

**MONITORING DECLINES IN WIDELY
DISTRIBUTED SPECIES: CASE STUDY OF
THE GREY PARTRIDGE (*PERDIX
PERDIX*) AND THE IUCN RED LIST**

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Abstract

The IUCN Red List is *the* authoritative tool for estimating extinction risk for species. The topic of widely distributed species in red listing has been much debated; what scale to use, how to best protect, and the logistics of how to carry out these large scale assessments. The grey partridge (*Perdix perdix*) was once a common species in Europe's agricultural landscape but has suffered from massive declines over the last half century. However, whilst the species has suffered from declines it is not listed as threatened on the IUCN Red List and one of the reasons behind this is that the species has a wide range. The aim of this study was to address the relationship between the scale of assessment, data availability and threat classification for wide ranging species; looking the grey partridge as a case study.

In chapter 2 the IUCN Red List was looked at in detail, to see how it was used at different scales, to see how best to protect species at the global or national level. Chapter 3 introduces the grey partridge which was used as a case study to see highlight the problems with red listing at the different spatial scales. The species has suffered from significant declines attributed to the intensification of global agriculture. Data availability was a huge constraint in this study along with how to use the different data sources in order to make an assessment. The results highlighted the problem of the different information sources, and also showed what kind of data is used over time. There is a considerable bias in the data towards Europe with almost no information available for North America (where the species has been introduced) and Asia. Ultimately this study shows that in order to make an accurate assessment for the grey partridge there needs to be a review in the way the partridge is evaluated; at both the local and global scale. From the studied literature a recommendation of listing the grey partridge as Endangered under A1 was made. However, due to the species relatively large population size and gaps in the data at the very least it should be reviewed in detail once population estimates are made for its Asian habitation.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION	1
SECTION 1.1 PROBLEM STATEMENT	1
SECTION 1.2 LITERATURE REVIEW	1
1.2.1 THE GREY PARTRIDGE	1
1.2.2 THE IUCN RED LIST	2
1.2.3 MONITORING SPECIES AT DIFFERENT SPATIAL SCALES	3
SECTION 1.3 AIM	4
SECTION 1.4 OBJECTIVES	4
CHAPTER 2: ISSUES IN RED LISTING WIDE RANGING SPECIES	5
SECTION 2.1 HISTORY AND INTRODUCTION TO THE IUCN RED LIST	5
SECTION 2.2 MAKING RED LIST ASSESSMENTS	6
SECTION 2.3 CRITERIA A: POPULATION TRENDS AND DECLINE	7
SECTION 2.4 ASSESSMENTS AT DIFFERENT SPATIAL SCALES	8
2.4.1 GLOBAL ASSESSMENTS	9
2.4.2 REGIONAL ASSESSMENTS	9
2.4.3 NATIONAL ASSESSMENTS	11
SECTION 2.5 UNCERTAINTY AND DATA QUALITY	11
CHAPTER 3: CASE STUDY –THE GREY PARTRIDGE (<i>PERDIX PERDIX</i>)	13
SECTION 3.1 THE GREY PARTRIDGE	13
3.1.1 ECOLOGY	13
3.1.2 DISTRIBUTION	15
SECTION 3.2 THE DECLINE OF <i>PERDIX PERDIX</i>	17
3.2.1 HISTORY OF DECLINE	18
3.2.2 CAUSES OF DECLINE	19
3.2.2i MECHANISATION	20
3.2.2ii PESTICIDES AND CHEMICALS	20
3.2.2iii SHOOTING	21
3.2.2iv HABITAT DEGRADATION OUTSIDE AGRICULTURE	22
3.2.2v GAMEKEEPERS AND PREDATOR CONTROL	22
3.2.2vi PARASITES AND DISEASE	23
3.2.3 SPATIAL AND TEMPORAL DIFFERENCES IN DECLINE	23
SECTION 3.3 CURRENT STATUS ON THE IUCN RED LIST	24
CHAPTER 4: METHODS	26
SECTION 4.1 SOURCES OF DATA	26
4.1.1 SCIENTIFIC STUDY AND LITERATURE	26
4.1.2 BAG COUNTS	26
4.1.3 CENTRE FOR POPULATION BIOLOGY (CPB)	27
SECTION 4.2 DATA SOURCES AND PARTRIDGE EVALUATION	27
4.2.1 PARTRIDGE SURVEY METHODS	28
4.2.1i NGC AND GAME BAG COUNTS	28
4.2.1ii SPRING CENSUS	28

4.2.1iii <i>POST BREEDING: AUGUST STUBBLE COUNT</i>	28
SECTION 4.3 DATA ANALYSIS	29
CHAPTER 5: RESULTS	30
<hr/>	
SECTION 5.1 PERSONAL RESEARCH	30
SECTION 5.2 CPB DATASET	32
CHAPTER 6: DICUSSION	37
<hr/>	
SECTION 6.1 MONITORING WIDELY DISTRIBUTED SPECIES	38
6.1.1 EXAMPLE OF THE TIGER	38
6.1.2 GLOBAL FISHERIES	39
SECTION 6.2 RECOMMENDATIONS	40
6.2.1 FOR IUCN RED LIST AND GREY PARTRIDGE	40
6.2.2 GREY PARTRIDGE CONSERVATION	42
SECTION 6.3 LIMITATIONS OF STUDY	44
SECTION 6.3 FURTHER RESEARCH	45
CONCLUSION AND ACKNOWLEDGEMENTS	46
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REFERENCES

APPENDICES

Chapter 1: Introduction

1.1 Problem Statement

Choosing what scale to monitor a species is a constant quandary in the field of conservation, especially if the species in question has a wide distribution. This is a problem faced by many species that have a large Area of Occurrence (AOO) but are declining, such as pelagic fish or migratory birds. Many of these species have inaccurate or data poor records on their population and the sheer size of their range makes it difficult to try and assess their threat status so perhaps how the Red List evaluates species that are wide ranging should be addressed. The spatial variation in population trends should also be examined i.e. how does a species that is declining at different rates in different places compare to a species that is declining uniformly across its range. Galliformes are amongst the most threatened of the bird orders, with approximately 26.4% species being listed as threatened. The grey partridge, *Perdix perdix*, was once a common species in Europe's agricultural landscape but has suffered from massive declines over the last half century. Habitat destruction and the increased use of pesticides caused by the intensification of agriculture post WWII can be cited as the main cause behind the falling numbers. However, whilst the species has suffered from declines it is not listed as threatened on the IUCN Red List. One of the reasons behind this is that the species has a wide range – it can be found, albeit in small numbers in some countries, over most of Europe and North-west Asia. Why is the species not listed on the Global Red List when clearly it has suffered from massive declines and is listed as threatened on the European Red List?

1.2 Literature Review

1.2.1 The Grey Partridge

The decline of the grey partridge has been well documented in the past, with the species being important both as a game bird and as an indicator species for farmland ecosystems. The grey partridge has seen an overall decline as high as 79%, but as mentioned is only listed as Least Concern on the Red List (BirdLife International, 2007). There has been a lot of previous research of which the most prominent publication is the seminal book by Potts (1986) *Partridge: Pesticides, Predation and Conservation*. This book gives a thorough overview of the decline of

the species as well as more detailed factors behind the decline such as pesticides and predation. However, whilst this book provides essentially all the information on partridge ecology it was also written more than 20 years ago. But, it remains the most comprehensive information on partridge decline; more recent publications focus on particular countries such as the paper by Bro et al (2001), which studies the environmental factors behind partridge decline in France. In the UK the partridge has been intensively studied and been the subject of many papers and several long term projects. The Sussex Study started in 1968 as a way of determining partridge declines and to date is the longest running projects on farmland in the world, there is also the GCTs Partridge Recovery Project (Aesbischer, 2003). A paper by De Leo et al (2004) compares partridge populations from the UK and continental Europe. The paper's aim was to model the extinction risk of the two different, and use it to design a stochastic demographic model and to use the model to assess the risk of extinction under different management practices. This is useful for making conservation decisions for the grey partridge but, does not look at the species as a whole. What the literature reviewed shows is that there is a need to look at the partridge decline over its entire range, how it varies spatially and why.

1.2.2 The IUCN Red List

The IUCN Red List has been well studied and has received much review since it was introduced in the 1960's (Mace et al, in press). The topic of interest here is one of spatial scale and this has also been investigated. There were a number of papers published around the period that the IUCN regional Red List guidelines were released. A paper by Gärdenfors (2001), which looked at how to classify threat to species at national vs. global scales, was published just before the regional guidelines. Gärdenfors (2001) highlighted the fact that when trying to assess a species at a smaller scale you cannot use the global Red List criteria as the population thresholds and timescales involved are more susceptible and arbitrary to change and so therefore the assessment would be inaccurate in its estimation of extinction risk. One other factor that Gärdenfors (2001) emphasized was the confusion of those making these smaller scale assessments; about how to do them. This aspect of confusion is reiterated in more detail in Miller et al (2007), which focuses on the problem of making small scale assessments using the IUCN's regional guidelines. The paper's aim was to 1) determine current and potential use of IUCN criteria and IUCN regional guidelines for red listing; 2) assess needs of regional users of the criteria; 3) evaluate the

feasibility of application of regional guidelines and 4) explore how national species lists and IUCN criteria have been incorporated in national conservation policies. Miller et al's study showed that that few countries have used the regional guidelines, perhaps due to no previous knowledge of their existence or confusion about how to use them. What is evident from the literature is that there is much confusion on making assessments, especially at the smaller scale. This will lead to inaccurate estimations of extinction risk. In relation to the grey partridge this is hugely significant as the species has a large range from its endemic home of Europe and Western Asia to its introduced home in the USA. One might assume as the species has such a large distribution it has a low risk of extinction.

1.2.3 Monitoring species at different spatial scales

One paper that ties the problem of spatial scale and monitoring declines in species is by Seminoff and Shanker (2008), which looks at the problem of assessing marine turtles for the IUCN Red List. Seminoff and Shanker (2008) discuss how assessing species which have a wide distribution is complex due to the difficulty of spatial scale. Simply looking at the population as a whole can lead to an oversimplification of the problem, missing out the differing local-level population dynamics and factors behind the trends. They use the example of the Leatherback turtle which is Critically Endangered (CR) on the Red List. But, the assessment is not entirely accurate as there are stable and increasing nesting populations in the Atlantic Ocean. A paper by Walters (2003) reinforces the danger of overlooking or oversimplifying the situation. Whilst the paper's focus is the spatial scale of fishing data, Walters advocates that it is a mistake to make assumptions about certain aspects of spatial data. The collapse of fish stocks has been well documented and often attributed to the oversight of population trends at both ends of the spatial scale. An example of this is just using the catch data from fished cells assuming it will be representative of the species population, whilst ignoring features such as shoaling or migration. Walters' conclusion is that ultimately certain assumptions *will* have to be made about aspects of the population but ignoring un-fished areas can lead to severe hyperdepletion of stocks. These papers are important for highlighting the problems of spatial scale in making conservation decisions, especially when it comes to species which are widely distributed such as pelagic fish or marine turtles. One of the interests of this study is how to assess the partridge when it has such a large range.

1.3 Aim

To address the relationship between the scale of assessment, data availability and threat classification for wide ranging species; looking the grey partridge as a case study.

1.4 Objectives

- A. Evaluate the use of trend data in threat assessments in the IUCN Red List to date, using examples from a range of taxa
- B. Examine how best to determine levels of threat when the species is wide ranging and often data poor. This will use the Grey Partridge as a case study to examine some of the issues raised by other studies.
- C. Evaluate the effect of the spatial scale of the data and the assessment itself on the outcome of threat assessments. Using the Grey Partridge and other studies, make recommendations on spatially problematic species assessments.
- D. Based on the analyses above, revisit the grey partridge assessment, and update it based on the data and insights obtained during the study.

Chapter 2: Issues in Red Listing Wide Ranging Species

2.1 History and introduction to the IUCN Red List

There has been unprecedented rates of extinction and loss of biodiversity, with the current extinction rate being 1000 times higher than background rates (Balmford, 1996; Butchart et al, 2004; Collen et al, 2006). But, information is needed to combat the current crisis of biodiversity loss - this information is needed to design, implement and plan effective conservation strategies whilst also communicating the scope and severity of the problem (Baillie et al, 2004). The IUCN Red List (RL) of threatened species was established to assess and monitor threat to species whilst also raising awareness and has become the most comprehensive resource in detailing threat statuses to species of plants and animals (Rodrigues et al, 2006; Mace et al, in press). It is supported by the RL consortium which consists of the IUCN, Birdlife International, Conservation International and NatureServe (Baillie et al, 2004; Butchart et al, 2004) The IUCN first produced the RL in 1966 (although prototypes had been circulating since 1962) and dealt solely with mammals – further volumes which included birds, reptiles and amphibians followed in 1968 (Baillie et al, 2004; Lamoureux et al 2003 Milner-Gulland et al, 2006). The early RLs were written and assessed by experts and the assessments were made without a protocol, thus were entirely subjective (Rodrigues et al, 2006; Seminoff and Shanker, 2008). At the time this idea was revolutionary, but the subjectivity and bias of the assessments was subsequently realised (Mace and Lande, 1991; Rodrigues et al, 2006). Because of the subjective nature of the assessments, they were vulnerable to scepticism, uncertainty, and controversy especially where there were potentially commercial interests at stake or the species in question raised strong emotions (Mace et al, in press).

The early assessments classified species as ‘endangered’, ‘vulnerable’ and ‘rare’ however, in 1984 the IUCN attempted to introduce more precisely defined categories; Extinct, Endangered, Vulnerable, Rare and Insufficiently known (Hill, Pers Comm; Mace et al, in press). These categories provided a set of definitions that could be applied to species, but judgment was still largely subjective and so there was still a lack of standardised criteria (Mace et al, in press). However this review of the RL identified the pressing need for a widely applicable and objective system and so a proposal for new categories with quantifiable criteria was made (Mace et al, in

press) In 1994 a new classification system was formally approved by the IUCN which took into account the major factors known to affect species vulnerability such as population size and tried to make assessment process more quantitative¹ (Mace et al, in press; Milner-Gulland et al, 2006; Seminoff and Shanker, 2008). The 1994 criteria incorporated a system that was qualitative and in theory could be used by anyone – and lead to the same conclusions (IUCN, 1994). However, the revised criteria still had its problems i.e. the assessments were mainly based on estimates, and some organisations do not use the RL and have their own method of classifying threat (Hill, Pers Comm; Miller et al, 2007). Over the next 10 years there was an intensive review of the criteria and in 2001 new criteria was revealed (Mace et al, in press). The new criteria included new threat statuses and new categories to be used in the assessments². The criteria were divided into sections; A: population trends, B: changes in range size and habitat, C: small population size and decline, D: Very small or restricted population and E: Quantitative analysis (such as Population Viability Analysis) (IUCN, 2001; Joseph and Possingham, 2008). Since the new criteria was introduced there have also been guidelines published by the RL for making regional assessments (section 2.4) which was met with some confusion (Miller et al, 2007). Currently the RL is updated and reviewed annually and to date there have been over 30,000 assessments (Lamoureux et al, 2003).

2.2 Making Red List Assessments

The IUCN (1996) states that the goals of its Red List are to 1) provide a global index of the state of degeneration of biodiversity and 2) identify and document those species most in need of conservation attention if global extinction rates are to be reduced (IUCN, 1996; Mace et al, in press). So, the criteria needs to be transparent and objective whilst also being applicable to a variety of species and habitats (Butchart et al, 2004; Mace et al, in press). The original criteria did not fulfil these requirements, however the criteria has changed dramatically since the first RL was published in 1967 and the manner in which assessments are made has also changed. The 2001 criteria is the most recent revision of the RL and is what assessments made today are based on. There are 3 categories representing threat level: Critically Endangered (CR), Endangered (EN), and Vulnerable (VU) (Hudson, 2002; IUCN, 2001). The categories are defined

¹ See Appendix 1 for the 1994 revised criteria

² See Appendix 2 for the 2001 criteria and thresholds

qualitatively by decreasing probabilities of extinction over increasing time scales and explicitly by 5 criteria (A through E) (Butchart et al, 2004; Butchart et al, 2006; Hudson, 2002; Mace et al, in press). To qualify for listing in any of the threat categories, a species needs to meet any one of the 5 criteria A through E at that level (Hudson, 2002; Mace et al, in press). Species that do not meet the thresholds for a threat category are listed as Least Concern (LC); however some species may not have been assessed against all the criteria due to lack of information and so these species may be listed as Data Deficient (DD) (Hudson, 2002; Mace et al, in press). The category Near Threatened (NT) is sometimes used if a species does not qualify as threatened but is close to the thresholds, or is likely to in the near future (IUCN, 2007a; Mace et al, in press).

Assessments are made usually by the IUCN Species Survival Commission (SSC) specialist groups appointed by the IUCN or by participants of Global Biodiversity Assessment workshops - however assessments can be made and submitted by anyone for consideration by the IUCN (IUCN, 2007a). The IUCN RL only ever includes global assessments – national or regional assessments are not considered, a species that is endemic should have the same status at both a national and global level (IUCN, 2007a). According to the IUCN assessment process, the data for the assessed taxon must include all available information across its entire range and assessors must take into account past and present literature. The 2001 criteria with the A – E categories details that the attributes specified (such as change in Area of Occurrence, AOO) must have been assessed over a 10 year or 3-generation time frame, of which the latter is used for long lived animals (Seminoff and Shanker, 2008).

2.3 Criteria A: Population trends and decline

Criteria A on which evaluated taxa are assigned a threat status based on negative population trends is of particular interest due to its relevance to the grey partridge and widely distributed species. For species, such as the grey partridge or pelagic fish, which have a potentially large Extent of Occurrence (EOO), criterion A and possibly E are the only applicable criteria (Seminoff and Shanker, 2008). The other criteria on which designations are based on changes in absolute numbers of mature individuals (criteria C and D) are considered inappropriate for organisms that are widely distributed as they may not accurately reflect population decline (Seminoff and Shanker, 2008). This widely held belief was given further credence in a study of

marine turtles by Seminoff and Shanker (2008). Leatherback turtles are classified as ‘Critically Endangered’ on the RL due to a decrease in global nesting trends. But, this designation failed to reflect that there are stable and increasing nesting populations in the Atlantic Ocean. The same is true of the hawksbill, green, logger-head and olive ridley turtles (Seminoff and Shanker, 2008). However, the opposite could also occur. Another scenario is that whilst the taxon has a wide distribution there is a core population which remains stable, but with declining populations on the peripheries of the range and so whilst the population is seen as declining the core population remains viable (Mrosovsky, 2004). What can be gathered from this point is that species which have large ranges are extremely hard to study due to costs, logistics and potentially low density. There are many examples of like this. The tiger is discussed in chapter 5 along with the global fisheries. Looking at the species on a large, general scale may lead to declines being missed at the finer scale. However, looking at species only at the finer scale could lead to details being missed in other localities (Joseph and Possingham, 2008). So a RL designation may not reflect the true risk of extinction (Seminoff and Shanker, 2008). As mentioned the criteria is assessed by evaluating population trends, but how reliable are the assessments made when sometimes the information is incomplete, based on estimates and projections? Criteria A poses a problem in its evaluation as temporal as well as spatial data is needed, although the data can encompass past, present and future (predicted) trends (Seminoff and Shanker, 2008). On the basis of decline rates only and with no threshold population sizes, criterion A has the potential to force the inclusion of some extremely abundant populations onto lists of threatened species (Mace et al, in press). It has therefore been controversial, especially for widespread species with historical declines that are believed to have stabilised (Mace et al, in press). Undoubtedly criterion A is important, but species listed in this way can represent a wide array of circumstances; in the case of species listed only under criterion A, there is real urgency to assess the causes of the decline and determine what interventions (if any) are necessary (Mace et al, in press).

2.4 Assessments at different spatial scales

The IUCN criteria were developed to try and increase objectivity and comparability of RLs and have been used globally by countries to develop regional, national and local lists of threatened species (Butchart et al, 2006; Miller et al, 2007). In this section the benefits and problems of

making assessments at the different spatial scales are discussed with special interest on the regional and global assessments.

2.4.3 Global assessments

The RL which is published by the IUCN is based on assessments made on a global scale (Gärdenfors et al, 2001; Miller et al, 2007). The IUCN Red List assesses the status of species at global level because this is the scale at which extinction occurs (Mace et al, in press). The regional, continental and national RLs are rarely taken into account when making or revising species assessments (Mace et al, in press; Miller et al, 2007). Not looking at the smaller scaled RLs is an oversight by the IUCN, as it is on the small scale where humans and biodiversity interact. However, this is not to say that RL is redundant. On the contrary it is a highly useful tool in the world of conservation. The most fundamental intended use of the system is to measure extinction risk and not other factors such as rarity or ecological role (Mace et al, in press). Apart from its many uses in species conservation, the IUCN Red List is used in applied and theoretical conservation research, in legislation, and for national and international conservation planning and priority setting (Mace et al, in press; Rodrigues et al, 2006).

There have also been a series of large-scale assessments for the different animal classes although there has been a bias towards the well known species i.e. mammals (Hudson, 2002; Rodrigues et al, 2006). A total evaluation of mammals and birds has been carried out with assessments currently being done on reptiles and amphibians (Mace et al, in press; Rodrigues et al, 2006). Whilst this is a positive aspect there is a dire need for a Taxonomic expansion of assessments as less than 2% of species have been examined (although the majority of the species lacking assessments are insects) (Hudson, 2002; Rodrigues et al, 2006). The assessments also need to be more rigorous and a major limitation of the RL is the lack of knowledge about most species and the instability of the application of species concepts (Rodrigues et al, 2006). There is also, as so often occurs in the field of conservation a severe lack of funding, leaving the IUCN unable to cope with increasing amounts of data (Rodrigues et al, 2006).

2.4.2 Regional assessments

Since RLs were first published there has been a demand for a system that could be used within countries or other defined areas (Mace et al, in press). However, the criteria as it stands is not

suitable to be used at a smaller scale as the criteria thresholds would not relate to the viability of the species (Keller et al, 2005; Mace et al, in press).

When the population to be assessed is regionally isolated from populations outside the region, it can be treated in the same way as an endemic species taxon and so the standard criteria can be used (Gärdenfors, 2001) But, when the criteria are applied to part of a population defined by a geopolitical border or to a regional population (which occasionally interchanges individuals with other populations beyond the border) the thresholds listed under each criterion will be incorrect as the unit being assessed is not the same as the actual species population (Gärdenfors et al, 2001; Miller et al, 2007). The RL criteria were developed to be used at a global scale and applying the criteria to only a portion of the population present within a particular region artificially divides the population into a restricted subpopulation, which have a higher risk of extinction (Gärdenfors et al, 2001; Mace et al, in press). One of the problems with global RLs is how to deal with cross border populations and the non-breeding phases of species that are nevertheless dependent on the region for certain resources (Collen et al, 2006). The artificially divided populations when assessed individually were seen to have a higher risk of extinction than they actually faced (Gärdenfors et al, 2001). To avoid this problem of incorrect regional assessments the IUCN developed regional guidelines which are adapted for use at the regional scale. These took into account the effect that subpopulations outside the region may have on the risk of extinction of the subpopulations in a particular region (Miller et al, 2007). The IUCN began to develop the regional guidelines in 1996, and there has been a continuing process of development, review, refinement, and further review since their formal adoption in 2003 (Gärdenfors et al, 2001; Mace et al, in press).

The regional guidelines have been tested in several countries where its strengths and weaknesses have been observed - with suggestions for improvements (Miller et al, 2007) But, no formal review has been done, and whilst there is a demand for regionally applicable IUCN criteria there has been no systematic study to see the extent of use or if it even meets the user's needs (Miller et al, 2007; Milner-Gulland et al, 2006). Miller et al (2007) carried out a survey of 180 countries about the regional guidelines. From their survey, Miller et al (2007) found that there was little response regarding the regional guidelines, which implied that few countries have used them or had no previous knowledge of their existence. One of the reasons behind the creation of a regional criterion was that those producing national Red Lists were feeling confused

about geographical scale and issues arising from political borders that divide a population (Gärdenfors et al, 2001). The regional RL guidelines, however, seem to have created as much confusion as there was previous to its existence, and so far few countries have used them (Keller et al, 2005).

2.4.1 National and local assessments

The IUCN red list is recognised as the authoritative source of information on the global conservation status of plants and animals, but it is at the local and regional scale that human actions and biodiversity collide and so interest in producing regional and local lists has increased (Miller et al, 2007; Milner-Gulland et al, 2006). National lists are influential in the protection and conservation of threatened species as the institutions that make them are often the national government (Miller et al, 2007). And, it is at the national level that generally the most effective conservation occurs. Indeed, few mechanisms are available to conserve species above the national level, and global conservation agreements such as CITES and the Convention on Biological Diversity (CBD) recognise national sovereignty and rely primarily on implementation within countries (Mace et al, in press).

But interpreting national lists is difficult as they often serve different purposes in different countries and therefore have a wide range (not standardised) of methodologies (Miller et al, 2007). There also may be a different stance in the thresholds and interpretations of the different threat categories. The RL tries to assess the extinction risk of a species and so unless the species is endemic, the extinction risk on a national list is not relevant. Currently 76 countries use the RL at the national level (Mace et al, in press).

2.5 Uncertainty and Data Quality

RAMAS is the software used by the IUCN RL to input data in order to make assessments (RAMAS, 2003). It allows for uncertainty in the data which is represented by a ‘fuzzy number’ which is a number whose value is not precisely known. This can lead to uncertain assessments. So what is the IUCN’s way of coping with uncertainty? With any species assessment there is bound to be inconsistent and missing data but still threat statuses are assigned. There are different kinds of uncertainty which according to Akçakaya et al (2000) are; semantic uncertainty, measurement error, and natural variability. Existing methods do not explicitly

consider the amount and quality of the data, despite the fact the data for different species vary markedly (Akçakaya et al, 2000). There is no consensus regarding the problem of how to rank species when data is missing; some ignore the issue and relegate the species to a non-threatened category, whilst others let the missing data induce a status near the middle threat categories (Akçakaya et al, 2000). Mace et al (in press) recommend representing uncertainty by assigning species to a range of categories instead of a single category, because the criteria require each species to be assigned to a single category, the range of categories representing uncertainty is indicated only in the documentation of the listing. So when the variables are uncertain, the reduction of the uncertainty into a single category of threat involves attitudes to risk and uncertainty thus, even though there will always be subjectivity when dealing with cases with large amounts of uncertainty, the recommended methods make such attitudes transparent and provide an objective way of transforming data uncertainties into a range of plausible threat categories.

Anyone can make a RL assessment, but data quality has to be ensured. The IUCN does have a peer review system in place to try and ensure data quality. This entails that all assessments are scrutinised by at least two people from a designated RL authority (IUCN, 2007b). For birds the RL authority is BirdLife International, and they provide all the assessments that appear on the RL (Baillie et al, 2004; IUCN, 2007b). Anyone can make a RL assessment, but data quality has to be ensured.

Chapter 3: Case Study –The Grey Partridge (*Perdix perdix*)

The grey partridge (here after referred to as the partridge) belongs to the avian order known as Galliformes which includes such families as the pheasants, quails and grouse (Brickle et al, 2008; Clark, 2007; Keane et al, 2005). It is well known that many species of birds are declining due to human factors however; some families and orders seem to be more vulnerable than others (Brickle et al, 2008; Keane et al, 2005). Currently on average about 12.4% of birds are listed as threatened but, with the Galliformes approximately 26.4% are listed as threatened making them globally one of the most vulnerable groups of birds (Brickle et al, 2008; Clark, 2007; Keane et al, 2005). The Galliformes order contains the vast majority of economically and socially important game birds and some species have been hunted for thousands of years (Brickle et al, 2009; Harris and Pimm, 2007; Keane et al, 2005; McGowan et al, 1995; Owens and Bennett, 2000). So why is it only recently that the species is perceived to be declining? This chapter gives an overview of the grey partridge; its ecology, decline and current status. Much of the information in this chapter is from Potts (1986) unless otherwise stated.

3.1 The Grey Partridge

3.1.1 Ecology

The grey partridge originated as a grassland bird on the open, largely treeless steppe (GCT, 2006). Its origin in the grassy, open steppe allowed it to adapt easily to arable farmland, where it can find both food, shelter and nest sites (GCT, 2006). It is a typical game bird of open arable landscapes (De Leo et al, 2004; Uimaniemi et al, 2000). It was the diffusion of agriculture into Europe, with the ensuing forest clearance, that allowed it to spread over much of the continent and let its population increase (De Leo et al, 2004). The partridge is one of three closely related species in the genus *Perdix*, and was thought originally to be a grouse (Potts, 1986). The partridge has many varieties that can be divided in to two groups; the rufous brown found in Western Europe and the paler grey found mainly in Eastern Europe as seen in figure 3.1.



Figure 3.1 Showing the difference in plumage colouration between the western (left) and eastern (right) grey partridge. The western *P. perdix* has a more vivid and bright colouration compared to the eastern partridge. Source: Google images (2008).

In these groups there are subspecies of *P. perdix* such as *P. p. sphagnetorum* or the *P. p. lucida*, but exactly how many subspecies there are is open to debate and testing using modern genetic methods. One aspect is that variation in the pigmentation of plumage is thought to be caused by diet and climate rather than genetic differences, and at present there are eight accepted subspecies.

The partridge prefers open, low intensity, mixed farmland comprising of small fields bounded by hedgerows and an important aspect of *P. perdix* habitat is having significant herbaceous cover (Buner et al, 2005; Šálek et al, 2004; Steihl, 1984). Whilst this is the preferred habitat there is little of this left since the agricultural mechanisation/intensification post WW2, and so the bird is commonly found on high intensity cereal farmland (Šálek et al, 2004). The hedgerows of fields and long grass provide the partridge with cover and nest areas (Steihl, 1984).

P. perdix breeds in its first summer and lays the largest brood of eggs of almost any bird, as many as 16 eggs. Chicks hatch typically in late June, and both parents look after them; feeding them on a diet consisting mainly of live insects (De Leo et al, 2004). By the end of the summer the surviving chicks, parents and other adult birds form groups called coveys³ – the covey will spend the winter together (De Leo et al, 2004). During the winter the birds feed mainly on grain from growing cereal, and may spend their entire lives in the same few fields (Potts, 1986). The

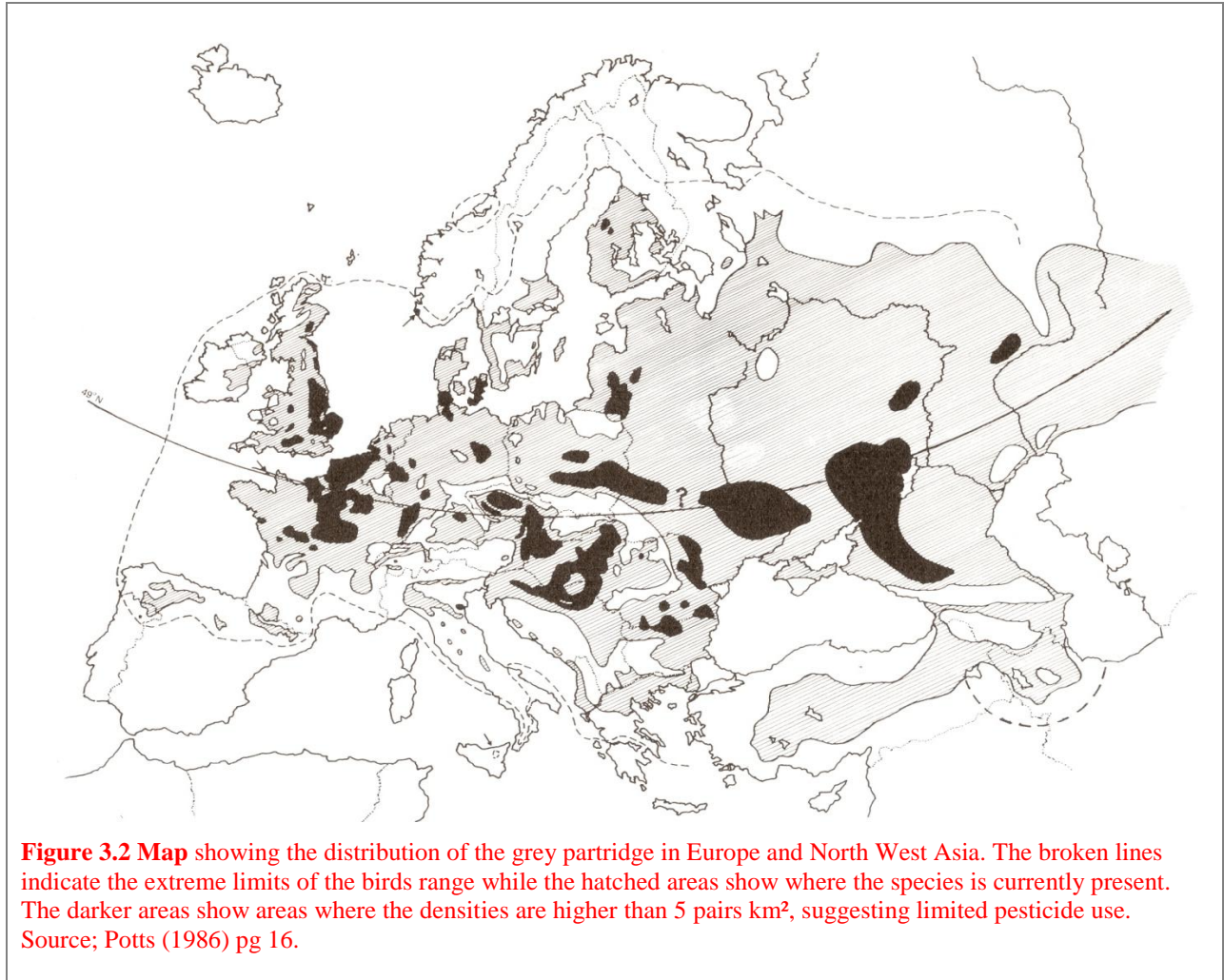
³ See Appendix 3 for definition

partridges pair off late in winter, and search for a nesting site which will ideally be covered by long grass (Potts, 1986).

3.1.2 Distribution

The Grey partridge is currently found across Europe into western Asia, and in some areas of northern USA and southern Canada (BirdLife International, 2007; Dumke et al, 1980; IUCN, 2007A; De Leo et al, 2004). The bird has a large range thought to be around 10,000,000 km² (BirdLife International, 2007; IUCN 2007). The partridge is thought to have originated in Asia and originally established itself in the Euro Mediterranean sub-region and then spread into Europe following the spread of agriculture (De Leo et al, 2004).

Currently, as can be seen in figure 3.2, the partridge has areas of high population densities in areas of the UK, France, Hungary, Czech Republic and Russia. However, there has been a contraction in the range of *P.perdix*. In the northern periphery there has been a marked retreat south, in some places such as Scandinavia and Russia by as much as 200 miles (Uimaniemi et al, 2000). However, the same has been seen in the southern extent of the grey partridge range. In Spain, Portugal and Italy there has been a large contraction in the range which was especially prominent in the 1960's. Figure 3.2 also shows the areas where *P.perdix* used to be found. What is not obvious in Figure 3.2 is where it is found in Asia. According to the IUCN (1996) the partridge is found in the following Asian countries: Azerbaijan, Iran, Mongolia and Uzbekistan. What is not known is the abundance in these countries which is an opportunity for further investigation.



P. perdix, whilst endemic to Europe and Asia has also been introduced in other countries as a game bird (Dumke et al, 1980). In the USA and Canada the partridge was first introduced in the nineteenth century, but there were no successful releases until the late 1800's/early 1900's (Dumke et al, 1980). Seen in figure 3.3 the primary range for the partridge extends from North West Dakota, USA through to Alberta, Canada (Dumke et al, 1980). There were other attempted releases in New Zealand, Australia, Chile and Hawaii but all ended in failure.

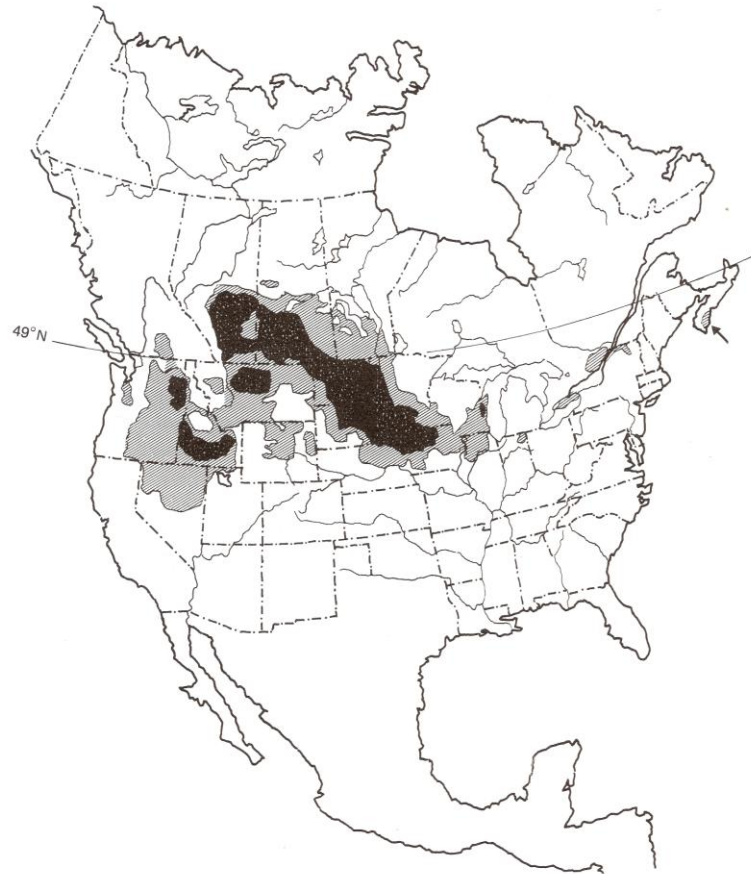


Figure 3.3 Map showing the distribution of the grey partridge in the USA. Dark areas indicate areas of partridge densities higher than 5 pairs km², which suggests limited use of pesticides. Source; Potts (1986) pg 20.

3.1.3 The economic importance of game birds

The Galliformes, or game birds, form an important economic and social part of rural life. All over Europe the birds have been hunted for thousands of years (Keane et al, 2005). The grey partridge is no exception; it has played an important role in hunting and shooting for many years (Bro et al, 2000). One reason behind the partridge's importance as a quarry species was its excitement when disturbed and its delicious flavour. Whilst the hunting of the partridge has been done for many years, using hunting dogs and falconry, it wasn't until the gun became viable to use as a hunting implement that it became popular. However, due to its importance as both a source of food and money forms of partridge conservation were established from the early 1600's. In former Czechoslovakia in 1630 a law existed where 2 hens and a cock should be released from every covey trapped.

In the British Isles there is still large revenue taken from the shooting of game birds. Benefits of shooting game birds to the local economy are significant with an estimated £600 million input into the rural economy per annum, and supporting around 40,000 full time jobs (Canning, 2006; Keane et al, 2005).

In the United States there is a huge hunting industry which has profits of hundreds of millions of dollars per annum. The sole reason for the grey partridge being introduced into the USA was as a game bird, and so it has significant economic importance (Dumke et al, 1980; Potts, 1986). Game birds in the USA in 1996 incurred revenue of more than \$4 billion and supported 55,546 jobs (DFG website).

3.2 The Decline of *Perdix perdix*

3.2.1 History of decline

The Partridge expanded into Europe with the advent of agriculture from the Asian steppes, northwards from the semi deserts of the Mediterranean (Donald et al, 2002). The widespread agricultural landscapes of Europe suited the species and provided the food and shelter it needed so its population could increase. The partridge was hugely abundant especially in areas of France where bag counts⁴ as high as 5000 were recorded. In the UK at the turn of the century there were as many as 2 million birds shot annually (Aesbischer and Ewald, 2004). Due to its importance as a hunting bird there have been records kept about numbers for hundreds of years, for instance spring counts to assess stocks were carried out in Austria from 1695. This element, which was used by game keepers and land owners for an economic purpose has in turn been used as a way of monitoring long term populations of the *P.perdix*.

However, agriculture which provided the partridge with its habitat became its adversary. The decline of the partridge can be linked back to the Second World War and the initiation of intensive farming that was sparked by food shortages. During WWII, Europe saw mass food shortages and many countries experienced starvation. Once the war had ended it was decided that a countries' population should never go hungry simply because it was unable to grow enough food. In the UK huge areas of land were given over to arable farming, which at first sight would seem to favour the partridge but, it was also the dawn of modern farming and modern farming techniques (De Leo et al, 2004). The EEC (now the EU) was formed in 1957 and

⁴ Covey: A family or small flock of birds. Especially refers to game birds.

member countries were bound to a Common Agricultural Policy (CAP). The CAP helped agriculture in two ways. Firstly, it guaranteed fixed prices, establishing a price threshold below which the EU became the buyer, taking the produce out of the market and storing it (Donald et al, 2002). This had the effect of keeping prices high and stable. Secondly, the CAP imposed levies on cheaper imports and granted export “refunds” to allow surpluses to be traded competitively on the world market (Donald et al, 2002). This financial security for farmers proved the basis for intensification since, for the first time, higher yields would be guaranteed to result in higher incomes (Donald et al, 2002). By creating a protected market with guaranteed prices, the CAP has acted as a spur to agricultural intensification, which in turn has been detrimental to wildlife (Donald et al, 2002). Farmland birds have accounted for some of the highest declines in farmland wildlife, with the grey partridge being one of the flagship species for farmland wildlife conservation (Donald et al, 2002; Donald et al, 2006; PECBMS, 2007).

The grey partridge has been declining by -7% per year as part of a long term trend but has seen an overall decline of about -79% over 50 years (PECBMS, 2007). Of course there are some countries which have seen major declines whilst in other countries the population maybe relatively stable. There are areas of missing data or data deficiency; for instance there is little to no data from Russia and many of the eastern European countries (PECBMS, 2007).

3.2.2 Causes of decline

As mentioned, after World War 2 governments invested heavily in expanding their agriculture so that sufficient food could be grown to support the respective population. About 50% of mainland Europe is used for food production of some description, and supports a huge variety of life (Donald et al, 2002). The area used for farmland has changed little in the last 50 years and so research has been directed at changes in management as the main cause of the decline in birds (Donald et al, 2002; Vickery et al, 2004). Scientific advances made during and after the war enabled more efficient farming practices; use of pesticides, fertilisers, herbicides and machines. Since the 1950's the partridge population in the UK declined by > 80% (Aebischer and Potts, 1995).

The situation of the grey partridge is not a unique occurrence, the same problems have been affecting farmland birds the world over (Panek, 1997). In Europe the problem is acute due to a long history of agricultural intensification (BirdLife, 2004; Bro et al, 2001). Overall farmland

birds in Europe have suffered larger declines than almost any other group. There has been an average decline of 44% from 1985 - 2005, compared to forest birds which have seen declines of roughly 9% (PECBMS, 2007). However, the plight of the farmland bird has been recognised and in recent years there has been the initiation of schemes such as the Countryside Stewardship Scheme in the UK. These schemes compensate farmers for leaving part of their land either untouched or restored to certain habitats (Defra, 2002).

3.2.2i Mechanisation

At the beginning of the century there was little to no use of machines in farming and the majority of the work was carried out by hand or beast. The introduction of mechanisation into agriculture revolutionised the industry, ploughing, sowing and reaping could all be done by one person in a much shorter time span. However, to accommodate the large machines and to give them room to manoeuvre fields were enlarged and vital partridge habitat went with it (De Leo et al, 2004). Hedgerows were removed along with permanent vegetative cover which partridges would use to nest in (Aebischer and Potts, 1995; Bro et al, 2001; Rands, 1986a). The permanent vegetative cover is also an important source of food (e.g. insects and seeds) for partridge chicks and so this has an impact on chick survival (Panek, 1997). This is also linked to predation; partridge predation rates are naturally high throughout the year and therefore the availability of cover is a key factor for partridge survival (Buner et al, 2005). Partridge nests were and continue to be directly destroyed by farm machinery (Bro et al, 2001; De Leo et al, 2004). There is also disturbance caused by the farm vehicles; noise and movement could cause birds to deteriorate in health, migrate or perhaps even die.

3.2.2ii Pesticides and Chemicals

The advent of chemicals in farming spelled disaster for the wildlife that depended on farmland for its habitat. Whilst pesticides and herbicides enabled more successful farming and decreased the loss of crops it severely affected surrounding wildlife. Increased use of fertilisers and pesticides led to a loss in biodiversity of plants and invertebrates. This led to a loss of available food for chicks which consequently led to low survival rates (Klansek, 2002; Panek, 1997; PECBMS, 2007; Rands 1986b; Tout and Perco, 2000; Uimaniemi et al, 2000). Studies show that chick survival rates are heavily dependent on the availability of insects, with about 95% of their

diet consisting of insects in the first few weeks (Panek, 1997). A study by the Game Conservancy Trust revealed that chick survival rates averaged 49% before the introduction of herbicides and 32% once their use became widespread, so one can see the marked affect that pesticides are having on partridge populations (Aesbischer and Potts, 1995). Chicks which feed on a more vegetarian diet show poorer growth.

There is also the direct effect of chemicals on the partridge. There has been little evidence recently of poisoning due to chemicals as laws are more stringent and there has been an increase in the use of more biodegradable pesticides. However, there have been cases where certain chemicals proved toxic to partridges; an example of this is dieldrin which was banned in 1962 due to its toxic effects.

3.2.2iii Shooting

Whist agriculture is the main direct cause of the decline in *P.perdix*; there have been indirect factors as well. For instance hunting *P.perdix* has occurred for hundreds of years and was apparently sustainable until the turn of the century. Due to the decline in numbers caused by changing agricultural practices from the 1950's hunting became unsustainable, and so in turn was part of the problem rather than acting as an advantage. Ironically, in the last few decades farming incomes have fallen which has driven some farms to diversify by using their land for hunting and shooting game birds (Aesbischer and Ewald, 2005). This has led to concern that shooting is damaging the remaining stocks of wild grey partridges which may inadvertently be shot when hunting pheasants and red-legged partridges (Aesbischer and Ewald, 2005). An example of this is in Italy, where the population of the partridge was falling dramatically since the change in agriculture but there was little to no change in the amount of shooting (Tout and Perco, 2000). This oversight exacerbated the already failing population problem (Tout and Perco, 2000). Italy now has very few self sustaining populations of the partridge as discussed in 3.2.3. In France, where partridge shooting is popular, breeding pair densities have been maintained stable only through a drastic reduction of shooting bags (Bro et al, 2001). This problem is faced by many species; habitat degradation leads to population decrease so that traditionally sustainable practices become unsustainable (McGowan et al, 1995).

3.2.2iv Habitat degradation outside agriculture

Habitat loss is always an important factor driving biodiversity loss. In the case of the grey partridge, since it is a bird of arable landscapes one might think that this particular feature is not relevant. However, *P.perdix* does not exclusively live on farms. Estates play an important role in providing habitats for *P.perdix*, especially in countries such as France, Germany and the UK. As grey partridges declined, many estates switched from managing wild partridge stocks to shoots based on releasing artificially reared Pheasants and Red-legged Partridges (Aesbischer and Ewald, 2005). Others abandoned shooting altogether in favour of intensive farming (Aesbischer and Ewald, 2005). Urban expansion also causes habitat degradation as well as habitat loss. There has been a dramatic increase in human population in the last century and as a result an expansion in urban areas. Whilst this is not a large factor in the decline of the grey partridge it still plays a part; this particular aspect is more of a feature in Eastern Europe where there has been more intense rural-urban migration.

3.2.2v Gamekeepers and predator control

Predation is a major factor of partridge mortality in the breeding season in spring/summer especially in areas where there is little predation control (Bro et al, 2001). Hens are the most affected as they are unable or unwilling to leave the nest site and mortality rates may be as high as 60% in the breeding season (Bro et al, 2001). Historically in Europe, estates were havens for partridges as they were economically important, and so they were watched and protected by gamekeepers or wardens. However there has been a loss in gamekeepers which has led to a lack of predator control during the breeding season, which in turn causes an increase in chick mortality (Aebischer and Potts, 1995; De Leo et al, 2004).

There is also thought to have been an increase in predation rate, concomitant with habitat alteration which is a possible cause of partridge decline (Bro et al, 2001). Predation by raptors has increased in recent years linked to the increase in raptor numbers through conservation efforts; this can be a sensitive issue as raptors are still a conservation issue in Europe but then, so is the grey partridge (Bro et al, 2001).

3.2.2vi Parasites and Disease

This particular environmental factor is not a major source for partridge decline but has been cause for concern. There has been evidence of disease and parasite transmission from released partridges and pheasants to wild partridges (De Leo et al, 2004).

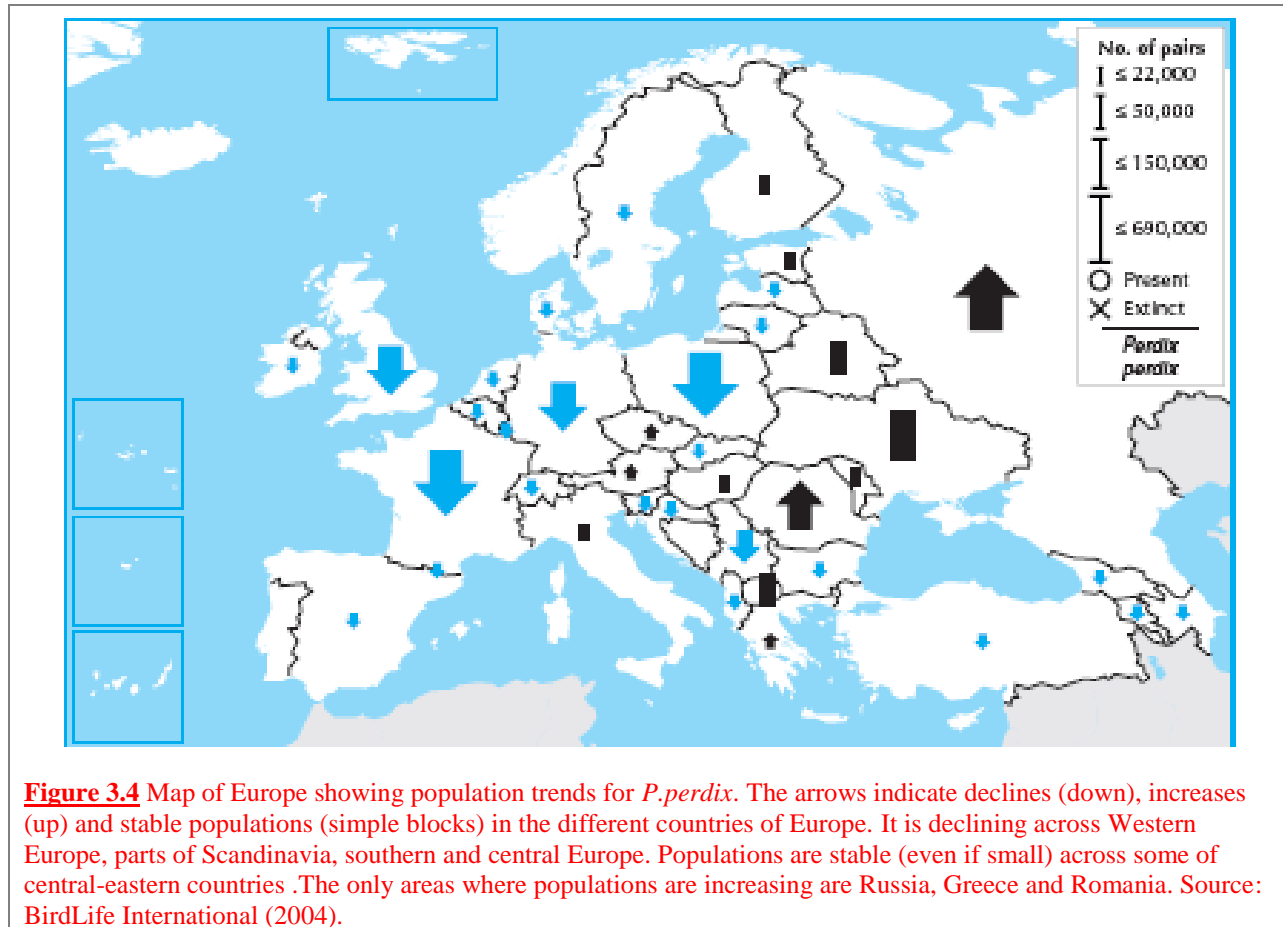
3.2.3 Spatial and temporal differences in decline

The decline of *P.perdix* has not been uniform across its range; some areas have seen a more marked decline whilst elsewhere populations have remained stable, figure 3.4 shows on a map the population status of *P.perdix* in Europe. The Iberian countries which mark the southern extent of the partridge's range have seen major declines (Acevedo et al, 2007). Other southern extremes of the partridge's range have also seen contractions northwards. In Greece *P.perdix* occurred south of the Gulf of Corinth but now occurs far to the north, and the status of the partridge in Iran is not known but there are suspected declines. Populations at the edge of their distribution range are of special interest because they help in our understanding of aspects such as ecological niches and threshold responses to environmental change (Acevedo et al, 2007).

Western Europe has seen some of the most dramatic declines that have occurred in countries where the partridge used to be plentiful. In Italy and Ireland there have been massive declines of 80% or more. Some of the earliest declines occurred in Ireland, which now only has two populations of the partridge remaining (Kavanagh, 1998; O'Gorman et al, 2000). Some of the Austro-Hungarian countries saw the highest densities of partridges in the world, for instance Hungary pre 1940 had a national bag of 1290000, but more recent population studies show that the national bag has fallen to almost nil and the national population perhaps as low as 30,000 (Báldi and Faragó, 2007). In Switzerland the partridge is currently extinct and in Germany the bag count fell from 1.5 million (pre 1940) to 28,000 in 1986 (Bro et al, 2001).

Eastern Europe has seen a less marked decline, mainly due to lag in agricultural development – however, now there *P.perdix* is declining more rapidly. The countries of the former Soviet Union had the highest bag counts of all, but also suffer from the most uncertainty due to lack of early data. Cultivated land in Eastern Europe is expanding continuously and stands at more than 2 million km², but the population status of *P.perdix* is still unknown but thought to be stable, with a possible increase, as can be seen in figure 3.4 (BirdLife International, 2004).

The introduced population of *P. perdix* in the USA has seen some changes since it was released but less dramatic than their European counterparts. A contraction in the range has occurred east of the Great Lakes due to reversion of the land to woodland. But, there has been no general retreat southwards as seen in the European and Asian populations.



3.3 Current status on the IUCN Red List

The grey partridge currently is listed as Least Concern on the IUCN Red List, although both BirdLife and the IUCN state that,

“Global population trends have not been quantified; there is evidence of population decline,”

However, the IUCN does not think that the population has reached the threshold criteria level of declining more than 30%. This assessment cannot be accurate as a) it states that population trends haven't been quantified; b) the last evaluation for this species was in 2000 before the new criteria was in use.

Another mitigating factor for this inaccurate evaluation is the partridge's status within Europe. As seen the partridge has seen dramatic declines in Europe which has led it to be assessed on the European Red List as Vulnerable, and its situation seen as unfavourable (BirdLife, 2004; BirdLife, 2007; Bro et al, 2001). National Red Lists are not considered when making global assessments, but the partridge is listed as endangered or critical in several countries such as Ireland, UK, Italy and Sweden (De Leo et al, 2004; UK BAP, 1995).

Chapter 4: Methods

4.1. Sources of data for grey partridge

From the review of data for the grey partridge it became patent that the information used for assessments came from a variety of sources which raised the question of data quality. This section looks at the different areas from data is obtained and how this affects assessments for the grey partridge.

4.1.1 Scientific study and literature

As mentioned in chapter 1 the partridge has been the subject of numerous studies and focus of scientific papers. Several long projects have been established, in the USA, UK but also in France (see Bro et al, 2000) and Ireland (e.g. Irish Grey Partridge Conservation Trust, see website for more details). These studies base their population estimate from actual surveys; the GCT has long term population trends from several different projects. The most common type of population census for the grey partridge is a count of pairs taken in springtime (Potts, 1986). Most studies cover small areas in a particular country, mostly in western and central Europe which could bias previous assessments. There is a severe lack of almost any information about the grey partridge in its Asian range, which seriously undermines any assessments previously made about the species. This is also a factor in this study, as any information from literature that was used is severely biased towards Europe. Partridge population estimates for the United States and Canada are also absent, the most relevant information is taken from bag counts where the highest numbers were 146,000 from North Dakota in 1988 and 91,000 in Saskatchewan (Carroll, 1993).

4.1.2 Bag Counts

For gamebirds bag counts are an important source of estimating population size, it is an indirect method but often used when direct counts are unfeasible (Cattadori et al, 2003; Potts, 1986). Red Grouse populations have long been studied using harvest data, and population estimates in these areas have been surmised from these counts (Bunnefield, 2008 Cattadori et al, 2003). Bag counts are the number of partridges (or any harvested species) shot on a given area over a certain

period. In the UK the GCT runs the National Gamebag Census (NGC) which was established in 1961. It acts as central repository of records from shooting estates in England, Wales, Scotland and Northern Ireland; the records comprise information from shooting and game keeping activities on the numbers of each quarry species shot annually (GCT, online). They also include data on the numbers of gamebirds released each year as well as historical data from the 20th and 19th centuries (GCT, online). There are obvious problems with using these data for trend analysis though. One of the major concerns is that harvesting data does not reflect actual population abundance but tends to underestimate low densities and overestimate high densities as a consequence of changes in harvesting effort (Cattadori et al, 2003). Corrections can be made to the harvesting effort so that bias is removed and real population trends revealed but this often is not possible (Cattadori et al, 2003). There is no universal linear relationship between bag count and actual population although some studies have demonstrated a good relationship (Cattadori et al, 2006; Potts, 1986). In summary bag counts must not be taken as true population estimates, but as indicators for population trends if the harvesting effort has been sufficiently amended.

4.1.3 Centre for Population Biology (CPB)

The dataset examined was produced by Lizzie Boakes of the Centre for Population Biology. It was taken from a larger database on Galliformes which has been used both for individual research and as part of the Global Population Dynamics Database run by CPB and the National Centre for Ecological Analysis and Synthesis (NCEAS). Lizzie Boakes current research is looking at spatial patterns in geographic range using the Galliformes as the case study. It encompasses more than 200,000 historical sightings dating from around 1800 to the present day and it being used to create a time-series of range maps for the Galliformes of Europe and Asia. The dataset which was used in this study comprised of historical and current sightings of grey partridge taken from Bird Atlases, journal articles and personal observations.

4.2 Data sources and partridge evaluation

There is a wealth of information available about the grey partridge but few (bar BirdLife, 2007) explicitly mentioned national populations, or previous population counts. Many discussed overall decline rates for their set country or European decline rates, but as far as can be seen from this study the only sources of information for a global decline rate was from Potts (1986) which was

made more than 20 years ago. This factor inhibits the study and in makes a current estimate of decline rate for any red list assessment very difficult. Outlined below are the various methods used for surveying the grey partridge. These are summarised to highlight

4.2.1 Partridge survey methods

Most common means for partridge population estimation is to use a variety of methods which are combined and analysed to obtain population trends. Fortunately with the partridge being a mainly sedentary bird it is easy to survey (Potts, 1986). The methods outlined here are taken from Potts (1986).

2.2.1i NGC and Game bag counts

As outlined in section 2.1.2 this is an important method for partridge population evaluation. In this country bag counts are managed by the GCTs NGC, other countries such as the USA have hunting censuses – USAs are overseen by the Fish and Wildlife Service. BirdLife International also uses bag counts in their assessments for certain species such as the red grouse and ring-necked pheasant (Birdlife, 2004).

2.2.1ii Spring census

The aim of the spring census is to count partridges (usually as pairs) in a certain area. The count is taken usually in the middle of March when birds have paired for mating but before stubble grows too high. This census is usually compared to nesting counts to see how feeding compares nesting sites. It is a relatively easy, accurate method of estimating partridge abundance over a small area.

2.2.1iii Post Breeding: August Stubble Count

This type of count is used to sample breeding success in the partridge. Counts are carried out in August post hatching but before birds have dispersed into their winter coveys. Surveyors walk or drive around the set area and count successful pairs and pairs without young. This census can show complete populations of small areas, as well as the breeding success of partridge pairs.

4.3 Data Analysis

From the dataset the points which had grey partridge population counts as well as dates were extracted and examined separately from the original dataset, along with the data source. The dataset has points from all over Europe, but with little data from outside Europe. The population counts are from surveys taken from the late 1800s onwards; however, these are not standardised censuses of populations and so should not be taken as true representations of partridge populations in Europe. The numbers for partridges were taken from a range of sources such as literature, bird atlases, websites, amateur reports and surveys.

The CPB dataset was investigated in several ways. One of the major tasks was to try and see if the dataset showed an overall decline in number of partridges. For this a Generalised Linear Model (GLM) is created with poisson error (to account for count data). The weighting of the different countries and used in the dataset was looked at. The number of records per country was calculated by summing how often it occurred in the dataset. This was then converted into an overall percentage.

Another aspect to be looked at is types of data used in the dataset along with how often that data source was used. The type of reference used is extracted much in the same manner as the countries data, i.e. report, journal, study and then summed to see how often this occurs. This total is then calculated as a percentage of the total number of references. A similar analysis is done comparing the data sources that are literature with the sources that are studies and personal observations. Number of records per year is shown to demonstrate sampling effort increasing over time. This was done to address the issues with the original decline data. The number of records for each year was calculated, by counting the records, and then plotted in a scatter graph.

Analysis on the dataset was conducted by R (R Development Core Team 2006)), and Microsoft Excel with data transformed as required.

Chapter 5: Results

5.1 Personal Research

There are major disparities in the data available for the grey partridge (Table 1). What can be seen is one that there is little to no information from a) Asia as none was found and b) from the former eastern Bloc countries such as Russia. The Iberian countries also show a lack in available data, Spain and Andorra show some whilst there was no data for Portugal (although it is expected that the species is regionally extinct). Figure 5.2 exhibits the weighting of the different sources of data which was used for Figure 5.1. Much of the information is from Bird Atlases, with bag counts being next. BirdLife International (2007) gained its information from its own previous reports, governmental reports and journal articles.

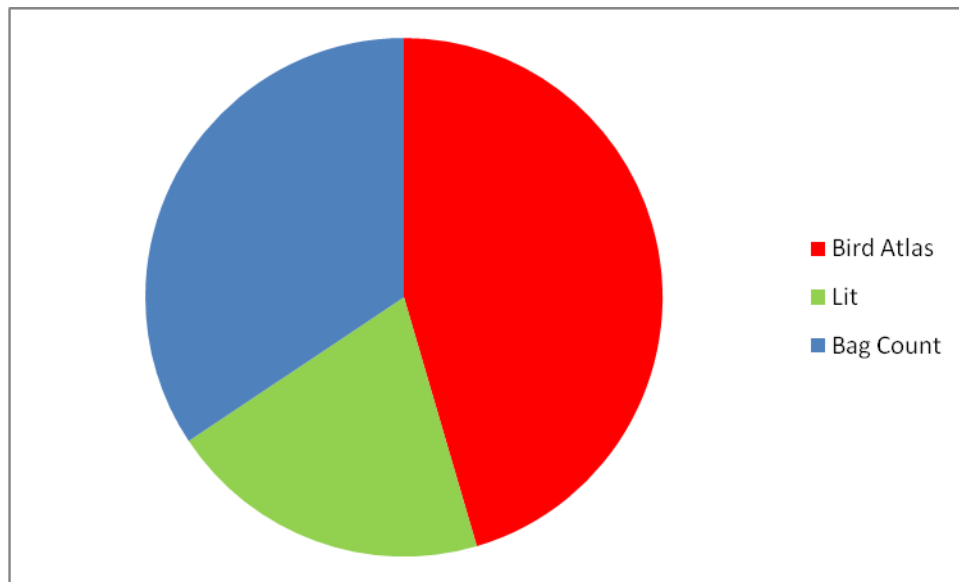


Figure 5.2 Chart showing the proportion of the data from Fig 4.1 coming from different information sources. Lit refers to information obtained from the peer-reviewed journals.

	Bag data pre-1940	Bag data post 1984	Current population	Overall Decline (% for last 50 years)	Data Sources
Ireland	7000	<100	20 pairs	>-80	BirdLife International (2007), Potts (1986)
UK	2,000,000	100,000	75,000 pairs	-80	BirdLife International (2007). GCT (online), Potts (1986),
France	40,000,000	215,000	500,000 pairs	-50	BirdLife International (2007), Bro et al (2000), Potts (1986),
Italy	500,000	<100,000 (released)	3,000 pairs	>-80	BirdLife International (2007), Potts (1986), Tout and Perco (2000)
Hungary	1,290,000	0	33,000 pairs		Báldi and Faragó (2007,) BirdLife International (2007), Potts (1986),
Germany	1,500,000	28,000	90,000 pairs		BirdLife International (2007), Potts (1986)
Poland	750,000	100,000	600,000 pairs		BirdLife International (2007), Panek (1997), Potts (1986)
Finland	18,000	3,250	5000 pairs		BirdLife International (2007), Potts (1986), Uimaniemi et al (2000)
Andorra	-	-	70 pairs		BirdLife International (2007)
Spain	-	-	6000 pairs		BirdLife International (2007)
Ukraine	-	-	90,000 pairs		BirdLife International (2007)
Switzerland	-	-	2 pairs	<80	BirdLife International (2007)
USA	1,084,000	<189,800	-		BirdLife International (2007), Potts (1986)
Austria	300,000	29,000	12000 pairs		BirdLife International (2007), Klansek (2002), Potts (1986).
Europe			2,000,000	-79	BirdLife International (2007), PEBMS (2007), Potts (1986)
Global	20,000,000	3,800,000	5,000,000	-75	BirdLife International (2004); BirdLife International (2007), IUCN (200), Potts (1986)

Table 1 Table showing examples of partridge data and its sources. This data was obtained from a variety of sources including peer reviewed journals and bird atlases as cited in the text. What it shows is the discrepancies in data available for the partridge.

5.2 CPB Dataset

The overall population over time in the CPB dataset is apparently increasing with time (Fig. 5.3).

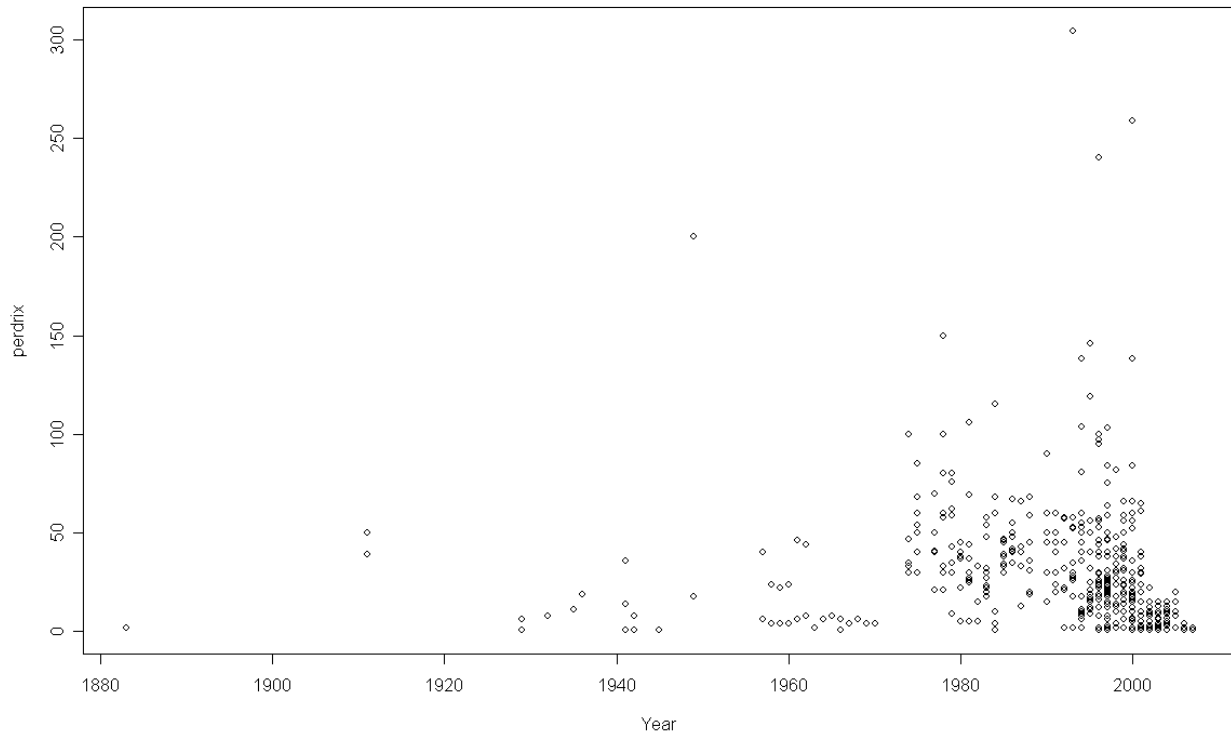


Figure 5.3 Graph showing overall trend data; Number of birds in total from CPB dataset (using only data points that include abundance)

Using the population count data only from the CPB database, the relationship between Year and total number counted in that year was investigated. The Anderson-Darling test for Normality gave an A-squared value of 0.98 (DF 54 and P-value 0.013), suggesting that the data are non-normal. A Generalised Linear Model (GLM) with Poisson error structure (to adjust for count data) was used to test for correlations between time and population. None of the original models showed significant declines. The third model looked at post 1980 data, however, the results still show that numbers are increasing with time and the post 2000 data was looked at. The poisson model still indicated that numbers were increasing over time, a simple linear model was made and showed numbers were decreasing with time (Table 2).

Residuals				
Min	1Q	Median	3Q	Max
-26.109	-11.758	-4.705	3.295	231.891
Coefficients				
	Estimate	Std.Error	t-value	Pr (> t)
Intercept	10728.6745	1888.7679	5.680	3.77e-08
Year	-5.3508	0.9434	-5.672	3.93e-08
DF: 247				
Residual Std.Error	Multiple R ²	Adjusted R ²	F – statistic	p - value
27.38	0.1152	0.1117	32.17	3.934e-08

Table 2 Summary of model of post 2000 data from CPB dataset.

Figure 5.4 shows the count data for the UK records in the dataset, it shows similar trends to the overall dataset. This is because the vast majority of the data is from the UK (Fig 5.5).

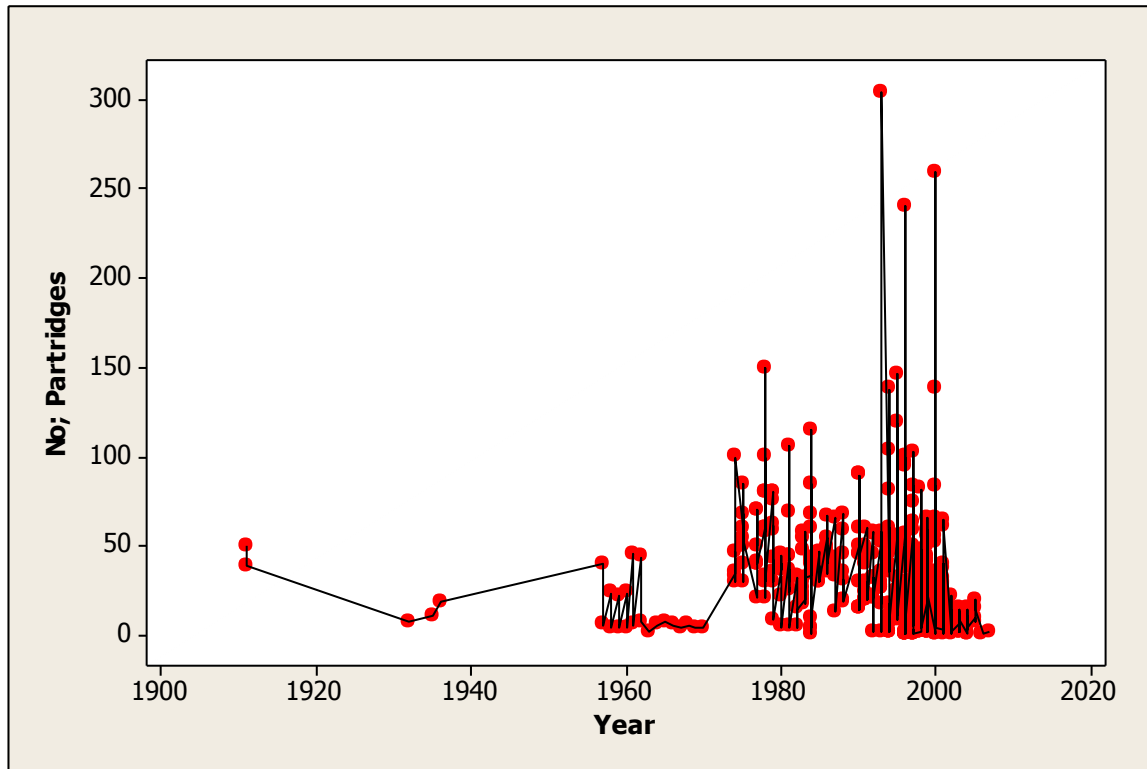


Figure 5.4 Graph showing the count data over time for the UK records.

In Figure 5.5 there is a heavy bias towards records in the UK, which accounts for 93% of all records in the dataset.

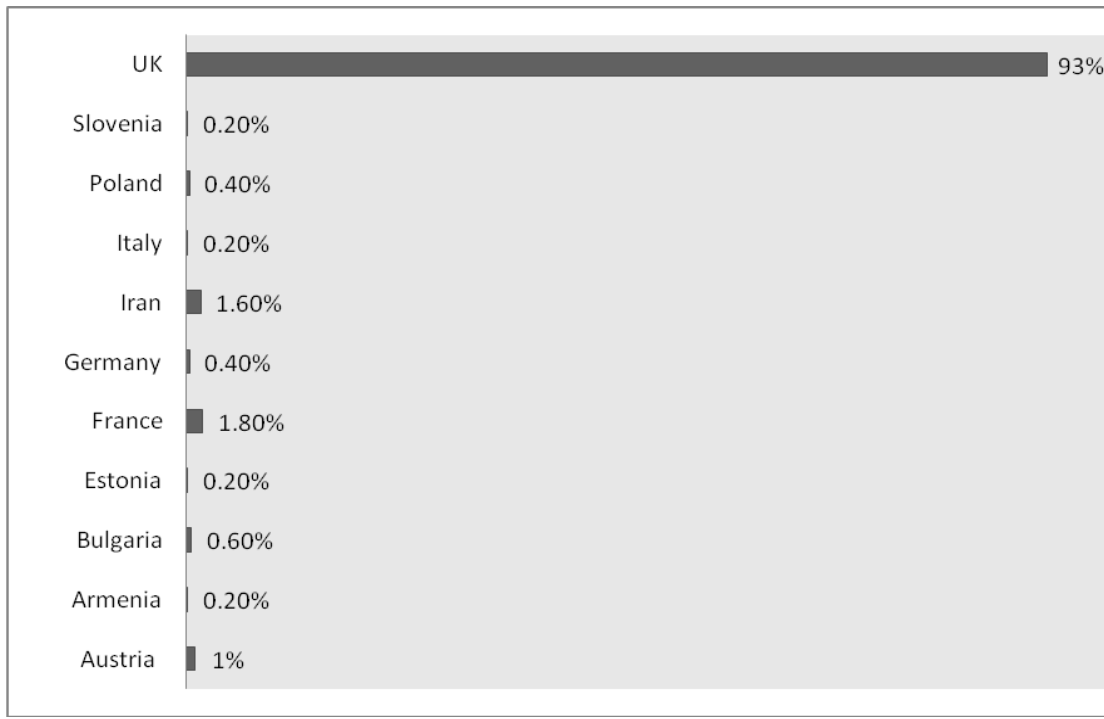


Figure 5.5 Bar chart showing the percentage of abundance records per country in dataset.

Figure 5.6 shows the different weighting of the data sources used in dataset from CPB. The most common source were reports with 66%, with studies accounting for 19% and journals, books and personal observations making up the rest. Books were only used as data sources for the older records and did not appear past 1950. Studies were more prevalent in the last ten years.

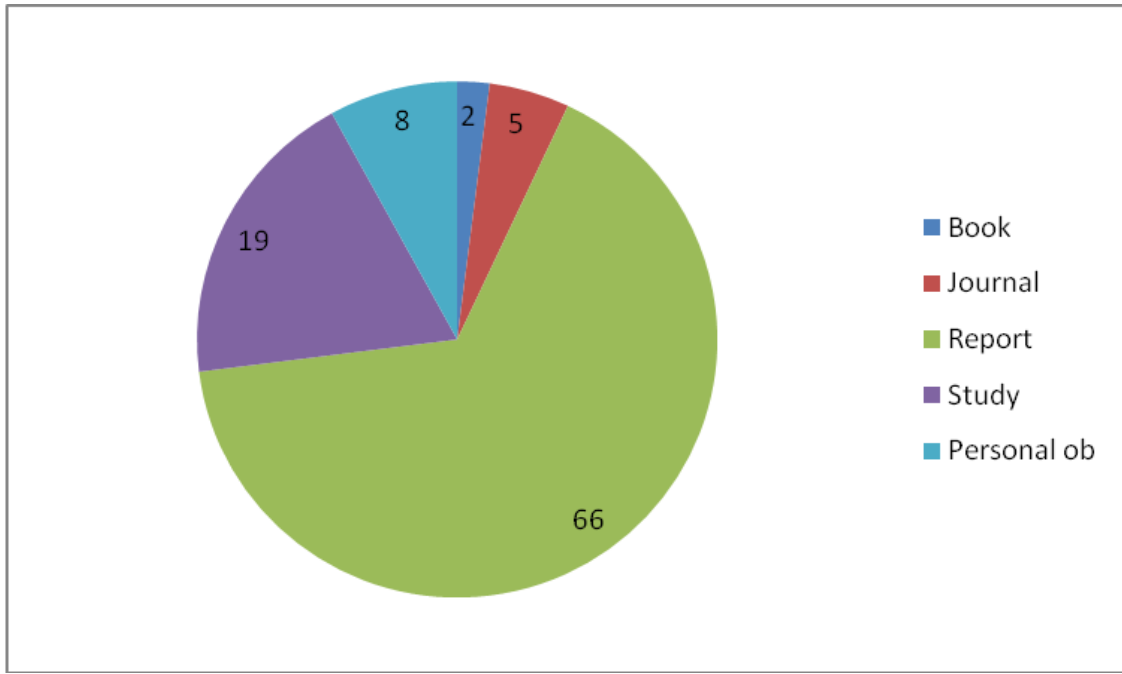


Figure 5.6 Pie chart of different sources used for partridge count (%) in CPB database.

In figure 5.7 literature accounts for 73% of the data records with studies accounting for 19% and personal observations 8%.

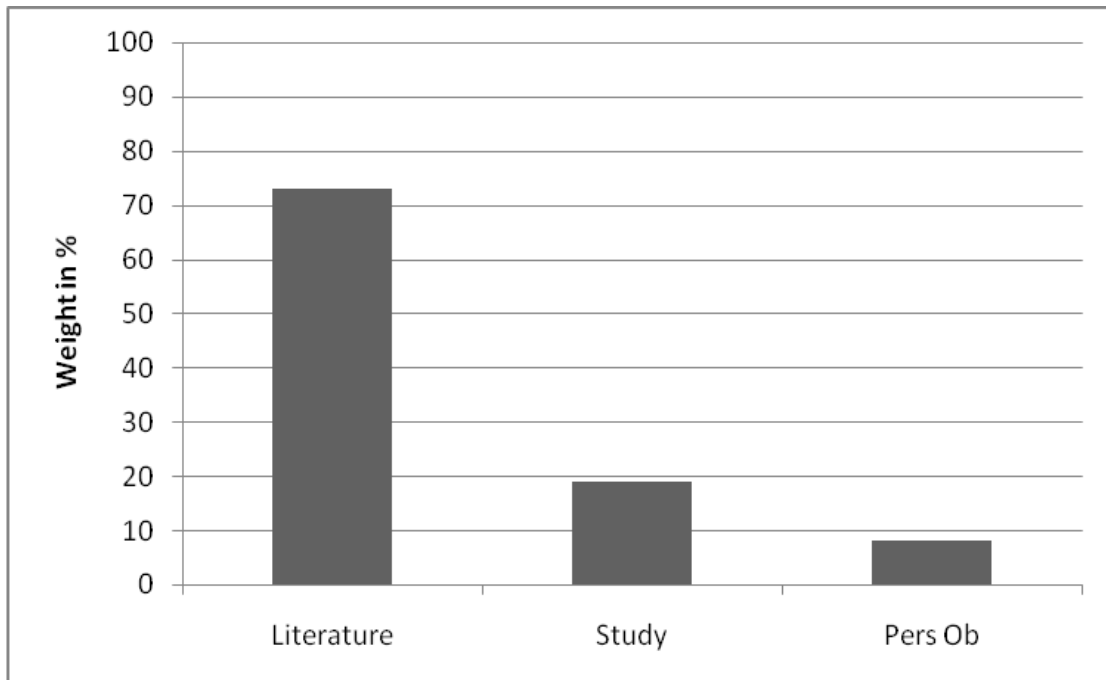


Figure 5.7 Chart showing literature vs. study and personal observation

In Figure 5.8 sampling effort increases over time with the highest number of records clustered about the late 1990's.

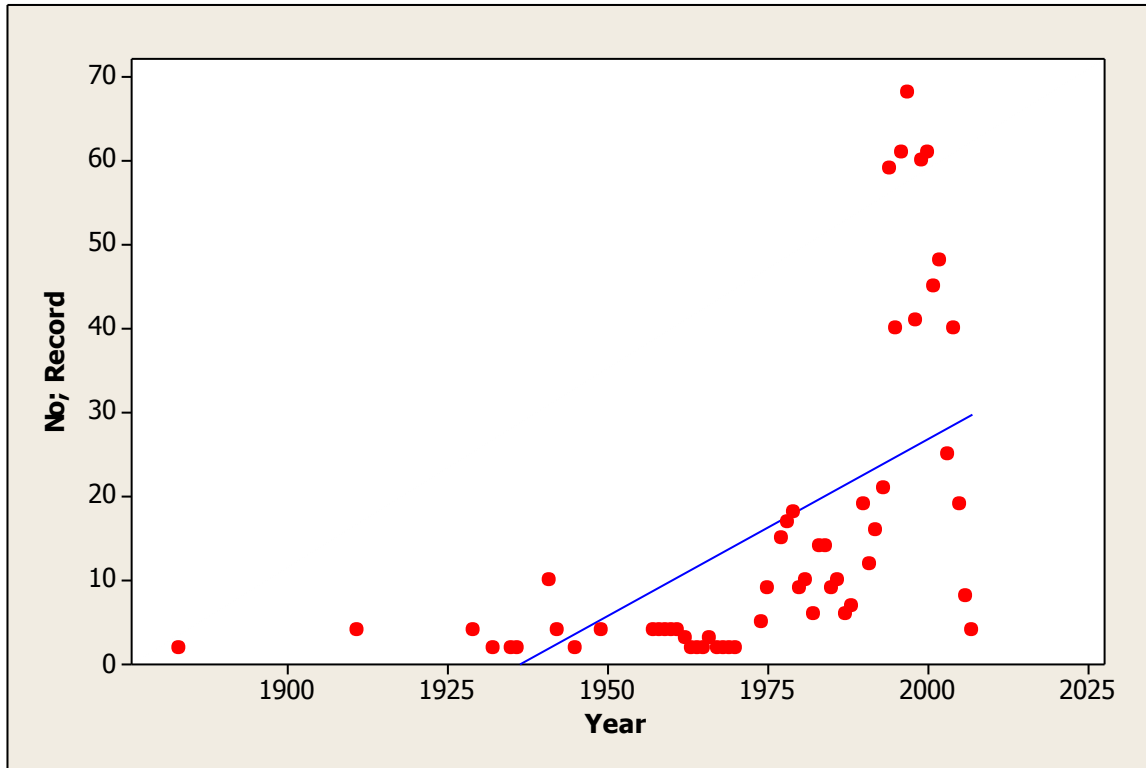


Figure 5.8 Scatter plot of Records per year showing increased sampling effort over time

Chapter 6: Discussion

If basing conservation decisions for the grey partridge on the results in chapter 5 one would deem that the species is not in fact declining. The results are erroneous due to the nature of the database. What is shown is the variation in the sources of information used in the dataset, the bias towards certain types of data sources and the increased effort in both sampling and literature over time. Table 1 shows the variation in the types of information available from personal research, with Figure 5.2 demonstrating the different weightings of the sources used. The dataset from CPB was expected to show a decline over time in the number of partridges. As can be seen in Figure 5.3 it shows the opposite with numbers apparently increasing over time. This can be accounted for by the increased sampling effort over time which is shown in Figure 5.8. To see if the dataset showed declines at different spatial scales the records for the UK over time were also plotted in Figure 5.4. Once again this shows similar results which can be attributed to an increase in sampling effort. There was a large bias in the dataset to records from the UK, which can be seen in Figure 5.5, which is why no other analyses were done on the other countries as the number of records were too small. This bias can be perhaps explained by the fact that the original database was created in the UK, and so communication and access to data is much easier. Figures 5.6 and 5.7 show the percentages of the different sources of information in a similar manner to Figure 5.2. Literature and in particular reports were by far the most prevalent type of record. This once again is perhaps due to this form of data is easier to access than personal observations and studies.

From the literature studied it can be seen that the grey partridge has suffered significant declines over its range and should be included on the RL as a threatened species. This chapter looks at the problems set out in the introduction using examples to reinforce the arguments, as well as making recommendations both for the conservation of the grey partridge and for further study.

5.1 Monitoring Wide Ranging Species

So what are the problems with evaluation widely distributed species? The apparent one is of spatial scale. At what scale do you want to monitor a species so that not only accurate and reliable estimates are made, but so you also can see population trends at different levels. Just looking at the population purely on the global scale enables one to set global policies but may result in missing important details on the finer scale. As seen in the Seminoff and Shanker example, there may be stable and even increasing populations of a species found on a national or local scale. With the grey partridge at present although there is a lack of data which supports this, populations appear to be fairly stable in the former eastern bloc countries of Europe. In the United States populations also appear to be reasonably unchanging. Here rise the arguments about which populations need protecting more; the populations that are most in danger, or the populations which are stable.

One of the problem in the evaluation of widely distributed species, as mentioned, is the over or under sight of population trends. This problem is not unique to birds, and can be seen in a wide array of taxa including mammals and marine species.

5.1.1 Example of the Tiger

Many of the large carnivores are problematic when it comes to monitoring as they have very large ranges and can be solitary. An example of this is the tiger *Panthera tigris*. The tiger, like the grey partridge, is a flagship and umbrella species and like the grey partridge is found over a huge area. The distribution of *P.tigris* and its subspecies' is huge (although much decreased); covering an area from eastern Russia to south-west Indonesia (IUCN, 2002). The species is difficult to monitor due to its solitary and cryptic nature (Karanth et al, 2003). Protecting wide-ranging mega fauna requires taking the "representation" approach designed for habitat conservation and adapting it to species conservation, so not only conserving individual populations but also the suite of adaptations and ecological interactions associated with them (Wikramanayake et al, 1998). However, there is still the problem of sampling. A study by Karanth et al in 2003 looked at his very problem. They looked at the methods and logistics of sampling tiger populations in India (where potential tiger habitat covers as much as 300,000km). Spatial sampling concerns the frequent inability of animal survey methods to cover the entire

area of interest (Wikramanayake et al, 1998). In such cases, one can representatively survey some subsets of that area, and then use these results to draw inferences about the entire area (Karanth et al, 2003). In a true animal census all animals are assumed to have been counted, and all areas are assumed to have been surveyed this, however, is rarely the case as funding and sheer feasibility rarely allow for an accurate count (Karanth et al, 2003). Karanth et al criticise the current scheme of monitoring tigers which involves a large scale labour intensive presence census, which ignores the need to map and geo-reference the tiger signs that are found. What can be gained from the case of the tiger is that even high profile species suffer from poor sampling designs, and that is a hugely difficult task to try and monitor a species over such a large area. To successfully monitor widely distributed species like the partridge, there needs to be an international consensus on sampling methods, as well as a system which can geo-reference and map populations both globally and nationally.

5.1.2 Global Fisheries

Spatial scale has and continues to be a problem with the world's fisheries. How does one even begin to try and monitor taxa which are a) highly mobile; b) found over a huge area and c) only truly visible underwater. Walters (2003), as discussed in chapter 1, stated the dangers of ignoring aspects of spatial data in the fishing industry. It was obvious in the late 1980's that global commercial fish stocks were declining, and that to exploit a population sustainably something had to be done (Hilary, 2008; Pitchford et al, 2007). Monitoring fish stocks has proved an onerous task for the world's fishery scientists, as you cannot conduct a census of the population in normal way. This has led to the development of fisheries science and an array of monitoring methods which include vastly complicated models with hundreds of parameters (Jentoft et al, 1998). These models try and involve different population dynamics such as: present population, past population, how much can be caught, so that sustainable yields can be estimated. There are many different models which use various harvest controls, but getting the data is still proving problematic and many of the models for sustainable yields rely on accurate catch reports. There is also much dispute on which is the best management scheme due to the expense and vast amount of data needed to implement such schemes (Jentoft et al, 1998; Pitchford et al, 2007). This can lead to over-fishing as quotas are not accurate.

An example of problematic monitoring is the southern Bluefin tuna. It is possibly the most valuable fish in the world, where an adult fish can fetch \$1000s of dollars (Hilary, 2008). But, due its exclusive status within the sushi industry it has been massively overexploited (Hilary, 2008; Matsuda et al, 1998). It has declined by more than 90% in the last 30 years and is listed as CR on the RL (Matsuda et al, 1998). It was majorly overfished by Australian and Japanese fisheries in the 1980's. However, it became apparent that the Japanese had been under-reporting their catch by as much as 100% (Hilary, 2008). So an already overexploited resource was more depleted than originally thought. This aspect of under-reporting is an important feature with game birds, accurate reports of harvest and shooting numbers are needed in order to accurately monitor the population trends.

In 1996 the FAO unveiled its new system for monitoring the worlds fisheries; The Fisheries Resources Monitoring System (FIRMS) (FAO, 2008). The ambitious project aims; “to pool information gathered from various regional fisheries management organizations, FAO and other agencies into a comprehensive, one-stop source of information on world fisheries and fishery resources.” (FAO, 2008). This kind of multi-organisational project requires massive amounts of funding and international co-operation. Unfortunately for most other taxa this is not feasible, as they are unlikely to be as commercially important. The partridge is economically important in Europe and a system not unlike this could be potentially set up. The lessons learned from fishing can be applied to widely distributed species. What is patently obvious is the need for reliable population counts to be able to create management policies that work.

5.2 Recommendations

5.2.1 For IUCN Red List and Grey Partridge

It is evident from previous research that the grey partridge has suffered significant declines across its range. Overall globally it is estimated that it has seen a decline of more than 70% over more than 50 years. Under Criteria A1 (see appendix 2 for detailed breakdown) and possibly A3 it should be designated as Endangered as it declined by more than 70% in 10 years or 3 generations. This result satisfies the aim set out in chapter 1. The global population whilst still large comparatively to many threatened species it is not evenly distributed throughout its range. There are smaller and independent units, which collectively may be far more threatened than would appear by looking at the global picture, as well as stable populations which are not

(Hudson, 2002; Mace et al, in press). The RL often downgrades species on the premise that whilst a species may have seen significant declines it has stable populations which thus decreases the risk of extinction (Mrosovsky, 2004). A potential resolution to the uneven spread of threats is to apply the criteria to the different populations and list them separately (Mrosovsky, 2004). This suggests that on the whole red listing for a species which has a wide distribution is not particularly practical unless there is a comprehensive breakdown of the different subpopulations. A recommendation to be made for the grey partridge is that if it cannot be listed as threatened due to its comparatively large population it should be listed as NT with a breakdown of the different listings for the subpopulations. In the very least the results highlight the need for a comprehensive review, and in the meantime perhaps the partridge should be viewed as DD. What is clear is that no matter how abundant a population, if it is declining rapidly without intervention it will go extinct. Take the example of the passenger pigeon which was once one of the most abundant birds on the planet with numbers in excess of 5 billion (IUCN, 2004). In spite of the huge population the species was declared as extinct in 1914 due to massive overexploitation as a cheap source of meat and habitat clearance (IUCN, 2004). The partridge is declining but probably has a low risk of going extinct globally in the near future although if agriculture continues to be managed in the detrimental manner it is the future for the partridge is uncertain.

As mentioned in chapter 2, often the most effective protection comes at the national level. National RLs for the partridge are common in Europe, and generally (especially in Western Europe) *P. perdix* has a high conservation status (Mace et al, in press). It is much easier to try and monitor a species within your country, but as also seen in chapter 2 there are complications. It is more straightforward for islands such as the UK and Ireland as being isolated by water means there is no species migration or interaction across international borders. For continental Europe and North-west Asia there is this problem. The grey partridge is a mainly sedentary bird and so for populations more central within a country there is little chance of movement across borders. Populations near borders may have interaction with populations in the neighbouring country. Conservation measures are often initiated on the basis of sparse data and incomplete knowledge and so the exchange of information is vitally important (Karanth et al, 2003). Information sharing is always a problem in international conservation, and so for reliable

monitoring both for national and international RLs the sharing of data will be needed (Milner-Gulland et al, 2006).

5.2.2 Grey Partridge Conservation

Several recent studies have shown that modern agriculture should be regarded as a major anthropogenic threat to biodiversity, comparable to global climate change in its ability to affect vast areas (BirdLife International, 2004; Donald et al, 2002). As seen in chapter 3, farmland birds have suffered from massive declines over the last century, and the grey partridge is one of the species that has seen the most dramatic declines. But, what can be done to slow or reverse the continued deterioration of this species. In Europe, as discussed in chapter 3, the formation of the EEC and subsequent CAP can be cited as a major cause of biodiversity loss. A paper by Donald et al (2002) discussed the CAP in relation to conserving Europe's farmland birds. Donald et al (2002) stressed the point that simply abandoning the CAP would not relieve the pressures on farmland wildlife. It could even lead to further intensification as farmers try to maximise their productivity in order to compete on the world market; the CAP led to bird decline but cutting off the CAP could also do the same thing. Donald et al (2002) had a series of recommendations on how to try and alleviate the situation without compromising the livelihoods of those involved. I have used these recommendations as a template for the work which needs to be done for the conservation of *P. perdix*, which is laid out below.

- a) *Encourage changes to agricultural practices and subsidies that make less intensive agriculture more profitable than systems that are more productive:* Recent work suggests that some organic systems not only produce higher quality crops and higher profits but also higher yields as well. There is also evidence for organic farms supporting higher densities of farmland birds (Vickery et al, 2004). The reduction in the use of chemicals would have a substantial impact on increasing partridge populations, as it is the use of chemicals that so detrimentally affects chick survival. Other suggestions for less intensive management which would benefit not only the grey partridge but other farmland species as well include; low intensity grazing of field margins to encourage grass growth, winter stubble followed by spring fallow which would act as a food source (Vickery et al, 2004).

- b) *Increase spending on agri-environment schemes*: Nationally prepared agri-environment schemes have the advantage of flexibility—national schemes can address national problems, and can have considerable success. There is evidence of national agri-environmental schemes being more successful than their multi-national counterparts. In the UK the case of the curlew is possibly the best example of an agri-environment scheme conserving a farmland bird (Donald et al, 2002; Peach et al, 2001). This farmland bird is found in the south-west of England and had declined dramatically both in numbers and range throughout the 20th Century, until it there only about 118 pairs - found in south Devon (Peach et al, 2001). The Countryside Stewardship Scheme (CSS) is a programme launched by the British government in 1991 which provide payments to landowners in return for adopting an agreed package of environmentally beneficial land management prescriptions (Peach et al, 2001). The curlew was adopted under the CSS in the early 1990s and consequently saw increases in numbers of 83% from 1992 – 1996 in CSS areas whereas outside CSS areas there was no improvement (Donald et al, 2002; Peach et al, 2001; Vickery et al, 2004). This shows that national applied schemes can be successful, and could act as example to be used for the grey partridge. A study by Buner et al (2005) showed that the released partridges preferred the areas in agricultural landscapes with the highest density of ecologically enhanced areas. Buner et al suggest that intensively cultivated arable areas should be prepared for re-colonisation by partridges by providing (treeless) hedges, permanent wild-flower strips and/or other perennial vegetation. This could be incorporated into a CSS scheme, and as the partridge is a flagship species it would include a number of other farmland species.
- c) *Identify and protect farming areas of particularly high biodiversity*: Farmland is not a homogeneous habitat, and across Europe there are areas of agriculturally maintained land which support communities of particular significance. These habitats tend to be areas which are/or resemble natural or semi-natural grasslands and steppes – which are important *P. perdix* habitats. The direction of agricultural subsidies to maintain marginal agriculture in areas of recognised biodiversity importance is a critical development in recent EU thinking. The idea here is strongly linked to point below.

- d) *Integrating nature conservation into agricultural policy*: Environmental requirements have not so far been fully incorporated into agricultural policy, being regarded more as an optional addition to activities and policies aimed mainly at increasing productivity. Full integration of biodiversity into EU agricultural policy is clearly an urgent need. Agri-environment schemes represent the only available mechanism to reduce declines in farmland biodiversity over large areas (Donald et al, 2006). They are therefore of importance if the 2010 targets to reduce or halt biodiversity loss, for the EC - which is a signatory of the CBD in its own right, are to be met.
- e) Shooting needs to be regulated by an official body to ensure sustainable harvests. In the UK and some other Western European countries such as the Netherlands there are set quotas for wild partridges shot per year, to make sure that the activity and partridge populations will see any deterioration.

The UK has adopted all of the above points in some form or the other and has seen some success. But, many species are still declining despite many of their habitat requirements being fulfilled and increased funding (Vickery et al, 2004). This could well be due to the quality and quantity of the resources created; i.e. what is better a small area of high quality habitat or a large area of lower quality (Vickery et al, 2004).

5.3 Limitations of Study

Whilst this study has been mostly successful in fulfilling its aims, there have been some factors which have restricted the outcomes. The dataset from CPB whilst useful did not show what was intended. This was partly due to the timeframe of the data. As is seen in the results there are data points from the late 1800s onwards. The starting dates were when partridges were at their most abundant and the data in theory should have shown this. However, as can be seen the populations seem to be increasing with time and not decreasing. What this can be attributed to is that more studies were carried out in the later years of the 20th century. This can be seen in the raw data which shows few data points earlier on and hundreds from the 1980s, 90s and 2000s. There were also intentions for graphs to show declines from various countries compared to European and global declines so that the differences in spatial scale of declines could be seen. Due to lack of

data this could not be done but could be looked at in a more detailed study. This was the ultimate limiting factor in the study, that there was no consistency in the sources of data; estimates of decline, bag data and counts from surveys but no real population estimates.

5.4 Further Study

This study emphasises the need for further research into the aspect of monitoring declines at different spatial scales. The grey partridge is merely the beginning of a whole range of species that could be investigated. What this study also highlights is the discrepancies that can be found in spatial data. What was obvious is that there is a wealth of information available about the grey partridge within the older members of the EU, whilst the newly joined members and countries outside Europe (with the exception of the USA) are severely lacking in almost any information at all about *P.perdix*. A detailed assessment of the status of *P.perdix* in these places would further provide the IUCN with information with which they could use in an evaluation of *P.perdix*.

Conclusion

Monitoring declines in species which are widely distributed is a complex process. What can be seen from this study is that not only data availability an issue but so is data quality. The IUCN is expected to make accurate and reliable assessments of species extinction risk but how is this possible when there are glaring holes in the information. The analysis of the CPB dataset was expected to show a decline over time of P.perdix. What it ultimately illustrated is an issue of data quality. The grey partridge has a well publicised decline but the data available maybe one of the factors behind its current status as LC.

The grey partridge should theoretically be designated as threatened and as a minimum should be listed as Data Deficient. What the case study ultimately shows is that with species which have large ranges getting information from all of its different occupied areas is problematic. The logistics of such a study are daunting, and may seem an impossible task. This emphasizes the need for the sharing of information about such species between countries, or else you potentially end up in a situation similar to the grey partridge where there are massive disparities in the data available and there is an issue of data quality.

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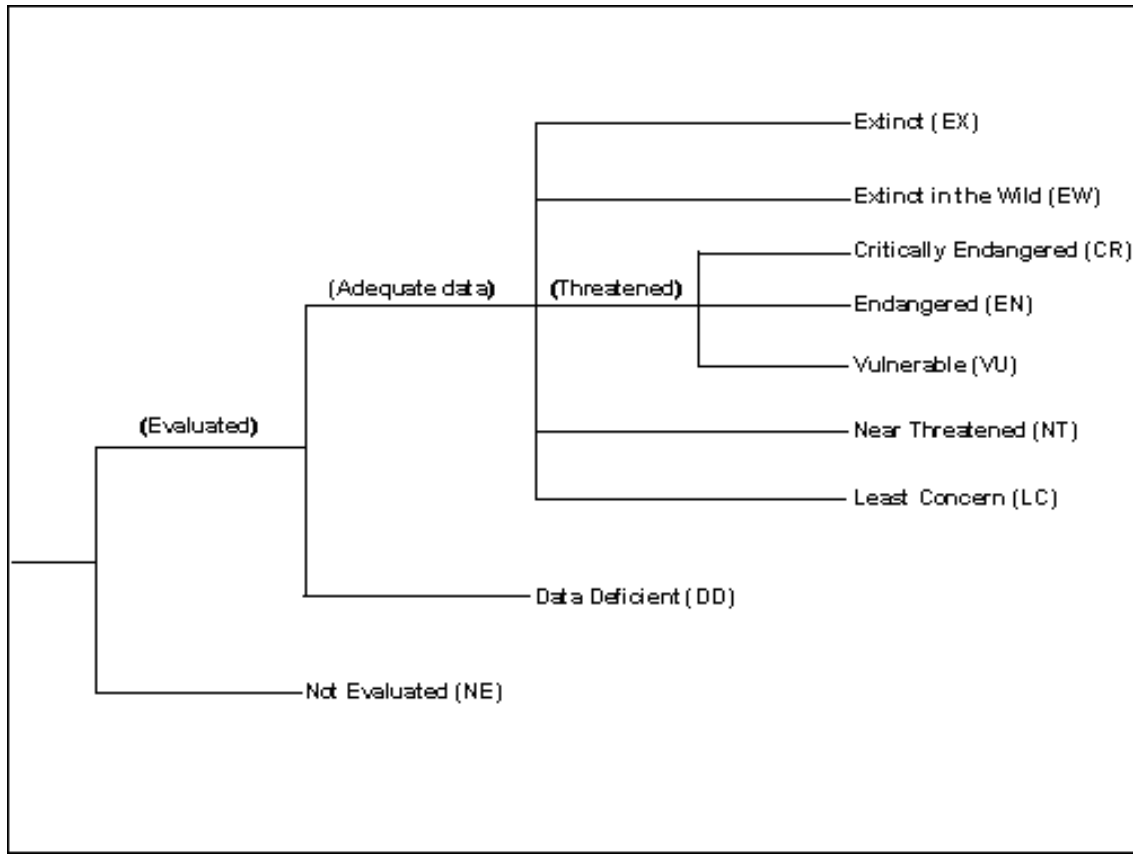
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Appendices

Appendix 1: 1994 Categories



Source; IUCN (1994)

Appendix 2: 2001 IUCN Criteria

Summary of the five criteria (A–E) used to evaluate if a taxon belongs in a threatened category (Critically Endangered, Endangered or Vulnerable).

Use any of the criteria A–E	Critically Endangered	Endangered	Vulnerable
A. Population reduction Declines measured over the longer of 10 years or 3 generations			
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3 & A4	≥ 80%	≥ 50%	≥ 30%
AI. Population reduction observed, estimated, inferred, or suspected in the past where the causes of the reduction are clearly reversible AND understood AND have ceased, based on and specifying any of the following:			
(a) direct observation			
(b) an index of abundance appropriate to the taxon			
(c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality			
(d) actual or potential levels of exploitation			
(e) effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.			
A2. Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased OR may not be understood OR may not be reversible, based on (a) to (e) under AI			
A3. Population reduction projected or suspected to be met in the future (up to a maximum of 100 years) based on (b) to (e) under AI.			
A4. An observed, estimated, inferred, projected or suspected population reduction (up to a maximum of 100 years) where the time period must include both the past and the future, and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible, based on (a) to (e) under AI.			
B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)			
B1. Extent of occurrence	< 100 km ²	< 5,000 km ²	< 20,000 km ²
B2. Area of occupancy	< 10 km ²	< 500 km ²	< 2,000 km ²
AND at least 2 of the following:			
(a) Severely fragmented, OR Number of locations = 1 ≤ 5 ≤ 10			
(b) Continuing decline in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals			
(c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals			
C. Small population size and decline			
Number of mature individuals	< 250	< 2,500	< 10,000
AND either C1 or C2:			
C1. An estimated continuing decline of at least:	25% in 3 years or 1 generation	20% in 5 years or 2 generations	10% in 10 years or 3 generations
(UP TO A MAX. OF 100 YEARS IN FUTURE)			
C2. A continuing decline AND (a) and/or (b):			
(a i) number mature individuals in each subpopulation:	< 50	< 250	< 1,000
(a ii) or % individuals in one subpopulation =	90–100%	95–100%	100%
(b) extreme fluctuations in the number of mature individuals			
D. Very small or restricted population			
Either:			
Number of mature individuals	< 50	< 250	D1. < 1,000
Restricted area of occupancy			AND/OR D2. typically: AOO < 20 km ² or number of locations ≤ 5
E. Quantitative Analysis			
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations (100 years max)	≥ 20% in 20 years or 5 generations (100 years max)	≥ 10% in 100 years

Appendix 3: Definitions

Bag or Bag Count

Is the quantity of game taken in a particular period. For instance a bag of 4000 taken over a week.