim *et al*. 2006), with the NNSS (2016) describing invasive non-native species as "any non-native animal or plant that has the ability to spread causing damage to the environment, the economy, our health and the way we live."

A small minority of introduced species successfully establish themselves in a non-native range and only a subset of these species become invasive (Williamson and Fitter 1996). The point at which a species becomes invasive is ambiguous, with factors such as spread, abundance and ecological and economical harm used in definition (Kolar and Lodge 2001). Characteristics, such as large natural ranges, broad feeding habits, being dispersive in nature and robust against a variety of climates, are thought to increase the success of establishment in foreign ranges (Ehrlich 1989; Daelher and Strong 1993; Cassey 2001a). The number of individuals introduced and the number of introduction locations in the new range are also important factors, with greater numbers and release locations offering a greater chance of the species finding favourable habitat and decreasing its vulnerability to extinction from stochastic events and natural catastrophes (Kolar and Lodge 2001; Duncan, Blackburn and Sol 2003). Important, too, are the characteristics of the introduction locations. Establishment and invasion of a species in a novel location are more likely to be successful if the new location closely matches their native range in climate and physiology (Duncan, Blackburn and Sol 2003). Concurrently, locations nearer the latitude of the species native range facilitates successful establishment and invasion (Cassey 2001b; Duncan, Blackburn and Sol 2003). Resource availability, competition with other species and the presence of predators and parasites can also have significant impacts on invasion success (Williamson and Fitter 1996; Duncan Blackburn and Sol 2003).

Alongside many accidental introductions, species have historically been imported and introduced into non-native landscapes for reasons such as sustenance and recreational hunting, as ornamental additions, and even as a means to try and control a previously introduced invasive species (Thompson 1922; Short, Kinnear and Robley 2002; Tizanni *et al.* 2014; Heldbjerg and Nyegaard 2015; Bicknell *et al*. 2010). Game species, such as lagomorphs and galliformes, have been introduced across the globe for sustenance and recreational hunting purposes, usually with no prior understanding of how these non-native species could impact indigenous wildlife.

There is some debate as to the vulnerability of native island flora and fauna to invasive species (Sol 2000; Duncan, Blackburn and Sol 2003; Gérard *et al*. 2016). Though introduced species can have ecologically and economically devastating effects, such as the invasive brown tree snake (*Bioga irregularis*) in Guam (Greene and Mason 1998), countless rat (*Rattus* sp.) introductions across the globe (see Harris 2009) and various cases of feral and domestic of cats (*Felis catus*) causing and contributing to the extinction of bird and small mammal species on islands (Galbreath and Brown 2004; Vázquez-Domínguez, Ceballos and Cruzado 2004), the presence of non-natural species can also be ecologically benign or even positive (Schlaepfer, Sax and Olden 2010; Martin-Albarracin *et al*. 2015).

1.2 Ecology of the common pheasant (*Phasianus colchicus*)

Native to Asia and southeast Europe, *Phasianus colchicus* (hereafter: pheasants) has been introduced across the northern hemisphere and Australasia (The Game Conservancy Trust 1997). They are considered an economically important game species, with the pheasant shooting industry worth over £2 billion a year in the UK alone (Public and Corporate Economic Consultants [PACEC] 2006). Being a large gamebird with a diverse natural range, pheasants possess many qualities required to be a successful invasive species, including generalist feeding habits and the ability to tolerate a range of climates and altitudes (Davey 2008). Due to their wide range, they are a species of least concern, though are hybridised where they have been introduced (BirdLife International 2015).

Pheasants are associated with woodland edges and rides where they can forage close to cover and males can partake in territorial displays (Lachlan and Bray 1976; Baxter, Saget and Hall 1996; The Game Conservancy Trust 1997). Farmland is utilised throughout their native and introduced ranges, with crops such as cereals, quinoa and kale being grown as a cover crop to offer food and protection specifically for game birds (Sage *et al*. 2005; Amano and Yamaura, 2007). Grasslands are preferred habitats, with a positive correlation found between pheasant densities and percent area of grassland (Haroldson *et al.* 2006; Pyo and You 2011). Wetlands and shrubland, in particular, are preferred winter habitats (Smith, Stewart and Gates 1999), wetlands also being important nesting, brooding and roosting habitat (Sather-Blair 1979; Homan, Linz and Bleier 2000; Luo *et al*. 2010). Home ranges have been found to vary between 18.4 (± 0.9 SE) and 246.1 (± 87.4 SE) ha with densities of territorial males increasing with greater availability of cropland and woodland edges (Smith, Stewart and Gates 1999; Robertson *et al*. 1993; Gabbert *et al.* 2001; Leif 2005). Smith, Stewart and Gates (1999) found no significant differences between the sexes in regards to the size home ranges. To roost, they will readily utilise woodland and shrubland as well as weedy fields with thick herbaceous cover. However, they are also known to roost in open fields (Warner 1981; Messinger 2015; GWCT n.d.).

Seeds, nuts, fruits, grasses and invertebrates are readily consumed by pheasants, as well as subterranean plant parts, including roots, rhizomes and bulbs, with a large proportion of their winter diet made up of green shoots. (Dalke 1937; Bicknell *et al.* 2010). They are mainly ground foragers, digging and scratching to expose food with foraging occurring mainly during the few hours after sunrise and before sunset (Dalke 1937; Chauhan 2014). Pheasants are also known to opportunistically prey upon vertebrates such as small mammals and herpetofauna (Tomsett 2011).

1.2.1 Pheasant breeding ecology

In the UK, breeding, nesting and brood rearing take place between February and August. Males establish territories and compete to gather harems through territorial displays of crowing, wing beating and plumage displays (Robertson 1993, The Game Conservancy Trust 1997). To nest, females will disperse away from male territories and are able to re-lay up to four times a year in response to clutch failures. If, however, a successfully hatched brood perishes, no further nesting attempts occur. Clutch sizes range from one to 28 eggs, 12 being average, with an approximate rate of one egg laid per day and 25 days of incubation. Pheasants have also been documented parasitising the nests of other hens and even the nests of other species (Robertson 1991; The Game Conservancy Trust 1997; Hagen *et al*. 2002; Holt *et al*. 2010). The habitats that pheasants nest in are diverse and include woodland, hedges, crop fields, grass fields, gardens and roadside ditches (The Game Conservancy Trust 1997).

Invertebrates are an important part of a pheasant chick's diet, with higher consumption rates of invertebrates positively correlating with higher brood survival (Hill 1985, The Game Conservancy Trust 1997; Doxon and Carroll 2010). Brood foraging ranges can vary between 1.5 and 11.1 ha with larger ranges associated with higher mortality (Hill 1985; Draycott *et al.* 2009). Availability of game crops, legumes and wetland were found to correlate positively with brood survival, however, the opposite is true of long term set-aside grassland and woodland (Bliss *et al*. 2006; Draycott *et al.* 2009).

1.2.2 Impacts of Pheasants

Agricultural pests

Common pheasants have long caused concern to farmers through the consumption and damage of crops (Maxson 1921; Einarsen 1943; West, Brunton and Cunningham 1969; Koopman and Pitt 2007; Werner *et al*. 2010; Esther, Tilcher and Jacob 2012). As part of a survey in South Dakota, 59% of respondents reported damage by pheasants to sunflower crops, causing yield losses of between 5-50% (Werner *et al*. 2011). They can also cause substantial damage to newly planted and young corn plants as well as matured ears of corn (Einarsen 1943; West, Brunton and Cunningham 1969). In Hawaii, farmers recognise pheasants as the most significant avian pest of vegetable, flower and corn crops (Koopman 2007). However, it is thought that most grain and corn taken by pheasants, across mainland USA at least, is waste grain (Dalke 1937; Hoodless *et al*. 2001).

Predators

Concern about predation of native reptiles and amphibians by introduced common pheasants is widespread, and pheasants are often considered threats to native herpetofauna (Edgar, Foster and

Baker 2010; Ward 2014; Sussex Amphibian and Reptile Group 2016; New Forest National Park 2016; Surrey Amphibian and Reptile group 2016). Small vertebrates, including herpetofauna, are often listed as items in pheasant diets, and it is known that pheasants will opportunistically consume small vertebrates, including snakes (Dimond *et al.* 2013; Tomsett 2011).

Using DNA analysis of faecal samples, Dimond *et al.* (2013) investigated the predation of pheasants on local reptiles. No reptile DNA was discovered in the samples, however, research continues to determine if reptile DNA can survive the digestion process.

Invertebrates are an important part of a pheasant chick's diet and are also readily consumed by adults (Hill 1985; Maxson 1921). It has been suggested that any damage to crops by pheasants may be offset by the benefit offered of eating pest insects and weeds (Burnett, 1921; Severin, 1933). However, this is disputed by others as pheasants will also consume invertebrates that perform important ecosystem functions such as pollination (Maxson, 1921).

Prey

Where pheasants are managed as a game species there can be a great deal of conflict with predators, particularly raptors which are protected by law (Kenward *et al.* 2001; Parrot 2015). Pheasants can provide an important food resource for marsh harriers (*Circus aeruginosus*); a strong positive correlation has been found between the abundance of marsh harriers and that of the common pheasant in their common native range in China (Luo *et al.* 2010). Buzzards (*Buteo buteo*) also utilise pheasants as a food item and have been associated with release pens, being blamed for 4.7% of pheasant poult deaths (Kenward *et al.* 2001). Recently, Natural England has issued a licence allowing the culling of a limited number of buzzards to protect young, hand reared pheasants (Natural England 2016). Conversely, predation at wild game bird nests by buzzards is considered to be low, with small mammals, such as rabbits and voles, more important food items (Graham, Redpath and Thirgood 1995; Kenward 2001; Valkama *et al*. 2005). As a known scavenger, buzzards will likely benefit from carcasses of pheasants, for example road kill (Bicknell *et al*. 2010).

Pheasants also provide a food source for animals considered pests, such as corvids and rats (Hill 1985; Jouventin, Bried and Micol 2003; Draycott *et al.* 2008). Crows and magpies scavenge carcasses and are considered major pests for predating pheasant nests (Hill 1985; The Game Conservancy Trust 1997; Draycott *et al.* 2008). Draycott *et al.* (2008) found that the highest percentage of predation on pheasant nests was by corvids (24%) while another 33% of unconfirmed predations were likely to be corvids or foxes. However, Madden, Arroyo and Amar's (2015) global review of the impacts of corvids on potential prey species found that, although corvids reduce breeding success in half of the cases studied (including cases with pheasants), overall abundance was only affected in ten percent of cases. It has been suggested that, compared to other birds, gamebird numbers are more likely to be limited by predators (Gibbons *et al*. 2007). Furthermore, it is thought nest predation among pheasants is likely to be density-dependant, as it is with grey partridge (*Perdix perdix*, Robertson 1991).

Habitat modification

Browsing by pheasants can change the vegetation structure, creating conditions that favour species of disturbed and fertile soil (Sage *et al*. 2005, Neumann *et al*. 2015). They can also increase bare ground, reduce hedge leaf density in the lower portions of hedges and decrease species richness on hedgebanks (Sage 2009). Bicknell *at al.* (2010) detail how pheasant browsing could have negative effects on the nesting success of yellowhammers (*Emberiza citronella*), and likely similar species, on game estates with pheasant releases. These effects are all correlated with pheasant stocking density and a maximum pen density of 700-1000 birds per hectare has been recommended to minimise effects on ground flora (Sage 2007).

Pheasants also have the potential to assist in the spread of non-native plants, though, interestingly, have become a beneficial non-native species in regards to seed dispersal. In certain areas in Hawaii, they have partially filled the niches of rare and extinct native species and provide a beneficial ecosystem service of native seed dispersal, maintaining and improving degraded habitats without being significant competitors of rare native birds (Cole *et al*. 1995).

Competitors

Bicknell *et al.* (2010) found the arthropod diet of yellowhammer chicks shares an ~80% similarity with the diet of pheasant chicks, indicating high competition for invertebrate food resources during the brooding season. The pheasants' greater size and larger clutches could therefore significantly decrease food availability for native farmland birds during this important period (Bicknell *et al.* 2010). Yellowhammer is now considered extinct in Jersey as a breeding bird, with possible rare migrant visitors in spring and autumn (Young and Young 2016).

Vectors of disease and parasites

Pheasants can carry and transmit a host of diseases and parasites including gapeworms (*Syngamus trachea*), Lyme disease (*Borrelia burgdorferi*) and the roundworm *Heterakis gallinarum* (Kurtenbach 1998; Bicknell *et al* 2010). Gapeworm is a parasite of poultry and passerines, residing in the trachea of the infected animal, which can debilitate health to the point of causing death. It is an economically important parasite of gamebirds and poultry and can have detrimental effects on the fecundity of wild passerines (Merck Sharp & Dohme Corp 2013; Holand *et al*. 2015). Pheasants have also been found to be better reservoirs for Lyme disease than rodents (Kurtenbach 1998).

1.3 Pheasants as a gamebird

Records of pheasants breeding in the wild in England date back to the 15th century (The Game Conservancy Trust 1997). Today in Britain, pheasant shooting is a multibillion pound industry, with over 35 million pheasants being reared and released into the British countryside each year (Bicknell *et al*. 2010). Many countries where pheasants have been introduced manage them as a game species with open and closed seasons for shooting and using them to make profits. With pheasant releases comes pheasant rearing pens, of which densities can be as high as 5000 birds per ha (Sage, Ludolf and Robertson 2005). These high stocking activities and release densities have naturally caused concern about the effects of release pens and habitat management on wildlife, prompting much research into the impacts on flora and fauna. The results have been mixed, however, producing both positive and negative conclusions (Robertson, Woodburn and Hill 1988; Stoate 2002; Draycott, Hoodless and Sage 2007; Davey 2008; Pressland 2009; Sage 2009; Bicknell *et al*. 2010; Neumann *et al*. 2015).

1.4 Study site: The Bailiwick of Jersey

The Bailiwick of Jersey (hereafter: Jersey) is the largest of the Channel Islands at 116.25 square km (States of Jersey 2016a). It is a British Crown Dependency, represented and defended by the UK, but with self-governed legal and judicial systems, comprising an independent environment department that constitutes its own wildlife laws. Financial services are Jersey’s largest source of income, generating just under 42% of all revenue in 2015 and employing 22% of Jersey’s labour force (States of Jersey 2016b; 2016c). Rental income from private households generates the next largest revenue (14%), while utilities, agriculture and manufacturing generate the least (figure 1.1, States of Jersey 2016b). Jersey’s resident population exceeds 100,000 and the island receives around 700,000 visitors a year, with Jersey’s scenery and landscape a key attraction (Visit Jersey 2015).

Situated 25 km from the French coast, in the Bay of St. Malo, and 137 km south of England (figure 1.2), Jersey has a temperate maritime climate with warm summers and mild, wet winters, with daytime temperatures rarely dropping below freezing point (Jersey Island Plan Review 1999). Average high temperatures in summer reach 21˚C and average low temperatures in winter drop to 4.3˚C (ClimaTemps 2016). Jersey’s average annual precipitation is 880 mm and there is, on average, 1882 hours of sunshine per year (ClimaTemps 2016).

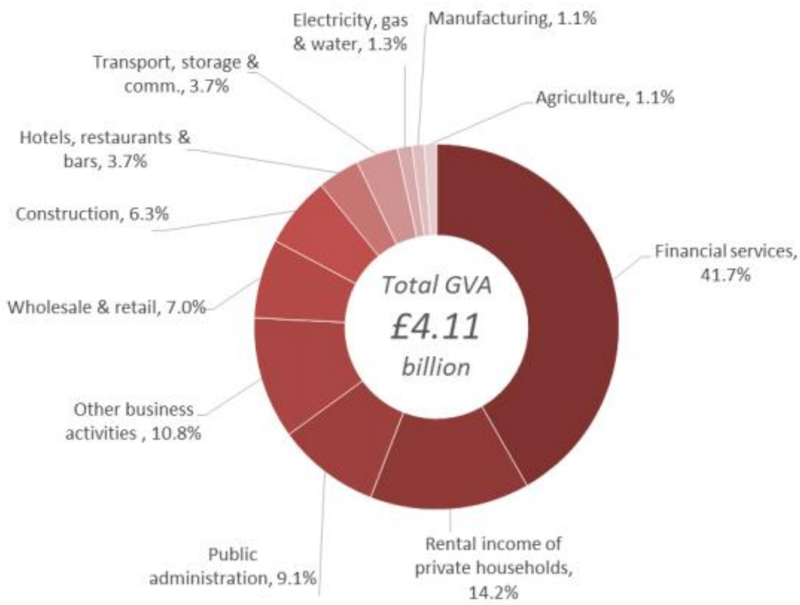

Figure 1.1: Jersey's economic activity by gross value added (GVA) in 2015. Graph taken from States of Jersey (2016b).

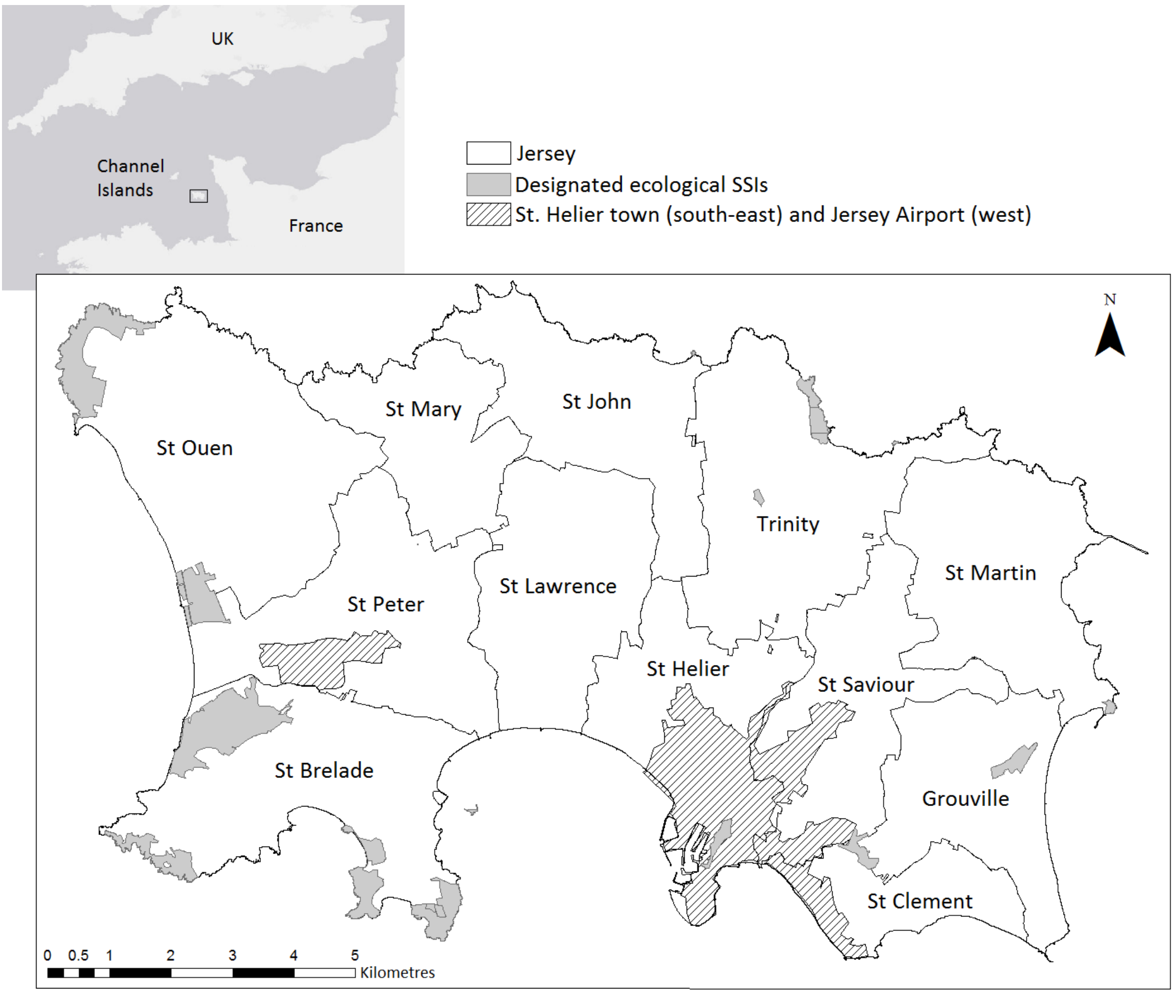

Figure 1.2: The Bailiwick of Jersey is the largest of the Channel Islands. It covers 116.25 km^2 and is divided into twelve parishes. Inset: modified from Esri, DeLorme, NAVTEQ (2016).

Agriculture

The agricultural sector generates just over 1% of Jersey's income (figure 1.1, States of Jersey 2016b). Despite its seemingly small contribution, agriculture is an important source of revenue in Jersey, with export crops valued at approximately £40 million annually (States of Jersey 2016a). The island's largest crop export, the Jersey Royal potato, was valued at £27.5 million in 2015 (States of Jersey 2016a). It is the only fresh fruit or vegetable to have an EU Protected Designation of Origin (PDO) and 30 km^2 of land was dedicated to Jersey Royal crops in 2015 (States of Jersey 2016a; 2016d). Narcissus flowers are the next largest crop export for Jersey with other crops including courgettes, cauliflower, maize and cereals (States of Jersey 2016a). Jersey's dairy industry shapes a large part of their landscape also, with their famous Jersey cows producing just under 14 million litres of milk, worth £13.7 million, in 2015 (States of Jersey 2016a).

Agriculture also shapes much of Jersey's landscape with around 62 square km (53% of Jersey's land area) dedicated to farming practices (States of Jersey 2016a). The high turnover of rotational crops has been characteristic of Jersey's agricultural landscape. Since 2000, land use changes over the years have seen increased areas of grassland, for silage and haylage, and decreased use of secondary crops, such as cereals (States of Jersey 2016a, table 1.1). This likely contributes to a great reduction in food resources for all of Jersey's granivorous birds. Over recent years, this is starting to be offset somewhat by initiatives such as Birds on the Edge's "Operation Hungry Gap" which encourages the sowing of winter bird crops and is trialling the use of laying down bird feed at pivotal times of year (Sellarés de Pedro 2015).

Table 1.1: Changes in area of land used to grow potato crops and crops considered important to pheasants in Jersey in 1986, 2000 and 2015. Data taken from the States of Jersey (1987; 2003; 2016a).

Crop		**1986**	**2000**	**2015**	**% difference 2000 -2015**
Potatoes	vergées	14,691	19,843	16,561	-16.5
	km^2	26.43	35.69	29.79	
Maize	vergées	0	2,467	2,089	-15.3
	km^2	0	4.44	3.75	
Cereal	vergées	740	2,312	924	-60
	km^2	1.33	4.16	1.66	
Outdoor fruit and veg	vergées	13,562	3,024	2,171	-28.2
	km^2	24.4	5.44	3.91	
Grassland	vergées	13,960	12,842	19,614	+52.7
	km^2	25.12	23.11	35.29	

Natural Environment

There is no completely natural habitat left in Jersey (States of Jersey 2015a). In addition to lattice of hedgerows across agricultural, Jersey's natural landscape accounts for 17% of Jersey's land surface (States of Jersey 2014a). This includes all semi-natural habitats, such as woodlands, dunes, cliffs, scrubland and grasslands and hedgerows, many of which are valued for their unique mix of biodiversity. The coast is a mix of rocky cliffs to the North, sandy beaches to the south and a collection of sand dunes to the East (Garland 1903; Le Sueur 1976; States of Jersey 2015a). Scrub and heathland are mainly concentrated around the North and West coast. The geology is dominated by granites in the north and southwest and the southeast, mudstone, siltstone, sandstone and grit in the mid-west and a mix of conglomerate, ignimbrite, andesite, granite and microgranite in the mid and north-east (Garland 1903; Le Sueur 1976; Brown 1982). The built environment accounts for 23% of Jersey's land surface (States of Jersey 2014a). St. Helier is the largest town, covering approximately 6.8 km^2, and is situated in the southeast, while Jersey Airport, approximately 2 km^2, is in the southwest.

The island boasts a mix of flora and fauna native to Britain and mainland Europe, including four native reptiles, three native amphibians and a vast array of resident and migratory birds (States of Jersey 2000). The Joint Nature Conservation Committee (JNCC) of the UK government lists 27 invasive plants, four invasive invertebrates (excluding marine species), two invasive reptiles, two invasive birds (including the pheasant), two invasive mammals and one invasive amphibian in Jersey. Other introduced species that have become naturalised include rabbits (*Oryctolagus cuniculus*), red squirrels (*Sciurus vulgaris*) and hedgehogs (*Erinaceus europaeus*). Its location provides genetic isolation for yearlong residential fauna, though hosts an abundance of migratory species.

1.5 Pheasants in Jersey

Records of pheasants imported into Jersey date back as far as the latter half of the 19th century (Socéité Jersiaise 1972). It is thought, however, that the population was not viable in the absence of reintroductions (Le Sueur 1976). The latest introduction in the mid-1980s saw the release of approximately 1600 pheasants, descended from 100 day old chicks imported in 1983, at various locations across the island for game hunting (C. Le Boutillier, 2016, personal communication, 15 March). Due to their unauthorised release, the States of Jersey protected all wild pheasants under the Protection of Birds (Jersey) Order 1963, which prohibited their hunting as a game species and prevented any means of controlling this newly introduced species. This protection, which now comes under the Conservation of Wildlife Law (Jersey) 2000, enabled the population to expand and spread across the island and pheasants are now considered a part of Jersey's countryside, much like they are in the UK. A report on a one day visit to Jersey by the Game Conservancy Limited (2006) in 2005, now the Game and Wildlife Conservation Trust (GWCT), states that pheasants are naturalised on Jersey and represent a 'healthy wild population'. The Jersey Bird Report (Société Jersiaise, 2014) estimates pheasant numbers are well over 1000, though this is a decrease from over a decade ago when the population of pheasants in Jersey was thought to number in the multiple thousands (Jackson, 2003).

Though there are no natural land predators of concern to pheasants on Jersey (except possibly a very small stoat population), there are abundant populations of domestic cats and rats, which pose a danger to eggs and young, and a small population of feral ferrets (Jouventin, Bried and Micol 2003; Russell 2013). There has also been an increase in the populations of corvids and birds of prey in Jersey, predominantly marsh harriers and buzzards (Young and Young 2016), with many Jersey residents suggesting that pheasants are playing an important role in the rise of bird of prey numbers. Remains of pheasants around marsh harrier nests during chick ringing provides anecdotal evidence of marsh harriers utilising pheasants as a prey species but offers no quantitative data of their importance as such a resource (G. Young 2016, personal communication, 6 October). Other birds of prey in Jersey that could benefit from pheasants as a food source include peregrines (*Falco peregrinus*) and hen harriers (*Circus cyaneus*).

As pheasants are not managed as a gamebird in Jersey and their release is prohibited, the negative impacts of high density release pens and any positive impacts of managing land for gamebirds do not apply. However, as a non-native species, pheasants may still potentially cause negative impacts. Little research on the impacts of pheasants outside of release pens and the management of habitats for wild gamebirds exists and any damage caused by pheasants in Jersey is not offset by any profit made by having them on the island. Jackson (2003) states damage to crops in Jersey is localised, causing substantial loss in only a few cases. However, the Game Conservancy Limited (2006) considers crop damage by pheasants a serious problem, particularly to high value crops such as Jersey Royal potatoes and advocates the culling of the pheasant population.

The Jersey Farmland Bird Monitoring Scheme, a collaboration between the Durrell Wildlife Conservation Trust, the Société Jersiaise, National Trust for Jersey and the States of Jersey Department of the Environment, has revealed a downward population trend for pheasants in Jersey since 2005 (figure 1.3; Young and Young 2016). Unfortunately, population abundance cannot be garnered from the results as pheasant numbers are reported as birds seen per 100 m and thus is not a true density estimate. The monitoring scheme's transects are also non-random in their design, with habitats suitable for specific birds of interest preferentially chosen (Young and Young 2016).

Therefore, any density and abundance estimates derived from the data could not be reliably extrapolated to the island as a whole.

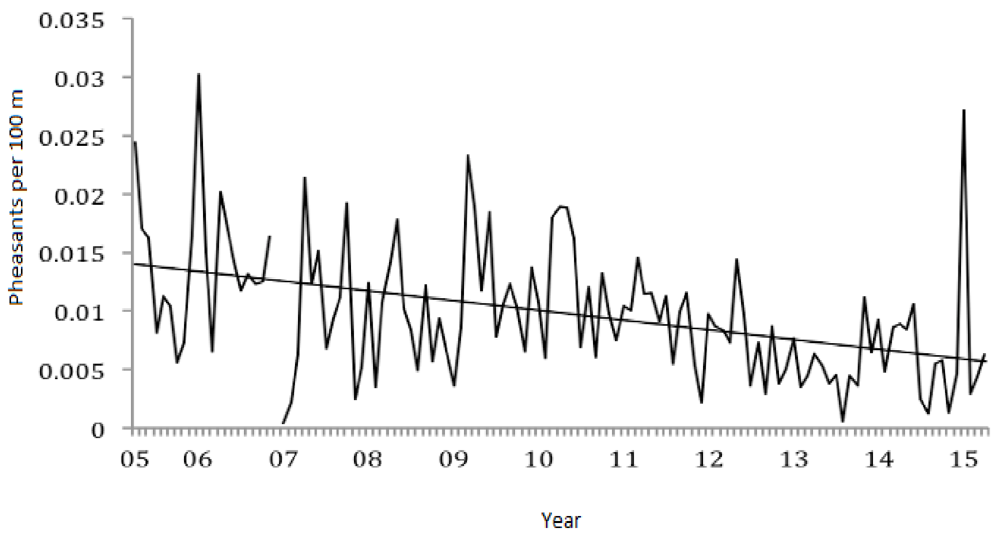

Figure 1.3: Birds on the Edge's Farmland Bird Monitoring Scheme shows a decrease in the sightings of pheasants per 100m of transect since 2005. Taken from Young and Young (2016).

1.6 Jersey law

In Jersey, pheasants are protected under the Conservation of Wildlife Law (Jersey) 2000, rendering it illegal to disturb, harm or kill pheasants, their young or their nests unless under licence. Pheasants are not classed as a game bird under Jersey law, as such there is no pheasant hunting season and the release of birds is prohibited. However, since 2005, licences to control pheasants can be granted to landowners under the Conservation of Wildlife (Jersey) Law 2000 to:

- preserve public health and safety,
- prevent serious damage to property such and livestock and crops, and
- prevent the spread of disease (States of Jersey 2014).

It is also prohibited under the Conservation of Wildlife Law (Jersey) 2000 to trap pheasants. Nevertheless, trapping remains a common activity in Jersey and the States of Jersey have applied to repeal this restriction, with a plan to issue licences for the use of traps, such as the Larsen trap (L. Napton 2016, personal communication, 21 March).

Though it has no legal administration, in both the UK and Jersey, pheasants are also offered international protection under the non-statutory obligation of the Bern Convention (1982). This offers protection for pheasants under Appendix III, prohibiting certain “means and methods of killing, capture and other forms of exploitation” including “semi-automatic or automatic weapons with a magazine capable of holding more than two rounds of ammunition”.

1.7 Aims and objectives

Little is known about the environmental and economic effects of this large, naturalised gamebird in Jersey and, as an introduced species, they potentially pose a threat to native wildlife and agriculture. The States of Jersey have recognised the need to gather baseline data on the introduced population of common pheasants residing on the island to aid in future wildlife law and management decisions. To make well informed management decisions on any species, a repeatable monitoring scheme to assess abundance and distribution needs to be put in place to allow the evaluation of the success of management actions against a baseline (Pellicioli and Ferrari 2013; Fowler, Sieg and Hedwall 2015; Engeman *et al*. 2016; Tilley *et al*. 2016). The overall success of a species management plan is also reliant on accurate, up-to-date data, and on public support with the views and education of the public being important tools to avoid conflict and improve management results (Coluccy *et al*. 2001; Fulton *et al.* 2004; Bremnar and Park 2007; Sijtsma, Vaske and Jacobs 2012; Verbrugge, Born and Lenders 2013). Therefore, this thesis aims to:

1. Provide density and abundance estimates of the Jersey pheasant population, using repeatable distance sampling techniques, and explore the population trend of Jersey’s pheasants using data from the UK Breeding Bird Survey,
2. Investigate the habitat utilisation of pheasants in Jersey to discover if there are any preferences for certain crops,
3. Investigate perceptions of Jersey residents regarding pheasants in Jersey and their management through the use of an online questionnaire,
4. Investigate and evaluate the impacts of pheasants on agriculture and native wildlife, including consumption and damage to crops and predation of sensitive native herpetofauna, through a combination of an online questionnaire and gastrointestinal analysis of pheasants shot under licence,
5. Discuss the invasive potential of pheasants in Jersey, and
6. Offer targeted management options for the pheasant population in Jersey.

Chapter 2: Distribution, abundance and habitat use of a naturalised island population: the common pheasant (*Phasianus colchicus*) in Jersey, UK Channel Islands.

Abstract

Non-native species can have major consequences for ecological systems and for the local economy. The first step to any successful species management plan is the production of baseline data to allow comparisons for future monitoring and the success of any management actions. Here we use distance sampling to provide comprehensive density and abundance estimates for the naturalised island population of pheasants on Jersey, Channel Islands, across three seasons to explore estimates at different times of year for optimal survey results. Results are compared to UK Breeding Bird Survey data, from which temporal population trends since 2002 have been derived, to validate the use of Breeding Bird Surveys to monitor pheasant population trends in Jersey. Additionally, we investigate the summer habitat utilisation of pheasants and assess pheasant preference for different crops on Jersey. We estimate a population of between 1011 and 1780 pheasants on Jersey in 2016 and reveal a fluctuating and overall decreasing population trend since 2002. Summer habitat preferences were found towards fields of new shoots, mustard and bare ground.

Keywords: Common pheasant, *Phasianus colchicus*, distance sampling, abundance and density, line transects, habitat, island population, introduced, non-native.

2.1 Introduction

Considered the second largest threat to biodiversity, invasive species can cause detrimental local scale effects through predation, competition, disease transmission and habitat alteration (Rushton *et al*. 2006; Sage 2009; Reynolds *et al*. 2013; Tizanni *et al.* 2014; Hudina *et al.* 2016). Additionally, they can become pests of agricultural crops, causing massive economic, as well as ecological, losses (Arim *et al*. 2006; Williams *et al*. 2010).

Native to Asia and southeast Europe, the common pheasant (*Phasianus colchicus*) has been introduced across Europe, North America and Australasia as a game species (GCT 1997). Though associated with arable land and woodland edges, the pheasant can adapt well to a range of climates and food sources and has the potential to become an invasive species (Davey 2008). In much of their introduced range, pheasant populations are supplemented annually with intentional releases for recreational hunting and aided by habitat management, such as provision of game crops, woodland management, controlled burning, set aside land, and the use of dedicated feeding stations (Mustin *et al*. 2012; GWCT n.d.). Today in Britain, pheasant shooting is a multibillion pound industry with over 35 million pheasants being reared and released into the British countryside each year (Bicknell *et al*. 2010; PACEC 2014). With such a large number of birds being reared in release pens, research into the effects of pheasants in their non-native range focuses largely on the impacts associated with these pens, at which pheasants occur in high densities, and game estate habitat management (Davey 2008; Mustin *et al*. 2012; Neumann *et al*. 2015). As such, little is known about the ecological effects introduced pheasants may have on the wider countryside or in areas where they are naturalised with no annual releases.

Thought to have descended from an introduction of around 1600 birds in the 1980s, the subsequent naturalisation of pheasants on the Bailiwick of Jersey, the largest of the Channel Islands, provides a unique insight into the invasive potential of pheasants. Here they have continued to flourish without the aid of annual introductions and pheasant habitat management (except perhaps the planting of cover crops), despite earlier failed attempts at introducing them to the island (Socéité Jersiaise 1973; Le Sueur 1975). The initial release took place in several locations across the island with the largest numbers released in St. Ouen in the north-west, and St. Martin in the north-east (see figure 1.1). Their spread was likely aided by the abundance of hedgerows across Jersey which provide a vast network of potential dispersal corridors and nesting cover for the pheasants on the island (Sage *et al.* 2009). At the time of this release, it seems predators were low in number (Jouventin, Bried and Micol 2003; Young and Young 2016). Today, populations of marsh harriers (*Circus aeruginosus*) and buzzards (*Buteo buteo*) are on the rise, as well as populations of corvids (*Corvus corone* and *Pica Pica*), domestic cats (*Felis catus*) and likely rats (*Rattus norvegicus*) (Jouventin, Bried and Micol 2003; Young and Young 2016).

Being a non-native species, the effect of pheasants on the local wildlife and agriculture is largely unknown and, as a small, agricultural island, this naturalised species is an economic and ecological concern in Jersey. Potential impacts include habitat degradation, predation of herpetofauna, competition with local songbirds and damage to crops, as well as providing an additional, abundant food source for other pest species such as corvids (Koopman and Pitt 2007; Sage 2009; Bicknell *et al*. 2010; Tomsett 2011; Dimond *et al*. 2013).

To understand what impacts an introduced species may have on local agriculture and wildlife, and how to best manage them, it is important to monitor their abundance and distribution. Baseline data is needed to allow monitoring of population trends and the scrutiny of species impacts and management actions (Pellicioli and Ferrari 2013; Fowler, Sieg and Hedwall 2015; Engeman *et al*.

2016; Tilley *et al*. 2016). This is best accomplished by easily repeatable and reliable surveys, ideally with minimal disturbance to the local flora and fauna (Pellicioli and Ferrari 2013; Tilley *et al*. 2016).

Currently, there are two ongoing bird monitoring schemes in Jersey: the Breeding Bird Survey (BBS) and the Jersey Farmland Bird Monitoring Scheme, a collaboration between the Durrell Wildlife Conservation Trust, the States of Jersey Department of the Environment, the Société Jersiaise and the National Trust for Jersey (Young and Young). The latter is an important source of information for the trends of Jersey's birds, however the data are presented as birds seen per 100m of transect and are therefore not a true density estimates (Young and Young 2016). The former combines Channel Island data with UK data to give overall trends (Harris *et al*. 2016).

Many methods have been used to look at the abundance of galliformes, including territory mapping, line transects and call counts (Robertson, *et al.* 1993; Luukkonen, Prince and Mao *et al.* 1997; Nijman 2007; GWCT n.d.). Due to resource and time constraints and lack of robust methods for statistical scrutiny, territory mapping is less favoured and deemed unsuitable for estimating density by some (Gottschalk and Huettmann 2001). Line transects and call counts are less costly in terms of resources and time. Coupled with distance survey methods, they are widely utilized by conservation organisations such as the British Trust for Ornithology (BTO), Royal Society for the Protection of Birds (RSPB) and the Joint Nature Conservation Committee (JNCC) and can be used to estimate densities and population numbers of a wide variety of species such as primates, cetaceans, trees and birds (Dodd and Meadows 2003; Newson *et* al. 2008; Buckland *et al.* 2010; Jenson and Meilby 2011; Paxton *et al* 2011; Harris *et al.* 2016).Bibby *et al.* (2000) describe line transects as "more efficient" and "accurate than point counts" with line transects preferable for larger, more easily detectable species and when time and budget are limited (Bibby, Jones and Marsdon 1998; Duarte and Vargas 2001). Cassey (1999) found only line transect distance sampling is comparable to true densities, producing densities similar to mark-recapture methods, and concluded overall that distance sampling techniques using line transects were robust, cost effective and caused minimal disturbance when compared with mark-recapture and point transect methods.

Consequently, distance sampling using line transects (Buckland *et al*. 2001; Thomas *et al*. 2010) was applied to provide baseline data for the monitoring of common pheasants in Jersey in order to inform future management strategies. Here we estimate population density and abundance and use local land use data to investigate habitat utilisation of this naturalised species. Raw BBS data, provided by the BTO, is also used to estimate yearly densities and abundances since 2002 to explore population trend. BBS estimates from 2016 are compared with estimates derived from this study to investigate the validity of using the BBS for the continued monitoring of the population trend of pheasants in Jersey.

2.2 Methods

2.2.1 Study area

The largest of the Channel Islands, the Bailiwick of Jersey covers an area of 116.25 square km. Around half of this area is used for agriculture - 53.23% in 2015 (States of Jersey 2016a). The primary crop is the Jersey Royal potato, with other crops including brassicas (e.g. broccoli), flowers, beans, tomatoes, strawberries, maize and cereals (States of Jersey 2016a).

In addition to agricultural land, Jersey's landscape consists of semi-natural areas, including woodland, scrubland and grasslands and small residential areas, and webbed with a lattice of hedgerows. The largest built up area is the town of St. Helier (~6.8 square km) situated in the south east. Jersey Airport (~2 square km) is situated in the west. Jersey has a moderate maritime climate with warm summers and mild, wet winters with daytime temperatures that rarely drop below freezing point. However, its location, 25 km off the coast of France in the Bay of St Malo, makes it vulnerable to strong winds from the Atlantic (Jersey Island Plan Review 1999).

2.2.2 Survey design

A 1 km square grid was overlaid on a map of Jersey. Nine existing Breeding Bird Survey (BBS) squares were adopted into the survey, with a further nine squares chosen randomly across the Island using a random number generator (figure 2.1) (see Appendix A). Squares were excluded if they (1) were >50% water, (2) in the town of St. Helier or the airport, or (3) had an adjacent square already selected. The final selection of survey squares resulted in a broad coverage of the island, encompassing coastal and inland areas and ecological Sites of Special Interest (SSIs, figure 2.1).

Transect survey methods were adapted from the BTO/JNCC/RSPB BBS (Harris *et al.*, 2015). Within each square, two line transects were established up to 1 km each in length. Where it was not possible to create 2 km of transect, such as in a square that was partially covered by sea, shorter transects were made.

Jersey's landscape is highly divided with characteristically small land parcels. Therefore, to avoid damaging or disturbing crops, livestock and sensitive ecological sites, many transects followed roads and footpaths. The distribution of pheasants has been found to be unaffected by roads, thus transects positioned along gravel and asphalt roads can be used without concern of bias caused by such features (Venturato, Cavallini and Dessì-Fulgheri 2010). Utilising roads and footpaths as transects also provide the benefits of providing easy terrain and navigation, allowing the observer to be more aware of their surroundings. For those transects that did cross into fields, permission to enter was gained from the landowner at the beginning of each survey season.

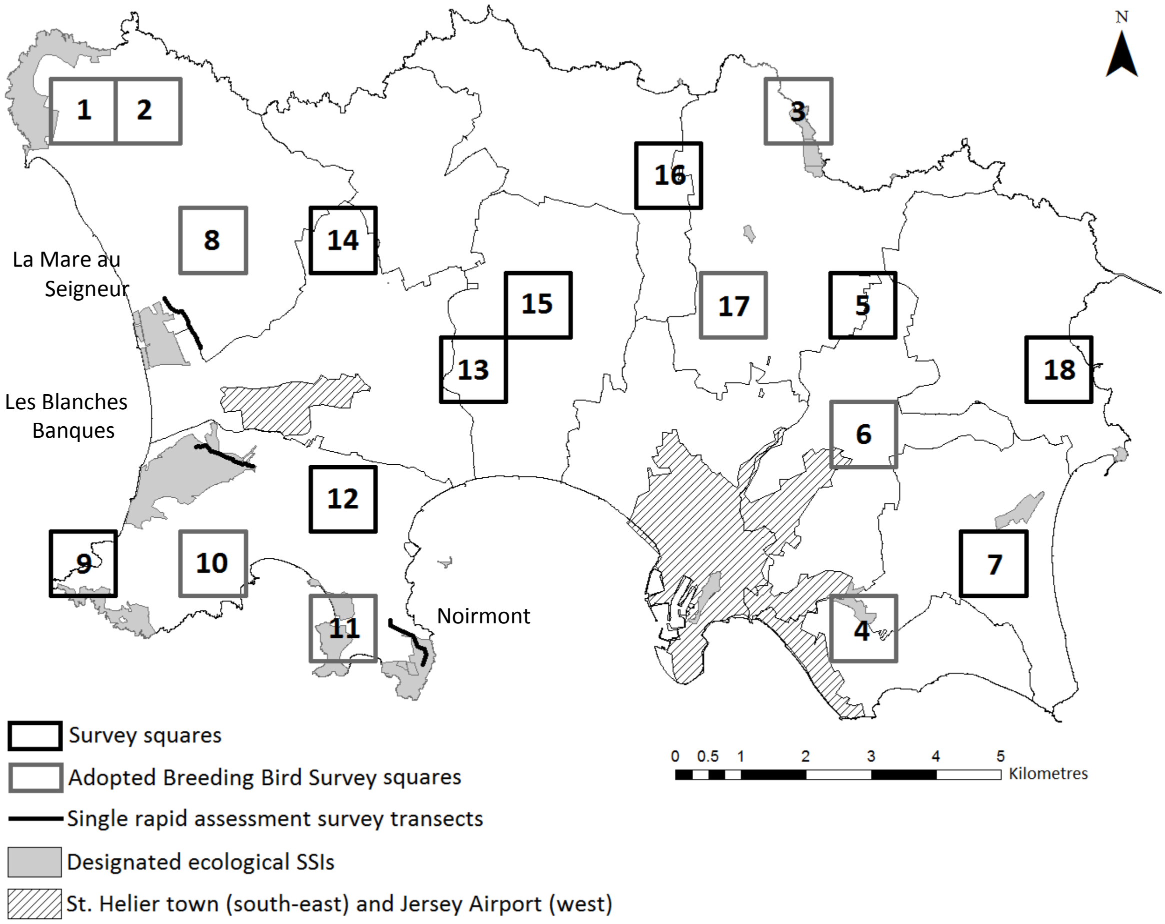

Figure 2.1: Eighteen areas were surveyed to provide estimates for density and abundance. Nine squares and their corresponding transects were adopted from the BBS (grey squares), while a further nine were chosen at random (black squares). The black lines in the west show where single, rapid assessment surveys were carried out in/near SSIs to investigate densities. These were surveyed at the end of the pre-breeding season. Grey areas are designated SSIs. Areas with diagonal lines represent the airport in the west and the town of St. Helier in the south east.

2.2.3 Data collection

Line transect surveys

Transects were visited once a week: three or four times during winter, from 14 November to 20 December 2015; five or six times during pre-breeding, between 1 February and 13 March 2016; and five or six times for post-breeding, between 13 June and 31 July 2016. Surveys were carried out in the morning, from half an hour before sunrise to mid-morning, and in the evening, up to two hours before sunset, as these are the time periods associated with most activity and territorial crowing in male pheasants (Dalke 1937; Greeley, Labisky and Mann 1962; GWCT n.d.; Warren and Baines 2011; Dahlgren 2013). Pre- and post-breeding surveys were conducted earlier than season estimates are normally conducted for UK populations because, after discussion with local conservation associates, it was apparent that Jersey's milder weather allows for an earlier breeding season compared to mainland UK.

All pheasants detected by visual or auditory means were recorded within four distances from the transect line: 0-25 m, 25-50 m, 50-100 m and >100 m. The positions of visually detected pheasants were also drawn onto a satellite image of the area, with a scale no greater than 1:4000. These points were then digitised into a GIS from which perpendicular distances to the transect line were obtained for each point.

Satellite image maps of each transect were used to aid in surveys. Each map featured the transect line and margins indicating the distance band categories (25 m, 50 m and 100 m). These allowed visual interpretation of bird distances in relation to land features, helping to reduce observer bias. Each observer was trained in data collection, which also involved conducting a trial survey whereby observations were compared between observers to aid in training and reduce possible observer bias. A total of five squares were surveyed by volunteers during the autumn/winter season, six during the pre-breeding and seven during the post-breeding season. Squares were assigned to individual volunteers based on the ease of access from their work or home. The majority of volunteers were current and previous volunteers for the BBS and Farmland Bird Surveys.

Each 1 km section of transect was assigned a habitat according to the classification by Newson *et al.* (2005) and Crick (1992). However, after initial exploration of the data in DISTANCE 6.2, it was determined the variety of habitats applied provided too many parameters and caused errors in the DISTANCE models. Therefore, simple habitat descriptions were assigned, consisting of three habitat classes: open, semi-open and closed, where semi-open and closed classes could be assigned as such based on reduced visibility caused by vegetation, for example woodland or tall crops, or manmade structures such as buildings or high banks. This allowed the calculation of a representative detection probability by habitat but removed the ability to give density estimates of specific habitat types. As transect squares were chosen at random, habitats within them are assumed to be representative of the island as a whole, still allowing robust island wide abundance and density estimates, though excluding the built up area of St. Helier and the airport. Indeed, the transects did cover a range of agricultural uses, woodland, scrubland, grassland and suburban, rural, semi-natural and protected areas (see Appendix A).

During pheasant surveys, a record of how the bird was detected (visual or auditory) was also noted. If a bird was heard then subsequently seen they were recorded as being seen. Pheasants that were detected visually had their locations drawn onto a map, whilst birds that were only audibly detected were assigned to a distance band. During the post-breeding season, juveniles were included in the counts to investigate proliferation.

A further three 1 km transects were chosen for rapid assessment in the east of the island. These were placed in or near ecological SSIs thought to contain high densities of pheasants and are important areas for herpetofauna. These SSIs are: La Mare au Seigneur, Les Blanches Blanques and Noirmont (figure 2.1). These were surveyed once at the end of the post-breeding survey season to further understand the distribution of the pheasants in regards to sensitive sites (figure 2.1). These transects were not used in the analysis to estimate density and abundance as they were not randomly selected, and were not surveyed during all seasons.

BBS surveys

Raw BBS data for 2002 to 2016 were provided by the BTO. Transects are surveyed during the morning twice annually on an 'early' (early April to mid-May) and a 'late' (mid-May to late June) spring visit conducted at least four weeks apart. Survey squares are initially chosen at random with the intention of their continued annual monitoring by the same volunteer, however, depending on the availability of the volunteers, survey squares can be abandoned and new ones put in place. The number of 1 km squares surveyed in Jersey each year ranged from three to twelve and transect length per square ranged from 1.6 to 2 km. Birds detected visually or audibly are recorded into one of three distance band (0-25m, 25-100 m, >100 m) based on perpendicular distance from the transect line. More details of the survey design and data collection can be found in Gregory *et al.* (1996) and on the BTO website: www.bto.org.

Habitat preferences

During the post-breeding season, ArcGIS was used to identify a 50 m buffer around transect lines. All land parcels that could easily be seen from the transect line within this buffer (ignoring roads and buildings) were assigned one of 10 habitat types: (1) non-natural grassland (including temporary, improved, wet and amenity grassland and orchards); (2) semi-natural grassland (including semi-natural grassland and ruderal fields); (3) scrub; (4) woodland; (5) potato; (6) maize and cereal; (7) mustard and phacelia; (8) other brassicas and calabrese; (9) shoots (including new crop and wild plant growth); or (10) bare (such as after a potato field has been ploughed or a field tilled ready for planting). These were adjusted week by week as land use changed, for example if a field of potatoes was ploughed and the habitat became bare ground. Each visually detected pheasant was assigned a habitat category in accordance with the type of habitat it was first sited in. Only those within the 50 m buffer were used to investigate habitat preference.

2.2.4 Data analysis

Density and abundance

Density and abundance estimates were calculated using software DISTANCE 6.2 (Thomas *et al.* 2010). Exact distances were used for sighted pheasants and central values of distance bands were used for those detected by sound only, for example those that were heard between 0 and 25m were all assigned a distance of 12.5m. Multiple-covariate distance sampling (MCDS) models were explored, as including covariates such as habitat type can improve modelling of the detection function and therefore improve density estimates (Newson *et al*. 2005). Best model was selected according to visual inspection of graphs, AIC, the K-S goodness of fit statistical test and the coefficient of variation (Buckland 2001). Survey effort for each transect equalled the length of the transect line multiplied by the number of replications (Buckland, Marsden and Green 2008).

The data generally adhered to a normal distribution, though detections by sound alone caused peaks in the data due to all data points being assigned the centre point of the distance band of detection (figure 2.3).The final model used to estimate density and abundance was an MCDS model with a half-normal key function and a cosine adjustment term. Habitat and mode of detection were used as covariates. Observations were truncated to 200m as very few sightings were made beyond this distance. Besides one concern where the detection probability remained at 1 for birds detected by sound in closed habitat during the pre-breeding season, this model fit the whole dataset and all seasons well, allowing comparative estimates. Poisson distributions, characteristic of animal counts and suitable for data accumulated from small sampling units and data collected by more than one observer (Norris and Pollock 2001; Schmidt, Rodríquez and Capistrano 2015), were assumed, improving confidence limits by 19% across the whole dataset and the post-breeding dataset, 39% for the autumn/winter dataset and 3% for the pre-breeding dataset. More detailed methods and final detection probabilities are shown in Appendix B.

Densities for each survey square were also estimated in DISTANCE 6.2 using either CDS (Conventional Distance Sampling) or MCDS model based on visual inspection and AIC. Squares with a low number of sightings, below the recommended 60-80 minimum (Buckland *et al*. 1993), were combined with nearby squares to produce sufficient data for accurate estimates.

Population trend

Raw data of pheasant sightings from the BBS were provided by the BTO for the years 1996 to 2016, including sightings for transects adopted by this study. Only the year 2002 onwards had sufficient sightings to be able to give reliable density estimates (n=>60). The BBS uses three distance categories; 0-25m, 25-100m and beyond 100m. For the purposes of this study, each transect used by the BTO was assigned one of the three habitat classes based on the habitat categories assigned by the BTO volunteers and ground-truthing. Those transects which were also used in this study were assigned the same habitat categories already assigned for the year 2016. Data was truncated to 100m from the transect line and the first two distance bands (0-25m and 25-100m) were used as intervals with density and abundance calculated in DISTANCE 6.2 (Thomas *et al.* 2010). Best model was fitted for each year based on visual inspection and AIC (see Appendix B for models chosen for each year). For 2016 BBS data, a MCDS model with a half-normal key function and a cosine adjustment term was used with habitat as a covariate and Poisson distribution assumed. Population trend was examined using linear regression.

Comparison between data sets

Z-tests were used to compare density estimates between survey seasons and BBS yearly density estimates using the formula:

$$Z = \frac{D_1 - D_2}{\sqrt{SE_1^2 + SE_2^2}}$$

where *D* is the density estimate in area *i*, SE_i = standard error of the density estimate in area *i* (Owiunji and Plumtre 1998; Bicknell and Peres 2010).

Habitat use

A Kolmogorov-Smirnov test revealed the data was non-normal (p=<0.001) thus habitat utilisation was investigated using a Krustal-Wallis test. (See Appendix C for number of pheasants seen in each habitat category for the pre- and post-breeding survey seasons).

2.3 Results

A total of 1504 pheasants were encountered along 552,575m of transect effort (table 2.1). Encounter rates ranged from 1.73 to 3.53 pheasants per km across all survey seasons. The highest numbers of pheasants seen compared to survey effort was during the pre-breeding season, the lowest in the autumn/winter season (table 2.1). The pre-breeding survey season also yielded the highest number of males to females and post-breeding the lowest.

Pheasants were encountered in all squares used in this survey. Highest rates of encounters occurred in the north-west (St. Ouen, St. Mary and St. John) and south-east (St. Clement and Grouville). Lowest rates of encounters occurred in the south-west (St. Brelade) and in the north-east (east St. John/north of Trinity). Successful breeding (observations of juveniles), was evident all over the island, including inland and coastal areas (figure 2.2). High numbers and/or breeding were observed in or near several SSI sites: Les Landes, La Mare au Seigneur, Noirmont, Grouville Marsh and Rue de Prés (figure 2.2).

Table 2.1: Survey effort and number of pheasants seen for each survey season.

Season	Period	Effort (m)	Total *N*	Males	Females	Juveniles	Sex ratio M:F
All	-	552,575	1504	1042	433	29	1:0.42
Autumn/winter	23 Nov - 19 Dec 2015	136,602	242	156	86	-	1:0.55
Pre-breeding	1 Feb - 15 March 2016	211,396	758	482	276	-	1:0.57
Post-breeding	13 June - 24 July 2016	204,577	504	404	71	29	1:0.18

2.3.1 Density and abundance

Density estimates ranged between 9.5 pheasants per km^2 (95% CI: 8.1-11.1) during autumn/winter, and 16.6 pheasants per km^2 (95% CI: 15.2-18.2) during pre-breeding. Total island-wide abundance ranged between 1011 (95% CI: 862-1187) in autumn/winter, and 1780 (95% CI: 1630-1944) during pre-breeding (table 2.2). Pheasant densities of survey areas, across all seasons, ranged from 2.9 pheasants per km^2 (95% CI: 2.3-3.6) in the southwest (squares 9 – 12), to 38.1 pheasants per km^2 (95% CI: 29.9-46.4) in the southeast (square 4, figure 2.3). Squares one and two, in the north-west, were also areas of high densities with 26.4 pheasants per km^2 (95% CI: 21.8-31.1, figure 2.3).

Of the 1 km rapid assessment transect routes, high numbers were seen near St Ouen's Pond and the La Mare au Seigneur SSI, with lower numbers in Noirmont and near Les Blanches Banques (table 2.3, figure 2.1).

Table 2.2: Density and abundance (*N*) estimates for pheasants in Jersey, Channel Islands.

Season	Density/km^2 (95% CI)	*N* (95% CI)
All	12.51 (11.75-13.31)	1335 (987-1567)
Autumn/winter	9.45 (8.05-11.09)	1011 (862-1187)
Pre-breeding	16.64 (15.24-18.17)	1780 (1630-1944)
Post-breeding	10.71 (9.62-11.95)	1147 (1029-1278)

Table 2.3: Numbers of pheasants seen for three rapid assessment transects near or in SSIs.

Area	SSI	Date	Length (m)	N	Males	Females
The Sand Dunes	Les Blanches Banques	18/3/16	1000	4	4	-
St Ouen's pond	La Mare au Seigneur	21/3/16	1000	19	15	4
Noirmont	Noirmont	13/3/16	1000	3	3	-

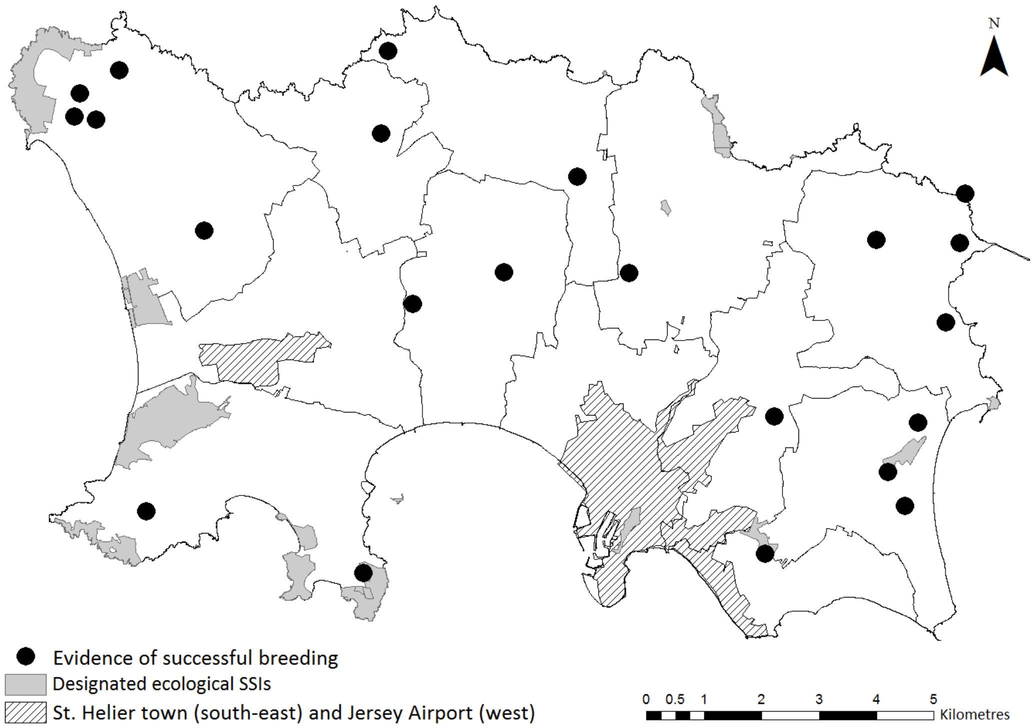

Figure 2.2: Locations of juveniles encountered during surveys or reported by volunteers and members of the public in 2016. This distribution demonstrates the island-wide breeding range of the pheasants but is by no means an exhaustive representation of breeding locations. Grey areas are designated SSIs. Areas with diagonal lines represent the airport in the west and the town of St. Helier in the south east.

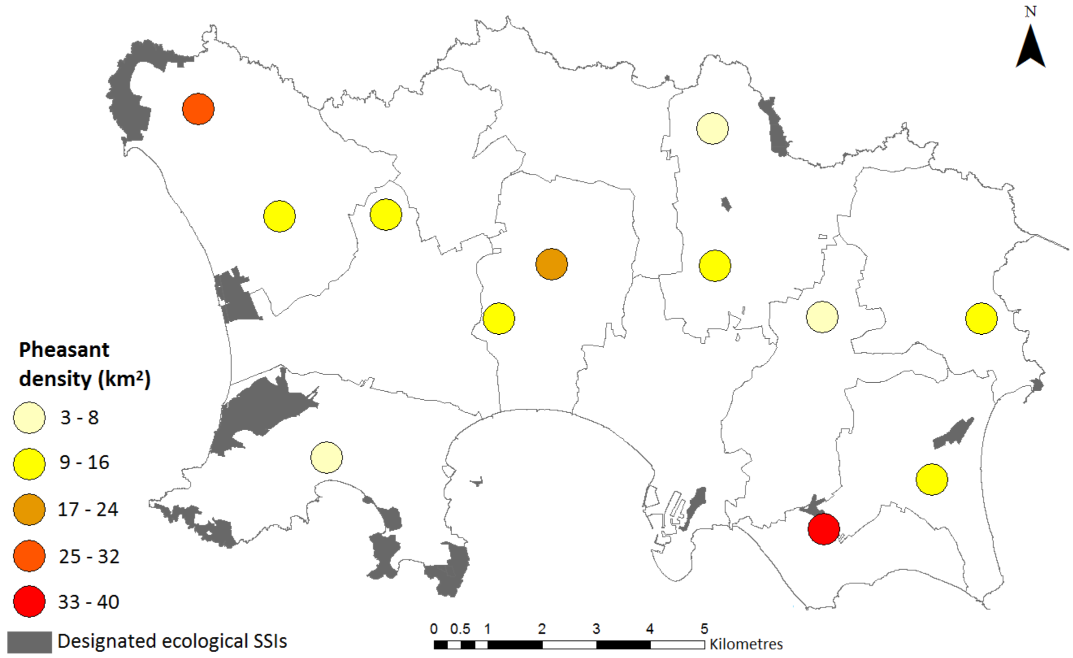

Figure 2.3: Pheasant density estimates (km^2) for survey squares using data from all seasons. Some transects were combined to create density estimates due to insufficient numbers. The density point is shown centrally to the survey square or centrally to the combined squares. Estimates rounded to the nearest whole number.

Comparison with BBS data

Significant differences between density estimates were found between the compiled dataset using all seasons and the pre-breeding season (z=4.865, p<0.001), with the pre-breeding surveys giving a higher estimate while post-breeding (z=-2.771, p=0.006) and autumn/winter (z=-3.522, p<0.001) are significantly lower than the combined estimate. The density and abundance estimates across all seasons are comparable with estimates derived from the 2016 BBS survey with no statistically significant differences in the estimates across this studies survey seasons or with the BBS data (All and BBS z=0.67, p=0.5; autumn/winter and BBS z=1.819, p=0.069; pre-breeding and BBS z=0.927, p=0.354; post-breeding z=1.373, p=0.17) (figure 2.4). That said, due to smaller sample size, the BBS confidence limits are comparably larger than those derived from this study.

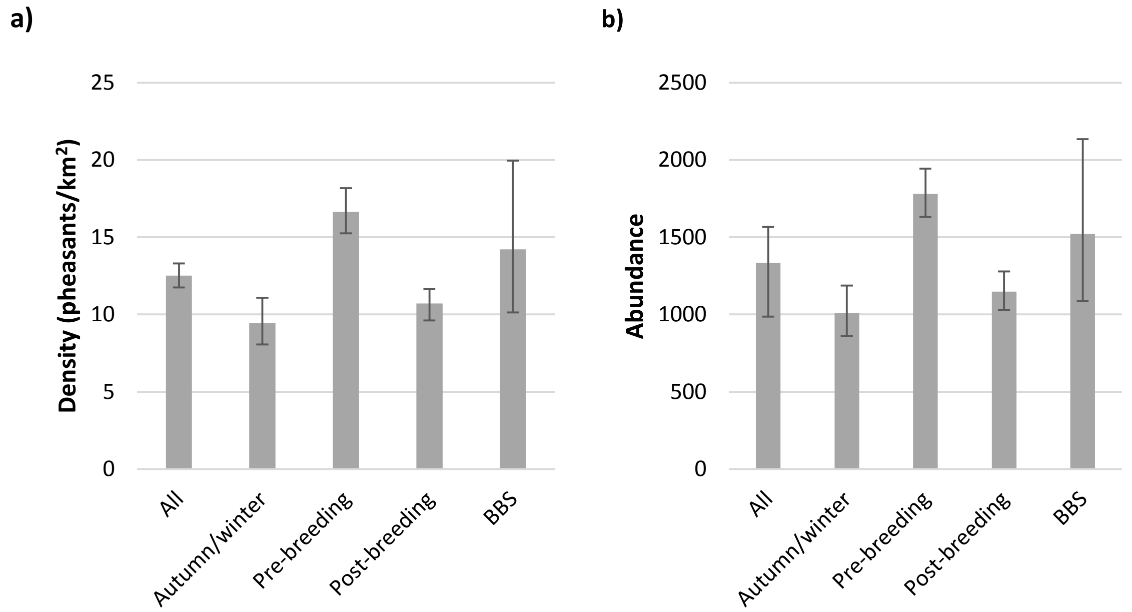

Figure 2.4: Densities per km^2 (a) and island-wide abundance (b) of pheasants in Jersey during the autumn and winter of 2015 and spring (pre-breeding) and summer (post-breeding) of 2016. The BBS data was collected in the spring of 2016, overlapping the end of the pre-breeding season.

2.3.2 Population trend

The BBS data set for the year 2002 was the first year to have sufficient data to fit a reliable model, thus years 1996 to 2001 were not included in the analysis. DISTANCE analysis of BBS data since 2000 shows fluctuations in the population trend (figure 2.5). After a peak in 2008/2009, there is a dip in 2014 to the lowest numbers in over a decade (figure 2.5). However, numbers rise again and a linear regression analysis shows there is no significant trend in population abundance (p=0.176, adjusted R^2=0.06).

In 2010 there was a significant decrease from the previous year (z=3.333, p=<0.001) (figure 2.5). Then, in 2013, there is significant increase (z=-2.033, p=0.021) immediately followed by another significant decrease in 2014 (z=3.289, p=0.001) (figure 2.5). Since 2014 there appears to have been a steady rise in numbers with the BBS 2016 estimate significantly higher than the BBS 2014 estimate (z=2.709, p=0.007).

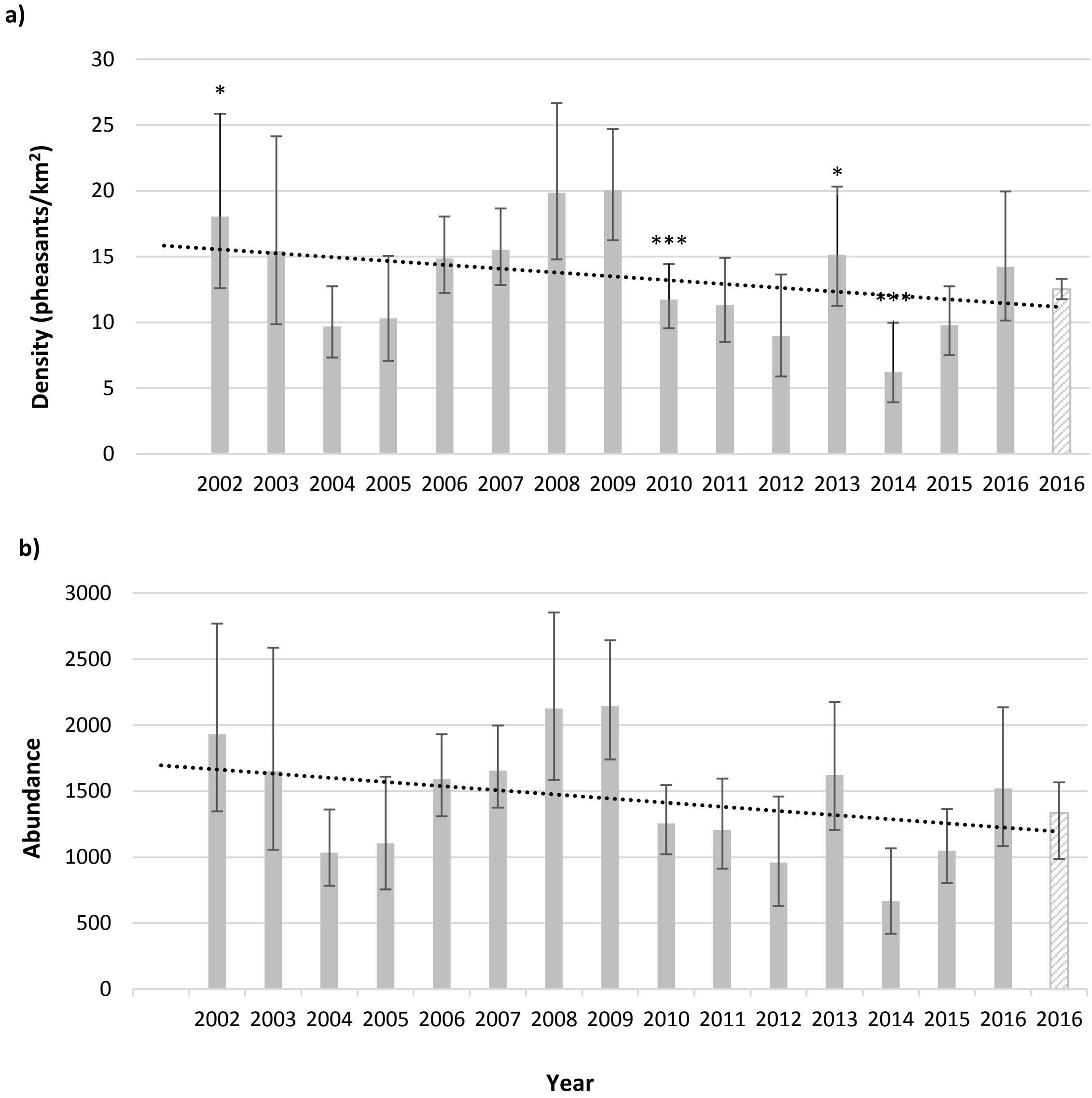

Figure 2.5: DISTANCE analysis on BTO data for Jersey, Channel Islands, since 2001 shows fluctuations in population (a) density and (b) abundance through the years. Error bars show the 95% confidence intervals. All models used the half-normal key function and cosine key adjustment term and Poisson distributions were assumed. The dotted line shows the population trend ((a) y=-0.153x + 14.409, R^2=0.0371; (b) y=16.473x + 1542.5, R^2=0.0367). The diagonal patterned bars show the estimates using data from this study across all survey seasons. Asterisks represent a statistically significant change in density from the previous year to the (*) p=<0.05 level and (***) p=<0.001 level.

2.3.3 Habitat use

Pheasants are preferentially utilising habitats independently of the area of each available (χ^2=26.592, 9, p=0.002). The highest numbers of pheasants per km^2 of habitat available were seen in fields of shoots and fields of mustard and phacelia (figure 2.6). Few pheasants were seen in scrubland, woodland, semi natural grassland and ruderal fields in comparison to area available and none were seen in maize or cereal (figure 2.6). See Appendix C for counts of pheasant in each habitat type for pre- and post-breeding survey seasons.

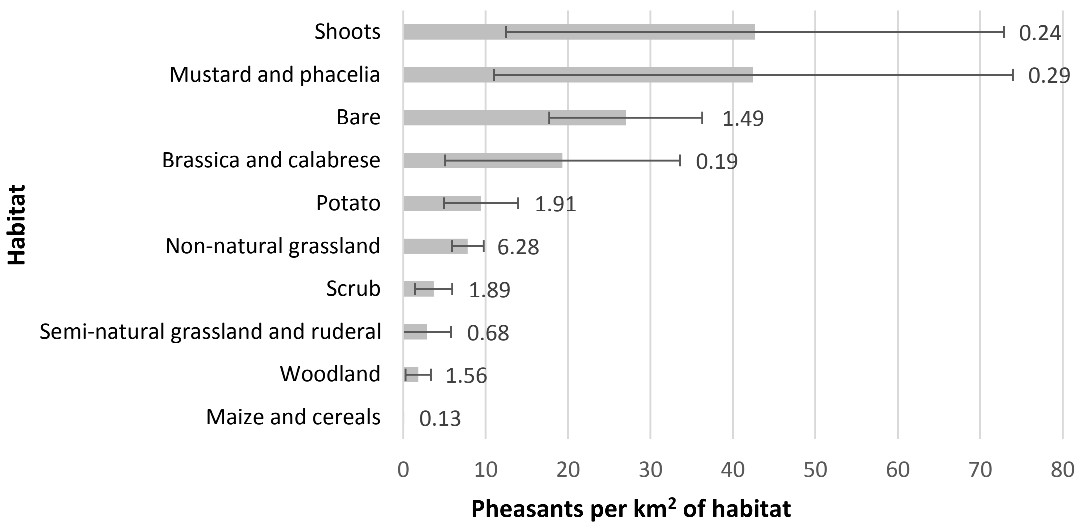

Figure 2.6: Average number of pheasants per available km^2 habitat across the six-week survey period. Data labels are area (km^2) of each habitat available combined over the survey period. Error bars represent standard error.

2.4 Discussion

Density estimates for pheasants in Jersey in 2016 vary between 9.5 per km^2 in the autumn/winter survey season, to 16.6 per km^2 in the pre-breeding season. Overall abundance in Jersey in 2016 is estimated between 1011 and 1780 pheasants, with pre-breeding season estimates giving the highest and most precise density and abundance estimates. The estimates produced by this study are also comparable with BBS estimates, validating BBS as a method to monitor pheasants in Jersey. The highest densities were observed in the south-east and north-west of the island and lowest densities in the south-west, with successful breeding evident across the island. The population trend shows a fluctuating cycle but remains stable overall. Preferences for certain summer crops and habitats were found with highest numbers per area of habitat available found in fields of shoots, mustard and bare ground.

2.4.1 Density and abundance

Overall density estimates in this study and from the BBS are below the densities released per hectare of game estate in the UK, which can range from 2.8 to 20 pheasants per hectare (28-200 pheasants per km^2; Robinson 2000; GWCT 2016). However, Bicknell *et al*. (2010) point out that density estimates ignore effects of clustering caused by selective use of habitats such as hedgerows as corridors or aggregations around feeders. Indeed, Jersey's dense network of hedgerows provides cover and numerous dispersal opportunities. Though no feeding stations for pheasants remain on Jersey, when looking at certain transects, hotspots of higher densities can be found in favoured fields (e.g., in square 4 in St. Clement transect and in squares 1 and 2 in St. Ouen, see figure 2.3).

The 2016 BBS dataset is only directly comparable with the pre-breeding survey and, though the pre-breeding estimates are 17.03% higher, there is an overlap in confidence intervals. Therefore, estimates derived from this more comprehensive study validate the use of BBS data to monitor pheasant population trends in Jersey. That said, caution when using BBS data should be exercised as, oftentimes, BBS squares are surveyed inconsistently which may provide unreliable comparisons in densities across years. Additionally, as transects are only sampled twice each year, it is possible some years will produce too few data to use a multiple covariate model to improve estimates (Newson *et al*. 2005).

If the pheasant population had successfully proliferated, an increase in abundance estimates for the post-breeding survey would be expected. The significant decrease in estimates between the post- and pre-breeding season surveys could indicate poor nest and brood success and the demise of some of the breeding population. However, there are a number of factors affecting the survey methods that could explain this fall in population numbers from the pre-breeding counts including the dispersion of females to nest and raise broods and the presence of taller, more abundant crop cover obscuring detection. That said, reassignments of habitat type based on the 'open, 'semi-open, 'closed' system used here, should have, at least in part, mitigated for a change obscurity. Though not significant, post-breeding estimates were higher than the autumn/winter estimates, suggesting the perceived drop in numbers from pre- to post-breeding is a practical issue to do with time of year.

Pre-breeding season data will likely give the most accurate density and abundance estimates due to the increased conspicuousness of the birds as they display and gather to breed, and due to the lower obscurity of crops at this time of year. Indeed, this data gave the highest and most precise density and abundance estimates. However, surveying only one season may provide an inaccurate view of where pheasant impacts may be most important. Some survey squares showed a marked increase in pheasant sightings during the post-breeding survey season. For example, square seven, situated near the Grouville Marsh SSI, experienced an increase in pheasant sightings from the pre-breeding to the post-breeding season, despite increased obscurity, and contained the highest number of juvenile sightings across all squares, suggesting the potential impact of pheasants can increase at certain times of year in certain areas. This result may, in part, be due to disturbance by agricultural practices and crop rotations, causing a redistribution of the population (Houts, Price and Applegate 2002), or females selectively moving into this area, perceiving it as superior brooding ground.

Besides the decrease in density estimates between pre- and post-breeding surveys, other factors point to poor nest and brood survival. Though she will reattempt nesting if a clutch fails, once a successful hatch occurs, a hen will not nest again, even if the whole brood perishes (Knight 2008). Riley (1998) observed decreasing body mass and survival rates for chicks hatched in later re-nesting attempts and, of only 29 juveniles (5.7% of the total) seen during the post-breeding period, eight, plus several observed outside of surveys, were very young and likely to be a second or even third breeding attempt, indicating earlier nesting attempts had failed. This suggests successful nesting and brood survival rates were low in 2016. This may, in part, be explained by fluctuating temperatures and higher than average rainfall, ranging from 151 to 214% of the cumulative average from March to August (Jersey Water 2016). Riley's (1998) five year study on chick survival in Iowa showed the greatest chick loss to exposure occurred during the year when rainfall was >100% of the average during the breeding season.

Being large, conspicuous birds, most pheasants were seen before they moved in response to the observer, if they moved in response at all. Being accustomed to passing humans, many birds exhibited a sit-and-wait response when observers were noticed, only moving if the observer continued to approach. On the few occasions where a bird had not been noticed until flushed, it is thought initial locations could be surmised with sufficient accuracy due the noisy nature of pheasants flushing and their conspicuousness upon moving, thus remaining in accordance with the second distance sampling assumption that "objects are detected at their initial location" (Buckland *et al*. 1993).

2.4.2 Population trend

The fluctuating trend is also shown by the Birds on the Edge Farmland Bird Monitoring scheme as well as a decreasing population trend (Young and Young 2016). Interestingly, abundance estimates for pheasants in Jersey seem to oscillate around the initial release number of 1600 pheasants in 1985, though it is clear the population has spread throughout the island and is not confined to the release areas. It is likely many of the original population failed to survive their first year or breed and have subsequently increased in number again, though the lower survival rate seen in released, hand-reared pheasants in mainland UK may have been less dramatic in Jersey due to the mild climate and limited number of ground predators (Musil and Connelly 2009).

Shooting effort is one possible determinant for the peaks and troughs in pheasant number over the years, however, with the incomplete nature of pheasant licence returns, no reliable conclusions can be drawn (see Chapter 3). Other important factors are natural predators and food availability. Numbers of marsh harriers, an important predator of pheasants in their native range, buzzards and crows, important predators of pheasants' nests, have increased over the last decade (Draycott *et al.* 2008; Luo *et al.* 2010; Young and Young 2016). The fluctuating densities seen in the population trend of pheasants in Jersey could reflect a predator-prey-food availability cycle such as that observed in the snowshoe hares and lynx of Canada, albeit on a more condensed scale (Krebs *et al*. 1995; Sheriff, Krebs and Boonstra 2009).

The EEA (2015) reported that over 50% of populations of traditional gamebirds in the EU are decreasing. Declines in wild pheasants, and other farmland birds, across Europe are being attributed to intensification in agricultural practices, resulting in a decrease in brooding habitat and food resources, increased hunting pressure after harvest and direct death by machinery (Tew and Macdonald 1993; Chamberlain *et al*. 2000; Bliss *et al*. 2006; Grüebler *et al*. 2008; Holá *et al*. 2015; Frenzel, Everaars and Schweiger 2016). Yearly differences in farming practice, timing of harvest, application of pesticides, quality of nesting sites, severe weather and nest predation have all been attributed to fluctuating pheasant numbers (Chiverton 1999; Houts, Price and Applegate 2002). Herbicides and insecticides can also effect grassland bird survival by poisoning birds or causing a decrease in food resources, such as invertebrates, essential for chick growth (Hill 1985, The Game Conservancy Trust 1997; Doxon and Carroll 2010; Mineau and Whiteside 2013; Hallman *et al.* 2014). In Jersey, pheasants are experiencing increased pressure from birds of prey and changes in agricultural methods, including: the use of heavier, faster machinery; faster turnaround of crops; a decline in grain crops; and increased use of grasses as a secondary crop with associated flailing (table 1.1).

2.4.3 Habitat utilisation

Pheasants in Jersey were shown to be preferentially utilising certain habitats. For the purpose of this study, fields of mustard and phacelia were combined, however only one of nine pheasants in this category was observed in phacelia and had been traversing out of the field. Though this habitat category had the highest numbers of pheasants per km^2 available, these were from very few sightings in small areas of fields. Non-natural grassland had one of the smaller numbers of pheasants per km^2, but more pheasants were seen in this category than any other (see Appendix C). Non-natural grassland encompassed fields that were improved or semi-improved and wet grassland, an important wintering and brooding habitat for pheasants (Sather-Blair 1979; Luo *et al*. 2010). These fields would have provided a variety of floral and invertebrate food sources. In Minnesota, Haroldson *et al.* (2006) found a positive correlation between pheasant numbers and the percentage area of grassland, at least up to 32%, and low and dry grassland were found to be the preferred habitat by common pheasants in South Korea (Pyo and You 2011). Grassland made up the largest area in this study, possibly explaining the lower number of pheasants per km^2. Bare fields were ploughed or tilled land, which would have exposed ground invertebrates as well as weed and waste seeds. Pheasants did show some preference for potato fields but the vast majority were seen resting or scratching in the bare tracks of the field, using the potato crop for cover if disturbed by the observer. Semi-natural grassland and ruderal fields also covered small areas, some of which were by a busy main road, possibly accounting for their lack of utilisation by pheasants.

No pheasants were seen in maize or cereal fields during the habitat surveys. This is likely because the crops covered a small area and were immature with no grain. Elsewhere, maize and cereals have been shown to be important and preferred dietary items for pheasants (Maxson 1921; Einarsen 1943; West, Brunton and Cunningham 1969; Koopman and Pitt 2007; Werner *et al*. 2010; Esther, Tilcher and Jacob 2012) and the timing of year was a limitation of this study when looking at habitat preferences. The post-breeding season was chosen to include potato crops, Jersey's most important export crop, but this meant other crops and vegetation cover that pheasants would likely prefer were out of season (West, Brunton and Cunningham 1969; Koopman and Pitt 2007; States of Jersey 2016a). For example, pheasants in Kansas utilise crop fields more than grassland in autumn and winter, possibly due to the presence of waste grain after harvest and the cover offered by stubble (Houts, Price and Applegate 2002).

2.4.4 Conclusions and recommendations:

Here we use line transects with distance sampling to provide the first comprehensive density and abundance estimates for pheasants in Jersey, providing a baseline against which future population monitoring can be evaluated. Ongoing monitoring of the pheasant population's trend and distribution will be important to inform management decisions on the future of this naturalised species in Jersey, to benefit local wildlife and agriculture. Provided a sufficient number of 1 km squares are surveyed, to meet minimum encounter rates and give reliable density estimates, BBS data can be utilised to monitor pheasant population trends on Jersey. This necessitates a collaboration of the States of Jersey with the BTO to allow the sharing of BBS data for use by the

States. Density and abundance estimates using distance sampling can be rendered with the use of free software such as 'R' and 'DISTANCE'. If independent surveys are to be undertaken, it is recommended they are conducted during the peak of the pre-breeding season in late February and early March. The distance bands used in this study are suitable to provide reliable estimates. For improved estimates, GIS can be used to calculate exact distances or adequately trained observers can estimate distances. (See Appendix D for examples on correct layout of data for input into DSITANCE).

One issue encountered was the peaks in the dataset caused by recording pheasants detected by sound only at a central distance to the distance bands. Often, a male would call once and, though a relative distance could be estimated, making a more accurate estimation on the distance was impossible. Accurately surmising the distance of calling birds is difficult, with accuracy affected by increasing distance and direction of the call (Alldredge, Simons and Pollock 2007). In this study, birds that were first heard and then visually detected were recorded as sighted birds. Using the initial mode of detection, i.e. audible, may alleviate the peaks caused in the data by giving a more spread range of distances from the transect line, at least near the transect line.

A baseline for summer habitat use is also set, however, more extensive research into the habitat utilisations using a larger sampling area, and the diet of pheasants in Jersey would need to be undertaken throughout the year to gain a better understanding of the impacts of pheasants on Jersey's agriculture. Habitat preference surveys should be conducted during different crop seasons, e.g. during maize and brassica seasons, and should focus on key times for agricultural crops, e.g. after sowing and maturation for cereal crops. It should be noted that presence does not necessarily prove consumption, therefore birds shot under licence should continue to be utilised for gastrointestinal analysis. Additionally, telemetry could be used to investigate habitat utilisations and preferences (Smith, Stewart and Gates 1999; Homan, Linz and Bleier 2000; Gooch *et al.* 2015).

Chapter 3: Attitudes and interactions of an island community toward a charismatic introduced species: the common pheasant (*Phasianus colchicus*) in Jersey, UK Channel Islands.

Abstract

Successful management of invasive species is often reliant upon the input and attitudes of local people towards the species in question. Communicating with and educating the local populace on the threats of non-native species can help to identify concerns people may have towards them and garner support, reduce conflict and increase the success of management plans. Here, an online questionnaire is used to investigate the attitudes of local people towards the naturalised population of pheasants in Jersey, Channel Islands, and to gather questionnaire derived data on the impacts of pheasants on local wildlife and agriculture. Pheasants are considered positive for Jersey's birds of prey but are thought by local people to negatively impact farmland birds, reptiles, amphibians and crops. Despite this result, pheasants are generally well received by Jersey's residents, the majority enjoying their presence and feeling they add to the appeal of Jersey's countryside. Arable farmers display the most adverse opinions, being more likely to consider pheasants as negative for farmland crops. Potatoes and grains were the crops damaged by pheasants for the highest percent of arable farmers with most damage happening after maturation of the crop. A third of farmers believe pheasants cause severe damage to their crops and 27% believe pheasants cause a substantial loss of profit on their yield. The percentages of residents who believe pheasants should be protected by legislation and those who do not are almost equal, though only a small minority feel pheasants should be eliminated from the island.

Keywords: Common pheasant, *Phasianus colchicus*, naturalised alien species, attitudes, pest management, human-wildlife conflict

3.1 Introduction

The common pheasant (*Phasianus colchibus*) can become a major agricultural pest in areas where it has been introduced, in addition to degrading habitat, competing for food with native wildlife and even predating vulnerable species (Koopman and Pitt 2007; Sage 2009; Bicknell *et al.* 2010; Edgar, Foster and Baker 2010). The population of pheasants in Jersey, UK Channel Islands, was originally introduced as a game species in the 1980s (Pheasants in Jersey, 2001). However, once released, they automatically became protected under the Protection of Birds (Jersey) Order 1963, making it illegal to shoot them. These introduced birds have since become naturalised, breeding and spreading across the island. Despite their prolific increase, they have remained a protected species. Though, due to problems such as damage to agricultural crops, since 2005 licences have been issued to control pheasants by shooting where they are deemed a pest, whereby a maximum of six nominated shooters are allowed to shoot in registered fields (Wildlife Law (Jersey) 2000).

There has been growing concern over the impacts the naturalised pheasant population in Jersey might be having on the local economy and wildlife. Of greatest concern is their consumption of crops, particularly the Jersey Royal potato, as well as competition with native wildlife, such as farmland birds, and their potential to predate Jersey's vulnerable resident herpetofauna. Some positive consequences have been associated with introduced pheasants, however these are limited to anthropogenic management of an area to benefit the survival and breeding of released pheasants (Mustin *et al.* 2012). For example, higher abundance and diversity of butterflies were seen in woodlands managed for pheasants due to wider rides and more open canopy cover (Robertson, Woodburn and Hill 1988). Conversely, Pressland (2009) found a decrease in invertebrate communities, including Lepidoptera, in association with pheasant release areas. One positive association with the presence of pheasants without the interference of man is the potential food source they provide for bird of prey populations (Kenward *et al.* 2001; Bicknell 2010; Luo *et al.* 2010). However, providing a food resource can have unwanted effects also, supporting populations of potential pest species such as carrion crows (*Corvus corone corone*) and magpies (*Pica pica*) (Hill 1985; The Game Conservancy Trust 1997; Draycott *et al.* 2008).

Social science methods are increasingly being used in conservation management, with questionnaires becoming a popular method to gather data on the knowledge and perceptions of stakeholders and the general public on issues such as species impact and environmental management decisions (White 2005). In conservation, questionnaires can be used to gather information on a variety of areas including public opinion of a species or management plan, the understanding local people have of a species, impacts of a species on local people and the extent of illegal activity against a species, e.g. poaching (Yonas *et al.* 2010; Yen *et al.* 2015; Kubo and Shoji 2016). Advantages of questionnaires over interviews include the option of complete anonymity and the ability to compare and statistically analyse responses (Newing 2011).

Deliberate intervention towards a non-native species is a sensitive issue and public perceptions of the species in question is important knowledge when making management decisions. Any species management plan should aim to communicate with the public and offer educational material to spread awareness and gain an understanding of management needs and concerns from both sides, with the aim of minimising conflicts (Bremnar and Park 2007; Sijtsma, Vaske and Jacobs 2012; Verbrugge, Born and Lenders 2013). Attention to resident values and attitudes is considered necessary for species management to be successful and it has been shown that even the most extreme methods can gain public support (Coluccy *et al*. 2001; Fulton *et al.* 2004).

In this study, an online questionnaire was used to investigate (i) resident perceptions of pheasants in Jersey, (ii) their knowledge on the laws surrounding pheasants, (iii) differences in attitudes between groups of residents towards pheasants and their impacts and (iv) to gather local information on the economic and ecological impacts of pheasants in Jersey. The results will aid the States of Jersey in making management decisions regarding the non-native pheasant population in Jersey and highlight any educational needs to reduce conflict.

3.2 Methods

3.2.1 Study area, economics and human demographics

Situated 25 km off the coast of France, in the Bay of St Malo, and 137 km south of England, the Bailiwick of Jersey is the largest of the Channel Islands at 116 square km (Jersey Island Plan Review 1999). On Jersey, approximately 62 square km (53%) is used for agriculture, which generates just over 1% of Jersey's income (States of Jersey 2016sa 2016b). The agricultural sector ranks 9th in terms of economic activity, with the finance sector being Jersey's largest source of revenue (States of Jersey 2016b; 2015c). The island's largest crop is Jersey Royal potatoes, worth tens of millions of pounds each year (States of Jersey 2014). It is the only fresh fruit or vegetable to have an EU Protected Designation of Origin (States of Jersey 2016d). Other food crops grown in Jersey include courgettes, cauliflower, beans, tomatoes, strawberries and a small amount of maize and cereals (States of Jersey 2016a). Jersey has a residential population of over 100,000 and receives around 700,000 visitors a year (Visit Jersey 2015).

Jersey hosts a mix of flora and fauna native to Britain and mainland Europe including a variety of resident and migratory birds, several species of bats, four reptiles and three amphibians. Forty-seven invasive alien species are listed for the island (Cornish *et al.* 2011). These include 27 invasive plants, thirteen invertebrates (including marine species), two reptiles, two birds (the pheasant (*Phasianus colchicus*) and the red-legged partridge (*Alectoris rufa*)), two mammals (the feral cat (*Felis catus*) and the feral ferret (*Mustela furo*)) and one amphibian (Cornish *et al*. 2011). Other introduced species that have become naturalised include rabbits (*Oryctolagus cuniculus*), red squirrels (*Sciurus vulgaris*) and hedgehogs (*Erinaceus europaeus*). Rats (*Rattus norvegicus*) are also abundant on the island. Protected species include all native herpetofauna, all native bats, a variety of birds, including common buzzards (*Buteo buteo*), yellowhammers (*Emberiza citrinella*) and skylarks (*Alauda arvensis*), and a variety of plants, including wild celery (A*pium graveolens*), lizard orchid (*Himantoglossum hircinum*) and Cyperus sedge (*Carex pseudocyperus*) (Cornish *et al*. 2011).

3.2.2 Questionnaire design and distribution

A 35 question online survey (Appendix E) using Survey Monkey (www.surveymonkey.co.uk) was distributed by email and advertised on social media (online newspapers, radio stations and Government Facebook pages). A pilot questionnaire was first sent out to the States of Jersey Department of the Environment employees and the Chief Minister's Department Communications Unit, with feedback used to improve subject focus, question wording and user friendliness, and ensuring it could be completed in an acceptable timeframe.

A variety of question types were used including closed format, dichotomous and Likert scale questions. Demographic data was gathered, including age, sex, employment, length of residency, involvement in countryside activates, landowner status and membership of environmental, conservation or agricultural organisations or magazines (table 3.1). Respondents were asked when and where they had first witnessed pheasants in Jersey and (i) if they were aware of the legislation protecting pheasants in Jersey, (ii) if they were aware pheasants could be killed under licence and (iii) if they agreed that pheasants should be protected from killing and harm. Five-point Likert questions were used to ask respondents whether they [-2] strongly disagreed, [-1] disagreed, [0] had no opinion, [1] agreed, or [2] strongly agreed with eleven statements regarding general perceptions towards pheasants (table 3.2). Five-point Likert questions were also used to understand whether residents thought pheasants were [-2] Very negatively, [-1] negatively, [0] had no effect, were [1] positively, or [2] very positively affecting birds of prey, farmland birds, reptiles, amphibians, arable crops, livestock and garden crops. In relation to the effects on wildlife, respondents were asked if they had ever seen a pheasant attacking or eating a reptile or amphibian and if they had ever seen a bird of pretty hunting, killing or eating a pheasant. The Likert scale was also used to understand the respondents' perceptions of the population trend of Jersey's pheasants and whether they considered the population to have [-2] decreased a lot [-1] decreased, [0] remained stable, [1] increased, or [2] increased a lot.

A section to be completed by arable farmers only was included, asking for information on where they worked, the types of crops effected by pheasants, to what extent and at what stage in the crops cycle. Arable farmers were also asked if the land they cultivated was registered under a pheasant shooting licence and if they thought the licences were a satisfactory means by which to protect their crops from pheasants.

The questionnaire URL was emailed to several mailing lists including the 'Farmer's Union', 'Roughshooters', 'Biodiversity News', 'Natural Trust', 'Single Area Payment' (SAP), the 'Société Jersiaise', 'Vegetable Club', 'Jersey Gardening Club' and the 'poultry owners database'. The questionnaire was also featured on the States of Jersey government website (www.gov.je) and the eco active blog, as well as appearing in several local newspapers/magazines and featured on local radio shows. The questionnaire was available online for three months from the 1st February to 29th April 2016. Two reminders were sent out to the targeted email lists, a reminder was posted on the government website and two articles encouraging participation published on online social media after the initial press releases.

3.2.3 Statistical analysis

To compare Likert scale responses between the general populous arable farmers, game shooters and those who work in the environment sector, two-tailed Mann-Whitney *U*-tests were used. The Mann-Whitney *U*-test has a power advantage over *t*-tests and lower Type III error rates when using data with non-normal distributions and uneven sample sizes (Bridge and Sawilowsky 1999; Macdonald 1999; Winter and Dodou 2012). Statistical analysis was carried out using IBM SPSS Statistics for Windows, version 23.0.

Responses were omitted from analysis due to containing no responses beyond giving consent for the answers to be used , having less than five questions answered (usually only the first one or two), or they were believed to be insincere or 'joke' responses.

3.2.4 Pheasant licence returns

Information collected as part of the licence application was obtained from the States of Jersey Department of the Environment archives for the years 2008-2015. Data used included (i) fields covered by licence, (ii) number of pheasants shot, including location where available, and (iii) reason for needing the licence, where available.

3.3 Results

A total of 548 usable responses were obtained from the survey. Table 3.1 details the demography of the response populace. The majority of respondents work in the finance and public sectors. Those aged 35 to 54 make up the highest percent of responses. The most common activity enjoyed by respondents in the countryside was walking, and game shooting the least. Less than 25% were landowners, while 40% were members of or subscribed to environmental, conservation or agricultural organisations or magazines (table 1.1). Of those that responded (n=530), 55.7% have been residents of Jersey their whole lives.

Table 3.1: Socioeconomic characteristics of respondents (n=548).

Characteristic	N	Percent of cases
Sex		
Male	293	53.5
Female	218	39.8
missing	37	6.7
Age		
18-24	21	3.8
25-34	81	14.8
35-44	123	22.4
45-54	131	23.9
55-64	114	20.8
65+	48	8.8
missing	30	5.5
Use of the countryside		
Wildlife watching	309	56.4
Game shooting	19	3.5
Horse riding	49	8.9
Dog walking	215	39.2
Walking	429	78.3
Recreation	311	56.8
Other	94	17.2
missing	18	3.3
Work sector		
Environmental	21	3.8
Agriculture and Fisheries	29	5.3
Finance	109	19.9
Wholesale and Retail	30	5.5
Transport and communications	10	1.8
Hospitality	15	2.7
Public Sector	107	19.5
Retired	78	14.2
Unemployed	26	4.7
Other	103	18.8
missing	20	3.6
Member of any farming, environmental or conservation organisation		
Yes	218	39.8
Landowner		
Yes	133	24.3

According to the respondents, the earliest sighting of a pheasant was in 1950-1955 in the centre of the island. The next first sighting by a respondent wasn't until 1966-1970, after which the number of first sightings per five years rises steadily until a peak in 2001-2005 (18.2% of respondents) when the number of first sightings decreases again in 2006-2010 and 2011-2015. Most first sightings occurred in the north-west of Jersey (27%) and the fewest occurred in the south-east (9.1%).

3.3.1 Legislation

Sixty two percent of respondents were aware that pheasants were protected by legislation in Jersey (n=543), while 66% were aware that licences can be issued to shoot pheasants (n=542). When asked if pheasants should be protected from killing and/or harm by legislation in Jersey, 51.2% of respondents answered 'no' (n=531), including 81% of arable farmers, 10.5% of shooters and 55% of environmental sector employees.

3.3.2 General perceptions

Between respondents who identified themselves as arable famers and those that did not, statistically significant differences were found for statements: (1) 'Pheasants add to the appeal of Jersey's countryside'; (2) 'Pheasants are a nuisance'; (3) 'Pheasants should be controlled as a pest'; (5) 'Pheasants should be treated as they are in the UK, as game birds with a closed hunting season'; and (8) 'Pheasants should be treated as pigeons and have all legal protection removed from them' ($p<0.05$ in all cases, see table 3.2). Arable farmers view pheasants more negatively, being more likely to consider them a nuisance and to consider that they need to be controlled as a pest with all legal protection removed.

Between respondents who engage in game shooting and those who do not, statistically significant differences were found for statements: (2) 'Pheasants are a nuisance'; (5) 'Pheasants should be treated as they are in the UK, as game birds with a closed hunting season'; (6) 'Pheasants should be eliminated from Jersey'; (8) 'Pheasants should be treated as pigeons and have all legal protection removed from them'; and (9) 'If pheasants were managed as a game species in Jersey, I would allow pheasant shoots on my land.' ($p<0.05$ in all cases, see table 3.2). Game shooters are more likely to disagree that pheasants should be eliminated from Jersey (all disagreed or strongly disagreed) and are more likely to agree that pheasant are a nuisance, should have a closed hunting season (all agreed or strongly agreed), and are more likely to allow shoots on their land, buy a game hunting licence and buy and/or consume meat from pheasant shoots. Shooters had a more spread view in regards to having all legal protection removed from pheasants, whereas non-game shooters were more likely to disagree.

Compared with all other respondents, those who work in the environmental sector showed significantly different responses to statements: (6) 'Pheasants should be eliminated from Jersey'; (7) 'We should be trying to increase the population of pheasants in Jersey'; and (11) 'If pheasants were managed as a game species in Jersey, I would buy and/or consume the meat from pheasant shoots' ($p<0.05$ in all cases, table 3.2). Environmental workers still lean towards disagreeing with elimination but not as strongly as the general populace. They are also more likely to disagree with increasing pheasant populations and are more open to the idea of buying and consuming the meat from pheasant shoots in Jersey.

Just over half of respondents (50.7%) believe pheasant numbers have 'increased' or 'increased a lot' over the past five years. Only 17.2% believe they have 'decreased' or 'decreased a lot' while 32.1% believe their numbers have remained stable. There was no significant difference between the general populace and arable farmers (U=3504, p=0.933) or shooters (U=3232, p=0.117). The response from those employed in the environmental sector differed significantly (U=3130, p=0.014), being more inclined towards a stable or decreasing trend with none choosing 'increased a lot' (table 3.3).

3.3.3 Impact on agriculture

Jersey Royal potatoes are cultivated as a main crop by the majority of arable famer respondents, with maize and other grains less popular as a main crop (figure 3.1a). The highest number of arable famers cultivated land in St. Martin and St. John and the least in St. Brelade and St. Clement (figure 3.1b). Thirty-three percent of arable farmers considered the damage to their crops by pheasants severe, 33.3% moderate and 33.3% mild (n=15). Twenty-seven percent feel damage by pheasants causes a substantial loss of profits on their yield, 33.3% a moderate loss and 33.3% no loss, while the remainder were unsure (n=15). The highest percent of arable farmers have experienced damage to their Jersey Royal potato crops by pheasants (61.11%) followed by other grains (38.98%, figure 3.3). These damages are most frequently caused after maturation (68.8%) followed by during germination (56.35, figure 3.2). The highest percent of crop loss was reported for brassicas and other grain, then fruit and root vegetables (table 3.3). Arable farmers consider pheasants to have more of a negative impact on farmland crops than the general populace (U=1555, Z=-3.850, $p<0.001$, figure 3.4).

Of the fifteen arable farmers who answered, 53.3% cultivated on land that was registered under a licence to shoot pheasants. Of these, 71.4% thought the licences were an effective solution to allow farmers and landowners to protect crops from damage by pheasants, while 46.7% of arable famers overall agreed it was an effective method.

Table 3.2: Responses of residents to statements regarding perceptions of pheasants in Jersey, Channel Islands, and Mann Whitney *U* *p*-values for responses to the statements by those who identified themselves to be arable farmers, game shooters or environmental sector employees compared with those who did not.

									P[2]		
	Statement	N	Strongly disagree	Disagree	No opinion	Agree	Strongly Agree	Don't know[1]	Arable farmers	Game shooters	Environment sector
1	Pheasants add to the appeal of Jersey's countryside.	530	6.2	13.1	12.0	43.1	22.3	3.3	**<0.001*****	0.909	0.087
2	Pheasants are a nuisance.	521	12.4	21.7	17.2	27.4	16.4	4.9	*<0.001****	*0.005***	0.417
3	Pheasants should be controlled as a pest.	511	11.1	19.7	16.4	27.4	18.6	6.8	*0.001***	0.085	0.271
4	I enjoy having pheasants in Jersey.	525	6.2	9.3	13.3	40.0	27.0	4.2	**0.002****	0.465	0.253
5	Pheasants should be treated as they are in the UK, as game birds with a closed hunting season.	500	10.9	28.6	16.4	20.8	14.4	8.8	0.821	*<0.001****	0.814
6	Pheasants should be eliminated from Jersey.	251	38.7	35.8	9.7	5.7	5.3	4.9	0.273	**0.005****	*0.010**
7	We should be trying to increase the population of pheasants in Jersey.	215	24.6	30.7	27.2	7.7	3.3	6.6	0.174	0.294	**0.025***
8	Pheasants should be treated as pigeons and have all legal protection removed from them.	501	9.9	13.0	12.8	33.4	22.4	8.6	*0.004***	*0.041**	0.113
9	If pheasants were managed as a game species in Jersey, I would allow pheasant shoots on my land.	497	29.7	16.8	17.2	16.6	10.4	9.3	0.457	*<0.001****	0.519
10	If pheasants were managed as a game species in Jersey, I would buy a game hunting licence.	508	38.9	26.6	14.4	7.3	5.5	7.3	0.153	*<0.001****	0.138
11	If pheasants were managed as a game species in Jersey, I would buy and/or consume the meat from pheasant shoots.	510	23.4	15.5	12.8	27.9	13.5	6.9	0.687	*<0.001****	*0.040**

[1] value for respondents who checked the 'don't know' box and for those who did not give any answer combined.

[2] P-values in bold are less in favour of the statement, p-values in italics are more in favour of the statement.

* Significant to the <0.05 level

** Significant to the <0.01 level

*** Significant to the <0.001 level

Table 3.3: Responses by various groups on their thoughts on the population trend of pheasants (*Phasianus colchicus*) in Jersey, Channel Islands, over the past five years.

Group	Decreased a lot	Decreased	Remained stable	Increased	Increased a lot	N
Overall	15	81	159	169	77	501
Arable farmers	1	2	4	6	2	15
Shooters	0	8	3	3	3	17
Environmental sector	1	7	5	6	0	19

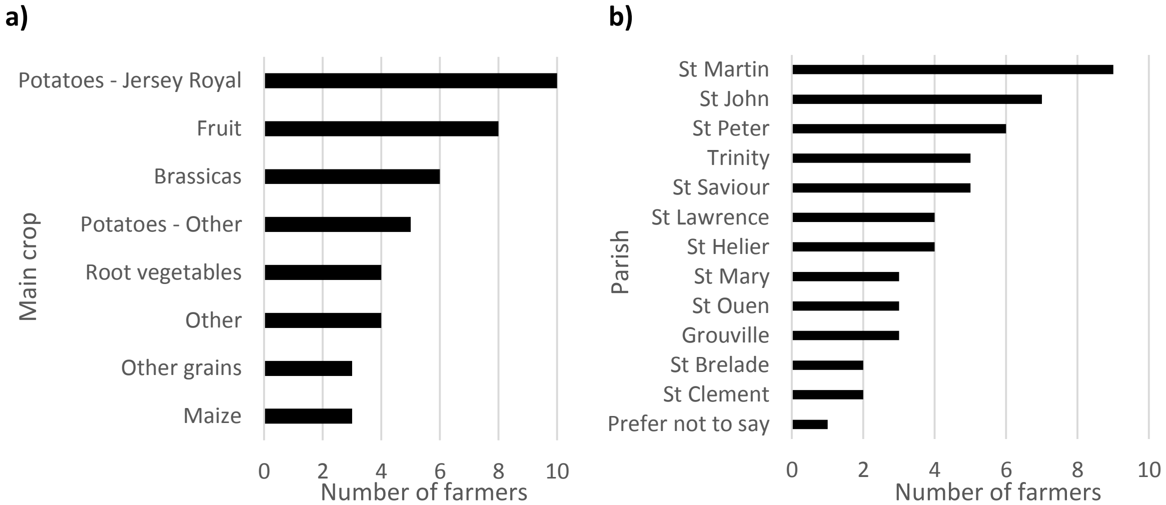

Figure 3.1: The (a) main crops and (b) areas in which crops are grown by responding arable farmers (n=16). Other includes: salads, daffodils and haylage.

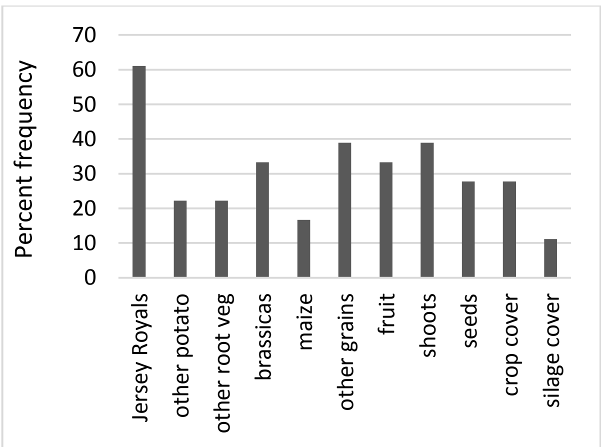

Figure 3.2: Percent frequency of arable farmers' responses to damage caused by pheasants (n=15). Cover includes plastic and netting.

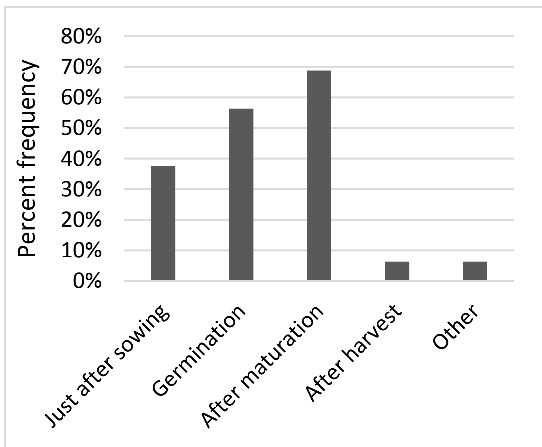

Figure 3.3: Percent frequency of arable farmers' responses to the stage pheasants cause most damage (n=15). The 'Other' category included young brassicas.

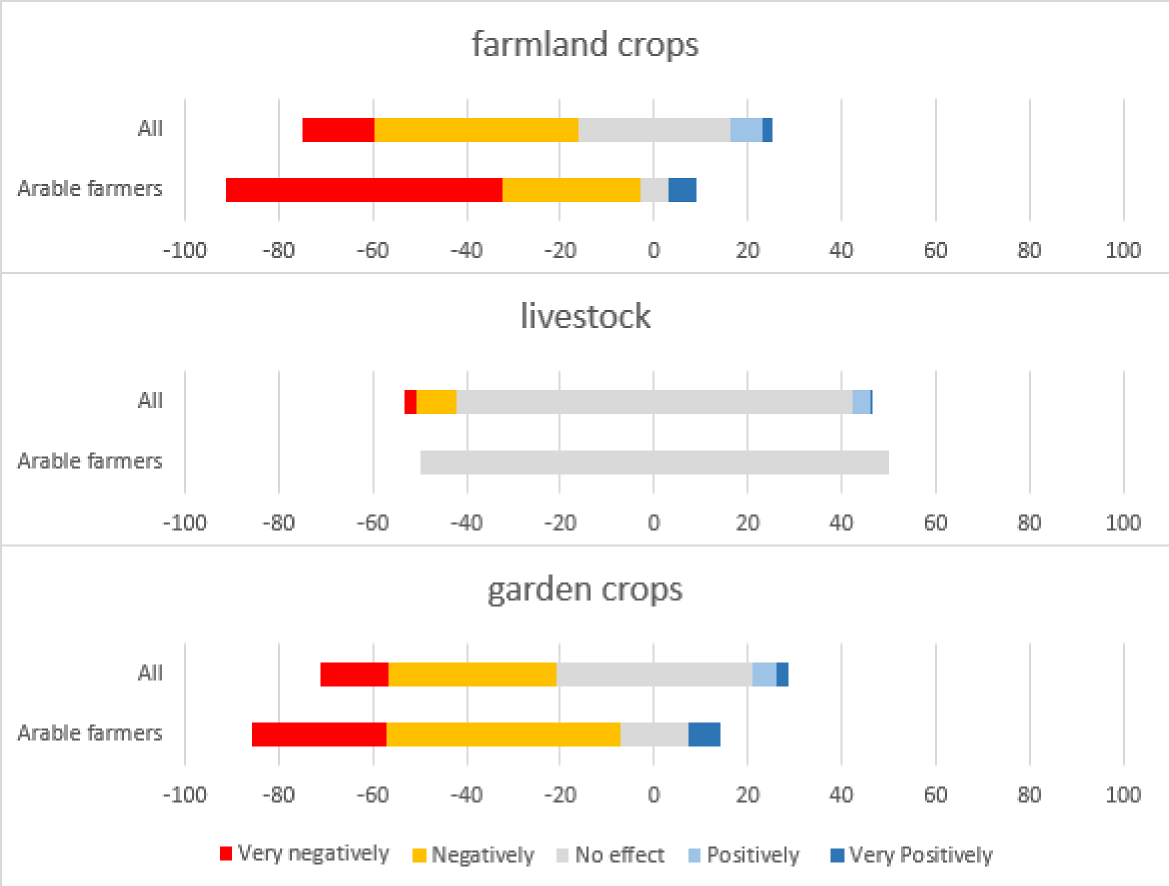

Figure 3.2: Percent frequency of respondents' perceptions of the impacts of pheasants on agriculture in Jersey, Channel Islands, by all respondents and arable farmers.

Table 3.4: Percent crop loss caused by pheasants to famers' crops in Jersey, Channel Islands. Note that the reports of 0% damage are all by the same respondent.

	% damage					
Crop	**0%**	**1-20%**	**21-40%**	**41-60%**	**61-80%**	**81-100%**
Potatoes – Jersey Royals	1	9	0	0	0	0
Potatoes – other	1	3	0	0	0	0
Root vegetables	1	2	1	0	0	0
Brassicas	1	5	1	1	0	0
Maize	1	3	0	0	0	0
Other grain	1	1	0	1	0	0
Fruit	1	4	2	0	0	0

3.3.4 Impact on wildlife

Of 548 respondents, 116 reported to have seen a bird of prey hunting, killing and/or eating a pheasant. Thirty-three respondents identified the bird of prey as a common buzzard, 28 identified marsh harriers, two hen harriers, one peregrine falcon, one unidentified falcon, eight sparrowhawks, four kestrels and three kites. Respondents also commented they had seen magpies, crows and seagulls attacking pheasants.

Twenty-two respondents have seen pheasants attacking and/or eating reptiles and amphibians, with three identifying slow worms, five wall or green lizards and six anurans (including one spawn).

Mann Whitney *U* tests show respondents are significantly more likely to regard pheasants as having positive impacts on birds of prey if they identify as arable farmers (U=1415, p=0.029), game shooters (U=1647, p=0.014) or environmental sector employees (U=2067, p=0.006) (table 3.5). Game shooters and environmental sector employees are also significantly more likely to regard pheasants as having negative impacts on reptiles (U=1047, p=0.019 and U=1070, p=0.002 respectively) and environmental sector employees are significantly more likely to regard pheasants as having a negative impact on amphibians (U=1325, p=0.005) (table 3.5). Overall, pheasants are seen to have a negative impact on farmland birds, reptiles and amphibians, but a positive impact on birds of prey (figure 3.4).

Table 3.5: Mann Whitney U *p*-values for responses to impacts of pheasants on groups of native wildlife by those who identified as arable farmers, game shooters or environmental sector employees compared and those who did not. P-values in **bold** = significantly more likely to view pheasants as having a negative impact, p-values in *italics* = significantly more likely to view pheasants as having a positive impact.

Wildlife	Arable farmers	Game shooters	Environmental sector employees
Farmland birds	0.154	0.424	0.528
Birds of prey	*0.029**	*0.014**	*0.006***
Reptiles	0.965	**0.019***	**0.002****
Amphibians	0.313	0.074	**0.008****

* Significant to the <0.05 level
* Significant to the <0.01 level
* Significant to the <0.001 level

3.3.5 Pheasant licence returns

Crops were the reason cited most for needing a licence to shoot pheasants, though most did not specify a type of crop (table 3.6). Less than 40% of licence holders provided details for needing a licence, with only 8.5% giving a reason in 2008 (table 3.6).

After an initial increase, the number of fields registered to licences issued has declined from 2392 in 2008, to 435 in 2015, an 82% decline. Since 2010, there is a 41% decrease. The number of licences have declined by 32% since 2008 and by 43% since 2011 (figure 3.7). There has also been a significant decrease in the number of pheasants shot over the years, with 81% less pheasants shot in 2015 that in 2008 (figure 3.5).

Figure 3.5: Percent frequency of respondents' perceptions of the impacts of pheasants on native wildlife by all respondents, arable farmers, shooters and environmental sector employees.

St. Ouen consistently has the highest number of fields registered to a licence, ranging from 353 in 2015, to 633 in 2010. St. John, St. Lawrence, St. Martin, St. Mary, St. Peter and Trinity also have high numbers of fields registered, usually >100 and often >200 and >300, while Grouville, St. Brelade, St. Clement, St. Helier and St. Saviour all consistently have <100 fields registered to licences.

Of those returns provided with location details, the highest number of pheasants were shot in St. Ouen and the lowest in St. Saviour since 2008 (table 3.7). St. Ouen and St. Saviour had the highest shooting effort per km^2 since 2008, while St. Brelade, St. Clement and Grouville had the lowest shooting effort (figure 3.6). For 2015, the highest reported number of pheasants shot were in Trinity and the lowest in St. Clement (table 3.7).

Table 3.6: Reasons given on pheasant licence applications and returns for the need for a licence to control pheasants (*Phasianus colchicus*) in Jersey, Channel Islands. There were no reasons found for 2008 and 2009.

Reason for licence to shoot	2010	2011	2012	2013	2014	2015
Unspecified crops	12	64	50	50	50	36
Potatoes	2	16	9	9	12	11
Plastic/netting	1	-	3	1	3	3
Maize	-	2	2	2	-	-
Brassica	-	1	-	-	-	-
Silage	-	1	-	-	2	-
Banks/hedging	-	2	3	1	-	-
Consuming animal feed	-	1	3	2	2	1
Health and safety concerns[1]	-	1	1	1	1	1
High numbers	1	4	3	2	3	2
Total responses*	16	81	67	60	61	45
% returns giving reason	8.5	37.7	35.5	38.7	39.5	36.6

[1] These include, but are not limited to, pheasants flushing in front of horse riders and cyclists and health hazards related to contamination by faeces.

* Some licences gave more than one reason, therefore total responses do not equal total number of reasons given.

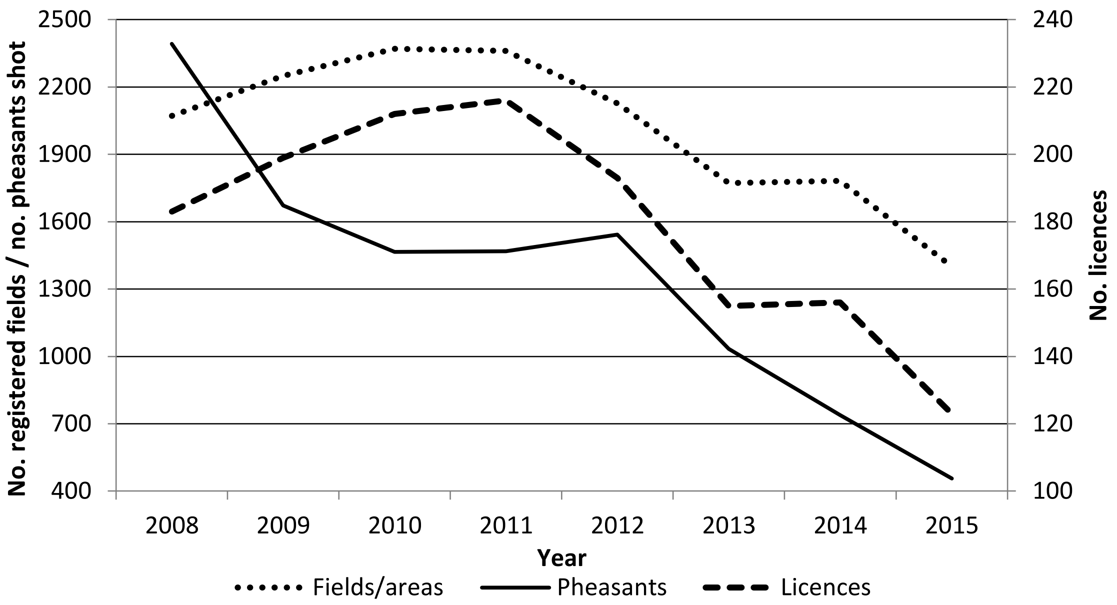

Figure 3.6: Total number of licences issued, field and areas registered to licences and number of pheasants shot under licence from 2008 to 2015, inclusive.

Table 3.7: Number of pheasant returns per parish in Jersey, Channel Islands, from 2008 to 2015. Note that not all licence holders gave information about where pheasants were shot, therefore returns on licences encompassing multiple parishes but without area information were excluded and the totals do not include all returns. Bold figures show the highest and lowest numbers shot that year.

Parish	2008	2009	2010	2011	2012	2013	2014	2015	Total
Grouville	**0**	21	40	57	57	74	38	6	293
St. Brélade	48	25	26	18	20	21	28	21	207
St. Clement	**0**	23	**0**	11	**3**	**2**	17	**0**	56
St. Helier	36	44	69	88	46	42	44	13	382
St. John	374	10	84	93	88	91	53	1	794
St. Lawrence	183	217	155	231	111	**145**	**100**	61	1203
St. Martin	112	160	156	254	171	140	95	25	1108
St. Mary	138	195	140	46	97	52	73	43	784
St. Ouen	**658**	**460**	188	**264**	**366**	**145**	65	78	**2214**
St. Peter	131	27	19	87	48	45	41	24	435
St. Saviour	2	**0**	1	**8**	15	3	**5**	3	**37**
Trinity	222	122	**207**	142	134	139	83	**104**	1153
Total	1904	1304	1085	1299	1156	899	642	379	8668

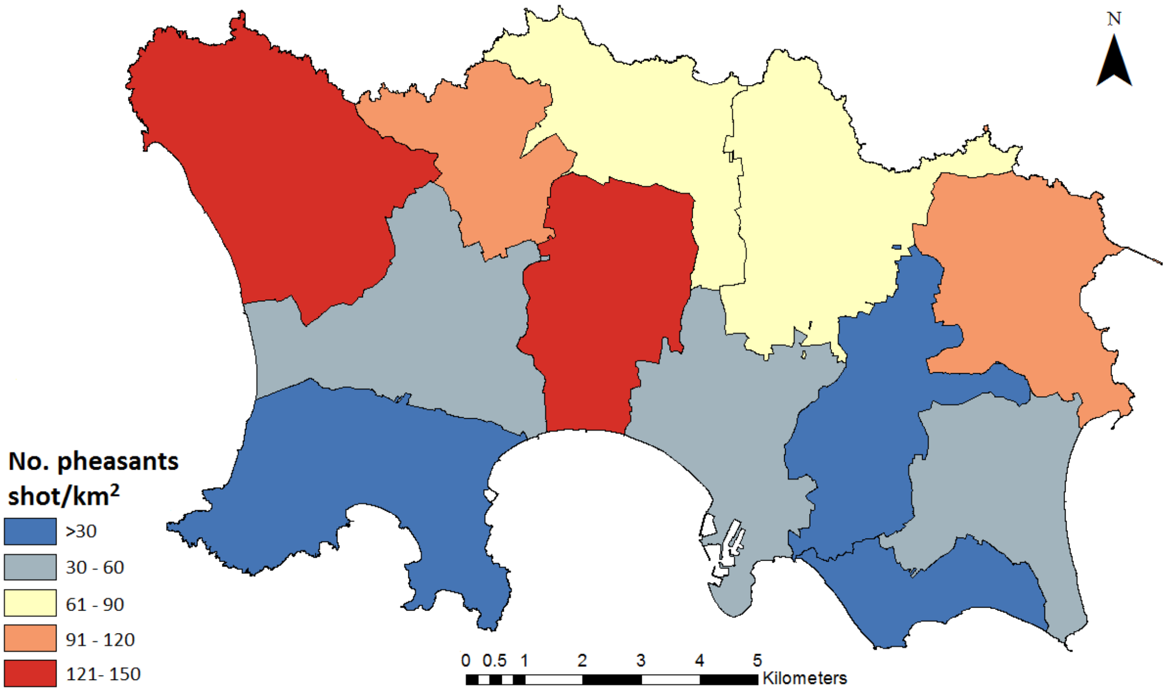

Figure 3.7: Reported shooting per km^2 for each parish since 2008 in Jersey, Channel Islands. Note that not all licence holders gave information about where pheasants were shot, therefore returns on licences encompassing multiple parishes but without area information were excluded and the shooting effort per parish does not include all returns.

3.4 Discussion

Though seen as negative for Jersey's farmland birds, herpetofauna and crops, pheasants are well received by Jersey's residents overall. As a nation, Jersey are undecided whether pheasants should be offered legislative protection (48.8% for, 51.2% against) but the majority disagree with elimination. Those most affected by the impacts of pheasants, i.e. arable farmers, have a significantly more negative view of this introduced species. In regards to crops, the highest percent of farmers experience damage to potatoes and brassicas and most damage occurs after crop maturation. Crop damage is the most cited reason for wanting a pheasant shooting licence but since 2008 the number of licences issued, fields registered to licences and numbers of pheasants shot has dramatically decreased.

3.4.2 Legislation

These results demonstrate that the management of Jersey's pheasants is likely to be a controversial issue and communication and education will be crucial in providing answers and alleviating tension (Coluccy *et al*. 2001; Fulton *et al.* 2004). It seemed many of those who agreed with protective legislation did so in conjunction with negative perceptions of recreational hunting, often considered a cruel sport even in those otherwise for hunting (Ljung *et al*. 2012). Thus, support for lethal management decisions could be swayed if they are deemed more humane (Coluccy *et al.* 2001). For example, a study on the attitudes of Missouri residents towards an agricultural pest, the Canadian goose (*Branta canadensis),* found that lethal control tended to gain more support if it is the only viable option, it is implemented in a humane way and if the animals can be processed for human consumption, such as through homeless shelters (Coluccy *et al*. 2001).

3.4.1 General perception

Despite being considered by Jersey's residents to have negative effects on crops and native farmland birds, reptiles and amphibians, overall perceptions of pheasants in Jersey are positive. The vast majority are against pheasants being eliminated from Jersey but the majority are also against pheasant populations being increased (table 3.2). A large proportion of respondents do seem to recognise the need to be able to manage the population, however, with high percentages regarding them as a nuisance and believing they should have all legal protection removed (table 3.2). Even so, many who have recognised the need for the management of the population, including arable farmers, have commented on their concern over allowing pheasants to be shot as a game species due to the dangers it poses to residents and livestock on such a small, well utilised island, as well as concern for the welfare of the pheasants themselves.

Agricultural farmers have more extreme views of pheasants being a nuisance and the negative impact they have on agricultural crops, and are more likely to think they should be controlled as a pest with all legal protection removed. Game shooters and environmental sector workers have more extreme views about the impacts pheasants have on native wildlife, both positive and negative. The more extreme responses from those who are directly involved with the species in question or the object of concern has been seen in many studies before, while those who do not see or who are not affected by an alien species tend to have more neutral or positive attitudes (Fischer *et al*. 2014; Harvey, Perez and Mazzotti 2015; Olzańska, Solarz and Najberek 2016). It has also been found that the lay public tend to be more accepting of more appealing, charismatic non-native species (Williams, Ericsson and Heberlain 2002; Verbrugge *et al*. 2013; Fischer *et al*. 2014). For example, over 40% of respondents from a study in the Netherlands thought ring-necked parakeets (*Psittacula krameri*), a conspicuous, aesthetically pleasing bird, much like the pheasant, should be accepted over control or eradication management plans, while species such as the less appealing, inconspicuous citrus long horned beetle (*Anoplophora chinensis*) received very little support for acceptance (Verbrugge *et al*. 2013). Bremnar and Park (2007) found the least support was shown for species control if the species in question was a bird.

In contrast to the majority response of an increasing population trend, when taking into account the years 2011 to 2016 (the last five years as specified by the population trend question), the trend line shows a stable relative population trend. The answers of the respondents to Likert questions may, in part, be due to response-order effects and the left-side bias associated with Likert scales, whereby, when presented with a Likert scale response system, respondents will choose the first acceptable alternative answer (Chan 1991; Friedman, Herskovitz and Pollack 1994; Nicholls *et al.* 2007). Responses regarding the trend in pheasant numbers were ordered from 'increased a lot' on the left to 'decreased a lot' on the right and may have introduced bias towards the increasing trend options. Alternatively, their answers may have been in response to an increased density and abundance in 2016 as part of a fluctuating population cycle (see Chapter 2).

3.4.3 Impacts on wildlife

Pheasants are seen to be having a negative impact on Jersey's farmland birds and herpetofauna (figure 3.4). Elsewhere, pheasants have been shown to negatively affect other bird species through habitat degradation, competing for food resources, interruption of courting rituals, nest parasitism and spreading parasites and disease (Sage 2009; Bicknell *et al*. 2010; Holt *et al*. 2010; Mustin *et al*. 2012). For example, it has been found that pheasant chicks share a high overlap in arthropod dietary composition with yellowhammer chicks and degrade hedgerow habitats, reducing suitable nesting sites for these birds (Sage 2009; Bicknell *et al*. 2010).

Pheasants are often listed as threats to and predators of herpetofauna and are known to predate reptiles (Edgar, Foster and Baker 2010; Tomsett 2011; Ward 2014; Sussex Amphibian and Reptile Group 2016; New Forest National Park 2016; Surrey Amphibian and Reptile group 2016). Several questionnaire respondents have seen pheasants attacking or eating reptiles and amphibians in Jersey, including all three of Jersey's lizard species and both anuran species. One respondent even commented they had seen pheasants consuming anuran spawn. This is cause for concern as pheasants in Jersey have been seen in high numbers and/or breeding in and around important areas for all seven of Jersey's native herpetofauna (Wilkinson, French and Starnes 2014; see Chapter 2).

Pheasants are seen to be having a positive impact on birds of prey and respondents have credited the rise in certain birds of prey species, namely marsh harriers (*Circus aeruginosus*) and buzzards (*Buteo buteo*), to the availability of pheasants as a food source (Young and Young 2016). Concurrently, birds of prey have been attributed by some locals for a decline in pheasant numbers, however, Underhill-Day (1989) found that predation by marsh harriers had little effect on wild gamebird numbers. Nest predation by corvids, on the other hand, has been attributed to over 10% of pheasant nest failures (Draycott *et al*. 2008).

Many studies have looked at the benefits and costs of introduced pheasants for wildlife (Robertson, Woodburn and Hill 1988; Stoate 2002; Draycott, Hoodless and Sage 2007; Davey 2008; Sage 2009; Bicknell *et al*. 2010; Neumann *et al*. 2015). However, the benefits mentioned are all dependent on human intervention and manipulation of habitats to boost pheasant survival and productivity, such as thinning of canopy cover, creation of rides, planting of gamecrops and provision of food (Robertson, Woodburn and Hill 1988; Stoate 2002; Draycott, Hoodless and Sage 2007). Jersey does not manage its landscape to benefit pheasants and so these pro arguments are not relevant, with the potential food resource offered to Jersey's raptors likely the only environmental benefit received from the presence of naturalised pheasants in Jersey. Many of the negative effects of pheasants centre on the high densities of pens and releases, which may indicate potential problems where pheasants occur in high densities in Jersey (Sage, Ludolf and Robertson 2005; Davey 2008; Sage 2009; Bicknell e*t al*. 2010).

3.4.4 Impacts on agriculture

Pheasants are known to consume a variety of crops and can become major pests with up to 96% of a pheasant's diet made up of crop grains in some areas at certain times of year (Fried 1940; Koopman and Pitt 2007; Esther *et al*. 2013). Many farmers and locals spoken to in Jersey confirmed pheasants consumed and damaged potato crops. Many see it as a problem, however crows and seagulls are a bigger concern for Jersey's arable farmers. Beside potatoes, respondents to the questionnaire commented that pheasants damage and consume brassica crops as well as maize and legumes. Another complaint that arose was the degradation of banks and resultant problems with the flooding of fields.

It is unclear if the arable farmers who did not work on land with a shooting licence did so because they felt it an inadequate solution or perhaps because they did not own the land to be able to obtain one. The inability for farmers to take advantage of shooting licences indicates the system is deficient for some.

3.4.5 Pheasant licence returns

The decline in licences, fields registered to licences and pheasants shot since 2008 suggests pheasants are becoming less of a problem. Only ~20% of the landowners who held pheasant licences in 2008 still do so in 2016. Unfortunately, it is uncertain if the decision to not renew is due to the issue being resolved or due to personal reasons. This could reflect a decrease in active shooters in Jersey, reducing a means as to control the pheasant population and resulting in the abandonment licences.

Due to incomplete returns, this data is unreliable for extrapolating population distribution and areas registered to pheasant licences may not necessarily be representative of the areas experiencing the greatest problems. For example, despite low shooting effort, surveys have revealed St. Clement contains comparatively high densities (see Chapter 2). That said, shooting effort can be inhibited by area; St. Clement is relatively built up and the high numbers of pheasants were seen in and around an SSI where shooting is prohibited.

3.4.6 Conclusions and recommendations

Understanding the attitudes of local people towards a non-native species and the needs for education and awareness can be vital for the success of species management plans and to avoid conflict (Coluccy *et al*. 2001; Bremnar and Park 2007; Sijtsma, Vaske and Jacobs 2012; Verbrugge, Born and Lenders 2013; Yen *et al.* 2015). Local and stakeholder knowledge can also provide important insight into the interactions with and impacts of non-native species on the local community and native wildlife (Schmidt *et al.* 2011; Kale 2012). Generally, perceptions of pheasants in Jersey are positive. However, there is an almost equal split in regards to their opinions on whether pheasants should be protected by legislation. Island wide support for any control is unlikely to be garnered unless there is strong evidence of pheasants having a negative impact on local wildlife or agriculture. This is especially true in regards to the large amount of concern expressed about the use of guns to cull pheasants in Jersey. Any management decision should allow options for farmers to protect their crops from this non-native species. Though the minority of Jersey's residents will be negatively affected by pheasants personally, wider support for the need to control a non-native species can be gained through education and by utilising management approaches that are deemed more socially acceptable (Coluccy 2011).

The low number of arable farmers participating in the survey (n=18) is a limitation to this study, giving a very narrow view of the problems arable farmers may face from the presence of pheasants in Jersey. There were 788 full and part time farm labourers in 2015 (excluding seasonal workers) meaning, assuming similar numbers in 2016, there was a <3% response rate to the questionnaire. There have been mixed findings in regards to the extent of bias caused by low response rates to questionnaires from (Roszkowski and Bean 1990; Cull *et al.* 2005; Sivo *et al*. 2006). In this case, the experience of an arable farmer may depend very much on where in Jersey they work, as the distribution of pheasants is considered in no way uniform.

A more extensive survey of Jersey's arable farmers would provide great insight into the losses and damages caused by pheasants, creating a more comprehensive picture of where pheasants are having the most impact and which could be used as educational material. The survey could take the form of a short postal questionnaire, featuring questions about damage to crops, including percentage loss, at what stage and affected areas. Ensuring the survey is short and sending reminders will increase response rates (Edwards *et al*. 2002; Sahlqvist *et al*. 2011). Many landowners rent their land out to arable farmers and a small number of shooters fill licence return forms out on behalf of the landowners, thus, postal surveys could perhaps gather information from those more directly involved with the growth and harvest of crops.

Chapter 4: Synopsis

Providing baseline data of abundance and distribution is essential for the monitoring of native and non-native species and to inform species management decisions (Pellicioli and Ferrari 2013; Henry and Anderson 2016). Additionally, considering public attitudes and addressing concerns of local people and stakeholders is vital to address conflicts regarding management decisions to improve their chances of success (Coluccy *et al*. 2001; Bremnar and Park 2007; Sijtsma, Vaske and Jacobs 2012; Verbrugge, Born and Lenders 2013; Yen *et al.* 2015). Here, the paucity of information regarding the distribution and abundance of pheasants in Jersey has been addressed and information on their ecology and ecological and economic impacts is provided. Baseline data are presented on the density and abundance of pheasants in Jersey and the habitats they utilise (Chapter 2). A questionnaire was also used to investigate the attitudes of Jersey's residents and gather information on the impacts of pheasants on native wildlife and agriculture (Chapter 3). In addition to these chapters, gastrointestinal examination of shot birds and those found as road kill on Jersey were conducted, providing some limited information the diet of pheasants in Jersey. Only low numbers of birds were obtained, so this prohibited analysis, but for completeness the findings of the examinations are provided in Appendix F.

4.1 Density and abundance

Jersey's pheasant population in 2016 stands between 1011 and 1780 with densities ranging between 2.95 and 38.14 pheasants per km^2. These densities are below or on the lower end of the scale for release densities per hectare of game estate in the UK (Robinson 2000; GWCT 2016). BBS data is suitable for providing reliable density and abundance estimates and can be used for future monitoring of pheasant populations trends. Alternatively, it is recommended that independent surveys should be conducted between late February and late March.

The pheasant population in Jersey is currently stable, though exhibits an oscillating cycle of peaks and troughs in abundance and density across the years (figure 2.5). Possible reasons for these fluctuating numbers include: bird of prey numbers; decrease in cereal crops and crop rotation; intensification of agricultural techniques; disturbance from recreational activities; and shooting effort. Highest densities were observed in the south-east and north-west and lowest densities in the south-west (figure 2.3).

4.2 Habitat preferences of pheasants in Jersey

Summer habitat preferences, by number of pheasants per km^2 habitat available, have been shown towards fields of shoots, mustard and bare ground (figure 2.6). No pheasants were observed in maize or cereal fields during the post-breeding season. However, maize and cereals can be important dietary items for pheasant populations in arable land and their absence from these crop fields is likely due to survey timing as maize and cereals were not yet mature (Maxson 1921; Einarsen 1943; West, Brunton and Cunningham 1969; Koopman and Pitt 2007; Werner *et al*. 2010). That said, it is thought the majority of grain consumed by pheasants is waste grain left after harvest (Dalke 1937; Hoodless *et al*. 2001). Overall, the highest numbers of pheasants during the post-breeding survey season were observed in non-natural grasslands, followed by bare ground then potato fields (Appendix C), whilst pre-breeding surveys saw the highest numbers of pheasants in non-natural grassland followed by maize and cereal stubble fields (Appendix C).

4.3 Resident perceptions of pheasants and their management in Jersey

Pheasants are generally well received by Jersey's residents, despite being seen as detrimental for crops, farmland birds, reptiles and amphibians (figures 3.1 and 3.4). Many residents enjoy seeing pheasants in the countryside and many consider pheasants to have played an important role in the rise in Jersey's birds of prey, specifically marsh harriers and buzzards. It is the select few who experience the greatest problems with pheasants that take the greatest issue with this introduced species. In some areas, damage to crops is occurring on an unacceptable level. As a populace, the residents of Jersey are undecided on whether pheasants should be offered protection with an almost equal divide between those in favour of legislative protection and those not (48.8% for and 51.2% against). However, the majority of residents disagree or strongly disagree with eliminating pheasants from Jersey (table 3.2).

4.4 Impacts of pheasants in Jersey

4.4.1 Impacts on wildlife

High numbers of pheasants are known to negatively impact fauna and flora but these studies usually look at areas in and around release pens. Jersey's pheasant population in comparison to Jersey's size are not as high as those previously studied. The pre-breeding survey gave the largest pheasant population estimates of 1780 pheasants and average densities of 16.64 pheasants per km^2 (Chapter 2). However, there are a few pockets within Jersey where densities are comparable to the lower end of release densities on game estates in the UK. Two particular hotspots found in this study were in St. Ouen, near Les Landes SSI, and St. Clements, in and around Rue des Pres SSI (figure 2.3).

It is possible that pheasants in Jersey are competing with other birds reliant on arthropod food during the breeding season, as well as competing for additional resources, for example at bird feeders. In an email, one resident detailed how she has repeatedly observed pheasants chasing squirrels from her garden and attributes the squirrels' increasing wariness to this exclusion behaviour (T. Hull, personal communication, 11 February 2016).

No evidence of predation on herpetofauna was found during gastrointestinal analysis (Appendix F), however, twenty-two respondents to the questionnaire have witnessed pheasants attacking and eating grass snakes, slow worms, anurans and wall and green lizards (Chapter 3). This is a low number considering sightings may span back over 60 years, though it is likely only a small percentage of actual predation events by pheasants towards herpetofauna.

One hundred and sixteen respondents to the questionnaire have seen birds of prey hunting, killing or eating a pheasant (Chapter 3). Pheasants are an important food source for marsh harriers in their shared native range (Luo *et al.* 2010). Many Jersey residents believe pheasants have declined in numbers with the increase in bird of prey numbers. Pheasant chicks in particular may provide an important food resource for Jersey's bird of prey during their breeding season. That said, for marsh harriers and buzzards, the two bird of prey species most likely to take advantage of pheasants as a prey source, there are considerably more options available to them. While birds have been shown to make up the largest proportion of marsh harrier diet, passerines, waterfowl and gulls and terns are all utilised by this species (Tornberg and Haapala 2013). In Europe, buzzards specialise more in small mammals (Valkama *et al*. 2005). If pheasants are an important resource for Jersey's birds of prey, their disappearance may result in increased predation pressure for native wildlife (Bramford 2003).

Pheasants in Jersey's SSIs

Several squares used as part of the distance sampling surveys encompassed, or were situated near, current and proposed SSIs. Others were visited as part of additional rapid surveys in response to high numbers being reported and/or being important areas for native wildlife. High numbers of pheasants were observed in or around Rue des Pres (square 4), Les Landes (squares 1 and 2), La Mare au Seigneur and Grouville Marsh (square 7) SSIs (figure 2.1). These areas are important for populations of wetland birds, lepidoptera, herpetofauna and rare flora (States of Jersey 2016b). Except, Les Landes, these SSIs feature wetland habitat, an important winter, nesting, brooding and roosting habitat for pheasants (Baxter and Wolfe 1968; Sather-Blair 1979; Luo *et al*. 2010). Small numbers were seen or heard in or near Egypte (square 3), Niormont, St. Peter's Valley (square 13), Les Blanches Blanques, Portelet Common and Ouaisne Common (square 11) and one female was seen in La Landes du Ouest (square 9, figure 2.1). These are all high traffic areas for dog walkers and joggers or, in the case of St. Peter's Valley, feature a busy main road.

4.4.2 Impacts on agriculture

It is the minority whose livelihoods are affected by these non-native birds and this minority deserve great consideration (Chapter 3). Farmers have reported damage to potatoes, root vegetables, brassicas, grain and fruit. As far as can be ascertained, the consumption of potato crops by common pheasants has not been recorded in scientific literature. Here, gastrointestinal investigation of pheasants in Jersey revealed potato in the crop and gizzard of one pheasant killed on the road during potato season (see Appendix F). Though the sample size was small (n=7) and cannot be considered a representative sample, gastrointestinal analysis has provided unique insight into the diets of Jersey's pheasants.

As with Jackson (2003), agricultural damage by pheasants is thought to be a localised occurrence on Jersey, though, this localised damage can occur at unacceptable levels with one farmer reporting pheasants had damaged 41-60% of their brassica and one reporting 41-60% damage to their grain crop (Chapter 3, table 3.4). One farmer also detailed how pheasants in Trinity pulled out and consumed up to 90% of newly sown sunflower seeds, resulting in a crop of only 60 sunflowers from a 25 kg bag of seeds (anon, personal communication, 19 February 2016). A third of farmers believe pheasants cause severe damage to their crops and 27% believe pheasants cause a substantial loss of profit on their yield (Chapter 3).

Only a fifth of the licences valid in 2008 were still registered in 2015, however it is unknown if those that did not renew have had their issue resolved or if other circumstances prevented them from renewing. The registering of new licences could indicate a shift in the areas where pheasants are considered a problem. Some licences are administered by a shooter on behalf of the landowners, possibly indicating a desire for game shooting rather than a need to control pheasants. Interestingly, the parish with one of the lowest reported shooting effort per km^2 (St. Clement) contained the survey square with the highest density (square 4, see figures 2.3 and 3.6) and those yielding some of the highest reported shooting effort contained the lowest densities, suggesting shooting effort does not reflect distribution densities (figures 2.3 and 3.6). However, it must be remembered that information on returns were not always complete and the reported numbers of pheasants shot in each parish are not exhaustive and may, therefore, be giving an unrepresentative view of shooting effort across parishes. The surveys were also not exhaustive and areas of higher densities may exist in parishes in areas not surveyed. It is also prudent to take into consideration the feasibility of shooting in certain areas, for example St. Clement is one of the more built up parishes in Jersey and the high densities were seen in and around an SSI where shooting is prohibited.

4.5 Invasive potential of pheasants in Jersey

Many characteristics of the species, including its broad diet, plasticity in habitat utilisation, robustness against harsh climates and varying altitudes, dispersive nature and large size, make pheasants a good candidate to become an invasive species (Ehrlich 1989; Daelher and Strong 1993; Williamson and Fitter 1996; Cassey 2001a; Davey 2008). Classification of a species as invasive is not always straightforward, especially if a species effect is largely unknown. If only taking into account the spread and abundance of the species, the island-wide colonisation of pheasants could already determine it to be an invasive species in Jersey. The differences in pheasant densities across Jersey may be indicative of incomplete dispersal, and perhaps potential for a larger population. Though, it more likely represents habitat heterogeneity, i.e. areas of more and less suitable habitats. Many species exhibit source and sink populations, whereby sink populations are dependent on recruitment by source populations (Dias 1996). Certain pockets of pheasant populations in Jersey could potentially be acting as source populations, allowing the spread of pheasants into less suitable areas.

The economic damage pheasants cause by consuming crops, even if localised, can also deem it as an invasive species (Koopman and Pitt 2007; NNSS 2016). Classification of the invasiveness of pheasants in Jersey based on ecological impacts are less clear, however, as there is only anecdotal evidence of negative impacts on native wildlife, such as predation of herpetofauna, and only speculation that they are crucial for bird of prey populations in Jersey, such as the marsh harrier. Typically, a species is considered invasive if their negative effects outweigh any positive effects they may have (Invasive Species Advisory Committee [ISAC] 2006).

Populations of invasive alien species have been known to collapse after periods of substantial growth (Simberloff and Gibbons 2004). Invasive birds that have experienced this boom and bust include budgerigars (*Melopsittacus undulates*) in Florida and the crested myna (*Acridotheres* cristatellus) along western North America. (Pranty 2001; Simberloff and Gibbons 2004). Given Jersey's history of pheasant populations relying on reintroductions and the fall in cereal crops grown in Jersey annually, it is possible the current population could experience, a bust after a boom period through the 1990s.

4.6 Targeted management options

4.3.1 Future Monitoring

Data from BBS transects can be used to provide reliable density and abundance estimates using freeware 'DISTANCE' (distancesampling.org) or 'R' (r-project.org). Here, DISTANCE 6.2, a graphical interface designed specifically for distance sampling, is used. For the purpose of deriving density estimates for Jersey, transects should be considered as the whole 1 km, not divided into 200 m as per the BBS methods (BTO 2015). Also, a simpler habitat categorisation should be used, such as the one used in this research (Chapter 2). If independent transects are to be undertaken as an alternative, it is recommended to use a minimum of six survey squares, each with two transect lines, though a greater number will yield more precise results. Using the results of this study as a baseline, the effects of any management decisions on densities and abundance can be scrutinised.

Additional transects in and around Jersey's SSIs could prove useful in discovering and monitoring hotspots of pheasant densities in ecologically sensitive areas. Many of Jersey's passerines have seen a decline in numbers over the past decade and many, potentially, have to compete with pheasants for food resources, particularly during brooding as it has been shown pheasants can reduce invertebrate biomass (Pressland 2009; Young and Young 2016). The Farmland Bird Monitoring scheme surveys a plethora of sites considered important for passerines of interest, including a number of SSIs (Young and Young 2016). These data could be utilised to monitor pheasants in areas where vulnerable species are most likely to be impacted by the presence of pheasants. Distance bands are used in data collection but have so far not been used to calculate density. Though the Farmland Bird Monitoring scheme has shown a decrease in pheasant numbers, some sites might be more utilised by this non-native species than others. However, significant areas, such as Rue des Pres, are not included and should be considered. Densities estimated in and around SSIs in this research can be used as a baseline to monitor pheasant numbers in these areas moving forward.

4.3.2 Management and legal protection

There are several options available to the States of Jersey in regards to managing the pheasant population, including: (i) retaining the current system, (ii) removing legislative protection, (iii) removing culling by licence, (vi) eliminating pheasants from Jersey, (v) managing pheasants as a game species and (vi) introducing a culling season. In all cases, continued monitoring of the species population trend is essential to allow the analysis of management actions. Though a controversial issue, the loss experienced by arable farmers from the consumption of crops by pheasants verifies the need to control pheasants as a pest species. The current licence system has proven unreliable in its details of returns, allowing no definitive conclusion to be drawn from the data collected. Thus, an alternative method such as a general licence can be considered to save time, money and resources.

The witness accounts of predation of Jersey's protected herpetofauna by respondents to the questionnaire (Chapter 3) and the close proximity of high densities of pheasants to SSIs (Chapter 2) highlights a need to control pheasants for the benefit of native wildlife also. As shooting by the public is prohibited in protected areas, the management of pheasants in SSIs would need to be the administered by the organisations responsible for protected areas of concern.

An important consideration is the health and safety of residents, livestock and wildlife. With Jersey being a small island that is so well utilised by the people, safe places to shoot are hard to come by, if existent, outside of shootings ranges. Several respondents have expressed their concerns in the questionnaire (Chapter 3) about the safety of allowing the shooting of pheasants in Jersey due to limited space and consider it a danger to residents and livestock. However, such methods might garner support in response to education about the effects of pheasants on Jersey's agriculture and native wildlife.

4.4 Further research

To determine the extent of any detrimental impacts of pheasant in Jersey, further research into their diet and habitat utilisations is needed, including the use of crop fields and ecologically sensitive areas (see 4.1 Future Monitoring above). Habitat preferences at different times of year can be investigated using densities of pheasants observed in available habitats, for example up to 50 m either side of transect lines (see Chapter 2). This is a small scale version of surveying habitat use. Alternately, larger areas can be used whereby observers aim to detect all pheasants within, for example, 1 km^2 quadrats from which densities per available habitat can be calculated. Alternatively, the analysis of habitat proportions within a radius of sighted pheasants could also be utilised to investigate habitat use (Gooch *et al*. 2015) as could telemetry (Smith, Stewart and Gates 1999; Homan, Linz and Bleier 2000; Gooch *et al.* 2015). The States of Jersey can make use of culled pheasants shot under licence for more comprehensive gastrointestinal analysis, possibly as part of a student work experience or university project. With particular regard to the concern of predation on herpetofauna, if it is found that reptile DNA can survive the digestion process, DNA fingerprinting of pheasant faecal samples can be used to investigate the diet of Jersey's pheasants (Dimond *et al*. 2013). However, collection of faecal samples is an arduous process and a large sample size is needed (Dimond *et al.* 2013).

To gain a more comprehensive understanding of the impacts of pheasants on agriculture, a survey of Jersey's agricultural farmers can be undertaken asking for details on crop damage, yield loss and current mitigations put in place, for example. This can be administered via a postal questionnaire, perhaps in partnership with the Royal Jersey Agricultural and Horticultural Society (RJA&HS) to increase reach and participation. The survey could take the form of a broader questionnaire about the impacts of pests in general on agriculture and how Jersey's farmers are trying to mitigate and how they would like to be able to mitigate against damages to their crops.

Research into the diets of Jersey's birds of prey and their relationship with pheasants is also recommended in order to foresee what impacts management of the pheasant population may have on these species. If pheasants are an important resource for Jersey's birds of prey, their numbers may be affected or alternative prey species, such as passerines, small mammals and reptiles, may experience increased predation pressure due to prey switching in response to the local extinction of a preferred prey species (Bramford 2003). If it is decided culling may be the best option, an experimental partial cull in high density areas may be carried out to monitor the effects on birds of prey, however, it should be considered that some high density areas may be acting as source populations and their extirpation may cause an island-wide population collapse.

4.5 Conclusions

For effective management solutions, the continued monitoring of the populations, trends and habitat use of pheasants on Jersey is needed. BBS methods have proven effective in estimating pheasant abundance on Jersey and for monitoring population trends. Its continued employment can be used to appraise management outcomes, utilising this study as a baseline. The impacts of a non-native species are not always obvious and the management of an introduced species can be a contentious issue, particularly when the species in question is a charismatic, aesthetically pleasing avian that is considered by locals to be as much a part of the landscape as any native species. As such, public awareness of the impacts of pheasants on wildlife and agriculture is crucial to gain support for management options to benefit the island's community and ecosystems. This can be aided by more comprehensive studies into the habitat utilisations and diets of Jersey's pheasants. When considering management options, the role pheasants' play as a food resource for birds of prey needs to be weighed against the apparent and potential negative impacts on Jersey's agriculture, farmland birds and herpetofauna.

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Appendix A: Transect sites and routes.

Figure AA.1: Square 1. Le Landes, St. Ouen.

Situated on the north west of the island, the area consists of a mix of fields used for arable farming and grazing of horses with a race track to the north west of the transects. Sheep have also been observed grazing in the fields in the north. These transects are BTO transects, surveyed twice a year as part of the BTOs Breeding Bird Survey. The square borders an ecological sight of scientific interest (SSI), Les Landes, which is popular with dog walkers and joggers. There are few blocks of trees within the square, the most significant being close to the SSI. Pheasants to the west of the square have been observed seeking cover in the SSI when flushed. Large areas were covered in polythene for the early Royal Jersey potato season. Birds of prey, especially marsh harriers and buzzards, are a common sight. They can usually be seen flying over the SSI and the adjacent fields or perched in said fields. A dead ferret was also observed on the transect. Note: the transect section to the north-east is part of square two and overlaps into square one. These two squares were surveyed one after the other to avoid any bias that may be caused by birds moving between transects.

Figure AA.2: Square 2. St. Ouen.

Situated on the northwest of the island square two borders square one on its east side. These transects are also BTO transects, as with those in square one, thus both were adopted for this research despite their close proximity. There are a greater number of clumped tress in and around square two, compared to one, with field use being mainly arable, dispersed with a few grazing fields for horses, though these are rotated between grazing and crops. Square two also features more houses and greenhouses. Large areas were covered in polythene for the early Royal Jersey potato season, including a field popular with pheasants, with more than twenty pheasants observed in the field at one time before the plastic was laid. Marsh harriers are a common sight.

Figure AA.3: Square 3. Egypte, Trinity.

Square three is also a BTO square. It begins by arable fields, passing a Nursery school, houses, poultry farm and a small boggy area, dense with bracken, before entering deciduous woodland. Pheasants have been seen foraging in the chicken fields. The second transect follows a coastal path with plenty of bracken and gorse. It borders the Bouley Bay and Hurets SSIs to the southeast, which are covered in bracken. Buzzards and marsh harriers are common sights as are seagulls and crows.

Figure AA.4: Square 4. Rue de Pres, St. Clements.

Another BTO square, the first transect of square four (the most southerly transect) passes through a suburban setting with views obscured by houses. The second transect passes through a golf course, agricultural fields and passed Rue des Pres SSI. Cows are frequently grazed on the fields. There are attractive clumps of trees to provide roosting and shelter for pheasants, including a comparatively large stretch of woodland in the east. Some fields were covered in polythene for the early Royal Jersey potato season. Marsh harriers, buzzards are frequently seen with crows a constant.

Figure AA.5: Square 5. Trinity.

The transects in square five pass a riding stables and associate grazing fields for horses, though the square is predominantly agricultural fields. Crops observed include daffodils and parsnips with stubble remaining from what is assumed to have been maize. Cows are also grazed in the area. There a few tree clumps with a larger wooded area in the northwest. Crows number in the hundreds and there are frequent sightings of buzzards.

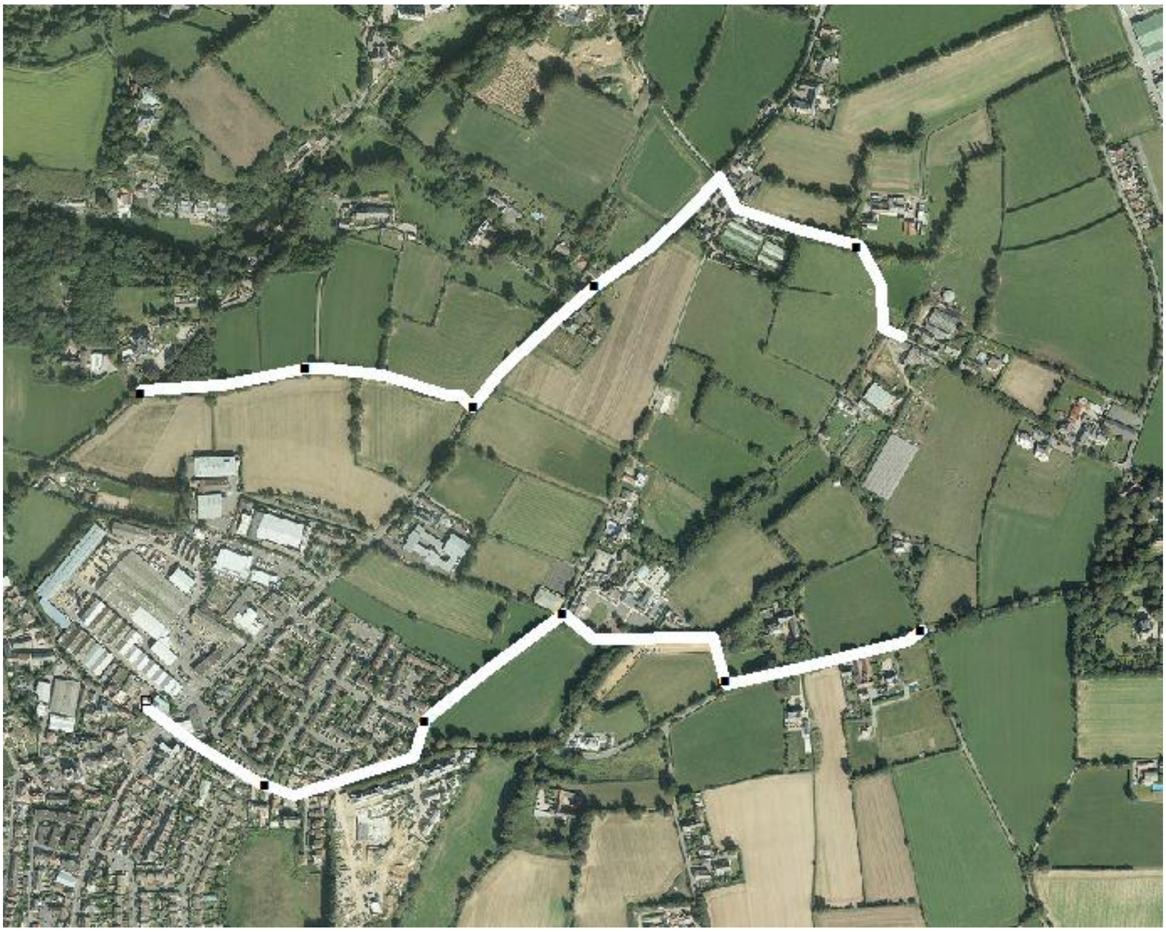


Figure AA.6: Square 6. St. Saviour.

Square six is a BTO square. Transects start of in a heavily built up area with a diner, petrol garage and housing estate. The transects open out on to agricultural fields with some grazing of cows. Some of the transect follows a main road with high walls, making it impossible to see some areas or dangerous to try for too long. There are areas of trees to the east and northwest. Magpies are abundant on in the area.

Figure AA.7: Square 7. Grouville Marsh, Grouville.

Square seven consists mostly of agricultural fields with a small town and golf course to the east and Grouville Marsh SSI to the north. The first transect, to the south, has been noted as eerily quiet, as far as birdlife goes, while marsh harriers and buzzards are frequent sights on the northern transect. The marsh is home to a variety of waterfowl including swans, coots and ducks, and also chickens. There are a few clumps of trees and a small area of brambly scrub.

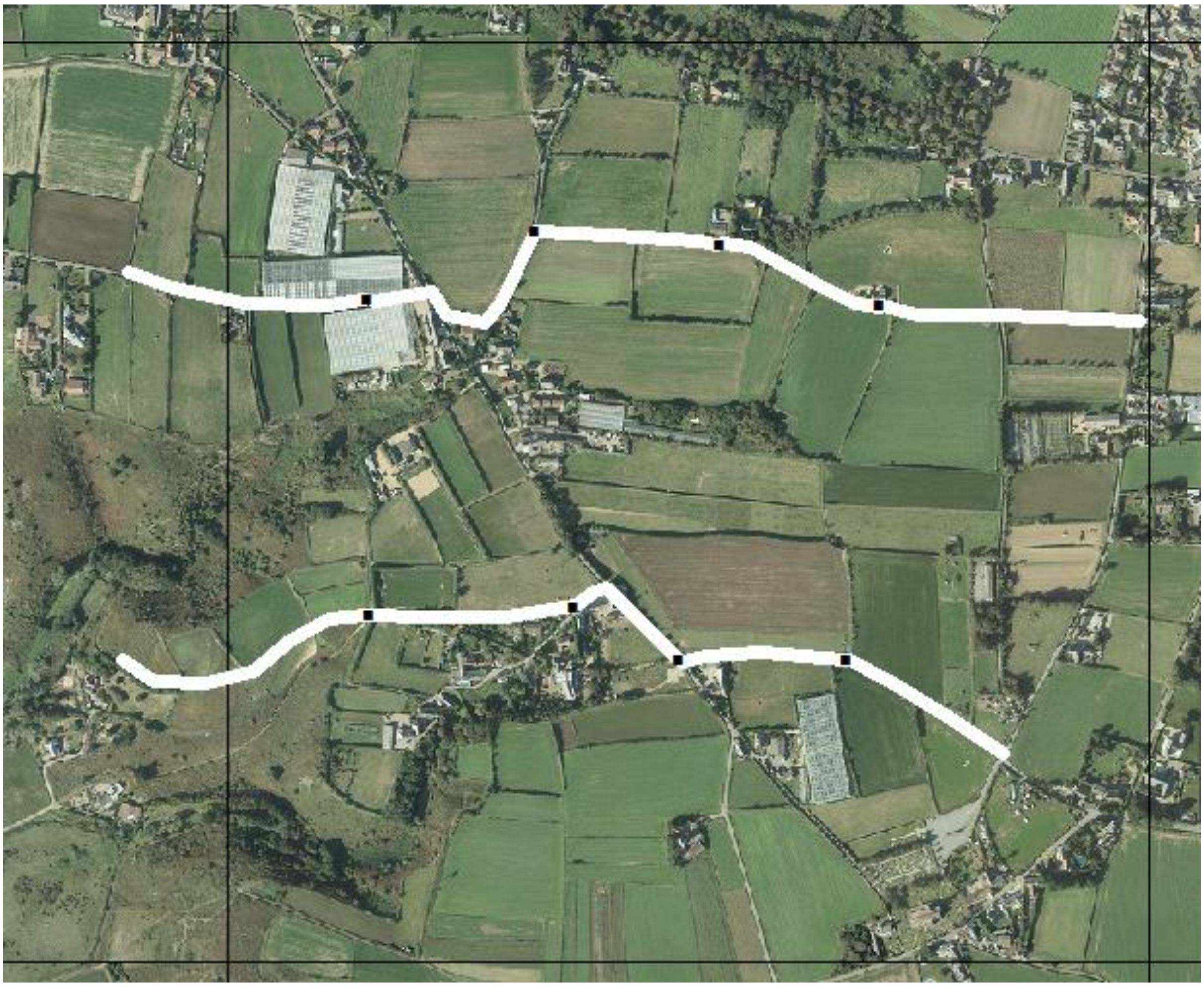


Figure AA.8: Square 8. St. Ouen.

Square eight is another BTO square and contains a lot of grazing land for horses, a few residential properties, glass houses and agricultural land with two small fields that had contained cereal crops in the south east. Pheasants have been observed in these fields after harvest, along with chickens from a chicken pen in the adjacent field. There are two properties home to a large amount of free roaming chickens. Cows are also grazed in a number of fields. It borders a square important for herpetofauna, containing five of Jersey's seven native herpetofauna species. There are at least two pairs of marsh harriers nesting to the west of the square with buzzards also a constant.

Figure AA.9: Square 9. La Landes du Ouest, St. Brélade.

Square nine contains the La Landes du Ouest SSI, an area important for green lizards. The area is coastal with areas of gorse, hottentot fig and rocky cliffs to the south. The northern transects features some arable fields and a few residential properties with large gardens. There is plenty of scrub. Large areas in the north were covered in polythene for the early Royal Jersey potato season. The area highly disturbed, frequented by walkers and dog walkers. There are a small number of crows and magpies with jackdaws also seen. Small birds of prey have also been seen, which were thought to be kestrels. Rabbits are also abundant.

Figure AA.10: Square 10. St. Brélade.

Square ten is a BTO square adopted for the purpose of this research. There are built up areas surrounded by agricultural land and woodland to the east. Large areas are covered in polythene for the early Royal Jersey potato season and the area is frequented by dog walkers. Crows are common.

Figure AA.11: Square 11. Ouaisne and Portlete Common, St. Brelade.

Square eleven is another BTO square. The transect starts on the dune heath of Ouaisne Bay SSI, an important breeding area for the agile frog (*Rana dalmatina*). Five of Jersey's seven herpetofauna species have been observed in the area. The second part of the transects cover Portelet Common SSI, an area of coastal heathland and gorse scrub. Crows are common, as are buzzards and marsh harriers. Peregrine falcons have also been seen. There are plenty of trees in the area but it is a highly disturbed site by dog walkers, possibly the most disturbed site of the study.

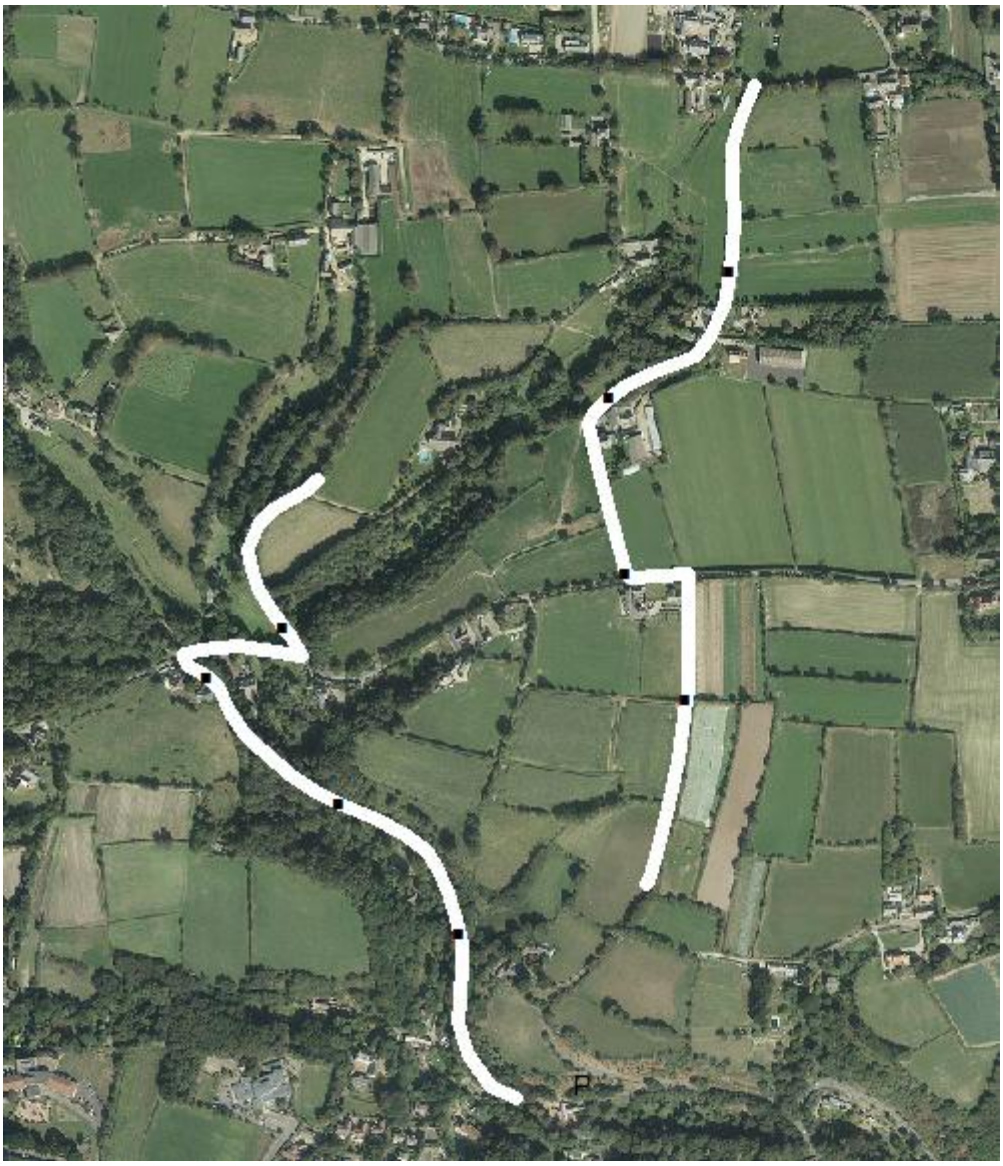


Figure AA.12: Square 12. St. Brélade.

Square 12 is an area of plenty of trees and agricultural land, interspersed with residential properties. The first part of the transect has obscured views by high sides on a cycle path. There is a dairy farm in the area and crows occur in the hundreds. Rabbits are common. Large areas were covered in polythene for the early Royal Jersey potato season including fields that had contained stubble from maize crops.

Figure AA.13: Square 13. St. Peter's Valley, St. Lawrence.

These transects occur right on the border of St. Lawrence and St. Peter and starts by following the major road through St. Peter's Valley. Woodland is abundant and there are a few commercial and domestic properties interspersed through the wooded area and agricultural land. There are also fields used for grazing horses. During the pre-breeding surveys at the beginning of 2016, there were major roadworks along the first half of the first transect, adding to the already high disturbance from traffic. Buzzards are frequently seen and crows are common.

Figure AA.14: Square 14. St. Peter.

These transects occur near the border with St. Ouen and St. Mary. An area of agricultural land interspersed with residential properties and a dairy farm. There are plenty of fields for grazing cows. Some areas were covered in polythene for the early Royal Jersey potato season. Crows are common and there are frequent sightings of marsh harriers.

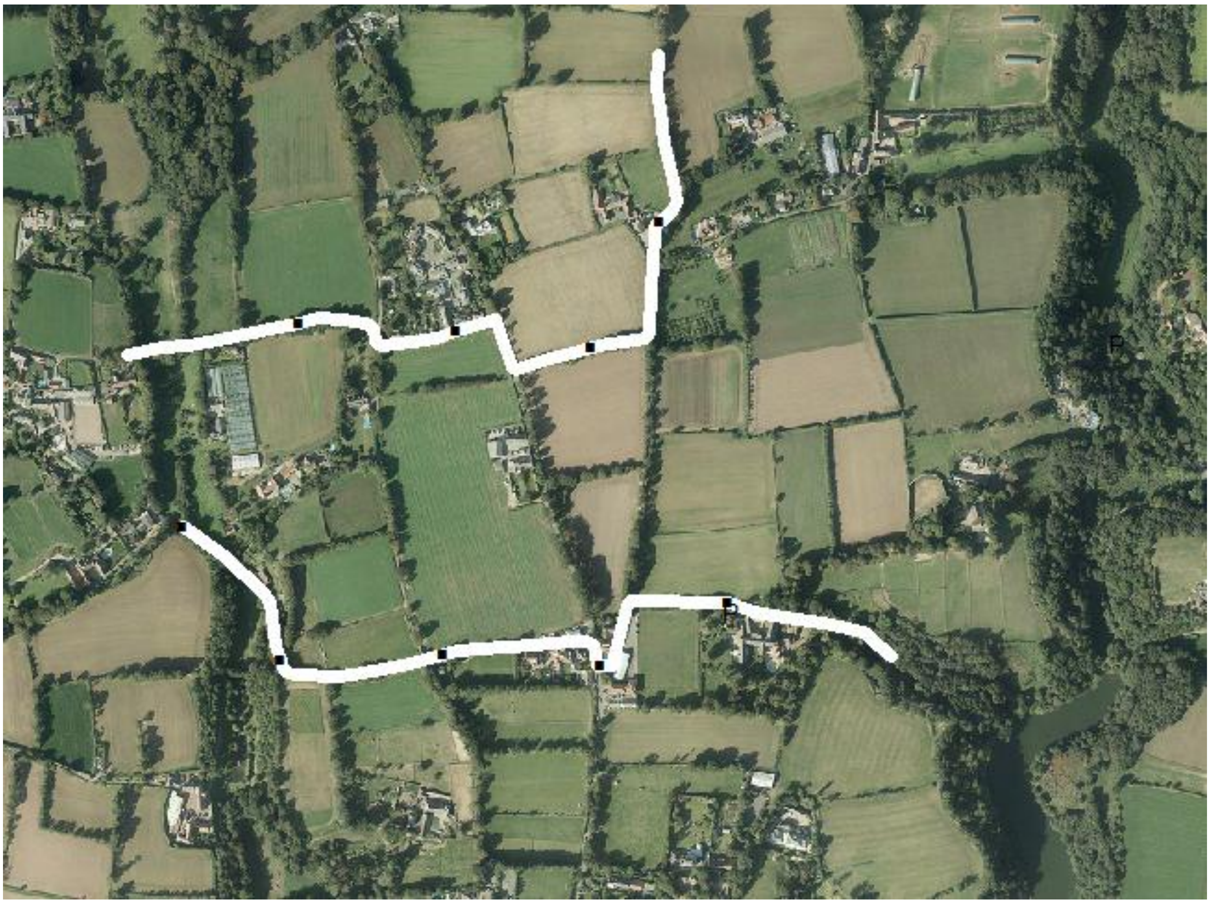


Figure AA.15: Square 15. St. Lawrence.

Square fifteen has plenty of wooded areas to the east and west. Agricultural land is mainly arable but with areas of grazing for cows horses and some sheep. Buzzards are a common sight. The first transect crosses a busy road. A male pheasant was observed roosting in a tree above the road in the first section of transect.

Figure AA.16: Square 16. St. John.

These transects actually start in Trinity but the majority are in St. John. It follows a major road and passes a built up industrial area on the first transect. The agricultural land is mainly arable. There are a few clumps of trees. Marsh harriers and buzzards have been seen. Crows are abundant.

Figure AA.17: Square 17. Trinity.

This is the final BTO square adopted for the purpose of this research. There are plenty of fields for grazing horses and large fields of green manure cover, dotted with residential properties. Clumps of trees are plentiful. Buzzards have been seen and crows are common.

Figure AA.18: Square 18. St. Martin.

Square eighteen is abundant in agricultural land, mainly arable with areas grazed by cows. Large areas were covered in polythene for the early Jersey Royal potato season. Marsh harriers and buzzards are often seen and crows are abundant. Roadworks were taking place towards the end of the pre-breeding survey at the south western part of the transects, though surprisingly more pheasants were seen in that area during this time.

Figure AA.19: St. Ouen's Pond, St. Ouen.

This is an area of flat agricultural and wetland to the west and undulating scrub dotted with residential properties to the east.

Figure AA.20: Sand Dunes, Creepy Valley, St. Brélade.

A potentially important area for grass snakes. The dunes are predominantly dune grassland with patches of open dune and dwarf scrub. The transect transitions into e patch of deciduous woodland and dense scrub behind Creepy Valley and by a golf course. Large areas of the woodland were flooded at the beginning of spring. The dunes are highly disturbed by dog walkers. The woodland seems quieter though there are plenty of tracks indicating at least some disturbance.

Figure AA.21: Noirmont, St. Brélade.

Includes an ecological SSI important for herpetofauna. The transect runs alongside a woodland to the east, and gorse and grassland to the west with grazing for sheep and horses. Noirmont Manor is situated near the north of the transect. The area is highly disturbed by walkers and dog walkers. Buzzards are also present.

Appendix B: Distance software methods, detection probabilities and models chosen for Breeding Bird Survey data.

Distance software methods

For robust, reliable density and abundance estimates, three assumptions must be obeyed:

1. Objects on the line or point are detected with certainty, i.e. all pheasants on the line are detected,
2. Objects are detected at their initial location, this assumes the pheasants are detected before they move in response to the observer, and
3. Measurements are exact, either exact distances from the line are correct or, where distance bands are used, the correct band is assigned (Buckland *et al*. 1993).

Even when assumptions are violated, the programme DISTANCE has shown to give unbiased or minimally biased results (Cassey 1999).

Several sources explain the underlying statistical concepts of distance sampling analysis (Buckland *et al*. 1993; Thomas *et al*. 2010). The general equation is expressed: $D=n/a\hat{p}_a$ where n = the number of detections, a = 2(wL, where w = half width of strip and L = length of transect) and P_a is the probability of detection in an area. To calculate a detection probability, a detection curve is modelled, assuming certain detection on the line and decreasing with increasing distance from the line where:

“g(y) = the probability of detecting an object given its perpendicular distance from the line

= prob (detection/distance y)” (Buckland *et al*. 1993).

Conventional distance sampling (CDS) analysis, based on the distance of objects from the line, offers the use of four key functions: uniform, half-normal, hazard-rate and negative exponential. Three adjustment terms can be used: cosine, Hermite or simple polynomials. Any combination of these can create a model to estimate density and abundance. The user can determine the most appropriate model to use based visual inspection of quantile-quantile (q-q) plots, the Akaike information criterion (AIC), the χ^2 and K-S (Kolmogorox-Smirnov) goodness-of-fit statistical tests, and the coefficient of variation of the density estimates. A model that fits well will have a non-significant K-S value, show a q-q lot with a reasonably straight line and have a comparatively lower AIC value (Thomas 2010).

Multiple-covariate distance sampling (MCDS) allows the inclusion of covariates in the analysis such as habitat, weather and observer variables, however, it is restricted to the use of the half-normal and hazard-rate key functions (Thomas 2010).

CDS models with all combinations of uniform, half-uniform and hazard-rate key functions and cosine, Hermite and simple polynomial adjustment terms were considered. MCDS models with half-uniform and hazard-rate key functions with cosine and simple polynomial adjustment terms were also considered with the addition of habitat or habitat and mode included as covariates. Thomas *et al.* (2010) discourage the use of the negative exponential key and it is ignored here.

Figure A2.1 shows the detection probability for each dataset. Table A2.1 shows the models chosen for each BBS year.

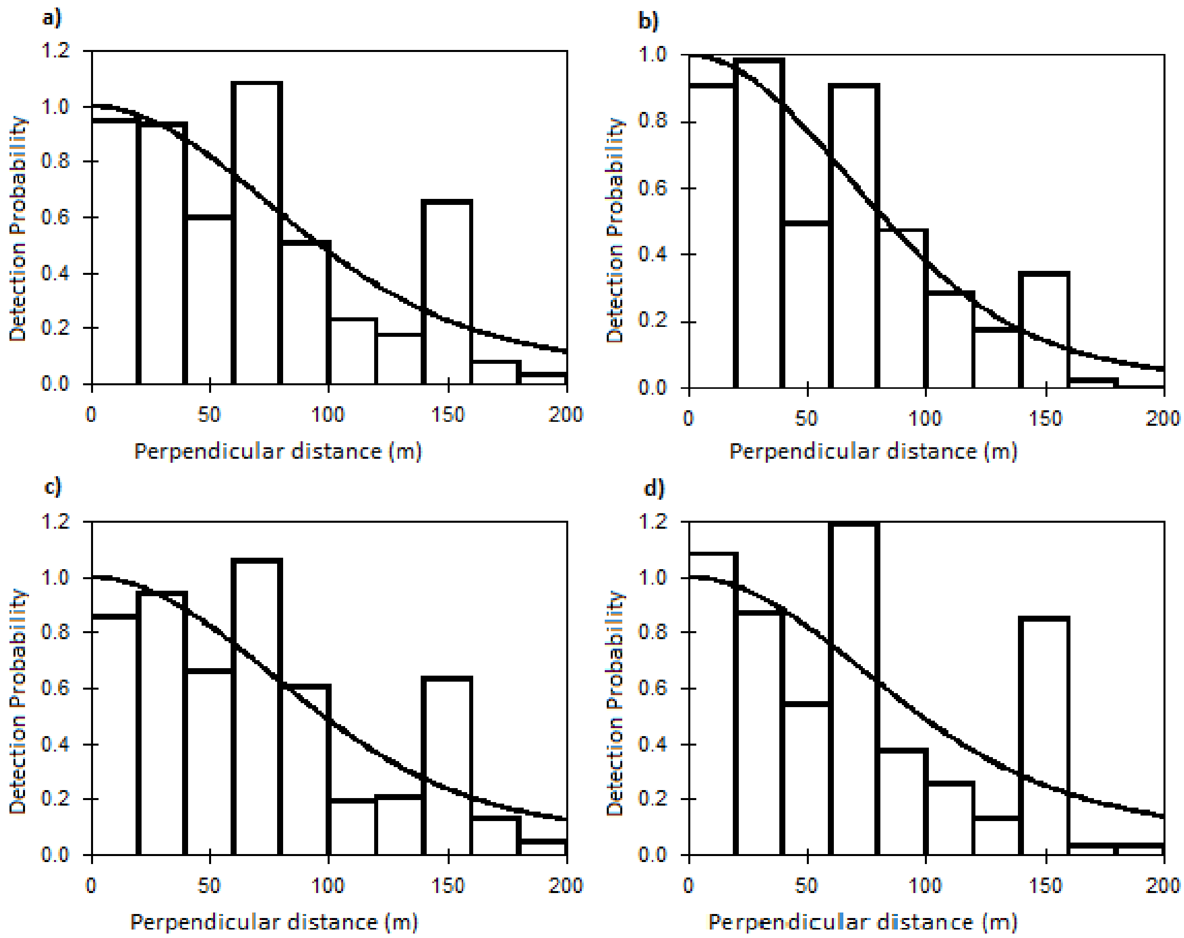


Figure AB.1: Detection probability for (a) entire dataset, (b) autumn/winter dataset, (c) pre-breeding dataset and (d) post-breeding dataset using half normal key function with a cosine adjustment term. Twenty metre intervals have been used for illustrative purposes only, exact distance were used for analysis except for pheasants detected by sound only. These contacts were given a distance central to the distance band they were detected in and are responsible for the peaks shown in the data.

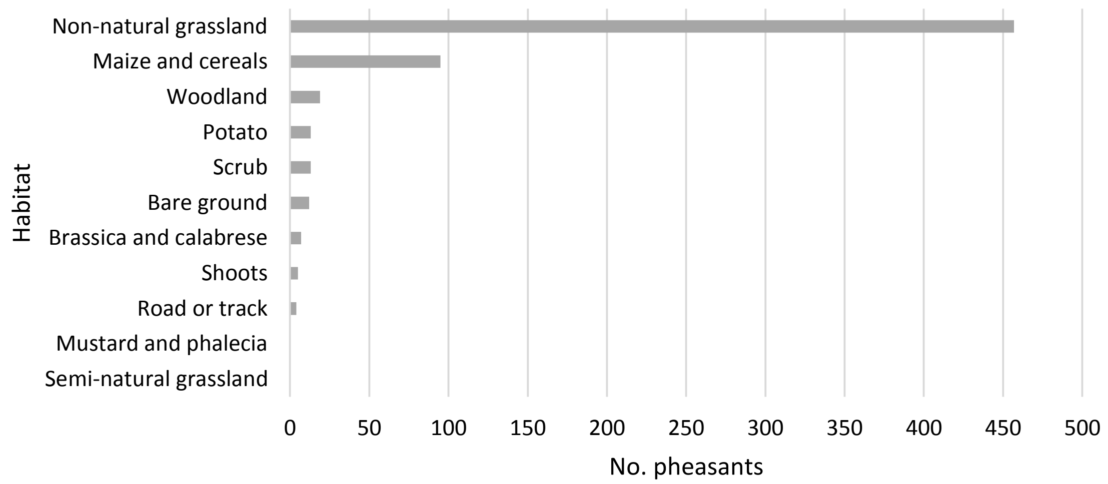
Table AB.1: Survey and model details of Breeding Bird Survey Data for pheasants in Jersey.

Year	Transects	Effort (m)	Key function	Adjustment term	Covariate(s)
2002	15	30000	Half normal	cosine	habitat
2003	16	31600	Half normal	cosine	-
2004	23	44800	Half normal	cosine	habitat
2005	30	58800	Half normal	cosine	-
2006	30	57600	Half normal	cosine	habitat
2007	42	82000	Half normal	cosine	habitat
2008	29	55200	Half normal	cosine	-
2009	33	63200	Half normal	cosine	habitat and period
2010	30	56800	Half normal	cosine	habitat
2011	29	55600	Half normal	cosine	habitat
2012	30	57600	Half normal	cosine	-
2013	37	70400	Half normal	cosine	habitat and period
2014	32	62400	Half normal	cosine	-
2015	27	52200	Half normal	cosine	habitat
2016	16	30800	Half normal	cosine	Habitat and period

Appendix C: Habitat utilisation by pheasants in Jersey.

Figure AC.1 shows the habitat use by all pheasants seen on and between transects for the pre- and post-breeding survey periods. Non-natural grassland remained the most utilised habitat across the seasons, with bare fields and potato fields being increasingly used as they became available and after plastic was removed. Utilisation of habitats is likely largely explained by availability, for example bare ground was not abundant in the pre-breeding surveys and mustard and phacelia were non-existent. Available maize and cereal fields were represented by stubble after harvest and likely held waste grain. In the post-breeding season, bare ground and potato covered a large area while maize and cereal crops were limited and young without grain.

a)



b)

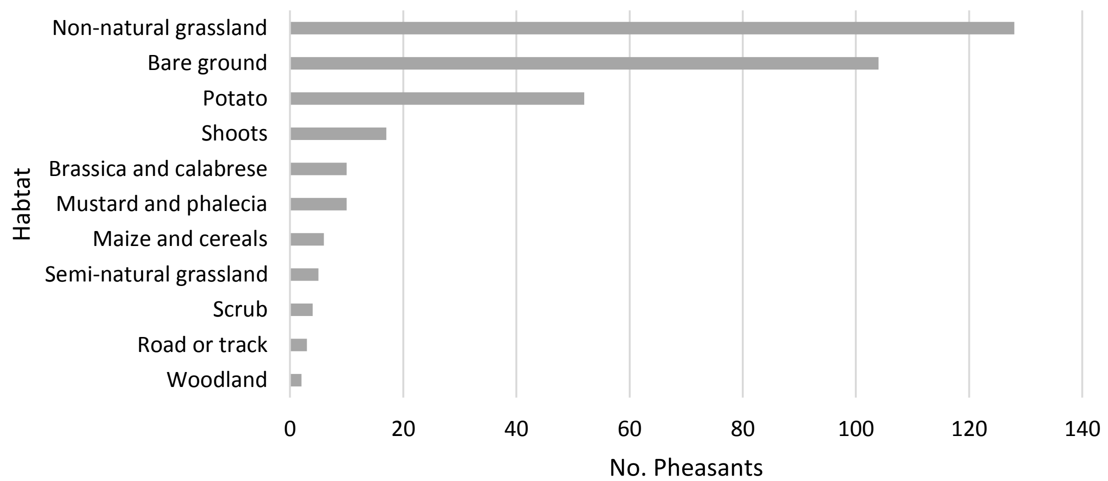


Figure AC.1: Numbers of pheasants seen in ten habitat types, plus roads or tracks, during the (a) pre-breeding and (b) post-breeding surveys. Note during the pre-breeding surveys maize and cereal fields represent stubbles left after harvest, potato fields were plastic covered and there were no mustard or phacelia crops. All pheasants seen in potato fields post-breeding were seen resting or scratching in the dirt tracks of the field except two male which were seen in the stubble after mowing. Post-breeding maize and cereals were represented by young plants with no grain.

Appendix D: Example survey data layout for input into DISTANCE and R.

Table AD.1: Example data layout for input into DISTANCE and R.

Sex	Detection[1]	Stratum	Area (km2)	Square[2]	Transect	Effort	Distance band*	Distance (m)*	Habitat[2]	Observer[1, 2]	Date[2]
M	sight	Jersey	107	1	1	3576	1	1.25	Op	CR	24/11/2015
F	sight	Jersey	107	1	1	3576	1	7.25	Op	CR	24/11/2015
F	sight	Jersey	107	1	1	3576	3	72.49	Op	CR	24/11/2015
M	sight	Jersey	107	1	2	3888	1	3.52	SO	CR	24/11/2015
M	sight	Jersey	107	2	3	3820	3	84.41	SO	CR	28/11/2015
F	sight	Jersey	107	2	3	3820	3	75.45	SO	CR	28/11/2015
M	sight	Jersey	107	2	4	3776	2	31.13	SO	CR	28/11/2015
F	sight	Jersey	107	2	4	3776	2	35.59	SO	CR	28/11/2015
F	sight	Jersey	107	2	4	3776	2	37.99	SO	CR	28/11/2015
F	sight	Jersey	107	2	4	3776	2	37.89	SO	CR	28/11/2015
M	sound	Jersey	107	3	5	5535	3	75^	Cl	LC	05/02/2016
M	sound	Jersey	107	3	6	2920	2	37.5^	Cl	CR	05/02/2016
M	sight	Jersey	107	4	8	2916	3	59.07	SO	SM	26/11/2015
M	sound	Jersey	107	4	8	2916	4	150^	SO	SM	26/11/2015
M	sight	Jersey	107	4	8	2916	2	44.13	SO	SM	26/11/2015
M	sight	Jersey	107	4	8	2916	2	44.38	SO	SM	26/11/2015
M	sound	Jersey	107	6	11	1165	2	37.5^	Cl	CR	27/11/2015
F	sight	Jersey	107	6	12	1201	1	5.36	SO	CR	27/11/2015
F	sight	Jersey	107	6	12	1201	4	125.85	SO	CR	27/11/2015

[1] These can be used as covariates in analysis

[2] Not necessary for analysis but useful for arranging data.

* Use distance bands or exact distances depending on methods of survey.

^ The central value of the distance category is used for pheasants detected by sound only.

Appendix E: Questionnaire.

The following questionnaire is to gather public opinion on the presence of common pheasants in Jersey. The data will be used as part of a Master of Science research project with DICE, at the University of Kent, and in conjunction with the Jersey States Department of the Environment. The results will be used to inform management decisions regarding the common pheasant in Jersey by the Department of the Environment.

The survey should take about ten minutes to complete. Your answers will be anonymous and confidential. If you change your mind and do not wish to submit your answers the survey can be quit at any time. Please choose 'yes' below to agree to your answers being used for this project.

Q1. I agree for my answers to be used as part of this project.

Yes

No

Q2. When did you first notice pheasants in Jersey?

1950-1955

1956-1960

1961-1965

1966-1970

1971-1975

1976-1980

1981-1985

1986-1990

1991-1995

1996-2000

2001-2005

2006-2010

2011-2015

Don't know

I've not noticed pheasants in Jersey

Q3. Where did you first notice pheasants in Jersey?

North-west of Jersey

South-west of Jersey

North-east of Jersey

South-east of Jersey

Centre of Jersey

Don’t know

If you can, please provide more location details such as parish or area name.

Comment box

Q4. Over the last five years, would you say the number of pheasants in Jersey has increased or decreased?

Increased a lot

Increased

Remained stable

Decreased

Decreased a lot

Don’t know

Effects on Wildlife

Q5. How do you think pheasants are affecting wildlife in Jersey?

Farmland birds:

Birds of Prey:

Reptiles:

and

Amphibians:

Very positively

Positively

No affect

Negatively

Very negatively

Don’t know

If you think a species not listed here is being affected by pheasants, please list them and how you think they are affected.

Comment box

Q6. Have you ever witnessed a bird of prey:

Hunting a pheasant?

Yes

No

Killing a pheasant?

Yes

No

Eating a pheasant?

Yes

No

If yes, what species of bird of prey?

Comment box

Q7. Have you ever witnessed a pheasant:

Attacking a reptile or amphibian?

Yes

No

Eating a reptile or amphibian?

Yes

No

If yes, which species of reptile and/or amphibian?

Comment box

Effects on Agriculture

Q8. How do you think pheasants are affecting agriculture in Jersey?

Farmland crops:

Livestock:

and

Garden crops:

Very positively

Positively

No affect

Negatively

Very negatively

Don’t know

Q9. If you think pheasants are impacting farmland or garden crops negatively, please indicate which crops you think they are impacting: (please tick all that apply).

Grain/cereals

Potatoes

Brassicas

Orchard fruit

Garden fruit or veg

N/A

Other (please specify)

Comment box

Q10. Please use this space to provide any further information you have regarding the effects of pheasants on wildlife or agriculture (please note, there is a section at the end for arable farmers to answer further questions on the impacts of pheasants on their crop).

Comment box

Laws

Q11. Did you know that pheasants are protected by legislation in Jersey?

Yes

No

Q12. Were you aware that, under certain circumstances, licences can be issued to shoot pheasants?

Yes

No

Q13. Do you think that pheasants should be protected from killing and/or harm by legislation in Jersey?

Yes

No

Q14. Please feel free to leave a comment on your opinion about the laws surrounding pheasants.

Comment box

Q15. How much do you agree or disagree with the following statements?

Pheasants add to the appeal of Jersey's countryside.

Pheasants are a nuisance.

Pheasants should be controlled as a pest.

Pheasants should be treated as they are in the UK, as game birds with a closed hunting season.

Pheasants should be eliminated from Jersey.

We should be trying to increase the population of pheasants in Jersey.

Pheasants should be treated as pigeons and have all legal protection removed from them.

If pheasants were managed as a game species in Jersey, I would allow pheasant shoots on my land.

If pheasants were managed as a game species in Jersey, I would buy a game hunting licence.

If pheasants were managed as a game species in Jersey, I would buy and/or consume the meat from pheasant shoots.

Strongly Agree

Agree

No opinion

Disagree

Strongly disagree

Q16. Please feel free to add any other comments on your thoughts about pheasants in Jersey.

Comment box

Arable farmers

Q17. Are you an arable farmer?

Yes

No

Q18. What is the main purpose of your crop(s)?

Consumption by the family.

To sell.

Both the above.

Other (please specify).

Comment box

Q19. What is/are your main crop(s)? (please select all that apply)

Potatoes - Jersey Royal

Potatoes - other

Root vegetables

Brassicas

Maize

Other grains

Fruit

Other (please specify)

Comment box

Q20. What damage have pheasants caused to your crop(s)? (please select all that apply)

Dug up and/or eaten Jersey Royal potatoes

Dug up and/or eaten other potatoes

Dug up and/or eaten root crops

Eaten/damaged maize

Eaten/damaged brassicas

Eaten/damaged fruit

Eaten shoots of new plants

Dug up and eaten newly planted seeds

Damaged plastic or netting covering crops

Damaged plastic covering haylage/silage

None

Q21. Do you think damage to your crop(s) by pheasants is:

Severe

Moderate

Mild

Non existent

Don't know

Q22. Do you think damage to your crop(s) by pheasants causes a loss of profits on your yield?

Yes, substantial loss

Yes, a moderate loss

No

Don't know

Q23. For the last season, what do you estimate the percentage of lost annual yield was due to damage by pheasants?

Potatoes – Jersey Royals	0%	1-20%	21-40%	41-60%	61-80%	81-100%	Don't know	N/A
Potatoes – other	0%	1-20%	21-40%	41-60%	61-80%	81-100%	Don't know	N/A
Root vegetables	0%	1-20%	21-40%	41-60%	61-80%	81-100%	Don't know	N/A
Brassicas	0%	1-20%	21-40%	41-60%	61-80%	81-100%	Don't know	N/A
Maize	0%	1-20%	21-40%	41-60%	61-80%	81-100%	Don't know	N/A
Other grain	0%	1-20%	21-40%	41-60%	61-80%	81-100%	Don't know	N/A
Fruit	0%	1-20%	21-40%	41-60%	61-80%	81-100%	Don't know	N/A

Q24. At what stage of crop cycle does most damage/loss by pheasants occur? (please select all that apply)

Just after sowing

Germination

After maturation

After harvest

Don't know

Other (please specify)

Comment box

Q25. What parishes do you grow crops in? (please select all that apply)

Grouville

St Clement

St Brelade

St Ouen

St Helier

St John

St Lawrence

St Mary

St Martin

St Saviour

St Peter

Trinity

Prefer not to say

Q26. Do you, or the owner of the land you cultivate, own a licence to shoot pheasants?

Yes

No

Don't know

Q27. Do you feel the pheasant licences are an effective solution to allow farmers and landowners to protect crops from damage by pheasants?

Yes

No

Don't know

Q28. Please any comments.

Comment box

About you

Q29. Are you:

Male

Female

Prefer

Q30. What is your age group?

18-24

25-34

35-44

45-54

56-64

65+

Prefer not to say

Q31. Have you been a resident of Jersey your whole life?

Yes

No

If no, when did you more to Jersey?

Comment box

Q32. Which sector do you work in?

Environmental

Agricultural and Fisheries

Finance (including legal work)

Wholesale and retail

Transport and communication

Hospitality

Public sector

Retired

Unemployed

Other (please specify)

Comment box

Q33. How do you enjoy the countryside? (please select all that apply)

Wildlife watching

Game shooter

Horse riding

Recreation

Dog walking

Walking

Other (please specify)

Comment box

Q34. Are you a member of any farming, environmental or conservation organisations or societies?

Yes

No

If yes please specify

Comment box

Q35. Are you a landowner?

Yes

No

Appendix F: Diet of Jersey's Pheasants (*Phasianus colchicus*).

Introduction

Understanding diet is important to understand the predatory impacts of an invasive alien species on native flora and fauna. Determining diet choices by field observations is difficult, especially if the focal species is small or browsing in dense vegetation, so more direct methods involving the analysis of gastrointestinal content and faecal samples are needed. With a wide variety of non-lethal and non-invasive methods available as alternatives, killing wild animals for the purpose of studying an organism's diet is no longer ethically accepted. However, where culling is already in place, taking advantage of the opportunity to investigate gastrointestinal content should be encouraged (King *et al*. 2008).

Methods

Sampling

Individuals with a licence to shoot pheasants were contacted by email asking them to donate any pheasants shot to the study. Emails sent out and media publications asking for participation in an online questionnaire (see Chapter 3) also asked members of the public to report dead pheasants, such as road kill, so that the carcasses may be collected.

Diet analysis

All pheasants were frozen until a suitable time to prevent further decomposition of gastrointestinal contents. They were allowed to defrost for one or two days prior to dissection. Before dissection birds were weighed and briefly looked over for any obvious signs of parasites. Contents of crops, gizzards, large and small intestines were removed and stored separately in a 70% ethanol solution for later identification (Rabinowitz *et al.* 2000; Doxon and Carroll 2010).

Samples were then examined under light microscope and identified to the nearest taxonomic order using published and online resources. Excess moisture was absorbed using coffee filter paper before each sample was weighed to the nearest 0.01 grams and volume measured to the nearest 0.1 millilitres.

Results

A total of seven pheasants (one female, six males) were obtained. Six were provided by licensed shooters and one was found as road kill. Table AF.1 provides details on the condition of the pheasants and the areas in which they were sampled. One sample, GO, was provided as a gizzard only with no details on date or area of sampling.

Table AF.2 lists the fauna species, to the nearest taxonomic order, found in the samples, including percent occurrence, weight and volume. Table AF.3 lists the invertebrate species, to the nearest taxonomic order, including percent occurrence and number of individuals consumed.

Discussion

In terms of percent occurrence and total weight and volume, goosefoot (*Chenopodium album*), black nightshade (*Solanum nigrum*) and smartweed (*Persicaria pensylvanica)* were found to be of high importance in the diet of Jersey's pheasants. All three are known agricultural weeds, the former two particularly being known weeds of potato fields.

Of the birds examined in this study, only one was killed during Jersey's outdoor potato season (♂5: Road kill, March 2016, Trinity). Killed early on in the 2016 season, which was delayed due to adverse weather, potato was, perhaps unsurprisingly, found in the crop and gizzard of this bird. After winter, a season of little food availability, hundreds of vergeés of land are ploughed and planted with potatoes, providing a single and widespread potential food resource.

In other research, crop grains have been a main emphasis of pheasant diet (Maxson 1921; Fried 1940; Einarsen 1943; West, Brunton and Cunningham 1969; Koopman and Pitt 2007; Werner *et al*. 2010; Esther, Tilcher and Jacob 2012). Grain crops on Jersey are few and far between. No grain was found in the crops or gizzards of this sample, however, it is uncertain if grain crops were available to the sampled pheasants whether due to season or location.

Acorns occurred in the highest weight and volume but were consumed by only one pheasant (♂1: Shot, Nov. 2015, St. John). The accompanying female (♀1: Shot, Nov. 2015, St. John), shot at the same time, had not consumed any acorns.

Parts from, at least, three caterpillars (Lepidoptera) were found in one bird (♂2: Shot, autumn 2015, St. John). Though they could not be identified any more accurately than order, it does provide evidence that pheasants are predating Lepidoptera in Jersey indicating they could be a cause for concern for vulnerable butterfly and moth species. Conversely, the same bird had consumed at least three Harlequin ladybirds (*Harmonia axyridis*), another introduced species from Asia that can have devastating effects on local ladybird populations and other insects through predation and competition and are known to predate Lepidoptera, including Noctuidae eggs (Roy and Brown 2015). *H. axyridis* can also cause problems for humans, causing allergic reactions and staining furniture when aggregating in houses during winter (Goetz 2007; Roy and Brown 2015).

Invertebrate prey was found in only one other pheasant (♂4: Shot, 2014, St. Ouen) and represented by a single hoverfly in the crop. No evidence of predation on herpetofauna was found in the samples. However, residents have reported seeing pheasants eating and attacking reptiles and amphibians (see Chapter 3).

Gravel, used to aid digestion, was found in all gizzards. The largest amount of gravel by weight was found in ♂2 (Shot, autumn 2015, St. John), which displayed a lack of subcutaneous and visceral fat and only small amounts of digestible content in the gizzard. Details of time of death were vague and the lack of body fat may be attributed to the loss of condition males experience toward the end of the demanding breeding season.

Browsing by pheasants can cause changes and damage to hedgerows and some farmers have complained of pheasants digging at banks and causing collapse.

Table AF.1: Details of the pheasants sampled for diet analysis.

ID	Died	Sex	Weight (g)	Condition details	Field no	Habitat	Location details
♀1	Nov 2015 *Shot*	F	1329	Good layer of subcutaneous fat	J1057A	Brassica	In a brassica field beside a field of cut corn with about 5 males and 6 females
♂1	Nov 2015 *Shot*	M	-	Good layer of subcutaneous fat	J1057A	Brassica	In a brassica field beside a field of cut corn with about 5 males and 6 females
♂2	Autumn 2015 *Shot*	M	1540	Barely any subcutaneous fat, no fat around organs. Nothing in crop, mostly gravel in gizzard.	J689	Grass field	Ashley Court Farm, North.
♂3	Autumn 2015 *Shot*	M	1418	Some fat, some gravel in gizzard. Had bled heavily, weight probably effected.	J451	Grass field	North Handois Res.
♂4	2014 *Shot*	M	1642	Very thick layer of subcutaneous fat. Organs covered in fat. Nothing in crop.	O1272/1279	Mustard?	Shot by pond.
♂5	10 March 2016 *Road kill*	M	1428	Good layer of subcutaneous fat.	T771	In road	Found on road, La Profunde Rue, by field 771, grassy field with a line of trees on road border, was likely crossing from the opposite grass field.
GO*	*Shot*	-	-	-	-	-	-

***** This sample was provided as the gizzard only, no details of when or where it was shot were provided.

Table AF.2: Fauna species found in the crops and gizzards of pheasants in Jersey, Channel Islands. Sample size = 7. See figures AF.1 to AF.14.

Plants					**Occurrence**		**Weight**	**Volume**
Family	**Genus**	**Species**	**Common names**	**Part**	***N***	**%**	***g***	***ml***
Amaranthaceae	*Chenopodium*	*album*	goosefoot	seeds	4	57.14	3.77	3.36
Amaryllidaceae	*Allium*	*paradoxum*	wild garlic	flowers	1	14.29	0.13	0.15
Asteraceae	-	-	aster	seeds	1	14.29	<0.01	<0.1
Poaceae	-	-	grass	seeds	4	57.14	0.04	0.3
Caryophyllaceae	*Stellaria*	*media*	common chickweed	seeds	2	28.57	<0.01	<0.1
Fagaceae	*Quercus*	-	oak tree	acorns	1	14.29	13.09	11.7
Polygonaceae	*Persicaria*	*pensylvanica*	pinkweed	seeds	4	57.14	4.15	3.6
Polygonaceae	*Rumex*	-	docks	seeds	4	57.14	0.01	<0.1
Solanaceae	*Solanum*	*tuberosum*	potato	potato	1	14.29	0.53	0.3
Solanaceae	*Solanum*	*nigrum*	black nightshade	fruit and seeds	4	57.14	6.05	6.52
Umbellifer	-	-	-	-	2	28.57	1.2	0.9
Unidentified #1	-	-	-	-	3	42.86	1.25	1.19
Unidentified #2*	-	-	-	-	1	14.29	0.3	0.2
Unidentified #3*	-	-	-	-	1	14.29	1.02	1

*these seeds were too fragmented and digested to identify. See figures AG.13 and AG.14.

Table AF.3: Invertebrate species found in the crops and gizzards of pheasants in Jersey, Channel Islands. Sample size = 7. See figures AF.15 to AF.18.

Invertebrates							**Occurrence**	
Order	**Family**	**Genus**	**Species**	**Common names**	***N***	**Stage**	***N***	**%**
Coleoptera	Coccinellidae	*Harmonia*	*axyridis*	harlequin ladybird	3	adult	1	14.29
Diptera	Syrphoidea	-	-	hoverfly	1	adult	1	14.29
Gastropoda	-	-	-	snail	3	eggs	1	14.29
Lepidoptera	-	-	-	moths and butterflies	3	caterpillar	1	14.29

a) b)

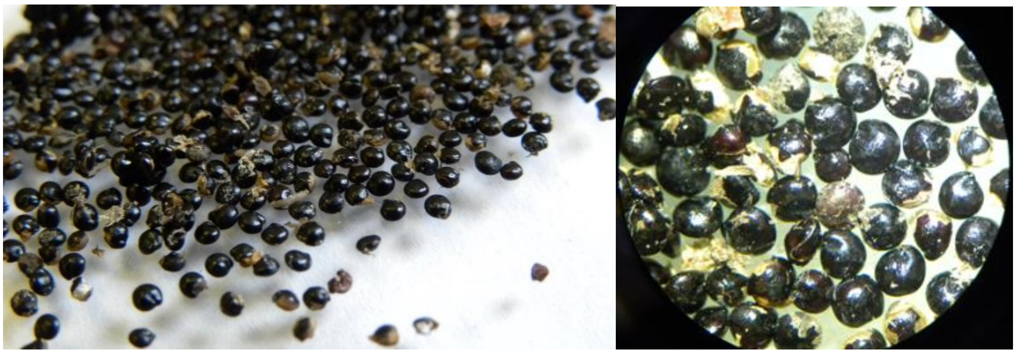


Figure AG.1: Goosefoot (*Chenopodium album*) seeds, b) magnification x40.

a) b)

Figure AG.2: Wild garlic (*Allium paradoxum*) flowers.

a) b)

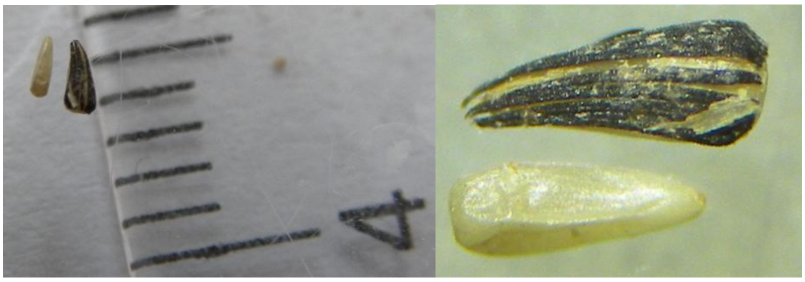


Figure AG.3: Aster seeds, b) magnification x40.

a) b) c)

Figure AG.4: Various grass (Poaceae) seeds, a) and b) magnification x40

Figure AG.5: Common chickweed (*Stellaria media*) seeds magnification x40.

Figure AG.6: Acorns from oak tree (*Quercus*).

a) b)

Figure AG.7: Pinkweed (*Persicaria pensylvanica*) seed, b) magnification x40

Figure AG.8: Dock (Rumex) seeds.

a) b)

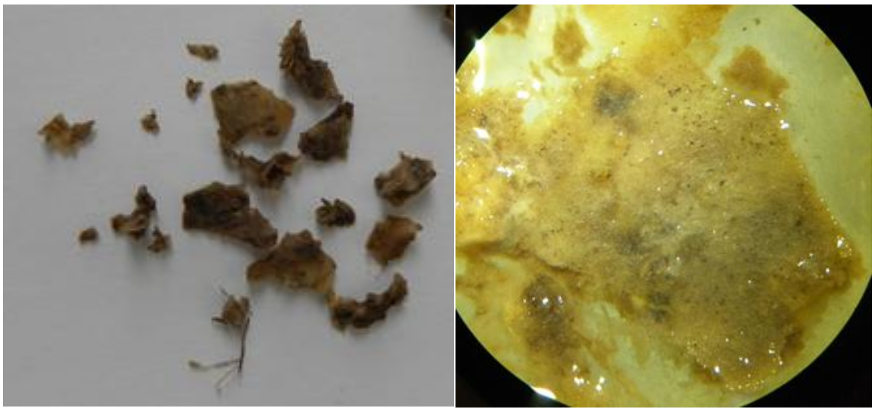


Figure AG.9: Potato (*Solanum tuberosum*), b) magnification x40.

Figure AG.10: Black nightshade (*Solanum nigrum*) seeds and pods.

Figure AG.11: Unidentified Umbellifer seeds.

a) b)

Figure AG.12: Unidentified seeds #1, a) dry and b) wet.

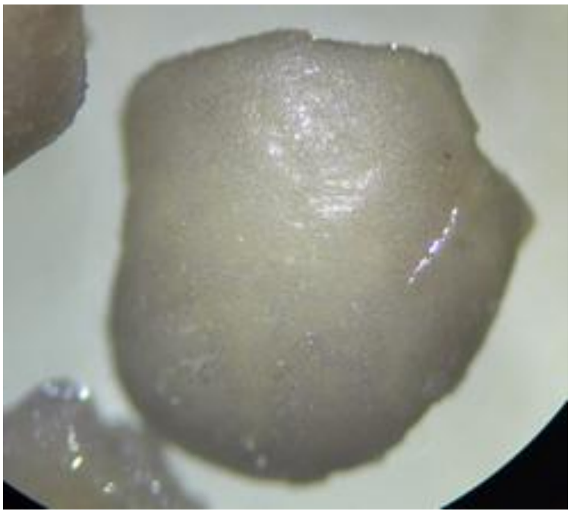


Figure AG.13: Unidentified seed #2 fragments, magnification x40.

Figure AG.14: Unidentified seed #3.

Figure AG.15: Invasive harlequin ladybird (*Harmonia axyridis*) remains, magnification x40.

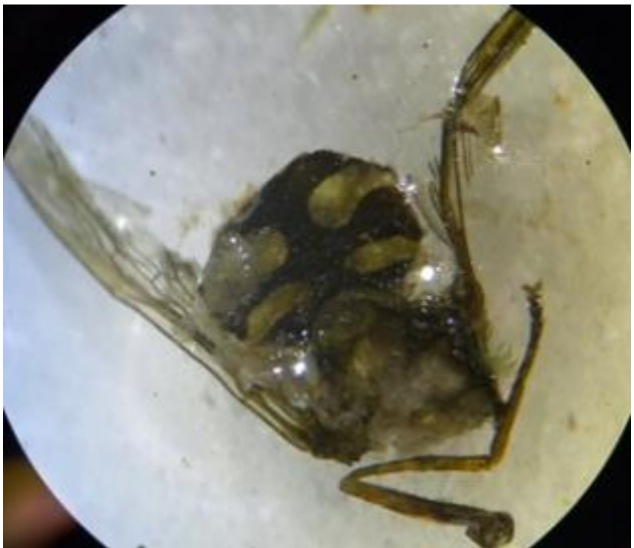


Figure AG.16: Hoverfly (Syrphoidea) remains, magnification x40.

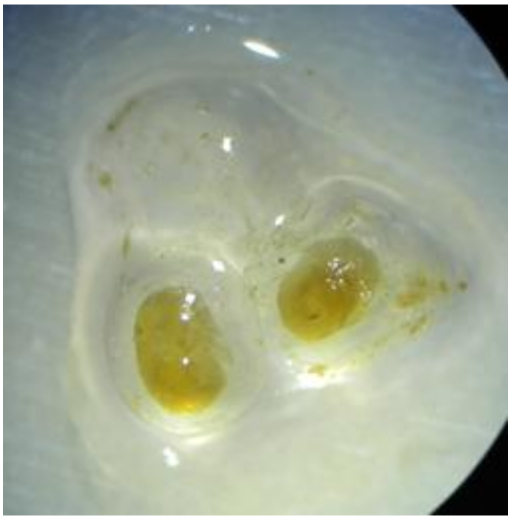


Figure AG.17: Gastropoda eggs. Magnification x40.

a) b)

Figure AG.18: Lepidoptera remains, b) magnification x40.