The impact of demographic factors on biodiversity
A case study of East Germany

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ABSTRACT

There is much concern about the loss of biodiversity and the role humans play in this process. Although numerous studies have investigated the impact of human population growth on biodiversity, little work has been done to investigate the effects of depopulation, and the linkages between different attributes of human populations and biodiversity are poorly understood. East Germany, where reunification in 1990 triggered accelerated depopulation processes, was used as a case study in order to examine how demographic changes in general and depopulation in particular interact with biodiversity and how this knowledge can be used for conservation management in East Germany. A Principal Component Analysis was carried out in order to summarize a number of demographic variables for the whole of Germany, which showed that East Germany is distinct from the rest of the country and needs to be treated and assessed separately in terms of its biodiversity and conservation potential. In order to consider several human population attributes jointly in terms of their impact on bird species over time, a regression analysis of bird index changes versus human demographic factors in East Germany and two West German *Länder* was carried out. The results suggest a negative relationship between bird numbers and affluence in terms of GNP, average wages and employment. They also point to a dependence of birds on humans and their actions, with bird numbers following changes in human numbers. The research confirmed that interactions between human demographics and biodiversity are complex and likely to be site-specific, species-specific and scale-dependent. Conservation managers therefore need objective indicators and measures in order to better understand anthropogenic linkages with biodiversity so they can make future-oriented, rational decisions. In the case of East Germany it is suggested to seize the ecological opportunities offered by depopulation, incentivise remaining inhabitants to leave and create large wilderness areas.

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Acronyms and Abbreviations

BfN	Bund für Naturschutz, federal government agency for national and international nature protection. Part of the German Ministry of Environment
FRG	Federal Republic of Germany
GDR	German Democratic Republic
GDP/GNP	Gross Domestic Product (GDP) measures the sum of incomes received by the various wealth creating sectors of the economy: manufacturing, agriculture, service industries. When the value of income from abroad is included (what domestic companies earn abroad minus what foreign companies earn here and expatriate) then the GDP becomes the Gross National Product (GNP). The difference between GNP and GDP is relatively small for most countries (Lynn, 2001).
HANPP	Human Appropriation of Net Primary Productivity (the amount of terrestrial NPP required to derive food and fibre products consumed by humans, including the organic matter that is lost during the harvesting and processing of whole plants into end products (Imhoff *et al.* 2004)
HPD	Human population density
NPP	Net Primary Production (net amount of solar energy converted to plant organic matter through photosynthesis, measured in Carbon units (Imhoff *et al.* 2004))
NRW	Nordrhein-Westfalen
NUTS	Nomenclature of Units for Territorial Statistics
PPP	Purchasing Power Parity (in the 20 countries with strong economic growth selected by Myers and Kent (2002), PPP dollars are between 1.3 – 5.3 times higher than conventional dollars)
StBA	Statistisches Bundesamt – Federal Office for Statistics. Part of the German Ministry of the Interior, collects and analyses data on economy, society and environment.

Definitions

area in agricultural use: "The sum of areas made up of arable farmland, including set-aside areas for which compensation payments are made, garden areas (excluding ornamental gardens), orchards, nurseries, permanent grassland, land planted with vines, osiers, poplars as well as christmas tree cultivation outside of forests" *("Die landwirtschaftlich genutzte Fläche (LF) umfasst alle landwirtschaftlich oder gärtnerisch genutzten Flächen einschließlich der im Rahmen des Stilllegungsprogramms stillgelegten Flächen. Zu ihr rechnen im Einzelnen folgende Kulturarten: Ackerland, Dauergrünland, Haus- und Nutzgärten, Obstanlagen, Baumschulflächen, Rebland und Weihnachtsbaumkulturen, Korbweiden- und Pappelanlagen außerhalb des Waldes" - StBA, 2008)*

East Germany: the area of the former GDR, synonymous with "new *Länder*"

ecological footprint: measures humanity's demand on the biosphere in terms of the area of biologically productive land and sea required to provide the resources we use and to absorb our waste. People consume resources and ecological services from all over the world, so their footprint is the sum of these areas, wherever they may be on the planet. The footprint area is expressed in global hectares (gha), hectares with world-average biological productivity. (WWF 2006)

Land/Länder (plural): German federal States – 16 in total, 5 of which make up the former GDR

'new' *Länder*: the five federal states making up East Germany, i.e. the former GDR (Brandenburg, Mecklenburg-Vorpommern, Sachen, Sachsen-Anhalt, Thüringen)

NUTS : The NUTS level to which an administrative unit belongs is determined as follows:

Level	*population*	*in Germany*
NUTS 1	3 – 7 million	Länder
NUTS 2	800 000 – 3 million	Regierungsbezirke
NUTS 3	150 000 – 800 000	Landkreise

source: EUROPA (2008)

West Germany - the area of the former Federal Republic of Germany, excluding the GDR

1. Introduction

1.1 Impact of human populations on biodiversity

As reported by the Millenium Ecosystem Assessment the world is faced with an enormous loss of biodiversity, which undermines not only the global system and the environment itself, but ultimately also the well-being of humans (MA 2005). Direct drivers of this loss are fragmentation, degradation and loss of habitat, climate change, overconsumption, exploitation, invasive species and pollution. All of these are inextricably linked to and exacerbated by human populations as underlying driving force. Although the negative effects of humans on biodiversity have been recognized for a long time (Marsh 1865), linkages between different demographic components and biodiversity are little understood beyond an intuitive level and do not seem to be addressed adequately by scientists, policy-makers or field workers.

Despite a general trend over geological time towards an overall net increase in biodiversity, there has been a marked decline in biodiversity over the last few thousand years due to the rapid expansion of humans (Ehrlich & Holdren 1971, Flannery 1994, Steadman 1995, Vitousek *et al*. 1997, The Population Institute 2006a, WWF 2006). The conversion of wilderness into agricultural and industrial landscapes is fundamentally linked to human population expansion and economic development and poses a great threat to biodiversity (Dobson 1996, Hannah *et al.* 1995, Goldewijk 2001), with habitat fragmentation from land-use changes (agriculture, infrastructure etc.) accounting for most of the human-generated pressures on mammals and birds (Cruz, 1996). Estimates of the proportion of global land area transformed into cropland and pastures range from 34 to 40 percent (Gaston & Spicer 2004, The Population Institute 2006b, Foley *et al.* 2005). These substantial land-use changes combined with hunting and anthropogenic ecosystem disruption have brought about the loss of many species as well as great reductions in the abundance of species not adapted to human disturbance.

1.2 Factors behind the impact

World population nearly quadrupled during the past century from 1.6 billion to 6 billion (UNFPA 2001), and although growth rates have been slowing since the 1970s, absolute growth is still very high. According to UN projections the world population will grow by a further 50 percent from 6 billion to 9.1 billion by 2050 (UNDP 2007). This equates to approximately 1 million more people every 5 days. Most of this growth occurs in biodiversity-rich developing nations, where four fifths of the world population lives (Bongaarts 2002). The poorest nations in Asia, Africa and Latin America have rapidly growing populations, whereas wealthier and more developed nations in Europe have zero or negative growth.

However, the way in which humans interact with their environment and how the environment responds to changes in human populations is dynamically determined not only by growth and subsequent density, but by many other complex factors such as consumption, human activities, migration patterns, affluence, age structure, sex ratio and environmental awareness, which vary from nation to nation. Given the empirical evidence for human populations' negative impact on biodiversity, the question is which attributes of populations are the strongest drivers in the process of biodiversity depletion. Consumption for one is known to have the capacity to impact the environment even more than sheer size of a population, as it is rooted in political, social and economic structures and lifestyle choices which can translate into a large ecological footprint (as a measure of the environmental impact of human population and consumption) (Imhoff *et al.* 2004, Myers & Kent 2003, Wackernagel & Yount 1998). Per-capita ecological footprints are much higher in developed than in developing countries (Rees 1996).

Europe, the focus continent of this study, has a large ecological footprint, in spite of the fact that since the year 2000, its population is generating negative momentum (i.e. a shrinking population going into an ever-steeper spiral of decline) due to decreasing numbers of young people and a trend towards smaller families and later motherhood (Lutz *et al.* 2003). By 2006 no EU state had a total fertility rate above the 2.1 children needed to replace two parents, while life expectancy is increasing (OPT 2007). Furthermore, a distinct shift from rural to urban living is taking place, with rural exodus being observed in many European regions, such as areas of Spain, France, Portugal and Germany (European Commission 2006, Wolf & Appel-Kummer 2005).

The implications of these trends will be explored in a case study of East Germany, where rural outmigration has led to rapid and large human population decreases since 1990, with further substantial losses projected. Agriculture and industry have been largely abandoned and nature is reclaiming large tracts of land. This seems to have allowed the natural recolonisation (or reappearance) of large mammals such as wolves (*Vulpes vulpes*) and, most recently, elks (*Alces alces)*.

1.3 Aims and objectives

Scientific and management approaches that consider the way humans interact with their environment and how the environment responds to changes in human populations and their activities and practices are clearly important, and this thesis sets out to contribute to a better understanding of how human population dynamics are linked to biodiversity change and what implications these dynamics may have for conservation. This kind of research has the potential to extend existing knowledge about the underlying mechanisms behind human impacts, which might feed into more holistic, anticipatory approaches to the long-term management of both biodiversity and population issues.

The hypothesis or assumption is that there is no simple causal relationship between population growth and biodiversity loss, but that there is a relationship between demographic change and biodiversity conservation which varies with different demographic attributes.

The aim of the study is therefore to explore how demographic changes in general and depopulation in particular interact with biodiversity and how this knowledge can be used for conservation management in East Germany.

This broad aim can be subdivided into the following objectives:

- to investigate changes in regional biodiversity over time and link these changes with various attributes of human populations in the same area and over the same time period

- to analyse the impact of some demographic attributes on biodiversity in the case study area of East Germany, using two West German *Länder* (NUTS 1) as controls
- to establish a better understanding of how human population dynamics might be linked to biodiversity
- to explore the implications for conservation management and make suggestions as to how to utilise knowledge about demographic interactions for the benefit of improved long-term conservation planning.

In order to fulfil these objectives, the study will follow two main strands of investigation:

- a theoretical strand investigating the linkage between demographic attributes and biodiversity by discussing and interpreting the literature
- a practical strand analysing the impact of various demographic attributes on biological data, using East Germany as a case study.

The study will start by giving a global overview of various demographic attributes and their impact on biodiversity, followed by a brief presentation of the problems involved in measuring biodiversity (Chapter 2). It will then focus in on Germany in Chapter 3, giving the political, socio-economic and biological context necessary to understand the prevailing situation in the East of the country. Chapter 4 will explore various biological and demographic data sources for their suitability for analysis and explain the methodology used for analysing the chosen data sets. Chapter 5 will then go on to assess the relative weightings of various demographic variables in a Principal Component Analysis, followed by a regression analysis of demographic variables against bird index data for 1992-2006. In the last two chapters, the results of these analyses and their limitations will be discussed, followed by a brief outline of the implications and recommendations for conservation management.

2. Global Background – The bigger picture

2.1 Population attributes

Even though population growth and density are at the core of environmental problems in many countries in the world, there are other demographic factors and aspects which play an important role in the relationship between human populations and their surrounding flora and fauna. In this context, Paul Ehrlich and John Holdren (1971, 1972) have popularised the **IPAT** formula according to which the ecological **I**mpact of humans is described as the product of the number of people (**P**opulation), the per-capita consumption (**A**ffluence) and the **T**echnologies employed. A high number in any one of these terms would produce a large impact, i.e. a small population can have a large impact if its per capita consumption is high or if it produces goods with polluting technologies. However, although the IPAT formula shows that the drivers behind human impact are interactive, complex and dynamic, it does by no means capture all of the population attributes that can affect human impact on the environment. A non-exhaustive list of such other factors which might be important in terms of their ecological impact includes activity, age structure, number of households, rate of change, sex ratio, birth rate, mortality, immigration rate and environmental awareness. Ideally all of these components should be looked at simultaneously, as many of them are intercorrelated and interact with each other, so that changes in one of them could cancel out improvements in others. The full complexity of these interactions is, however, beyond the format of this study which does not allow an in-depth discussion and linkage of all of these, so that only some of the demographic attributes will be more closely investigated in the following sub-sections.

2.1.1 Size, density and growth

Human population size, density and rate of growth are considered important drivers of biodiversity loss (Ehrlich & Holdren 1971, Thompson & Jones 1999, Pimm *et al.* 1995). The growth rate of a population may influence a nation's ability to develop innovations and institutions, and research suggests that the faster the growth, the more likely the effects are to be detrimental, with very rapid growth exacerbating socio-economic problems (Stokes & Anderson 1990).

There are numerous examples for the association between high human density and the loss of biodiversity. Thompson & Jones (1999) found that local plant species extinctions in Britain were linked to human population density. Woodroffe (2000) used historic and contemporary data to examine the correlation between human population density and probability of persistence of many large carnivore species such as wolves, mountain lions and grizzly bears in the USA. She found that occurrence and persistence decline with increasing density of humans, and that there is a general association between human density and carnivore extinction, although with considerable variations between species. A study by Hoare & du Toit (1999) shows elephant density to be negatively correlated to human density in Zimbabwe. However, carnivore or large herbivore persistence might not be fully representative for other mammals, as they are more likely to be directly persecuted and killed in densely populated areas due to the potential danger they pose to people or their crops, thus perhaps suffering an exacerbated human density effect.

However, even though humans are generally assumed to be a threat to nature and are often reported to have negative effects on biodiversity, Araújo (2003), Luck (2007) and Pautasso & McKinney (2007) have shown this relationship to be more tenuous and complex than perhaps initially thought. They found that high human population densities can coincide with high species richness. Possible explanations given by the authors include the scale of the sampling unit used (the larger the unit, the more likely it is to find both high biodiversity and high population density within that unit), introduced species (the likelihood of introducing species not previously present in a region increases with the number of people) and energy availability in terms of primary production (the higher the environmental productivity of a region, the more species, including humans, that region can sustain). The latter argument is confirmed by a study by Kühn *et al.* (2004) on plant richness in German cites, which concludes that human settlements are preferentially located in areas of pre-existing high biodiversity, so that richness is high not because of but in spite of high human population density. Whatever the reasons for these reported positive relationships may be, numbers of individuals is another matter: Human density is widely associated with a reduction in the abundance of other species, be it through land-use changes, biological invasion, hunting or persecution (Hugo *et al.* 2008). Luck's (2007) review of the relationship between human population density and biodiversity showed "*overwhelmingly a decline in abundance with increases in HPD*".

Numerous studies have investigated the impacts a growing human population can have on its natural surroundings, but less work has been done to examine the opposite side of the coin, i.e. what happens when people leave a region and population density decreases. Does this give scope for increased biodiversity? Do species come back? This was certainly the case in the Great Plains of America for buffaloes (*Bison bison)*, once North America's most abundant big mammal (Chadwick 2006, Matheson, personal communication 4/6/2008). In the 16th century tens of millions of bison are thought to have roamed the North American plains (Freese *et al*. 2007, FWS 2008). By 1890 all but a few hundred had been hunted down (Nesheim 2004) and deprived of their native habitat through the plowing, farming and fencing activities of the rapidly expanding population of European settlers, which rapidly changed the character of the country from native grassland and abundant wild life to one of vast grainfields unsuited to wild life, with multiple consequences for grassland biodiversity (Freese *et al*. 2007). But years of drought in the 1920s and 30s as well as soil depletion and erosion led people to abandon their farms and leave rural areas. Three-quarters of Plains counties (322 of 443) have lost population since 1930 (Martin 2001), even though the US population has tripled over the same period (US Census Bureau 2000a). The decline of traditional agricultural land and the retreat of humans is seen by some as a chance to restore the Plains to their former natural state by reintroducing buffaloes and replanting prairie grass. Scientists Frank and Deborah Popper have been promoting the idea of an ecologically and economically sustainable use of the Plains in the form of a 'Buffalo Commons' (Figure 1).

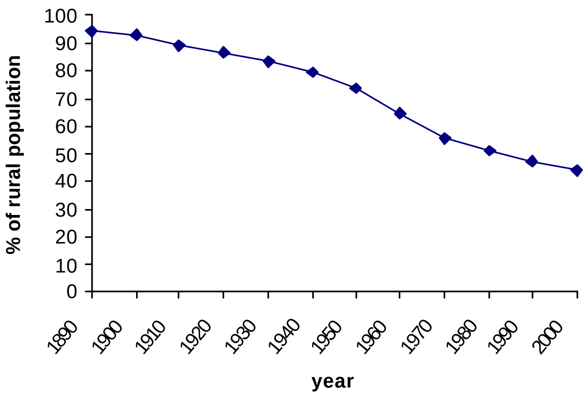
Figure 1: Buffalo Tallgrass Prairie, Osage County, Oklahoma, 2008

Successfully so, it seems: "*The total number of buffalo on US and Canadian private and public lands approaches 400,000*" they wrote in 2004, "*a remarkable figure for a large species that nearly went extinct less than a century ago*." As for economic viability, the Poppers see new uses for the land centred around conservation, ecotourism, bison meat marketing and luxury hunting enterprises. And buffalo are not the only species on the up – the Plains now also host substantial populations of white-tailed deer, water-fowl, teals and coyotes, to name but a few (Martin 2001).

What are the drivers behind this rewilding process? At least in this instance they do not seem to be population size or density per se. Taking one of the Prairie states, North Dakota, as example, this has had a fairly stable, low population size and density since 1920 (fluctuating between 618.000 and 680.000 inhabitants, i.e. between 3.4 and 3.8 people/km² (US Census Bureau 2000a). Crucially, however, the proportion of rural population has decreased continually from 86 percent in 1920 to 44 percent in 2000 (Figure 2), while buffalo numbers have increased from near extinction at the turn of the century to roughly 31,000 (Figure 3). In neighbouring Minnesota the overall human population almost doubled over the same period (density 23.8/km²), while the proportion of rural inhabitants shrunk from 56 to 32 percent (US Census Bureau 2000b). Buffalo herds in Minnesota have increased to 12,300 farmed animals plus several thousand state- and privately-owned animals (D. Hartwig, personal communication 3/6/08; MDA, personal communication 6/6/2008).

Figure 2

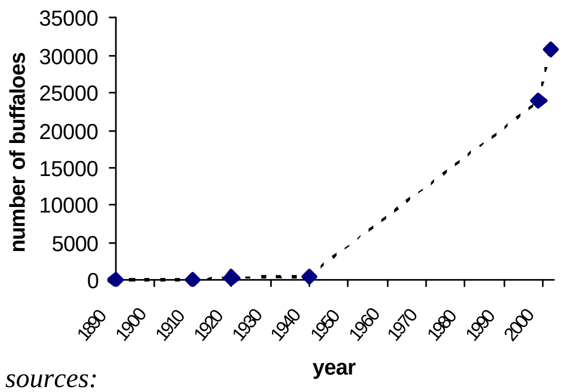
Percentage of rural population in North Dakota from 1890 to 2000



sources: U.S. Census Bureau 2000a, 2000c

Figure 3

Number of buffaloes in North Dakota from 1850 to 2002



sources:
Data for 1920: New York Times, 1924
Data for 1935: Derr J. (2006)
Data for 1999: Sell *et al.* (1999)
Data for 2002: Hartwig and North Dakota Buffalo Association, pers.communication June 2008

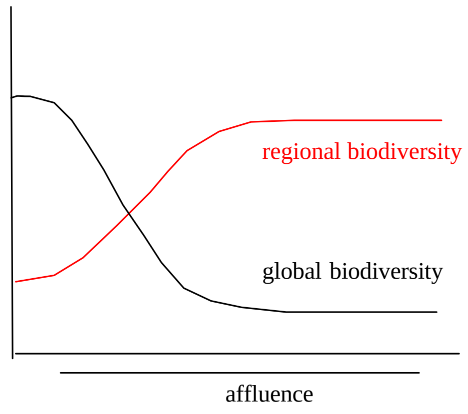
Regarding the rural exodus, a similar trend is evident worldwide: People move from rural areas to urban centres in search of better economic and social conditions (The Population Institute 2006b). As from this year half the world's population, 3.3 billion people, are thought to live in urban areas (UNFPA 2007). The proportion of rural population has declined over the last century both in developing and developed countries. Investigating the relationship between rural population and forest trends in France, Mather & Needle (2000) found the curve of forest cover to be almost the mirror image of that of rural population – as the latter decreases, the former increases.

The problem with human density as a measure for changes in the natural environment is therefore that, albeit easy to use and determine, it has the disadvantage of giving no indication of how the density distribution is structured, i.e. whether it is even or bimodal. Another problem, partially related to the first one, is the importance of scale when examining population processes based on human density: Depopulation has to be studied at a small scale – in the case of the Great Plains, for example, or, as will be shown later on, in East Germany, it is not enough to look at demographic data on a state or *Länder* level. Real trends only become apparent by examining changes in rural and urban migration and other patterns. On a regional scale it is therefore important to know how population is distributed, even though on a global or national scale of threat (in terms of anthropogenic climate change, air or oceanic pollution) this is of less importance. In practice, these problems probably make human density difficult to use for complex measurements, so that other, supplementary indicators are needed.

2.1.2 Affluence and consumption

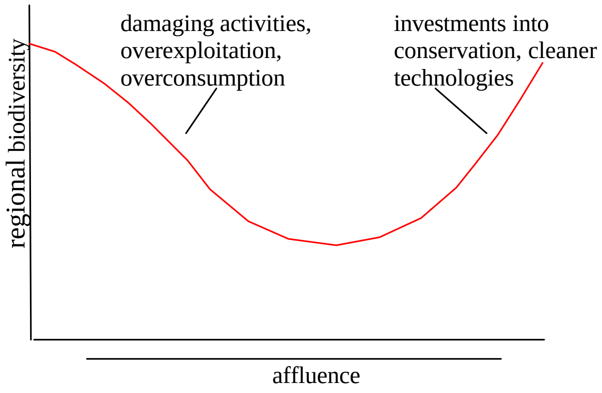
Affluence and consumption are complex measures. Where consumption depends on affluence, they are interdependent, although this is not necessarily the case where direct consumption of net primary productivity (NPP) is concerned. Human consumption of NPP is likely to impact local ecosystems and thus have important consequences for biodiversity. A study by Rojstaczer *et al*. (2001) estimates human appropriation of global net primary productivity (HANPP) to be around 32 percent. However, Imhoff *et al*. (2004) show that consumption in terms of HANPP is very unevenly distributed, with average annual HANPP per capita being almost twice as high in industrialized than in developing nations. Affluent countries can import products for their consumption, so that with increasing affluence, consumption increases. The Population Institute (2004) estimates that about 20 percent of the world's population consumes 70 percent of the world's material resources and possesses 80 percent of its wealth. The ecological impact is therefore often simply displaced from one country to another, with affluent societies passing the buck to people in other places or other times. Environmental quality can be a luxury good affordable only to affluent countries which have a greater capacity to remedy environmental problems as their economies develop and can afford to invest in green technologies and the preservation or restoration of their regional environment. Regional biodiversity may therefore increase with affluence, while global biodiversity declines (Figure 4).

Figure 4 – Effect of affluence on regional and global biodiversity



It is possible that in the early stages of the development of an affluent society biodiversity will suffer from increased resource use and environmental degradation, followed by improvements in later stages – as society grows out of its environmental problems, demand for high-quality environment rises and resources for environmental investments increase. The result would be similar to an inverted, environmental Kuznets curve (Kuznets 1955) (Figure 5), with the upward part of the curve being congruent with the red line for regional biodiversity of Figure 4. Levels of resource use and environmental degradation are, of course, mediated by a number of factors such as production technology, disposal of by- products generated in the production and consumption process and the disposal of commodities themselves. There are also other complicating factors: Although the impact of production processes might decrease and indicators such as air and water quality might improve with increasing affluence, consumption-based measures of environmental impact such as CO_2 and waste would almost certainly not decline with increasing per capita income.

Figure 5 – Effect of affluence on regional biodiversity



Hence it is doubtful if even regional biodiversity really does ever improve with increasing affluence. In an analysis of over 100 countries Naidoo & Adamowicz (2001) showed that in most taxonomic groups the number of threatened species increased with increasing per-capita GNP. Czech *et al*. (2005) found a close correlation between US GDP and the number of threatened species in the US. The turning point at which biodiversity might improve, i.e. the shape of the line in Figure 5, is therefore not only case-specific but probably also dependent on the various measures used for both consumption and affluence, all of which will have different implications and all of which are imperfect. GNP as a crude measure for a country's affluence, for example, might not take account of actual purchasing power or of the distribution of the per-capita income. Also, if per-capita GNP is bimodally distributed, with some very rich and some very poor people, forces on biodiversity might be quite different than in a normal distribution mode.

Growing consumption of goods, resources and energy can cause major ecological damage, and both consumption itself and its impact on biodiversity can be measured in various ways and through various indicators. Consumption could, for example, be measured in terms of number of motor vehicles in use, as transport has the potential to have adverse effects on biodiversity through habitat fragmentation, energy usage and emissions as well as by using land that could have supported animals and plants. In China, the number of cars has increased from 1.1 million in 1990 to 6 million in 2000, with an expected total of 34 million by 2010 (Myers & Kent 2003). In Britain, transport demands are expected to keep growing, with an average growth of UK private car stock of about 1.6 percent each year between 2000 and 2010 (SEWTA 2005). In Halle, the largest town in East Germany's *Land* Sachsen-Anhalt, the proportion of people using cars to commute to work has risen from 16 percent in 1982 to 46 percent in 1996 (Fliegner 1998). Car use is, however, likely to affect biodiversity most if road networks are increased, i.e. if car use is a reflection either of a growing number of people or a growing number of consumers. This is not necessarily the case in a situation of rural exodus like in East Germany, where increasing car use probably reflects weak public transport systems and low density of places of employment, so that dependence on cars rises in rural areas.

2.1.3 Human activities

Many scientists believe that we are currently undergoing a mass extinction driven by human activities. Almost all human activities have the potential of damaging biodiversity, either directly by land-use changes, disruption of habitats or direct harvesting, or indirectly through climate change, pollution, introduction of invasive species etc., and are therefore often in conflict with conservation. However, activities and their repercussions on biodiversity are likely to be very different in countries in different states of development: Developed countries may deplete biodiversity through agricultural intensification and industrial pollution, developing countries through subsistence agriculture and hunting. In developing countries with strong economic growth and transition countries such as China and India biodiversity depletion may be largely driven by 'new consumers', defined by Myers & Kent (2003) as persons with purchasing power of over PPP $2,500 per person per year, who have large impact on economic activities and hence on environmental repercussions.

Depending on the type and intensity of the activities they engage in, people can have negative effects even at low densities, for example if they are intensively managing land for agriculture, thus reducing biodiversity and/or preventing repopulation by animals. This is even true for the very early days of human expansion on the planet, when humans, in spite of their extremely low density, exterminated a large number of species by means of fire and direct hunting (Flannery 1994, Steadman 1995, Vitousek *et al*. 1997).

However, insofar as human activities create habitat mosaics and thus increase natural heterogeneity and productivity, they can also be beneficial to non-human species, although a recent study by Hugo & van Rensberg (2008) in South Africa found that this applies only to common species, not to rare species, and only when land transformation levels are low.

2.1.3.1 Impact arithmetics

Like consumption, human activities can be measured in various ways, either directly as industrial or agricultural output, transportation miles etc., or indirectly by means of their impact in terms of greenhouse gas emissions, waste production etc. But however measured, the per-capita impact has to be multiplied by the number of people engaging in a potentially damaging activity or doing the consumption. Using consumption of NPP as an example, East and South Central Asia have the lowest per-capita consumption of any region, but host almost half the world population and thereby appropriate 72 percent of its regional NPP (versus 24 percent for the USA) (Imhoff *et al*. 2004). As population grows, demand for goods grows. Also, continued population growth can cancel out efforts to improve the efficiency and cleanliness of technologies and to stabilize per-capita consumption levels. The environmental impact of per-capita consumption and activity is therefore clearly also a function of the population size.

2.1.4 Age structure

Does the age structure of a population, i.e. the relative proportions of different age groups, matter to its impact on biodiversity? Age structure results from the fertility rates and migration patterns prevailing in a society, both of which vary according to national or regional circumstances. The world's youth population (those between the ages of 12 and 24) has now reached a historical high of 1.5 billion – 1.3 billion of whom are in developing countries (World Bank 2007). Developing countries often lack the financial resources, infrastructure and strategic planning needed to accommodate these young people. With some 130 million youths unable to read or write, nearly half of the world's unemployed are youths, and the Middle East and North Africa alone must create 100 million jobs by 2020 to meet demand for work (UNDP 2007). 'Youth bulges' are statistically associated with conflict and political instability, apparently regardless of economic or educational status (Goldstone 2002, de Sherbinen 1995), which in turn might prove fatal to any species living in the conflict area and will inevitably banish any conservation efforts from the national agenda. Furthermore, rather than looking at populations in a 'snap-shot' manner, the reproductive potential of large cohorts of children and juveniles has to be taken into account, as these can lead to sharp increases in the size of the population forming families and seeking work in decades to come.

Contrary to developing countries the population of EU nations has been aging for some time and is expected to continue doing so over the coming decades, as life expectancies increase, and, as appears likely, birth rates remain low (York 2006). Alan Greenspan's

(2007) claim that older people consume more resources than children is supported by Dietz *et al*. (2007), who suggest that a higher proportion of adults in a population may increase environmental impact as children and juveniles do not engage in production activities and thus have substantially less impact than adults. It could, however, be argued that youngsters are still consumers, as they need to be fed, clothed and entertained. Richard York (2006) found that populations with a high proportion of older people consume more energy than those more dominated by the young, as older populations tend to have smaller household sizes and more consumers of energy-intensive products, such as cars. Assuming that energy use in terms of fossil fuel consumption impacts biodiversity (via climate change, extraction, processing, waste etc), this would mean that there are certain aspects of older populations which may affect biodiversity more adversely than large cohorts of young people would.

The above simplifies age structure into just two categories – children and juveniles versus older people. An in-depth study into the impact of age on biodiversity would have to look at different age categories in a more detailed way. Taking a third category of 'young adults' (aged 18-25) into account, Jones & Dunlap (1992), for example, found age to be one of the best predictors of environmental concern in the U.S., with young people being the biggest supporters of environmental protection in terms of federal spending. In this context, however, it is important to distinguish between attitudes and behaviour, as environmentally friendly attitudes are not always followed by environmentally friendly behaviour. Other research does, in fact, show that older people are more willing than young people to behave in an environmentally friendly manner, even though their attitudes are not as positive as those of the young (Engel & Plötschke 1998).

2.2 Biodiversity

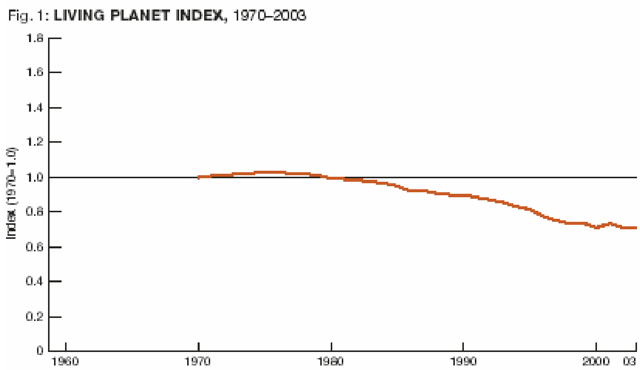
In the context of this study biodiversity is to be understood to mean the variety of different species, populations and ecosystems, including abundance of populations and individuals. Many complex factors can influence and exacerbate the impact of human populations on biodiversity, and biodiversity is only one of many environmental indicators of human impact, soil degradation, erosion, forest vegetation cover and air quality being some of the others. A degradation in any one of these, however, can be expected to have negative repercussions on biodiversity.

Unfortunately, knowledge about temporal changes in biodiversity patterns is limited. Historical data on biodiversity or population sizes at the country level simply do not exist for most countries (Naidoo & Adamowicz 2001, Goldstone 2002, Capistrano *et al*. 2005, Young 2007). There are few complete, accurate distribution records of species (except for some endangered species) in specific sites over time (Hortal 2008) and very little monitoring of changes in biodiversity takes place outside protected areas. Even for very visible, large mammals such as red deer in Europe reliable quantitative data are non-existent or at best patchy (Milner *et al.* 2006).

Standardization of data is another problem. Although the European Union is beginning to establish standards and protocols for biodiversity data collections in the form of its LIFEWATCH project (European Commission 2008a), even among participating countries, species lists are rarely collected in a consistent way and significant information gaps remain (EPI 2008). The use of different classifications and methodologies means that information is inconsistently formatted across studies which makes comparisons between the different data sources difficult.

Another problem is the large scale on which data are generally made available. Although some nation-wide data can be found on databanks such as the Global Biodiversity Information Facility, European Mammal Assessment or the German Bund für Naturschutz, data for specific regions within a country are not readily available. Hence, significant information gaps remain and biodiversity changes are difficult to measure beyond very general trends (Figure 6).

Figure 6 – Overall trends in vertebrate populations



This index shows the overall trends for populations of vertebrate species. It declined by 29% between 1970 and 2003

source: WWF, 2006

Detailed and comparable time-series data for variables such as species richness, abundance or composition would, however, be important for assessing progress towards the target set by 190 nations, among them Germany, at the CBD Conference of Parties in 2002 "*to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth*" (CBD, 2008).

In the absence of direct measures, proxies such as the degree of conversion of natural land-cover to other forms of land-use (agriculture, pasture, industry, etc) can be used as an indication of the state of biodiversity (Capistrano *et al.* 2005). Indicators could also be based on extinction risk (certain threatened species, for example mammals and birds, could be taken as a percentage of all such species in the country) or on surface of protected areas. Or, as suggested by Scholes & Biggs (2005), a 'Biodiversity Intactness Index' could be used that estimates current population sizes of certain well-understood taxonomic groups relative to premodern times by combining data on land-use with expert assessments of how this land-use affects the abundance of each group.

3. Background – East Germany

In East Germany accelerated depopulation processes were triggered in 1989. This region therefore lends itself to investigating the complex environmental, societal and spatial impacts a shrinking human population might have on biodiversity.

3.1 The German Democratic Republic

At the end of the 2nd World War Germany was divided up among the four allied forces, with the Eastern portion of the country, made up largely of the Northern German Plain, being allocated as the Soviet occupational zone. Here the Soviet Union created a socialist state in 1949, the German Democratic Republic (GDR), which was separated by fences and wide border strips, the so-called Iron Curtain, from the western Federal Republic of Germany (FRG). Because Berlin lay 160 km inside the GDR and was split into a Western and Eastern part, over 2.7 million East Germans (CIA, no date) fled to the west via West Berlin. In order to stop this outflux of skilled labour, the GDR built the Berlin wall in 1961, thus effectively closing off East Germany and its people from the West for 28 years.

Private estates were expropriated and agriculture was collectivised. East German agriculture was relatively productive and the GDR was almost self-sufficient in basic foodstuffs (Fulbrook 1992). Central planning was introduced for both agricultural and industrial production, and the economy performed well, attaining in the 1980s the highest per-capita production of the Eastern bloc and becoming the twelfth most important trading nation in the world (Fulbrook 1992). There was guaranteed employment, food and housing prices were low, with no extremes of wealth and poverty. However, what set out to be a classless society marking a total break with the Nazi past soon turned into a bureaucratic party dictatorship. Environmental protection in the GDR was cruelly neglected, with agricultural and industrial planning targets taking precedence (Behrens & Hoffmann 2007). The decline of the USSR and the end of the Cold War led to the fall of the Berlin wall in November 1989 and the reunification of two Germanies with very different socio-economic and political systems in 1990.

Figure 7 – Map of Germany (with population densities for East Germany, Hessen and NRW)

source map: http://www.maps-of-germany.co.uk/large-map-of-east-west-Germany.htm
©2006 Code Network Media Group.
source density data: StBA, 2008

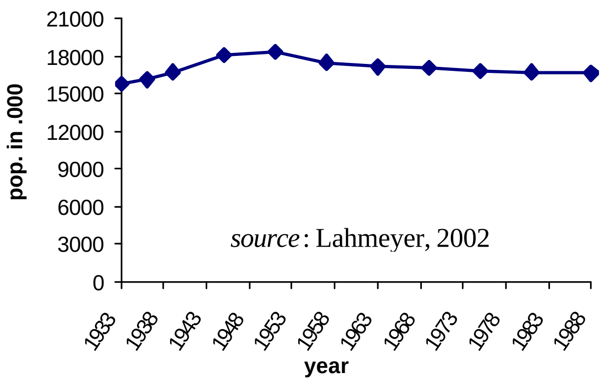
3.2 Demographic and socio-economic trends in the ‘new’ East Germany

Contrary to all generalisations about German efficiency, the reorganisation in the five new *Länder* – Brandenburg, Mecklenburg-Vorpommern, Sachsen, Sachsen-Anhalt and Thüringen - was chaotic. The immediate transition from a planned to a market economy and the complete transfer of the Western legal and social systems led to East Germany’s de-industrialisation and large-scale loss of employment (Figure 8). Three years after reunification East German economy had lost over 60 percent of its industrial output (Walter 1995). Unemployment rates rocketed everywhere in East Germany by up to 20% between 1995 and 2001 (Kröhnert *et al*. 2004). In May 2008, unemployment in the East (13.4 percent) is still more than double that in the West (6.4 percent) (BfA 2008).

Figure 8: *Abandoned pram factory Opel & Kühne AG in Zeitz (Sachsen-Anhalt), 2006*

source: http://www.flickr.com/photos/ sperrzone/212812485/

Figure 9 - Population in East Germany between 1933-1988



While for decades before reunification, population numbers in East Germany had hardly fluctuated (Figure 9), migration from East to West Germany was now high. This, in combination with one of the lowest birth rates in the world (0.77 - 1.2) led to a population decrease in East Germany between 1990 and 2006 of 12.5 percent or nearly 2 million people (StBA, 2008).

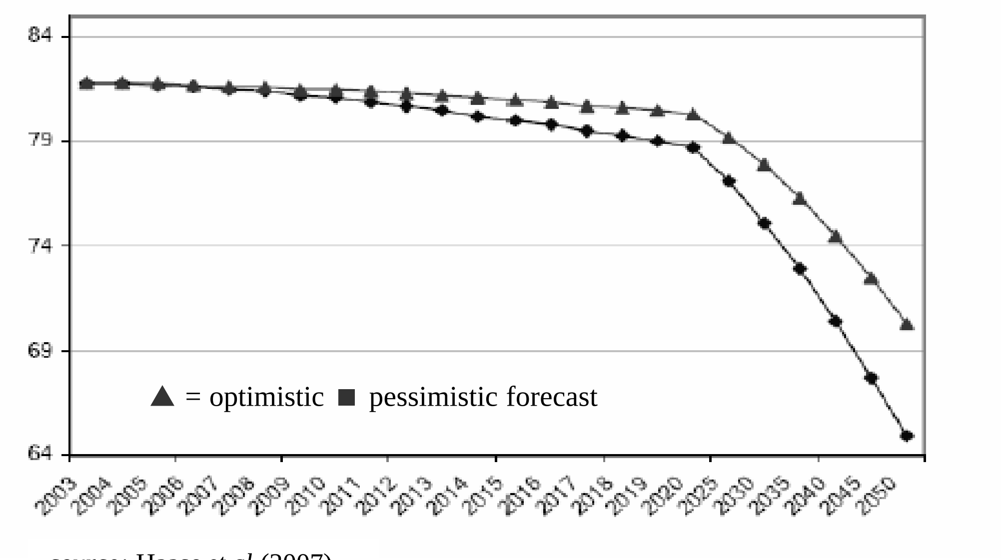
Looking at this in a European context, four of the ten EU regions with highest population decreases between 1996 and 2004 are in East Germany, with Sachsen, Sachsen-Anhalt und Mecklenburg-Vorpommern all regressing by over 5% (BBR, 2007). Further substantial losses in East Germany are projected until 2020 (see Table 1), and the long-term projection for Germany as a whole shows massive losses in population (Figure 10) .

Table 1 - Projected population changes in Germany until 2050 in million people

New *Länder*	people	%
Brandenburg	-148.000	-6
Mecklenburg-Vorpommern	-169.000	-10
Sachsen	-398.000	-9
Sachsen-Anhalt	-356.000	-14
Thüringen	-281.000	-12

source: StBA 2008

Figure 10 – Forecast population trend for East Germany from 2005 to 2020



source: Haase *et al* (2007)

Both Table 1 and Figure 10 illustrate the importance of finding ways of integrating the dynamics of decreasing numbers of people into long- and medium-term conservation planning, as depopulation will continue to accelerate.

Driven by a variety of factors such as low birth rates, increased longevity and migration, Germany is ageing. A global comparison shows Germany to be well below both world and EU average in the youngest age group and well above in the 65+ group (Table 2).

Table 2 - Age groups in percent

	0-14 years	15-64 years	65+ years
world	27.0	66.2	8.0
EU	16.0	67.2	16.8
Germany	13.1	66.2	20.0

source: The World Factbook, 2008

However, trends vary greatly in the different *Länder,* with East Germany experiencing a markedly different development than the rest of the country since reunification. The East-to-West migration affected the age structure in East Germany particularly strongly, as most internal migrants are people of working age. As a consequence, the new *Länder* now have a higher proportion of older people than the rest of Germany. This trend is expected to continue, with 21% over 65-year-olds in 2005 rising to 28% in 2020, compared to 19% and 22% respectively for West Germany (StBA 2008)

Migration not only occurs from East to West, but also within the East itself: Agglomerations are growing, rural regions are emptying (Schmid & Tenbrock 2005). In brief, inhabitants of rural areas are becoming rarer and older.

The sudden economic changes brought an abrupt rise in affluence and consumption in East Germany. In the first four years after reunification the number of private cars in the East increased by over 20 percent, the number of lorries more than doubled (versus +5.6 percent and +12.8 percent respectively in the West) (DIW 1996). Average incomes rose from approx. 12,000 DM (6,000 €) (Stern 2006) in 1990 to nearly 22.000 € in 2006 (StBA 2008). Activity patterns changed with de-industrialisation and rising unemployment. Other structural changes in the East included the disintegration of many multi-person-households after the reunification, so that the proportion of one-person-households rose from 27 to 37 percent between 1991 and 2005 (Kröhnert *et al*. 2004).

3.3 Heterogeneity

Human demography in East Germany is very heterogenous, with some rural areas showing major declines in human population and urban centres showing increases. Brandenburg for example, the largest of the five East German *Länder* and the only one where overall population has remained almost stable since 1990, is a mosaic of very different regions. The changes taking place here can only be fully appreciated in conservation terms by looking at them at a smaller scale. People gravitate towards Berlin, situated in the centre of this *Land* (Berlin itself being a separate *Land* and administratively not part of Brandenburg), thus causing a strong demographic disparity. The commuter belt outside and around Berlin which makes up 15 percent of Brandenburg's total area has increased by 27 percent between 1994 and 2004, and is now home to 39 percent of all Brandenburgers (Kröhnert *et al.* 2006). In contrast, most of the rest of Brandenburg is experiencing strong population losses. In Uckermark, for example, Germany's largest *Landkreis* (NUTS 3) (circled on Figure 7), the population has shrunk by 20 percent since 1990 to a density of 44 people/km² in 2007 (Amt für Statistik Berlin-Brandenburg 2007).

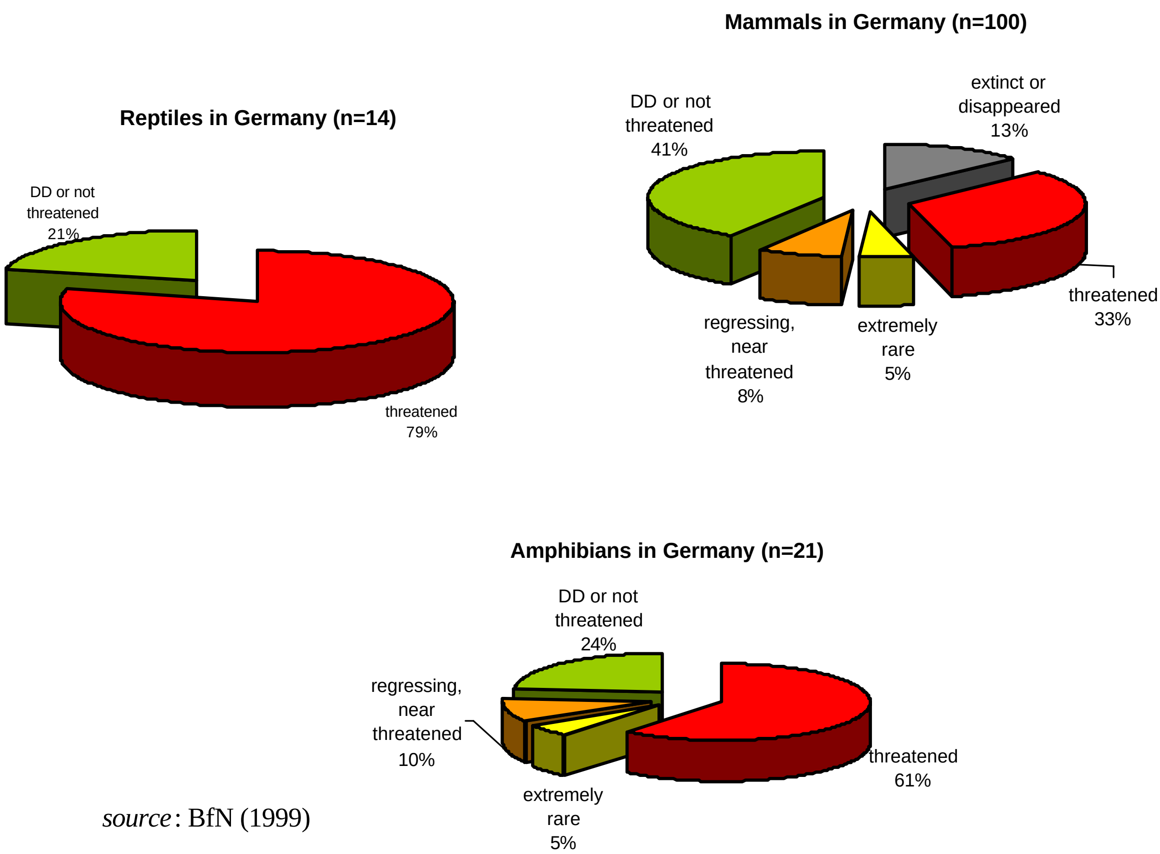
The perception of population shrinkage and potential concomitant biodiversity changes therefore depends on the scale of the sampling unit and the area under examination. Analyses on a local scale may give very different results from those on a regional or national scale. This tallies both with the ‘Buffalo Commons’ example presented in section 2.1.1 and with a study by Pautasso & Chiarucci (2008), who found that correlations between humans and veteran tree biodiversity in Italy depended on grid size.

3.4 Biodiversity in Germany

In Germany, the StBA (Federal Office for Statistics) is currently working on an area sampling concept in order to determine the status and development of ecosystems, especially in regard to biodiversity, but this concept is not yet in place and environmental and biodiversity data are therefore scarce and unstandardized (BMU 2007). The threat status of various biodiversity components is being documented nationally via *Rote Listen* which are revised and published by the Bundesamt für Naturschutz roughly every 10 years (last time 1998).

Approximately 45,000 animal species are found in Germany, 16,000 of which have been assessed for their red list status (BfN 1998). Germany has 788 plant communities, over 48 percent of which are considered threatened (CBD 2005).

Figure 11: Overview of the national *Rote Liste* status of three vertebrate groups



source: BfN (1999)

In East Germany, however, demographic developments and changes in agricultural policy of the past 18 years appear to have had certain positive effects on biodiversity. Wolves, originally present all over Europe, were extirpated in the 18th and 19th century from large central European regions through hunting and the disappearance of forests (Berlin Institute 2003). Since reunification, depopulating regions such as Lausitz in Sachsen (circled on Figure 7) on the Polish border have become ideal territory for wolves who, contrary to the people of this region, have lots of offspring: at least 40 wolf cubs have been born here since 2000 (Gruschwitz 2007) (Figure 12a).

The Lausitz town of Weißwasser, site of a thriving glass industry during GDR times and now in the centre of the major wolf area, lost more inhabitants than any other part of East Germany: 32.4 percent in 13 years (Herfert 2003). Elks are also making a come-back: small numbers of these animals, which last lived on German territory in medieval times, are migrating back into Germany from Poland (Tagesspiegel Berlin 2006, Tagesspiegel Potsdam 2007) (Figure 12b)

www.galium.ws/aktion_wolf.html

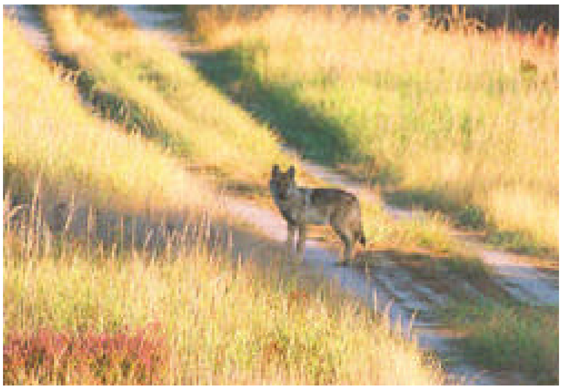


Figure 12a: Wolf of the Lausitz population (Photo: Büro Lupus)

Figure 12b: One of several elk sightings in East Brandenburg in 2007 (Naturschutzbund Brandenburg www.brandenburg.nabu.de/m03/m03_04/07377.html)

The measurement of changes in biodiversity is a complex problem. Apart from the issues already mentioned in chapter 2.2, recolonisation by 'new' species in particular is a series of probabilities rather than a concrete, measurable change. Seeing elks, for instance, does not necessarily mean that these animals are now established in the area. Their recolonisation is a gradual process, in the course of which they will migrate into East Germany with an ever-increasing chance over time of staying and reproducing there.

4. Methodology

4.1 Data Selection – Demographic data

Data for nine demographic variables for five East German and eight West German *Länder* were obtained from the GENESIS databank of the StBA (accessible to registered, fee-paying users only) and the Federal Office for Motor Vehicles (Kraftfahrzeugbundesamt, 2008). These variables were population density, number of households, proportion of area in agricultural use, proportion of forest area, number of cars, unemployment rate, annual average wages, GNP and median age. Although agricultural and forest area are land-use rather than demographic data, these were included as a reflection of human activities. Median age was calculated for each *Land* based on numbers of inhabitants in 91 age categories from "under 1 year olds" to "90+ year olds". The data were collated in Table A1 (Appendix A). Only some of the data were available for 2007, hence all data refer to year 2006.

4.2 Data Selection – Biological data

Various sources of biodiversity data were explored and their usability in the context of this study assessed.

4.2.1 Changes in *Rote Liste* status

Many studies use the proportion or percentage of threatened species as the measure of population changes. The German red lists of threatened species, however, could not be used in this way for the following reasons:

- Within Germany, there are national *Rote Listen* for animals, plants, plant communities and biotopes, and regional ones for many more taxonomic groups, for which each *Land* presently still applies different criteria (Ulrich Lanz, personal communication 18/5/2008). Different lists are based on different collection methods and updated in different intervals, and data collection efforts, administrative support and comprehensiveness of publication vary from *Land* to *Land*. Comparability is therefore limited.
- Unlike the IUCN criteria, the German *Rote Liste* criteria are purely qualitative (see Box 1) and thus open to interpretation. It is unclear how expressions such as "rare", "moderate" or "compared to before" are to be understood (Box 1). This leaves a wide margin of variation among different assessors and even within one *Land*.

Box 1

ROTE LISTE

The term *Rote Liste* is retained in this text where reference is made to German red listing criteria (introduced 1977), as these are different from the IUCN criteria (introduced 1963). The table below gives approximate correspondences (IUCN 2001, Ludwig *et al.* 2006):

German categories	IUCN categories
-	**EX** extinct
0 Ausgestorben oder verschollen	**EW** extinct in the wild
1 vom Aussterben bedroht	**CR** critically endangered
2 stark gefährdet	**EN** Endangered
3 gefährdet	**VU** Vulnerable
R Gefährdung anzunehmen	- likely to be endangered
G Gefährdung anzunehmen	**LR** Lower Risk
V Vorwarnliste, zurückgehend	**nt** - near threatened
D Daten ungenügend	**DD** Data deficient

Example: *Rote Liste Nordrhein-Westfalen definition for category 2 (stark gefährdet / endangered):*

"Species that have considerably regressed or are considerably threatened by current or foreseeable human impacts

- *today very rare to rare and significantly shrinking over the entire area* ***or***
- *still moderately frequent, but due to encroachment very severely threatened*
- *spectrum of sites of habitats largely restricted compared to before* ***or***
- *several group-specific risk factors apply*

- Most national *Rote Listen* are revised only every 10 years. The new edition for animals is not expected to appear before 2009 (Norbert Hirneisen, personal communication 18/6/2008).
- Data are rarely available electronically. *Rote Listen* catalogues have to be purchased by mail-order for individual taxonomic groups and assessment periods.

4.2.2. Hunting data

The numbers of deer belonging to three species (*Dama dama, Cervus elaphus, Capreolus capreolus*) shot over a 20-year time period in all five East German and two West German *Länder* were obtained from the German national hunting association (Deutscher Jagdschutz-Verband, 2007). Had it been possible to obtain equally detailed figures for hunting effort in terms of changes in licence holders and hunting quotas, the number of killed deer could have been correlated to the deer population in the various *Länder* and used as a proxy for changes in actual population numbers. However, due to the absence of controls for effort the use of this data set had to be abandoned.

4.2.3 Bird index data

Birds were the only taxonomic group to be found with a large set of temporally and regionally differentiated survey data. The data used for this study were provided by the Dachverband Deutscher Avifaunisten (DDA), the umbrella organisation of German ornithologists. The DDA has been carrying out a monitoring programme for common breeding birds in Germany since 1989 based on territory mapping and point-stop counts which provides reliable information on changes in distribution and numbers of bird species all over Germany (Flade & Schwarz 2004). In order to ensure representativeness of the index data, the StBA identified 1,000 sample areas of 1 km² size, where bird populations are monitored by volunteers and expert ornithologists (DDA, no date). For the purposes of this study the DDA provided bird index data from 1992 until 2007 for various bird species for three regions: East Germany as a whole (i.e. accumulated data for all five East German *Länder* together) and two West German *Länder*, Hessen and Nordrhein-Westfalen (NRW) (Appendix D). The data sets for Hessen and NRW were requested in order to contrast the depopulating region of East Germany against one growing *Land* of average population density (Hessen), and against NRW, which has the highest population density of all *Länder* with strong growth (StBA 2008).

4.3 Data analysis

4.3.1 Correlation matrix and Principal Component Analysis for demographic data

The aim of this analysis was to examine the correlations between the demographic variables and to give each *Land* a score which takes all available demographic characteristics into account, firstly in order to summarize all relative similarities and differences between the *Länder* and to illustrate them visually, and secondly to reduce the number of demographic variables.

Based on the demographic variables contained in Table A1 in Appendix A, MINITAB® Release 14.1 (Minitab Inc.) was used to obtain a summary statistic for each variable (Appendix A, Table A2), followed by the correlation coefficient matrix for the nine variables (Table 3).

In order to obtain a score for each *Land,* a Principle Component Analysis was carried out on all nine variables, starting with an eigenanalysis of the correlation matrix which summarizes the variability in the data set (Appendix A, Table A3).

The coefficient or weighting given to each variable in each of the nine principal components to account for the maximum amount of variation was calculated (Table 4). These coefficients were used to obtain scores for each of the *Länder* by multiplying them with the standardized data for each of the *Länder* (Appendix A, Table A6), thus giving the final scores for plotting (Table 5, Figure 13).

4.3.2 Regression analysis of bird index data versus demographic factors

In order to consider several human population attributes jointly in terms of their impact on bird species over time, a regression analysis of bird index changes versus human demographic factors in Germany was carried out. In each regression, the bird species is the response variable, the demographic factors are the predictors or explanatory variables.

Regarding the demographic variables, some of the attributes used in the PCA, i.e. cars, age, number of households, could not be taken up in the regression analysis, as no data could be obtained on the required temporal and/or spatial scale. Therefore, the variables for the demographic component of the regression analysis were: population density, unemployment rate, forest area, agricultural area, average wages and GNP. The year 2007 was omitted from the analysis due to unavailability of some of the demographic data for this year, so that the regression analysis applies to a timespan from 1992 to 2006.

Regarding the bird index data, only bird species for which data were available for all three regions (East Germany, Hessen, NRW) were taken into account for this study. Migratory species were excluded from the study so as to exclude effects of changing conditions in the wintering grounds or on the migration route. The remaining 11 study species were: linnet (*Carduelis cannabina*), tree sparrow (*Passer montanus*), skylark (*Alauda arvensis*), goldfinch (*Carduelis carduelis*) and yellowhammer (*Emberiza citrinella*) (farmland species); greater spotted woodpecker (*Dendrocopos major*), lesser spotted woodpecker (*Dendrocopos minor*), nuthatch (*Sitta europaea*), coal tit (*Parus ater*) and tree creeper (*Certhia familiaris)* (forest species); and house sparrow (*Passer domesticus)* (urban species). (The underlined species are indicator species according to the German sustainability index for biodiversity - see Box 2).

Box 2

Sustainability Index for Biodiversity

(*Nachhaltigkeitsindikator für die Artenvielfalt)*

This index was developed by the BfN as part of the German government's national sustainability strategy to reflect the state of nature and countryside and its changes in Germany. It is based on population changes of 59 bird species considered indicative of their respective habitat. Biodiversity is thus reflected indirectly via habitat quality. The indicator is composed of six sub-indicators for the main habitat types (farmland, forests, human settlements, freshwater, coastal/sea, alpine). For each bird species experts have set a target value for 2015 based on the likely population size if all legislative measures regarding nature protection and sustainability are fully implemented. This population size is the 100% value, against which deviations can be measured (BfN 2007a)

For each bird species index a stepwise linear multiple regression model was fitted for the six explanatory variables (population density, unemployment rate, forest area, agricultural area, average wages and GNP) using the forward stepwise method in MINITAB®. Alpha to enter was set at 0.25. Where this algorithm returned the first significant explanatory variable with a proportion of the variance less than subsequent ones, the model was refitted using both backward and forward/backward methods to confirm the significant explanatory variables. In all cases it did so. Significance was assessed by t, and the proportion of variance quoted is the adjusted R^2. This measure compensates for additional explanatory variables and helps to identify the most economical model (Grafen & Hails 2002).

The regression results are presented as scatterplots for each bird species and each region, showing the relationship between the species and the respective demographic component. Only statistically significant relationships ($p < 0.05$) are shown. In each case, the relationship identified as contributing the most to the variability of the bird index is shown as the larger graph. A simple linear regression trendline is fitted for illustrative purposes only. For the other significant variables that are significant but not as big, a scatterplot is provided without a trendline.

The 'R^2 adjusted values' are cumulative. They give the cumulative proportion of variance in the bird index accounted for by the variation in the respective demographic variable and are shown in each graph together with the p value. A summary of the main relationships is given on page 43, Tables 6a and 6b. Full regression results are printed out in Appendix B.

5. Results

5.1 Correlation matrix of demographic data

The results in this section are based on the data contained in Tables A1 and A2 (Appendix A), which show great variability between the different Länder. In order to make this information easier to digest, a number of tests were carried out to structure and summarize the data.

Table 3 - Correlation matrix *(with p values)*, showing the intercorrelations among the eight variables.

	popdens	househ	agri-area	forest	cars	unempl	av wages	GNP
households	0.587 *0.035*							
agri-area	-0.549 *n.s.*	-0.132 *n.s.*						
forest	0.165 *n.s.*	0.093 *n.s.*	-0.861 *0.000*					
cars	-0.114 *n.s.*	-0.091 *n.s.*	0.576 *0.039*	-0.556 *0.049*				
unempl	-0.478 *n.s.*	-0.497 *n.s.*	0.482 *n.s.*	-0.369 *n.s.*	0.818 *0.001*			
av wages	0.624 *0.023*	0.626 *0.022*	-0.570 *0.042*	0.439 *n.s.*	-0.668 *0.013*	-0.915 *0.000*		
GNP	0.588 *0.034*	0.990 *0.000*	-0.188 *n.s.*	0.156 *n.s.*	-0.192 *n.s.*	-0.581 *0.037*	0.705 *0.007*	
median age	-0.446 *n.s.*	-0.594 *0.032*	0.320 *n.s.*	-0.237 *n.s.*	0.586 *0.035*	0.889 *0.000*	-0.865 *0.000*	-0.660 *0.014*

n.s. = p > 0.05

Strong positive correlations between:
- population density and number of households /
  population density and GNP
- cars and agricultural area /
  cars and unemployment
- GNP and no. of households /
  GNP and average wages
- age and cars /
  age and unemployment

Strong negative correlations between:
- agricultural area and forest area
- cars and average wages
- households and age/
  wages and age /
  GNP and age

5.2 PCA

The eigenanalysis of the correlation matrix (Appendix A, Table A3) indicates that over three quarters (78.6 percent) of the variation in the data is explained by only two sets of scores, PC1 and PC2. Only these two principal components were therefore used for the subsequent analysis. The coefficients or weights calculated for each variable in those two principal components to account for the maximum amount of variation are shown in Table 4 (further calculation details in Appendix A, A5 and A6).

Table 4 – Coefficients for demographic variables

Variable	PC1	PC2
popdensity	-0.294	-0.187
households	-0.306	-0.456
agri-area	0.285	-0.431
forest	-0.231	0.487
cars	0.299	-0.391
unempl	0.401	-0.057
av wages	-0.423	-0.009
GNP	-0.336	-0.408
median age	0.378	0.106

(x standardized data for each Land)

Table 5 – Scores for each *Land*

Land	score 1	score 2
W-BW	-3.04985	-0.06878
W-Bay	-2.55987	-0.13607
E-BB	1.71896	1.17582
W-Hess	-2.12232	0.99619
E-MV	3.22404	-0.47132
W-Nie	-0.15130	-0.99676
W-NrW	-2.52540	-3.10976
W-RhPf	-1.68240	1.88421
W-Saar	-0.98198	1.95905
E-Sachs	2.12521	-0.28078
E-SaA	2.97541	-0.40163
W-SchH	1.11885	-1.24647
E-Thü	1.91063	0.69631

Figure 13 - Principal Component Analysis of socio-economic data of 13 German Länder

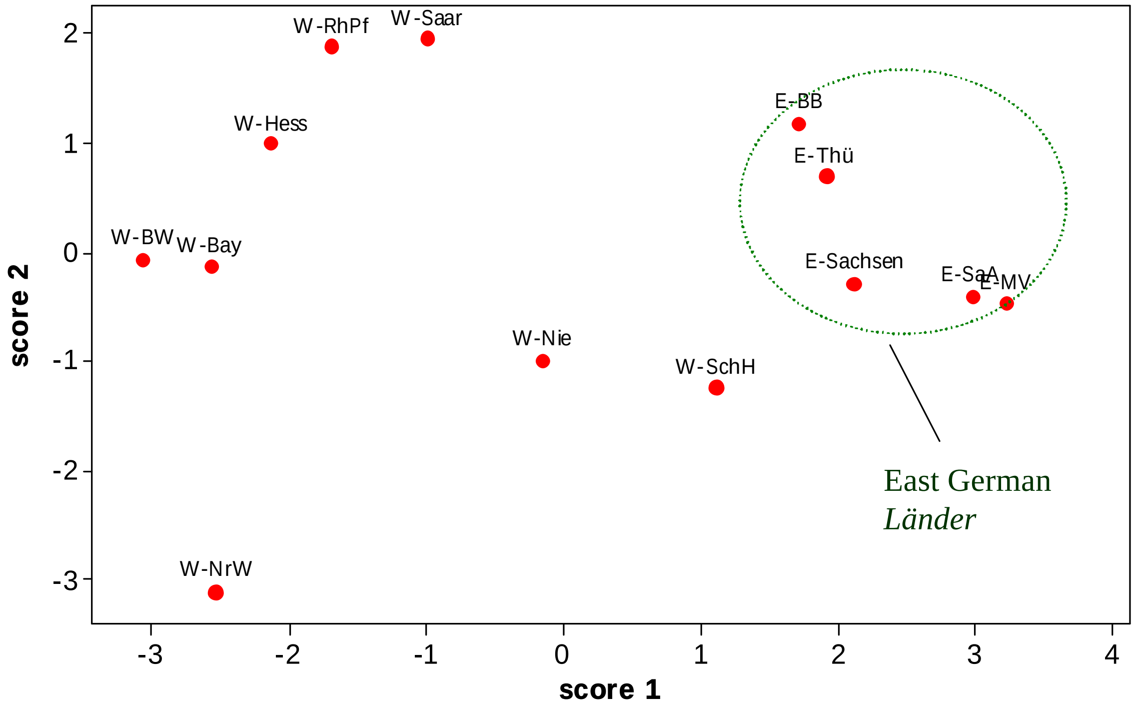


Figure 13 summarizes the data and shows that the *Länder* are well spread out. Looking at the first principal component (x axis), the coefficients for agricultural area, number of cars, unemployment and median age are large and positive (Table 4). Table A1 (Appendix A) shows that these variables are above average in the East Germany *Länder*, which are shown clustered on the upper right-hand side of Figure 13. Score 1 also has large negative coefficients for pop density, number of households, forests, average wages, number of households, and GNP. This means that *Länder* with high pop density, high numbers of households, high average wages and high GNP are on the left-hand side of the graph. These are all in West Germany (Table A1). The X axis (score 1) could therefore be said to represent economic development, with a low score representing a higher level of economic development.

The second principal component, represented by Score 2, has only one large positive coefficient, for forest area. However, as all bar one *Länder* are situated in the upper half of the plot, this does not seem to be a distinguishing factor between the *Länder*.

The one *Land* in the bottom left hand corner of the plot (Nordhein-Westfalen) has strikingly high values for number of households and GNP, both of which are more than three times above the German average (Table A1).

The PCA identified two principal components within which the variables population density, number of households, agricultural area, number of cars, unemployment rate, average wages, GNP and median age all have large coefficients. The initial number of variables could therefore not be reduced. Although proportion of forest area had not been identified as a distinguishing factor between the *Länder* in the PCA, this was nevertheless included in the analysis in order to see whether changes in forest area might play a role for certain bird species.

5.3 Regression analysis results

Full results in Appendix B

Summary results on page 43

5.3.1 - Linnet *(Carduelis cannabina)*

Figure 14a - EAST GERMANY Linnet vs pop. density 1992-2006

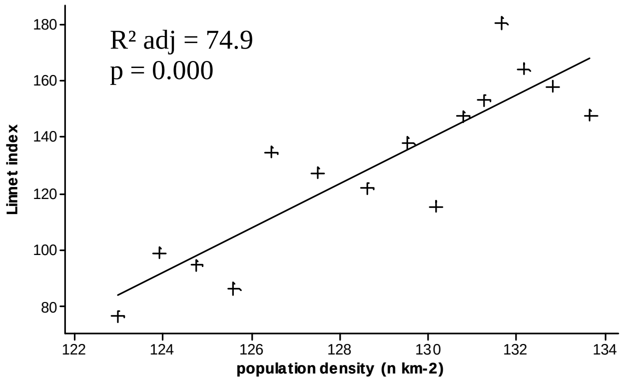


Fig.14b - EAST GERMANY - Linnet vs unemployment 1992-2006

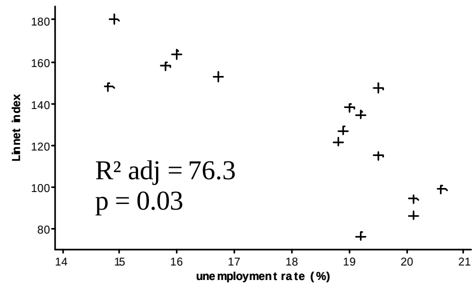


Figure 14c - HESSEN - Linnet vs GNP 1992-2006

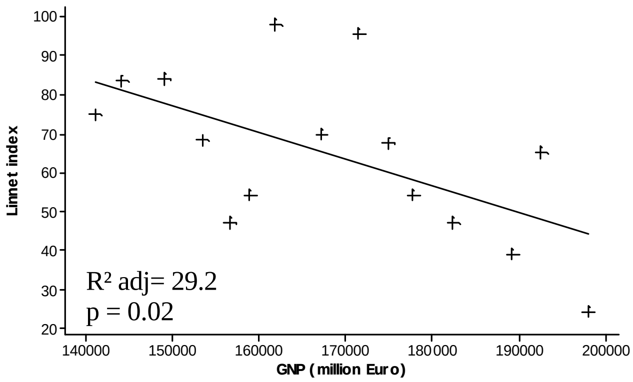
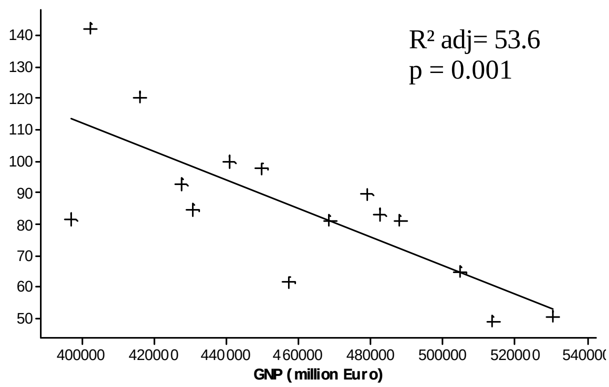


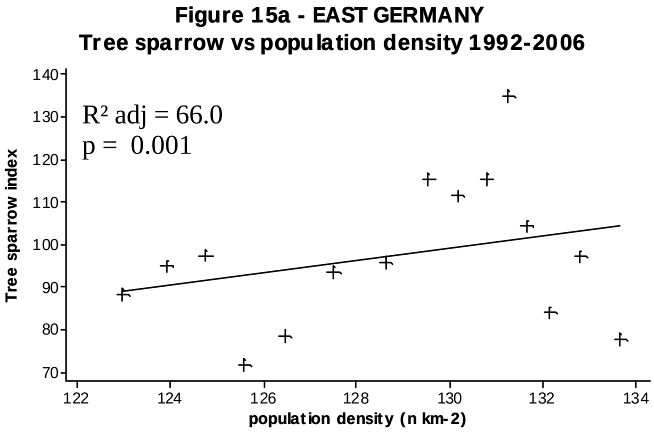
Figure 14d - NRW - Linnet vs GNP 1992-2006

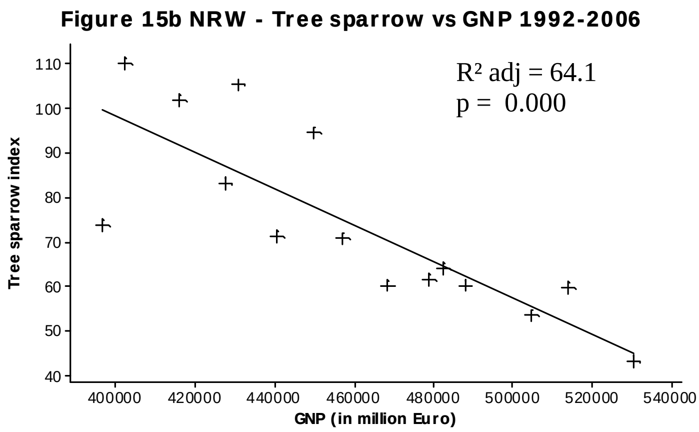


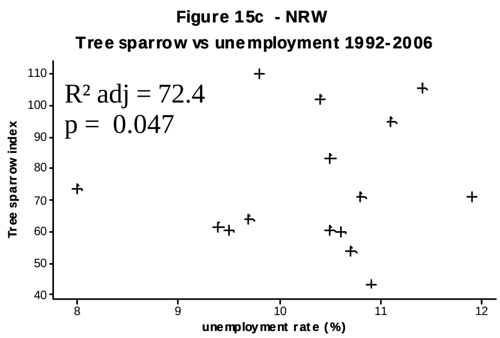
The analysis for changes in linnet populations in East Germany shows a strong positive relationship between this species and population density. In fact, nearly 75 percent of the variability of the linnet bird index is explained by population density alone. There is one other explanatory variable, unemployment, which accounts for just over a further one percent of the total variability, with linnets decreasing with rising unemployment.

Both Hessen and NRW indicate a negative relationship between linnet numbers and GNP, accounting for roughly one third of the index variability in Hessen and for over half in NRW. In both *Länder* linnets are decreasing with increasing GNP.

5.3.2 Tree Sparrow *(Passer montanus)*







For the East German tree sparrow population a cumulative total of 66 percent of the variability of the index is accounted for by population density. This applies when forest area and GNP are also in the model, although the relationship with these two variables was identified as not significant ($p > 0.05$).

In Hessen there was no evidence for a relationship between changes in tree sparrow numbers and any of the demographic variables in the model.

In NRW there is a negative relationship between tree sparrows and GNP, accounting for 64 percent of the variation in the index. The second variable identified as having a significant relationship with tree sparrow numbers is unemployment. This accounts for a further 8 percent of the index variation.

5.3.3 Skylark *(Alauda arvensis)*

Figure 16a EAST GERMANY - Skylark vs forest area 1992-2006

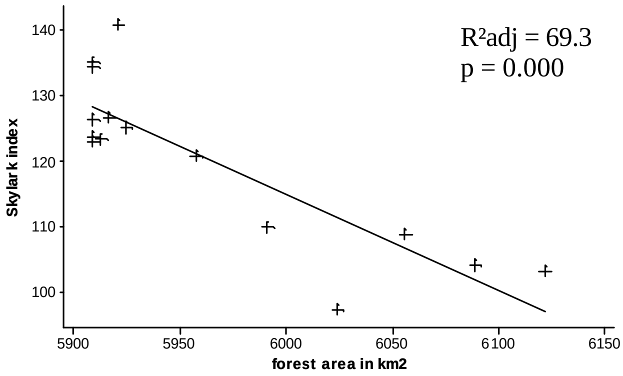


Figure 16b HESSEN - Skylark vs agricultural area 1992-2006

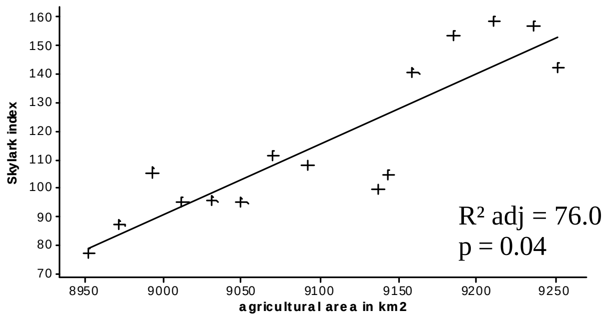


Figure 16c NRW - Skylark vs forest area 1992-2006

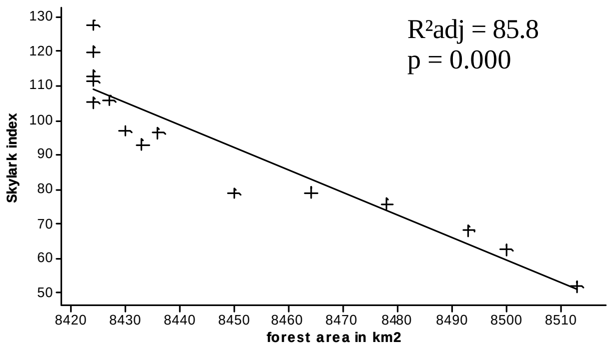


Figure 16d NRW - Skylark vs agricultural area 1992-2006

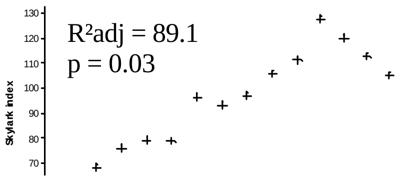
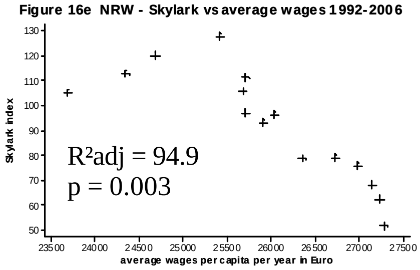


Figure 16e NRW - Skylark vs average wages 1992-2006



Skylarks in East Germany are negatively related to forest area, i.e. there were more skylarks in years when the forest area was between 5900 and 5930 km² than in years when the forest area was larger.

In Hessen a positive relation with agricultural area was identified which accounts for 76 percent of the variability in the index data.

In NRW skylarks are negatively related with forest, with a similar pattern as in East Germany, and forest area accounting for almost 86 percent of the variability of the index. The regression analysis identified two further significant relationships: a positive one with agricultural area, and a negative one with average wages, each accounting for around further 4 percent of variability in the skylark index.

5.3.4 Goldfinch *(Carduelis carduelis)*

Figure 17a - EAST GERMANY
Goldfinch vs population density 1992-2006

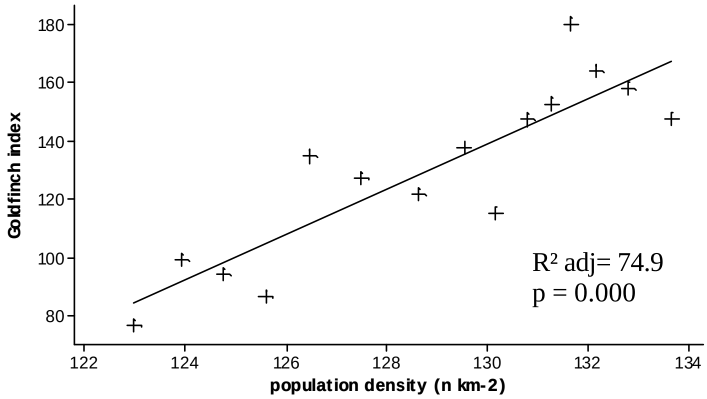


Figure 17b HESSEN - Goldfinch vs agricultural area 1992-2006

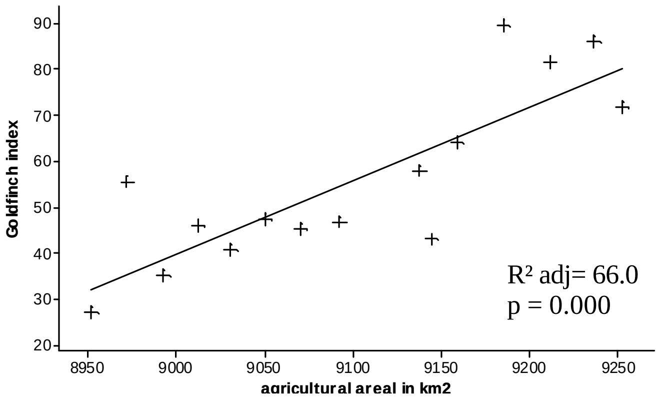
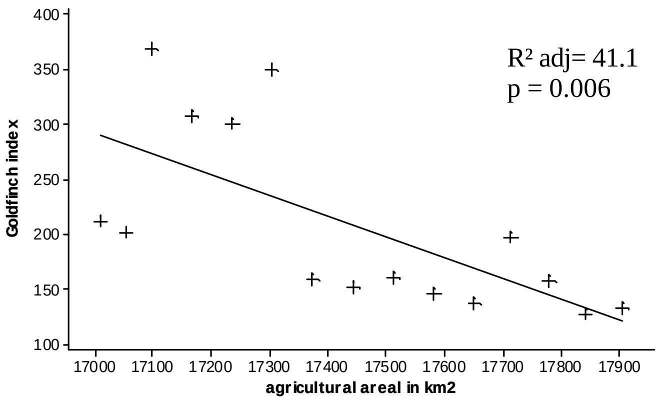


Figure 17c NRW - Goldfinch vs agricultural area 1992-2006



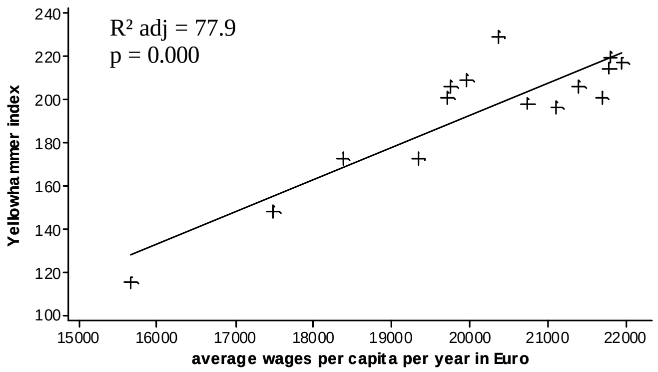
In East Germany the goldfinch shows a positive relationship with population density, accounting for 75 percent of the variability in the index.

In Hessen there is only one strong relationship, which is positive and concerns agricultural area.

In contrast to this, goldfinches show a negative relationship with agricultural area in NRW, explaining 41 percent of the variability in the index data.

5.3.5 **Yellowhammer** *(Emberiza citrinella)*

Figure 18a - EAST GERMANY
Yellowhammer vs average wages 1992-2006



re 18b EAST GERMANY - Yellowhammer vs agricultural area 1992-2006

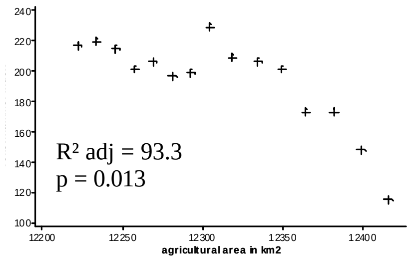


Figure 18c HESSEN - Yellowhammer vs forest area 1992-2006

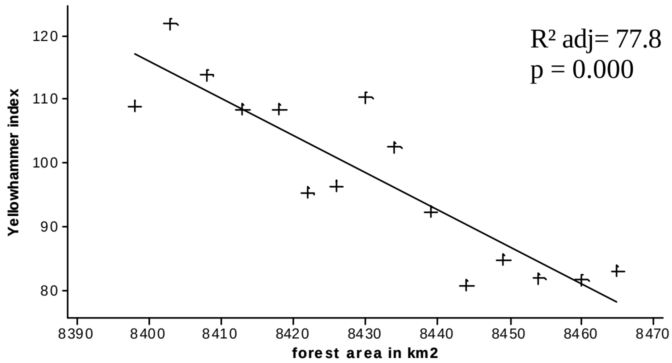


Figure 18d NRW - Yellowhammer vs forest area 1992-2006

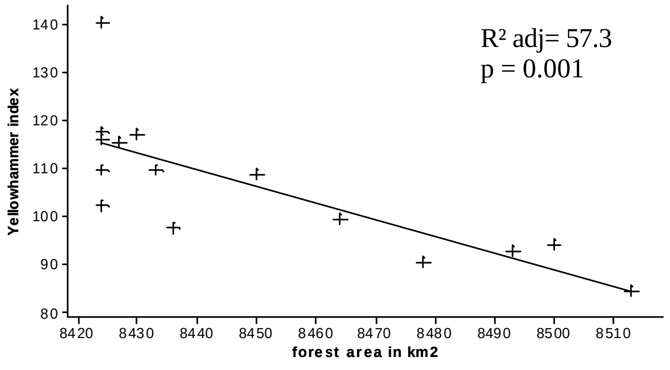
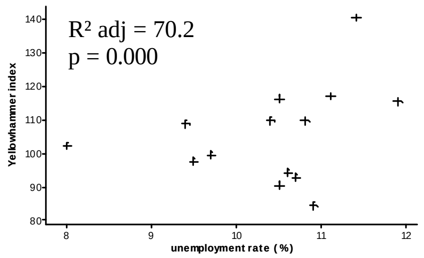


Figure 18e NRW - Yellowhammer vs unemployment 1992-2006



Nearly 80 percent of the variation of the yellowhammer index in East Germany is explained by average wages, with yellowhammer populations increasing with rising wages.

Both in Hessen and NRW most of the variation in the yellowhammer index was accounted for by a negative relationship with forest area (78 and 57 percent respectively). In NRW a further 13 percent is explained by a positive relationship with unemployment.

5.3.6 Greater spotted woodpecker (*Dendrocopos major)*

Figure 19a - EAST GERMANY
Greater spotted woodpecker vs unemployment 1992-2006

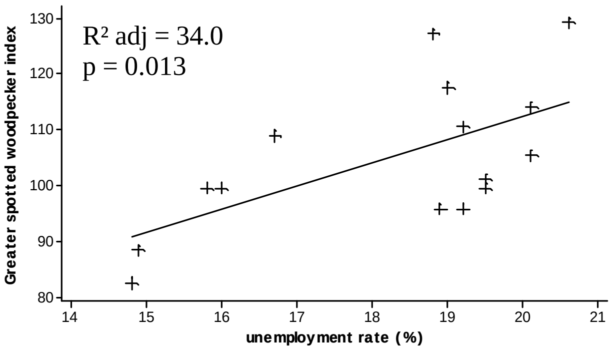
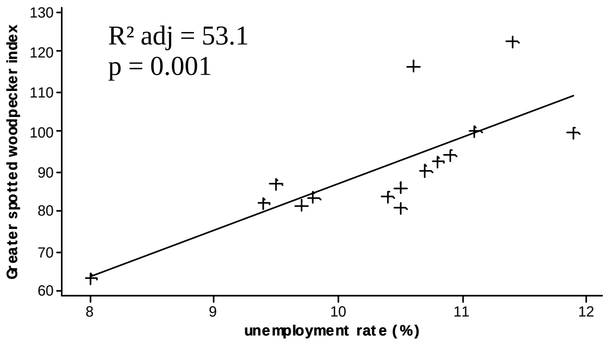


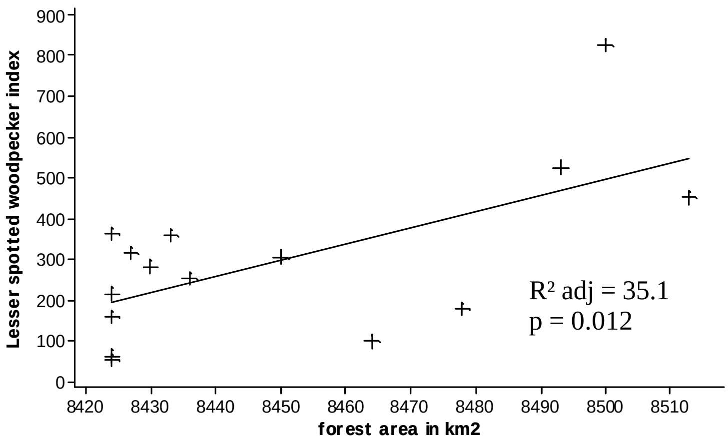
Figure 19b - NRW
Greater spotted woodpecker vs unemployment 1992-2006



Both in East Germany and in NRW the greated spotted woodpecker index is positively related to unemployment. Woodpecker numbers are rising with rising unemployment.
In Hessen none of the variables in the model were identified as being related to changes in numbers of this woodpecker species.

5.3.7 Lesser spotted woodpecker *(Dendrocopos minor)*

Figure 20 NRW - Lesser sp WP vs forest area



In East Germany or Hessen there is no evidence for any relationship between lesser spotted woodpeckers and the demographic variables in the model.
In Nordrhein-Westfalen a positive relationship with forest area was identified, accounting for over one third of the total index variability.

5.3.8 Nuthatch (*Sitta europaea*)

Figure 21a EAST GERMANY - Nuthatch vs forest area 1992-2006

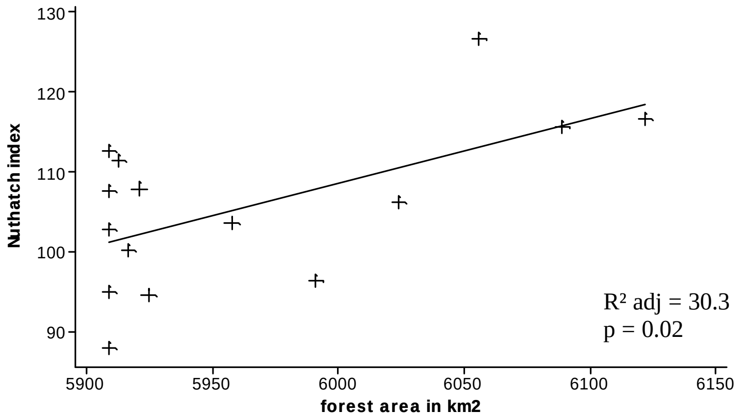
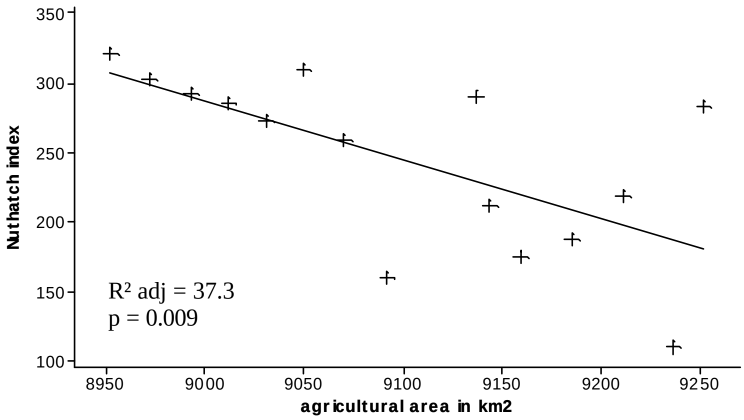


Figure 21b HESSEN - Nuthatch vs agricultural area 1992-2006



In East Germany, out of the six demographic variables tested, nuthatches have a relationship with forest area only. This relationship is positive and explains 30 percent of the variability of the index, but as was the case for skylarks, the plot shows most data points clustered around a forest area of between 5900 and 5950 km², with only six points beyond the 5950 mark.

In Hessen a negative relationship with agricultural area was identified; nuthatch numbers are going down as farmland area increases. This relationship explains 37 percent of the index variability.

In NRW there was no evidence for any significant relationship between nuthatch numbers and the demographic variables in the model.

5.3.9 Coal tit *(Parus ater)*

Figure 22a - EAST GERMANY
coal tit vs agricultural area 1992-2006

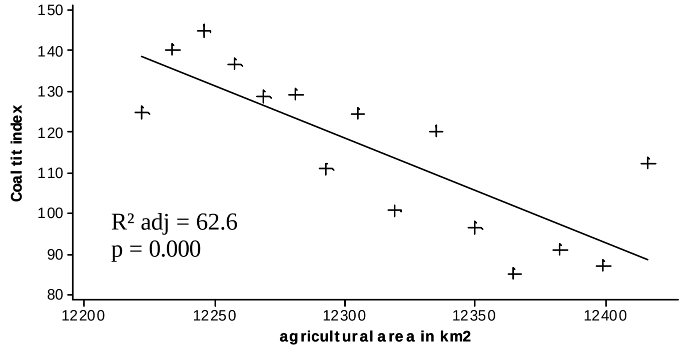


Figure 22b HESSEN - coal tit vs population density 1992-2006

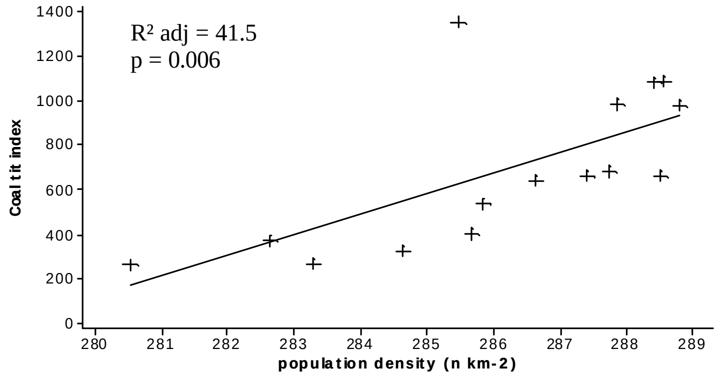


Figure 22c NRW - coal tit vs GNP 1992-2006

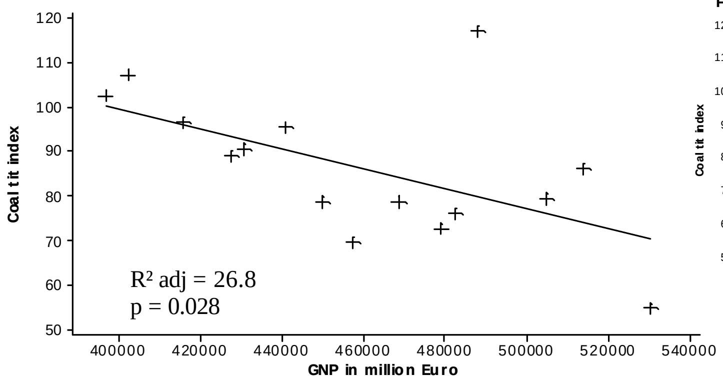
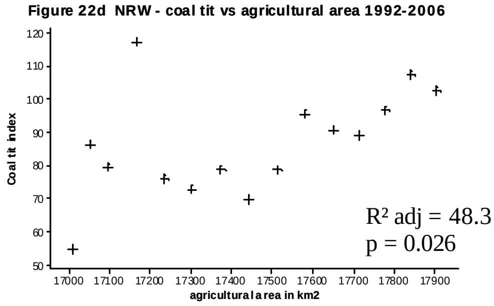


Figure 22d NRW - coal tit vs agricultural area 1992-2006

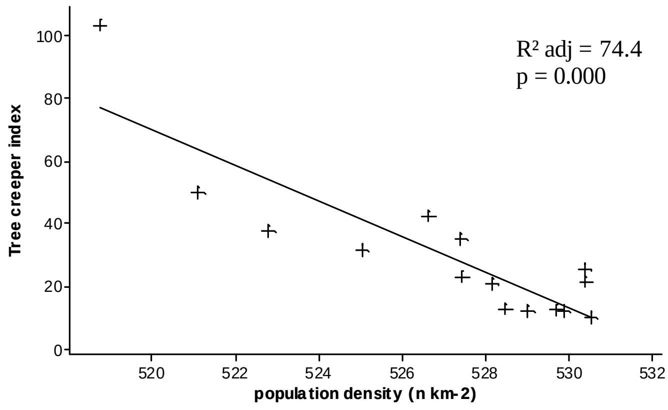


Coal tits in East Germany are negatively related to agricultural area, whereas in Hessen they show a positive relationship with population density. These relationships account for approximately 63 and 42 percent of the coal tit indices respectively.

In NRW coal tit numbers are negatively related to GNP (explaining 27 percent of the index variability), but there is also evidence for a relationship with agriculture with an explanatory power of a further 21 percent.

5.3.10 Tree Creeper (*Certhia familiaris)*

Figure 23 NRW - Tree creeper vs population density 1992-2006



The only significant relationship identified for tree creepers was a negative one with population density in Nordrhein-Westfalen, explaining three quarters of the total variability in the tree creeper index of this *Land*.

5.3.11 House Sparrow (*Passer domesticus)*

Figure 24a - EAST GERMANY
House sparrow vs average wages 1992-2006

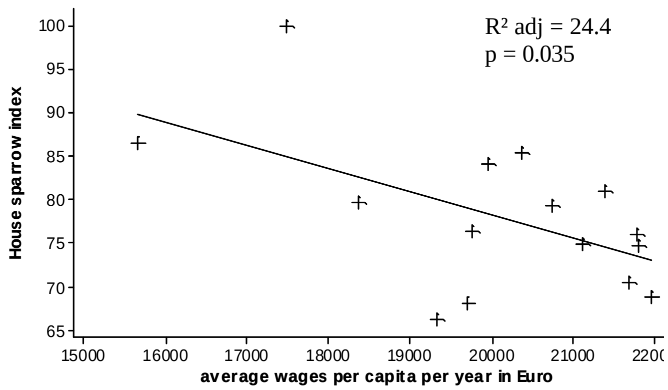
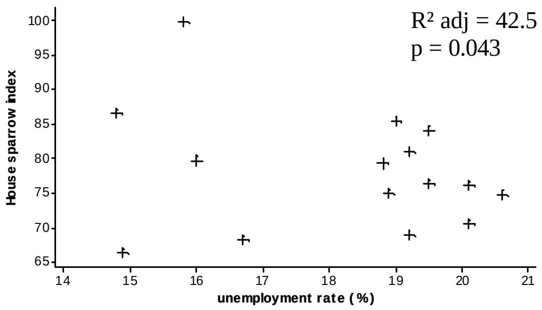


Figure 24b - EAST GERMANY
House sparrow vs unemployment 1992-2006



House sparrows in East Germany are negatively related to average wages and positively to unemployment. These two relationship together explain just under 43 percent of the variability of the sparrow index for this region.

No evidence for any significant relationship was found for Hessen and NRW.

5.4 Summary of main relationships

EG = East Germany He = Hessen NRW = Nordrhein-Westfalen
(Relationships contributing most to bird index variability in bold, secondary ones in smaller font)

Table 6a - Positive relationships between demographic factor/bird species

		popul. density	unempl.	forest area	agricult. area	wages	GNP
farmland spp							
Linnet	**Carduelis cannabina**	**EG**					
Tree sparrow	*Passer montanus*	**EG**	NRW				
Skylark	*Alauda arvensis*				**He,** NRW		
Goldfinch	*Carduelis carduelis*	**EG**			**He**		
Yellowhammer	*Emberiza citrinella*		NRW			**EG**	
forest spp							
Greater sp. woodp.	*Dendrocopos major*		**EG, NRW**				
Lesser sp. woodp.	*Dendrocopos minor*			**NRW**			
Nuthatch	**Sitta europaea**			**EG**			
Coal tit	*Parus ater*	**He**					
Tree creeper	*Certhia familiaris*						
urban spp							
House sparrow	*Passer domesticus*		EG				

Table 6b - Negative relationships between demographic factor/bird species

		popul. density	unempl.	forest area	agricult. area	wages	GNP
farmland spp							
Linnet	**Carduelis cannabina**		EG				**He, NRW**
Tree sparrow	*Passer montanus*						**NRW**
Skylark	*Alauda arvensis*			**EG, NRW**		NRW	
Goldfinch	*Carduelis carduelis*				**NRW**		
Yellowhammer	*Emberiza citrinella*			**He, NRW**			
forest spp							
Greater sp. woodp.	*Dendrocopos major*						
Lesser sp. woodp.	*Dendrocopos minor*						
Nuthatch	**Sitta europaea**				**He**		
Coal tit	*Parus ater*				**EG**		**NRW**
Tree creeper	*Certhia familiaris*	**NRW**					
urban spp							
House sparrow	*Passer domesticus*					**EG**	

In summary, in six cases and for five of the eleven analysed species a negative relationship with measures of affluence, i.e. GNP and wages, was identified. There was also evidence for a positive relationship with unemployment in a further five cases. Four species have positive relationships with population density, three of which concern East Germany.

6. Discussion

6.1 Correlation matrix and PCA for demographic data

Some of the correlations shown in Table 3 are unsurprising, such as the positive relationships between average wages and GNP or between population density and number of households, as these are closely interrelated and one will feed into the other, thus forming positive feedback loops. All the factors are inevitably correlated with each other in varying degrees, so that each correlation will have several explanatory factors feeding into it. Both average wages and GNP, for example, negatively correlate with median age, with a larger proportion of older, retired people (higher median age) not earning any wages which will in turn result in a lower GNP.

The perhaps slightly unexpected highly significant positive correlation between cars and unemployment is likely to be due to the high contribution East Germany makes to both these variables. Table A1 shows above average numbers of cars and unemployment rates in all East German *Länder*. The underlying driver for both these variables may be the rural and economically depressed nature of this region, where work is hard to find and lack of infrastructure and public transport makes car use essential for everyday life (Kröhnert *et al.* 2006).

The correlation matrix also shows that the number of households increases with affluence, i.e. the higher the GNP of a *Land*, the more likely its inhabitants are to form smaller households and leave home early. This is interesting in the light of recent studies by Liu *et al*. (2003) and Linderman *et al*. (2005) which found density of households (rather than density of people) to be a key measure of threat to biodiversity. Also, smaller households will probably not require smaller flats, and population shrinkage therefore does not necessarily equate to a decrease in land use for human habitations.

Conservation planning could greatly benefit from knowing not only the demographic facts of a region, but also the interactions between them. This knowledge would allow better predictions about future trends so as to pre-empt problems and to actively incorporate demographic realities into conservation action. For example, knowing that age and unemployment are correlated could offer opportunities for targeting unemployed, older people as conservation volunteers, whereas a demonstrable positive correlation between unemployment and number of cars could act as an early-warning system for regional governments to ensure that adequate public transport provisions are made when unemployment rises.

The plotted PCA results (Figure 13) summarize the demographic data and clearly show that East Germany is still, nearly 20 years after reunification, distinct from the rest of Germany, and that this region therefore needs to be treated and assessed separately in terms of its conservation potential and its biodiversity.

6.2 Bird regression analysis

6.2.1 Discussion of the data sets used for the analysis

6.2.1.1 The bird index data set

Many of the bird index data provided by the DDA show large standard errors (Appendix D). Whilst birds surveys have constant effort, they are at least partially based on volunteer labour and so the quality of data will vary from observer to observer. The large standard errors for tree sparrows for example could be due to observer bias, unfamiliarity or patchiness. Tree sparrows are hard to spot, whereas the more easily visible skylarks and yellowhammers have smaller standard errors. Also, although sample sizes were generally large, they vary from species to species and region to region.

On a more general note, the importance of scale comes to mind again – more precise and informative conclusions might have been drawn from the analysis if the data for the five new Länder had not been lumped together into an overall data set for East Germany. A summing of indicators over a large scale is potentially dangerous, as positive developments in one area could ‘mask’ negative trends in another.

6.2.1.2 The agricultural data set

After reunification the intensity of agriculture in East Germany decreased drastically. In addition, an EU policy introduced in 1989 required farmers to set aside a minimum of 10% of their arable land. This meant that 15-20% of former agricultural land was turned fallow in the new *Länder* (BfN 2008a). However, the data provided by the GENESIS databank for "*agricultural area in current use*" include per definition "*all set-aside fallow land for which compensation payments is made*". Data on set-side areas per *Land* is only available from 2000 onward (EUROSTAT 2008; Irmgard Krüger, personal communication 29/7/08; Marita Quandel-Albring, personal communication 28/7/08).

This is a bitter blow for any attempt to accurately assess the impact of agricultural changes on bird populations in Germany, as land-use changes in the form of set-asides are likely to strongly affect birds by providing new habitat. From literature it is known that set-asides were very different in East and West Germany in quality, quantity and time (Flade & Sudfeldt 2008), and set-aside areas are thought to have played a vital role in the recovery of many farmland bird species during the last 15 years (Flade *et al*. 2008). An accurate analysis of the impact of agricultural area on biodiversity would therefore require not only knowledge about the exact proportions of arable farmland set aside over time in each region, but also about the fate of the set-aside land, as not all set-aside areas are beneficial to biodiversity. In many cases, such areas were planted with grass and clover mixes, which typically offer only limited habitat for birds and wildlife in general (Lebensraum Brache 2007). The example of the yellowhammer, a farmland bird, shows that this species doubled in numbers in East Germany while the 10% set-aside scheme was in force (Appendix C, Figure 25, dotted box). From 1994, however, farmers were encouraged by the EU to grow renewable materials (e.g. oilseed rape) on fallow land. Accordingly, Figure 25 shows a stabilisation of yellowhammer populations since 1996.

The results of the regression analysis will therefore inevitably be tainted by the incompleteness of the variable 'agricultural area' (for EU definition of this term, see "area in agricultural use" in Definitions section), which is purely quantitative, without any qualitative dimension. This being the only data set available for 1992 to 2006 and for the different regions, it was included in the analysis in spite of its limitations. Had the changes in set-aside areas been included in the model, the outcome of the regression analysis is likely to have been different.

6.2.2 Interpretation of the bird regression results

The results of the stepwise linear multiple regression of bird index data versus demographic factors will be discussed in view of the impact of each of the demographic factors on the respective bird species.

6.2.2.1 Population density

Population density is the best explanatory variable for the increase in linnets, tree sparrows, goldfinches in East Germany and coals tits in Hessen (Table 6a, Figures 14a, 15a, 17a, 22b), with the abundance of these species increasing with human population. This is in keeping with findings of Gaston & Evans (2004) that overall regional bird species densities in Europe are higher in areas with more people, and with the review by Luck (2007) which shows birds to have a significant positive correlation with human density. Both studies speculate that humans and birds respond similarly to spatial energy availability in terms of NPP. Scale-dependence of the results, as already discussed in sections 2.1.1 and 3.3, is another possibility.

Three of the four positive relationships between birds and population density detected in this study occurred in East Germany, where there are less people now than there were 16 years ago. Although the relationship is positive, it effectively means that 16 years ago, when there were more people, there were also more linnets, tree sparrows and goldfinches, and since then both people and those bird species have decreased in numbers. Positive relationship in this instance means a mutual decrease over time.

Only Hessen (Figure 22b) shows a 'true' positive relationship between human population density and coal tits, i.e. coal tit abundance increases over time with population density. Of the variables contained in the model, population density offers the best explanation for the increase in bird numbers here, even though the relationship accounts for less than half the total index variability. Although coal tits prefer nesting in coniferous woodland, they also occur in many other habitats, including gardens (BTO, no date) and their rise in numbers may be due to increased garden feeding and provision of nesting boxes. Nordrhein-Westfalen, however, the most densely populated *Land* with the most pronounced human population growth, shows no positive relationships between human density and bird abundance. On the contrary, here tree creepers are negatively correlated to human numbers (Figure 23). Inspection of the tree creeper graph for NRW in Appendix D, page 81, however, shows a massive crash in the abundance of this species in NRW between 1992 and 1994, whereas numbers have remained relatively stable in Hessen and East Germany. This leads to suspect that another factor, specific to NRW, would, had it been included in the model, have had greater explanatory power for the decline of this bird species than population density.

In general, these results show a dependence of birds on humans and their actions, with bird numbers following changes in human numbers.

6.2.2.2 Unemployment

Rising unemployment is the main explanatory variable in the model for the increase in greater spotted woodpeckers both in East Germany and NRW (Figures 19a, 19b). This forest bird may, in a round-about way, benefit from the fact that with increasing numbers of unemployed people, more people are free to engage in recreational activities. According to Frank Hermann of the Hunting Association Thüringen (personal communication 1/7/2008) forests in Germany are affected by rising unemployment via increasing numbers of walkers, hikers, riders, joggers and mountainbikers. This leads to permanent disturbances for many forest-dwelling species, some of which (foxes, martens, owls etc.) are predators of forest birds. The demise of these predators may increase the nesting and foraging success of certain forest birds.

Insofar as unemployment is correlated to level of affluence, this positive relationship - which also applies to tree sparrows and yellowhammers in NRW (Fig. 12c, 18b) and house sparrows in East Germany (Fig. 21b) - could be based on the same tentative interpretations as will be advanced for GNP and average wages in section 6.2.3.5., with high levels of unemployment translating into lower average wages and lower GNP.

6.2.2.3 Forest area

The results for forest area are less clear than might have been expected at least for forest bird species. Only two of the five forest birds (lesser spotted woodpeckers in NRW and nuthatches in East Germany) show a positive relationship with forest area (Figures 20, 21a). Farmland birds on the other hand - skylarks in East Germany and NRW (Figures 16a, 16c) and yellowhammers in Hessen and NRW (18c, 18d) – do not appear to like forest growth and are negatively related to it. Although in all three study regions forest area has increased in the last 16 years, this increase was almost negligible in Hessen and NRW (0.8 and 1.1 percent respectively). In East Germany forest area has grown by over 6 percent, but most of this growth took place from 2000 onwards (Appendix B2). There was hardly any change in area in the first 9 years of the study, hence these nine years show as a cluster of dots on the left-hand side of the graphs. Only nuthatches appear to have benefited from this increase of East German forests (Fig. 18a).

The negative relationship of some of the farmland species and forest growth could be due to the negative correlation between agricultural and forest area identified in Table 3, i.e. forest being extended to the detriment of farmland. More specifically, the negative relationship between yellowhammers in Hessen and NRW with forest area might be due to the preferred habitat of this species being hedgerows and grass margins along edges of wood. Increases in forest area may destroy these and thus affect yellowhammer populations.

In general, however, the forest area increase in the two West German *Länder* may have been too small to be meaningful, and overall forest quality brought about by changes in forestry policy promoting new tree growth (I. Niemetz, personal communication 3/7/2008) may have been a more decisive factor for changes in forest bird species than forest quantity.

6.2.2.4 Agricultural area

Agricultural area is positively related to skylarks in Hessen and NRW (Figures 16b, 16d) and to goldfinches in Hessen (Figure 17b), but negatively to goldfinches in NRW, nuthatches in Hessen and coal tits in East Germany (Figures 17c, 21b, 22b). Due to the inherent problems of this variable explained in 6.2.1.2 the results of this relationship are purely based on possible effects of quantitative changes in area. The "*area in agricultural use*" has decreased in all three study regions (-1.6% in East Germany,

-3.3% in Hessen, -5.1% in NRW) (Appendix B2). The changes in the abundance of the respective bird species related to agriculture are more likely to be due to qualitative rather than quantitative changes in farmland, i.e. more organic farming, more set-aside areas or changes in crop-types or harvesting methods, which may provide more or better food, habitat or nesting sites for certain species. In the case of the exclusively seed-eating goldfinch, for example, such qualitative agricultural changes benefitting this species may have been made in Hessen, but not in NRW.

6.2.2.5 GNP and average wages

Interestingly, GNP is negatively related to linnets in Hessen and NRW, as well as to tree sparrows and coal tits in NRW (Figures 14c, 14d, 15b, 22c). Another measure of affluence, average wages, is negatively related to house sparrows in East Germany (Figure 24a) and skylarks in NRW (Figure 16e). As GNP and wages increase, these bird species decrease. This tallies with findings of Shaw, Chamberlain & Evans (2008) who investigated the recent massive declines of house sparrows in Northern Europe and found evidence for these birds being more numerous in areas with relatively low socio-economic status. Shaw *et al.* suggest that house sparrows have disappeared from more affluent areas because their habitat is more likely to have changed in these areas, for example through loss of brownfield field sites, more tidy gardens with lots of paving etc. More deprived areas, on the other hand, tend to have older houses in worse state of repair which are more suitable for nesting sites, as well as gardens with areas of rough grass, nettles and weeds which are linked to increased bird diversity. Changes in affluence of an area might therefore affect foraging and nesting success and predation risk. This does not only apply to house sparrows – linnets, for example, are also strongly connected to humans in the sense that they like brownfield sites and human disturbed habitat (Dr Glenn Baggott, personal communication 21/7/08), which are more likely to persist in less affluent areas.

The positive relationship between yellowhammers and wages in East Germany (Figure 18a) is more likely to be due to the points raised in section 6.2.1.2., i.e. qualitative changes in agriculture, than the rise in average wages. It is one of the limitations of this analysis that it can only reflect the strongest relationships out of the variables provided.

6.3 Limitations of the analysis

It should be pointed out that a) not all taxonomic groups will have the same relationship with human population attributes as birds, and b) that any apparent relationship may mask or be the result of other trends or variables which are not tested in this study. Any analysis is only as good as the variables it contains, and not only are there numerous demographic factors not included in this study that would merit analysis in the future (as listed in section 2.1), but the results obtained could also have been improved if other relevant data had been available on the required temporal and spatial scales. Human activity, for example, is an important demographic variable that should be included in a study of this kind, if appropriate and reliable measures can be obtained. The 'Buffalo Commons' example in section 2.1.1 illustrates the potential importance of such a variable by showing that even at very low densities people can have great impact in rural areas due to their activity. In some cases, very few people suffice to destroy whole landscapes if they are efficient, technologically well-equipped farmers, and it is in fact the abandonment of the activity rather than the outmigration of the inhabitants per se that will impact biodiversity. At least in developed countries it is often not the number of people that matters most, but the fact that a few (or all of the few that are there) are doing things that are ecologically negative. Hence, conservation managers will need to be aware that many problems will not be cured by depopulation or reduced population growth.

The interactions between the variables, which are the basis of this study, are also one of its limitations. All the variables are more or less correlated with other. Hence, forest bird species, for example, may be negatively related to population density just because population density is negatively related to forest area. It is therefore important not to infer causation from correlation.

Furthermore, there is a time lag between depopulation, a possible improvement in habitat suitability and a species' response to it, so that the species' recovery or decline in response to a demographic change may take considerable time (depending, among other things, on its life cycle) and may therefore not be reflected appropriately when looking at relatively short timespans.

Also, many factors other than those of a demographic nature (ecological conditions, spatial distribution patterns, climate change etc.) might influence animal and plant populations in general and birds in particular and lead to further complex correlations. Climate change, for example, can affect bird habitat directly as well as indirectly through changes in crop cultivation (Birdlife International 2008a), and environmental awareness can differ from region to region (Seip *et al.* 2005). Changes in bird species indices could therefore result from a variety of factors, relatively independent of human population attributes, including those that arise from a growing environmental awareness and greater investments in nature protection, hunting bans, pesticide reductions etc.

Another aspect that has to be taken into account is that some ecosystems or species may be able to tolerate human intrusion, whereas others are more vulnerable to humans and their practices. Human impact therefore depends, among other things, also on the resilience of the specific ecosystem component, so that different countries or study sites may require the inclusion of different variables.

As protected areas can make a significant contribution to the abundance of birds and other species, future studies should distinguish between developments within and outside protected areas. In this context it is noteworthy that five biosphere reserves with a total area of 2600 km² have been created in East Germany since 1990 (UNESCO 2008), and the area of nature reserves in Germany overall has increased by nearly 30% since 1998 (BfN 2008b).

6.4 Looking at the bigger picture

When changes in biodiversity occur, it is vital to look at all aspects of the situation, including the policy and legislative background. This is exemplified by the case of the reestablishment of wolves in East Germany since reunification (NABU 2005), which by all accounts points to a strong link between human depopulation and recolonisation by large mammals. The reality is, however, not quite a simple as that. Individual wolves have always migrated from Poland to East Germany in the past, but as they were not protected in the GDR they were usually shot fairly quickly. Reunification in 1990 made the wolf a strictly protected species (Möckel 2005), and it is therefore perhaps not astonishing that they now thrive.

In conclusion, although demographic attributes are no doubt a crucial factor in the interaction between people and biodiversity, they do not suffice on their own to explain all the patterns observed and this study does not claim they do so. Faced with such an array of complex, interacting factors, and the scarcity of reliable, consistent, regional-scale data over time the study can only hope to give a brief glimpse into a multitude of interwoven layers and should mainly be seen as illustrating, rather than explaining or solving, this complexity. It might also serve to point to the importance of a more in-depth examination of underlying drivers on a case-specific basis, as these are likely to vary from species to species and area to area.

7. Implications for conservation planning

7.1 Planning for the future

In Europe, mammal extinctions are most prevalent in the most densely populated countries (with the exception of the Netherlands) (Tremmel 2005). The current demographic developments of shrinking human populations in Europe could therefore offer a chance to halt and reverse the loss of species and to reestablish healthy ecosystems over large regions. Conservation planners in East Germany have to ask themselves: What are the opportunities offered by the region's current and future demographic situation and how can these be seized to promote biodiversity? Meaningful planning must be long-term and take future developments into account. As shown in Table 1 and Figure 10, East Germany is depopulating and this trend will continue well into the future. The population of Brandenburg, for example, is forecast to shrink from a current 2.5 million to 1.8 million by 2050 (MIR 2008). However, even at current population levels Brandenburg's expenditures (after deducting inter-state fiscal adjustments and federal and European subsidies) are twice as high as its revenues (Minsterium der Finanzen Brandenburg 2007).

Given that shrinking processes on most socio-economic levels are interdependent and mutually reinforcing, depopulation could quickly result in a downward spiral. Lack of economic growth will make more young people leave in search of work or better opportunities, so that their skills and taxes are no longer available for a potential future economic upturn. If only old people are left, this means there will be less or no activity,

Box 3

The different types of protected areas in Germany

Low level of nature protection:

Protected Landscapes (*Landschaftsschutzgebiete)* – Landscapes of particular historical, cultural or recreational importance. Not used for intact natural areas.

Nature Parks (*Naturparke*) - Cultural landscapes which have evolved as a result of long-term human intervention, usage and exploitation and are to be maintained and used touristically in its current form.

Higher level of nature protection:

Biosphere Reserves (*Biosphärenreservate*) – Areas within the UNESCOs MAP programme for the protection of special vegetation zones or characteristic ecosystems.
13 Biosphärenreservate, 3% of total German territory.

Protected Nature Area (*Naturschutzgebiet***) –** Areas set aside for the preservation and restoration of habitats and species. Human usage allowed if protection is maintained. 60% of all *Naturschutzgebiete* are smaller than 50 ha (and hence ill-protected against external factors such as eutrophication or drainage). Large number of *Naturschutzgebiete*, 1.2 mil ha = 3.3 % of total German territory

National Parks (*Nationalparke*) – Clearly defined, extensive areas of particular ecological value legally protected from damaging human interventions. Aim is to safeguard natural processes. Certain targeted interventions to maximise biodiversity or to reestablish ecological balance are permitted, including eradication of invasives, reintroduction of locally extirpated species and 'adjustment' of game populations (Makowski 1997). Only form of protected area in Germany where nature has priority over humans (Box 4)
14 Nationalparks, 9134 km², 2.6% of total area or Germany, the two largest of which are mudflats (*Schleswig-Holsteinisches Wattenmeer*, *Niedersächsisches Wattenmeer*) of approx. 7200 km².

sources: Bundesnaturschutzgesetz (Federal Nature Conservation Act) §23-§27.
Umweltbundesamt (2007). Area percentages: BfN (2008c)

Box 4

German Nature Conservation Act, last revised April 2008

Article 24 National Parks

(1) National Parks are areas designated on a legally binding basis as areas to be protected on a uniform basis that meet the following criteria:
1. The area concerned is an entity of major size with specifically characteristic features;
2. the criteria defined for *Naturschutzgebiete* ('nature conservation areas') are met in the greater part of the area, and
3. the greater part of the area concerned is in a state characterized by no or little human impact; or the area concerned is suitable for developing/ being developed into a state which safeguards undisturbed ecosystemary interactions and their natural dynamic processes to the extent possible.

(2) The aim of National Parks is to safeguard, in the greater part of the area concerned, undisturbed ecosystemary interactions and their natural dynamic processes to the extent possible. Where and to the extent to which this is compatible with the protection purpose, National Parks should also serve the purposes of scientific monitoring and surveillance, education in the field of natural history, biology and related subjects, as well as enable the general public to experience nature.

(3) The *Länder* shall ensure that National Parks receive the same level of protection as that afforded to *Naturschutzgebiete* ('nature conservation areas'), taking into account their particular protection purpose and allowing for exemptions required in view of the size of the area and its human settlements.

Source: Bundesjustizministerium, 2008 - BNatSchG less taxes, less GNP, higher expenditures for health care facilities and higher energy requirements (York 2006). The feedback between financial and demographic problems will cause a further increase in the cost of infrastructure maintenance which will in turn increase the per capita tax burden, while tax revenues – and thus also potentially disposable funds for conservation investments – continue to decrease. Sustainability is likely to suffer, with fewer people using more resources. Effective measures are therefore required to address conservation requirements as well as social needs.

7.2 Making a case for wilderness areas in East Germany

In terms of protected areas Germany currently lags well behind the European average of 15 percent: most *Länder* have assigned only 9 to 12 percent of their land area as protected (BfN 2004). Of the different types of protected areas in Germany only National Parks have to be largely free of human impact (Boxes 3 and 4). National Parks, however, make up only 0.6 percent of the total German terrestrial territory (excluding the extensive Northern German mudflats).

This means there are virtually no ‘wilderness’ areas in Germany entirely left to natural processes. For many species such processes are, however, of great importance and their protection should therefore be a vital part of nature conservation. The modern day interpretation of wilderness according to IUCN category 1(b) is: "*A large area of unmodified or slightly modified land, and/or sea, retaining its natural character and influence, without permanent or significant habitation, which is protected and managed so as to preserve its natural condition*." Such wilderness areas would be legally in keeping with the type of protection foreseen in §24 of the German Federal Nature Conservation Act regarding National Parks, which states one of its aims to be to "*safeguard … undisturbed ecosystemary interactions and their natural dynamic processes* " (BNatSchG §24(2), 2008. For full text see Box 4). They would also feed into the EU biodiversity policy based on the 1992 habitats directive, which prioritises the creation of a European ecological network of special areas of conservation, called Natura 2000, and promotes the integration of nature protection requirements into EU policies such as agriculture, regional development and transport (European Commission 2005). In general, scientists increasingly call for habitat restoration to focus on a landscape scale rather than on individual reserves (Taylor 2004a), and large tracts of landscapes with little human influence are hard to find in fragmented Europe.

Depopulation is almost a pre-condition for the reestablishment of wilderness areas, because as long as human population size and density increase there is little hope for the fragmentation of habitat to be reversed and for larger areas to be protected.

The response to depopulation in Europe generally revolves around one of two strategies: Either the government develops resettlement strategies or regions are left to their own devices and gradually revert to a more natural state. The problem with leaving restoration to natural processes is that they take time, measured in decades or centuries (Dobson 1996). There is, however, a third solution. A recent report carried out by the Berlin Institut für Bevölkerung und Entwicklung for the Brandenburg parliament makes the unconventional and controversial suggestion to actively encourage the rural exodus of large regions by paying the remaining inhabitants incentives to move away and helping them find jobs (Klingholz *et al.* 2007). This would accelerate the re-instatement of natural processes over large areas and create natural landscapes and wilderness attractive not only to many animal and plant species, but also to tourists. Rather than trying to artificially stop the population erosion and pump ever more money into the failing economy and infrastructure of many of its regions, East Germany could play a pioneering role in dealing with demographic change and create new revenue streams and livelihoods from nature through tourism, sustainable hunting, recreational and educational activities etc.

Acceptance of this solution would require nothing less than a paradigm shift. Stakeholders will have to agree to speed up the demographic decline and institute a 'rewilding' strategy, which could eventually include the reintroduction of recently extirpated species such as the European bison (*Bison bonanus),* the lynx (*Lynx lynx),* last seen in Thüringen in 1843, or the beaver (*Castor fiber*), disappeared from Sachsen since 1840 (BfN 2007b, WWF Deutschland 2006b). Conflicting interests will have be resolved: Is biodiversity more important than, say, unemployment? The benefits of biodiversity being far less immediate and tangible, decision makers will be under pressure from the public to act to improve economic rather than ecological conditions and local politicians are not likely to be keen on actively promoting the loss of their electorate. But maybe the time has come to concentrate on the positive side-effects of East Germany's demographic decline and to see this as a chance for ecological restoration and development of green corridors and networks, creating contiguous habitat for recolonisation by large mammals and other wildlife.

7.3 Rewilding examples from other countries

East Germany is a special case due to the speed of the depopulation processes that took place here and comparisons are therefore difficult. The 'Buffalo Commons' example from North America presented in section 2.1.1 seems the most relevant comparison, albeit on another continent. In Europe inspiration can be taken from the Oostvaardersplassen region of Holland, which was artificially created from reclaimed land in 1968, originally for industrial purposes. In the wake of the oil crisis in the early seventies the land was left barren which led to rapid scrub encroachment and the subsequent introduction of large herbivores such as deer, wild ponies and Heck cattle (reconstructed aurochs). Today Oostvaardersplassen is species-rich and one of Europe's foremost wetland regions, and the Netherlands are planning a Dutch Ecological Network which will eventually link to a Pan European Ecological Network (Taylor 2004b). In Scotland the pioneering 'Trees for Life' project is regenerating ancient pine forests and the un-fenced reintroduction of some of Scotlands extirpated mammals is planned (Schofield 2005).

7.4 Recommendations and conclusions

This study has established and documented relationships between human demographic components and changes in bird abundance which might give conservation managers better insight into how they can use or manage demography in order to make better decisions regarding biodiversity. Of the demographic factors tested, the study established affluence to be the most prominent one, affecting bird abundance negatively in Germany. It also confirmed that biodiversity depletion and recovery are likely to be related to multiple, interconnected factors, the effects of which cannot easily be separated from each other, that changes in biodiversity are likely to be site-specific and species-specific and that their perception is scale-dependent.

Based on this, the following points may offer a way forward:

- We need to deepen our understanding of the anthropogenic linkages and causes of environmental impacts and implement conservation strategies that reflect this understanding and alleviate the impact of humans on biodiversity. Whatever it is conservation managers want to do, they need to know the relationship between people and biodiversity in order to make rational decisions. For this they need objective indicators and measures that inform decisions, and therefore a comprehensive quantification of human impacts on biodiversity needs to be done. The necessary information should be collected in an interdisciplinary effort by biologists, conservationists, demographers and social scientists.

- More time-series data, especially for biological variables, need to be collected and made freely available in order to enable researchers to track biodiversity changes over time and link these with changes in human demography over the same time period and the same region. If scientists are able to better identify factors correlated to biodiversity loss, then these factors could act as an early-warning system and be integrated into management and planning decisions.

- Germany needs to accelerate the standardization of its red listing efforts and more data ought to be made available electronically and free of charge.

- Modern conservation practitioners must go beyond documenting species loss, population declines and habitat degradation. An anticipatory and pro-active approach to demographic and biodiversity problems is necessary. Demographic change is a reality and should be accepted; rather than stopping people from leaving East Germany they should be encouraged to do so. The example of the 'Buffalo Commons' in America and of the resurgence of wolves and elks in East Germany shows that recolonisation by large mammals in a depopulating region is possible. According to Dr Scherfose of the Bundesamt für Naturschutz (quoted in Klingholz *et al.* 2007) human depopulation will have positive impacts on efforts to set up more National Parks and especially more contiguous National Parks. Such parks could promote new economic objectives and in future generate income a) through the ecosystem services provided by them (CO_2 sequestration, nutrient cycling, water purification, climate and air quality regulation etc.) once these are fully recognized and rewarded by society and b) by comprehensively marketing nature.

- There is evidence that traditional land-use in Europe has fostered habitat and species richness (Hampicke 2006, Heath & Tucker 1995) and therefore new ways of coexistence between wilderness areas and low-intensity, innovative or traditional land-uses beneficial to biodiversity should be explored.

- Within the EU, supra-national conservation efforts should be promoted. According to UN (2004) forecasts, East Germany's neighbouring Poland is, like Germany itself, one of the top ten countries worldwide in terms of population decreases between 2000-2050. The whole region of East Germany and Western Poland therefore offers great conservation potential. In 2007, the European Commission approved a "Poland-Germany Cross-border Cooperation Programme" with a budget of €124 million for the period 2007-2013. The programme's aim is to "*support the development of social frameworks, entrepreneurship, tourism and action to protect and improve the environment*" (Europa 2008). German and Polish conservation managers should apply for large parts of these funds to be invested in the establishment of large, cross-border wilderness areas. They will be able to do so more convincingly if they dispose of solid information about the interaction between socio-economic factors and biodiversity.

- The EU Commission has recently abolished the set-aside requirement for farmers in order to "*allow them to maximise their production potential*" (European Commission 2008b). This means that the proportion of fallow land is likely to decrease drastically, which will greatly impact not only farmland birds, but also biodiversity in general, as many fauna and fauna species have no other habitat left but the fallow parts of farmland. Conservation managers in Germany should address this problem and lobby the EU Council to reverse the abolition or to make other adequate provisions. The UK Environment Secretary Hilary Benn set a good example by announcing last month that EU subsidized farmers in the UK will be "*required to dedicate a small fraction of their land to wildlife friendly habitats*" as from 2009 (Birdlife International 2008b)

Given the availability of adequate data, future studies could explore critical human density thresholds, i.e. whether there is a turning point below which the per-capita human impact on biodiversity can be absorbed and above which it starts having severely negative effects. Furthermore, studies could be carried out to investigate the differences in sensitivity of different species to human pressures, the effect of protected areas and the role distance from densely populated areas might play.

Much remains to be learnt and done if current demographic trends prevailing not only in East Germany, but in the whole of Europe are to be used to the advantage of nature conservation and thus ultimately also to the benefit of future human generations.

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REFERENCES

Amt für Statistik Berlin-Brandenburg (2007) *Bevölkerungsstatistik, Bevölkerungsstand im Land Brandenburg am 31. Dezember 2007 nach Kreisen* [online] Available from: <http://www.statistik-berlin-brandenburg.de/daten/daten-bev2.pdf> [Accessed on 14/7/08]

Araújo, M.B. (2003) The coincidence of people and biodiversity, *Global Ecology and Biogeography*, **12**(1), 5-12

BBR (2007) Bundesamt für Bauwesen und Raumordnung (Federal Office for Building and Planning), *Raumbeobachtung*, [online] Available from: www.bbr.bund.de/.../DE/Raumbeob achtung/GlossarIndikatoren /indikatoren__dyncatalog> [Accessed 7 July 2008]

Behrens H. & Hoffmann J. (2007) *Umweltschutz in der DDR – Analysen und Zeitzeugen-berichte*. Institut für Umweltgeschichte und Regionalentwicklung e.V., Oekom Verlag, Munich

Berlin Institut für Bevölkerung und Entwicklung (2003) Newsletter, *Wenn ländliche Regionen sich entvölkern, gewinnt die Natur* [online] Available from: <http://www.berlininstitut.org/ newsletter/newsletter_oktober_2003.html#l3> [Accessed 24 June 2008]

BfA (2008) Bundesagentur für Arbeit. *Statistik – Der Arbeitsmarkt in Deutschland* [online] Available from: <http://statistik.arbeitsamt.de/statistik/index.php?id=BGW&dbtyp=1&typ=WO> [Accessed 13 June 2008]

BfN (1998) Bundesamt für Naturschutz, *Rote Listen im europäischen Vergleich* [online] Available from: <http://www.bfn.de/0322_abb34.html?&0= > [Accessed 30 May 2008]

BfN (1999) *Rote Liste, Gefährdungssituation der Tiere in Deutschland* [online] Available from: <http://www.bfn.de/fileadmin/MDB/documents/030101_gruppe.pdf> [Accessed 15 June 2008]

BfN (2004) Daten zur Natur 2004, Landwirtschaftsverlag Bonn (ISBN 978-3784338514)

BfN (2007a) *Nachhaltigkeitsindikator für die Artenvielfalt* [online] Available from: <http://www.bfn.de/0315_nachhaltigkeit.html> [Accessed on 15 July 08]

BfN (2007b) *Vilmer Thesen zum Wisent in Deutschlands,* Workshop, Insel Vilm June 2007[online] Available from: <http://www.bfn.de/fileadmin/MDB/documents/themen/landschafts undbiotopschutz/ Wisentpositionspapier_20070725_FINAL.pdf> [Accessed on 1 September 08]

BfN (2008a) *Bedeutung der Flächenstilllegung für die biologische Vielfalt*, [online] Available from: <http://www.bfn.de/fileadmin/MDB/documents/themen/landwirtschaft/ flaechenstilllegung_ kurzfassung.pdf> [Accessed 10 August 2008]

BfN (2008b) Daten zur Natur 2008, Landwirtschaftsverlag Bonn (ISBN 978-3-7843-3858-3)

BfN (2008c) *Gebietsschutz/Großschutzgebiete* [online] Available from: <http://www.bfn.de/ 0308_gebietsschutz.html> [Accessed 19 August 2008]

Birdlife International (2008a) *Setting-aside space for UK birds*, News article 29/07/2008 [online] Available from: <http://www.birdlife.org/news/news/2008/07/setaside_uk.html> [Accessed 15 August 08]

Birdlife International (2008b) *The IUCN Red List 2008: Climate change and continental drift* [online] Available from: <http://www.birdlife.org/news/news/2008/05/red_list_launch. html> [Accessed 23 August 08]

BMU (2007) Bundesminsterium für Umwelt, Naturschutz und Reaktorsicherheit**,** Berlin**.** *Nationale Strategie zur biologischen Vielfalt* **(**National biodiversity strategy**)**[online] Available from: <http://www.bmu.de/naturschutz_biologische_vielfalt/downloads /doc/40333.php> [Accessed 3 July 2008]

Bongaarts, J. (2002) Population: Ignoring its impact. *Scientific American*, **286**(1), 67-69

BTO (British Trust for Ornithology) (no date), Garden Bird Watch [online] Available from: <http://www.bto.org/gbw/Species/BIRDS_COATI.htm> [Accessed 10 August 2008]

Bundesjustizministerium (2008) (Federal Ministry of Justice), Bundesnaturschutzgesetz - Gesetz über Naturschutz und Landschaftspflege, amendment of version 2002, [online] Available from: <http://www.buzer.de/gesetz/2122/a30108.htm> [Accessed 18 August 2008]

Capistrano D., Samper C., Lee M.J. (editors) (2005) *Ecosystems and Human Well-Being, Multiscale Assessments*, Volume 4, Chapter 8, pg 183, Island Press, Washington

CBD (2005) 3rd National Report, Germany [online] Available from: <www.cbd.int/doc/world/de/de-nr-03en.pdf> [Accessed on 16 May 08]

CBD (2008) Convention on Biological Diversity. *The Biodiversity 2010 Target* [online] Available from: <http://www.cbd.int/2010-target/> [Accessed on 12 August 08]

Chadwick D.H., (2006) Where the Buffalo Now Roam. *Defenders Magazine*, Autumn 2006 edition, [online] Available from: http://www.defenders.org/newsroom/defenders_ magazine/ fall_2006/where_the_buffalo_now_roam.php?ht=buffalo%20buffalo> [Accessed 29 May 2008]

CIA (no date) *The Wall on the front lines of the cold war: Documents on the intelligence war in Berlin, 1946 to 1961*. [online] Available from: <https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/books-and-monographs/on-the-front-lines-of-the-cold-war-documents-on-the-intelligence-war-in-berlin-1946-to-1961/art-9.html> [Accessed 6 June 2008]

Cruz, M.(1996) Management options for biodiversity protection and population. In: *Human population, biodiversity and protected areas: science and policy issues. Report of a workshop, April 20-21, 1995*, Washington, DC, edited by Victoria Dompka. Washington, D.C., AAAS, International Directorate, 1996, 71-89.

Czech B, Trauger D.L., Farley J., Costanza R., Daly H.E., Hall C.A.S., Noss R.F., Krall L., Krausman P.R., (2005) Establishing Indicators for Biodiversity, *Science*, **308**, 791-792

DDA (no date) Deutscher Dachverband der Avifaunisten.Website,*Gebietsinformationssystem*, [online] Available from: <http://www.dda-web.de/index.php> [Accessed May-July 2008]

de Sherbinin, A. (1995) World Population Growth and U.S. National Security, WW Environmental Change and Security Project Report, 1995 Spring(1), 24-39

Derr J. (2006) *The Ultimate genetic Survivor, The Ecological Future of the North Americal Bison*, [online] Available from: <http://www.wcs.org/media/file/GENETICS.Derr.pdf> [Accessed on 18/5/08]

Deutscher Jagdschutzverband (2007) *Daten und Fakten, Jahresstrecken*, [online] Available from: <http://www.jagd-online.de/datenfakten/jahresstrecken/?meta_id=261> [Accessed May 2008]

Dietz, T., Rosa, E.A., York R. (2007) Driving the human ecological footprint, *Frontiers in Ecology and the Environment*, **5**(1), 13-18

DIW (1996) Deutsches Institut für Wirtschaftsforschung, *Weiterhin Wachstum von Fahrleistungen und Kraftstoffverbrauch im Strassenverkehr*, edited by Rieke H., [online] Available from: <http://www.diw-berlin.de/deutsch/96_14_2/30650.html> [Accessed 30 June 2008]

Dobson, A.P. (1996) Habitat Fragmentation and Loss in: *Conservation and Biodiversity*, Scientific American Library, New York

Ehrlich, P.R. & Holdren, J.P. (1971) Impact of population growth, *Science*, **171**, 1212-1216.

Ehrlich, P.R. & Holdren, J.P. (1972) Review of The Closing Circle, *Environment*, **14**, 24-39

Engel U. & Plötschke, M. (1998) Willingness to pay for the environment: Social structure, value orientations and environmental behaviour in a multilevel perspective. *Innovation,* **1**(3), 315-332

EPI (2008) *Environmental Performance Index 2008, Biodiversity and Habitat* [online] Available from: <http://epi.yale.edu/BiodiversityAndHabitat>[Accessed 29 June 2008]

Europa (2008) European Union Portal Site, Operational Programme 2007-2013: Poland-Germany (Sachsen) [online] Available from <http://europa.eu/rapid/pressReleasesAction.do?reference =MEMO /08/350&format=HTML&aged =0&language=EN&guiLanguage=en> [Accessed 23 Aug. 2008]

European Commission (2005) *Environmental fact sheet: Nature and biodiversity* [online] Available from: <http://ec.europa.eu/environment/pubs/pdf/factsheets/biodiversity.pdf > [Accessed 20 August 2008]

European Commission (2006) *Stemming the rural exodus from France, Spain and Portugal.* Programme: INTERREG II C South West Europe, Project: Organisation and revitalisation of rural areas [online] Available from: <ec.europa.eu/regional_policy/projects/stories/pdf> [Accessed on 23 Aug 2008]

European Commission (2008a) *LIFEWATCH designs biodiversity data infrastructure,* Infocentre, [online] Available from: <http://ec.europa.eu/research/infocentre/article_en.cfm?id=/research/ headlines/news/article_08_05_28_en.html&item=Infocentre&artid=7295> [Accessed on 26 June 2008]

European Commission (2008b) *Agriculture and Rural Development, Health Check of the CAP reform* [online] Available from: <http://ec.europa.eu/agriculture/healthcheck/consultation /slides_en.pdf> [Accessed 29 June 2008]

EUROSTAT (2008) European Commission, *Agricultural Information System* [online] Available from: <http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1996,45323734&_dad=portal &_schema=PORTAL& screen=welcomeref&open=/agri/ef/ef_lu/ef_lu_ov&language=de&product =EU_MASTER_agriculture&root=EU_MASTER_agriculture&scrollto=218 > [Accessed 30 July 2008]

Flade M. & Schwarz, J. (2004) Ergebnisse des DDA-Monitoringprogramms, Teil II: Bestandsentwicklung von Waldvögeln in Deutschland 1989-2003. *Vogelwelt,* **125**, 177-213.

Flade M. & Sudfeldt C. (2008) Vögel und Schutz der biologischen Vielfalt in Deutschland, *Der Falke*, **55**, 70-78

Flade, M., Grüneberg. C., Sudfeldt C. & Wahl J. (2008) Birds and biodiversity in Germany – 2010 Target, DDA, NABU, DRV, DO-G, Münster

Flannery, T. (1994) *The Future Eaters, An Ecological History of the Australasian Lands and People,* Grove Press, New York

Fliegner, S. (1998) Wandel der Automobilität in Ostdeutschland unter der Perspektive autoreduzierter Mobilität am Beispiel des Paulusviertels in Halle (Saale). *Hallesches Jahrbuch der Geowissenschaften,* **20**, 117-135.

Foley, J.A., DeFries R., Asner G.P., Barford C., Bonan G., Carpenter S.R., Chapin F.S, Coe M.T, Daily G.C., Gibbs H.K., Helkowski J.H., Holloway T., Howard E.A., Kucharik C.J., Monfreda C., Patz J.A., Colin Prentice I., Ramankutty N., Snyder P.K., (2005) Global Consequences of Land Use, *Science,* **309**, 570 - 574

Freese C.H., Aune K.E., Boyd D.P., Derr J.N., Forrest S,C, Gates C.C., Gogan P.J., Grassel S.M., Halbert N.D., Kunkel K., Redford K.H., (2007) Second chance for the plains bison, *Biological Conservation*, **136**(1), 175-184

Fulbrook, M. (1992) *The two Germanies, 1945-1990*. Chapter: Economy and Society in the GDR, 234-235, Macmillian Press Ltd, London

FWS - US Fish & Wildlife Service (2008) *Time line of the American bison* [online] Available from: <http://www.fws.gov/bisonrange/timeline.htm> [Accessed 29 May 2008]

Gaston K.J. & Evans K.L. (2004) Birds and people in Europe. *Proceedings of the Royal Society London B*, **271**, 1649–1655.

Gaston K.J. & Spicer J.I. (2004) *Biodiversity: An Introduction*, 2nd edition, Blackwell Publishing, Oxford, pg 119

Goldewijk K.K. (2001) Estimating global land use change over the past 300 years: The HYDE Database, *Global Biogeochemical Cycles*, **15**(2), 417–433

Goldstone J.A. (2002) Population and Security: How Demographic Change Can Lead to Violent Conflict, *Journal of International Affairs*, **56**(1), 3-21

Grafen, A. & Hails, R. (2002) *Modern statistics for the life sciences*. Oxford University Press

Greenspan, A. (2007) *The Age of Turbulence*, Chapter 22: The World retires – But can it afford to? Penguin Group, New York, pg 412

Gruschwitz M. (2007) Wolfsmanagement im Freistaat Sachsen, Sächsische Staatskanzlei, [online] Available from <http://www.umwelt-und-energie.de/files/pdfs/allgemein/application/pdf/wolf_gruschwitz.pdf> [Accessed 7 May 08]

Haase D., Seppelt R., Haase A. (2007) Land use impacts of demographic change – lessons from Eastern German urban regions, in: *Use of Landscape Sciences for the Assessment of Environmental Security*. Petrosillo I., Müller F., Jones K.B., Zurlini G., Krauze K., Victorov S., Li B.-L., Kepner W.G. (Eds.) Springer, pp. 329-344

Hampicke, U. (2006) Efficient conservation in Europe's agricultural countryside - rationale, methods and policy reorientation. *Outlook on Agriculture*, **35**, 97-105.

Hannah L, Carr J.L., Landerani A.(1995) Human Disturbance and Natural Habitat - A Biome Level Analysis Of A Global Data Set, *Biodiversity and Conservation*, **4**(2), 128-155

Heath, M.F., Tucker, G.M. (1995) Ornithological value and pastoral farming systems. In: McCracken, D.I., Bignal, E.M., Wenlock, S.E. (Eds.), *Farming on the Edge: The Nature of Traditional Farmland in Europe*. Joint Nature Conservation Committee, Peterborough, pp. 54–59.

Herfert G. (2003) Politiker müssen den Mut haben, auch unpopuläre Entscheidungen zu treffen, *Das Parlament*, **37**

Hoare, R.E & du Toit, J.T. (1999) Coexistence between people and elephants in African savannas. *Conservation Biology*. **13**, 633-639

Hortal J., Jimenez-Valverde A, Gomez J.F., Lobo J.M., Baselga A. (2008) Historical bias in biodiversity inventories affects the observed environmental niche of the species, *Oikos*, **117**(6), 847-858

Hugo S. & van Rensburg B.J. (2008) The maintenance of a positive spatial correlation between South African bird species richness and human population density. *Global Ecological Biogeography*, **17,** 611-621

Imhoff, M.J., Bounoua L., Ricketts T., Loucks C., Harriss R., Lawrence W.R. (2004) Global patterns in human consumption of net primary production, *Nature*, **429**, 870-873

IUCN (2001) IUCN Red List Categories and Criteria. Version 3.1 – Gland & Cambridge (IUCN Survival Commission)

Jones, R.E. & Dunlap R.E. (1992) The Social Bases of Environmental Concern: Have They Changed Over Time? *Rural Sociology,* **57**, 28-47

Klingholz R., Steffens M-L., Weber A. (2007) Gutachten zum demografischen Wandel im Land Brandenburg. Eine Expertise im Auftrag des Brandenburgischen Landtages, Berlin Institut für Bevölkerung und Entwicklung, [online] Available from: <http://www.berlin-institut.org/fileadmin/ user_upload/Studien/Brandenburg_Webversion.pdf> [Accessed 15 June 08]

Kraftfahrzeugbundesamt (Federal Office for motor vehicles) (2008) Statistik Fahrzeugbestand, [online] Available from: <http://www.kba.de> [Accessed 6 July 2008]

Kröhnert, S., van Olst N., Klingholz R. (2004) *Deutschland 2020: Die demografische Zukunft der Nation,* Berlin Institut für Bevölkerung und Entwicklung, [online] <http://www.berlin-institut.org/ fileadmin/user_upload/Studien/ D_2020_Webversion.pdf> [Accessed 13/6/08]

Kröhnert S., Medicus F., Klingholz R. (2006) *Die demografische Lage der Nation. Wie zukunfts-fähig sind Deutschlands Regionen?* [online] Available from: <http://www.berlin-institut.org/ fileadmin/user_upload/Studien/ Demografische_Lage_dt_Kurzfassung_Webversion.pdf> Accessed 6 July 2008]

Kühn, I., Brandl R., Klotz, S. (2004) The flora of German cities is naturally species rich, *Evolutionary Ecology Research,* **6**, 749-764

Kuznets, S. (1955) Economic Growth and Income Inequality, *American Economic Review*, **45**, 1–28.

Lahmeyer, J. (2002) *Historical demographic developments in East Germany*, source: *Statistisches Jahrbuch der Deutschen Demokratischen Republik*, [online] Available from: <www.populstat.info> [Accessed 6 July 2008]

Lebensraum Brache (2007) Agrarpolitik, [online] Available from: <http://www.lebensraum-brache.de/_downloads/service/downloads/eigene/2007_Endbericht_Lebensraum_Brache.pdf ?PHPSESSID =8757364cb97e36a20cfbb045f05778c4 > [Accessed 1 August 2008]

Linderman, M., An L., Bearer, S., He, G., Ouyang, Z. & Liu, J. (2005) Modelling the spatio–temporal dynamics and interactions of households, landscapes, and giant panda habitat. *Ecological Modelling*, **183**, 47–65.

Liu, J., Daily, G.C., Ehrlich, P.R., Luck, G.W. (2003) Effects of household dynamics on resource consumption and biodiversity. *Nature,* **421**, 530–533.

Luck, G.W. (2007) A review of the relationship between human population density and biodiversity, *Biological Review*, **82,** 607-645

Ludwig G., Haupt H., Gruttke H., Binot-Hafke M (2006) Methodische Anleitung zur Erstellung Roter Listen gefährdeter Tiere, Pflanzen und Pilze. BfN-Skripten 191. Bonn (BfN)

Lutz, W., O'Neill, B.C., Scherbov, S. (2003) Europe's population at a turning point, *Science,* **299**, 1991-1992.

Lynn, R. (2001) Intelligence and the Wealth and Poverty of Nations National Wealth and Rates of Economic Growth [online] Available from: <http://www.rlynn.co.uk/pages/article_intelligence /4.asp> [Accessed 31 May 2008]

MA (2005) Millennium Ecosystem Assessment, Ecosystems and Human Well-Being: Current State and Trends, Chapter 4, Biodiversity [online] Available from: <http://www.millenniumassessment.org/en/Condition.aspx> [Accessed 1 May 2008]

Makowski H. (1997) *Nationalparke in Deutschland. Schatzkammern der Natur, Kampfplätze des Naturschutzes*. Wachholtz, Neumünster

Marsh, G.P. (1865) Man and Nature: Or, Physical Geography as Modified by Human Action, Charles Scribner, New York

Martin, G., (2001) Where the buffalo roam again. *San Francisco Chronicle* [online] Available from: <http://www.sfgate.com/cgi-bin/article.cgi?file=/chronicle/archive/2001/04/22/MN39309.DTL 22/4/2001> [Accessed 29 May 2008]

Mather A. S. & Needle C. L. (2000) The Relationships of Population and Forest Trends, *The Geographical Journal*, **166**(1), pp. 2-13

Milner J.M., Bonenfant C., Mysterud A., Gaillard J-M, Csanyi S., Stensetz N.C. (2006) Temporal and spatial development of red deer harvesting in Europe: biological and cultural factors, *Journal of Applied Ecology*, 43, 721-734

Ministerium der Finanzen Brandenburg (2007) Comparison of revenue and expenditures of the budget 2006, [online] Available from: <www.mdf.brandenburg.de> [Accessed 10 July 2008]

MIR (2008) Ministerium für Infrastruktur und Raumordnung, Brandenburg in Daten und Zahlen. Available from: <www.mir.brandenburg.de> [Accessed 6 July 2008]

Möckel, R. (2005) *Wölfe im südlichen Brandenburg - Chronik der Wiederbesiedlung bis Dezember 2004.* pp 48-58 in: Sonderausgabe der Mitteilungen für Sächsische Säugetierfreunde. Naturschutzbund (NABU) Sachsen, Leipzig, Deutschland.

Myers N. & Kent J. (2003) New Consumers: The Influence of Affluence on the Environment. *Proceedings of the National Academy of Sciences of the United States of America*, **100**(8), 4963-4968

NABU (2005) – Naturschutzbund Deutschland. *Die Wölfe sind wieder da.* [online] Available from: <http://www.nabu.de/m01/m01_03/03792.html> [Accessed 10 August 2008]

Naidoo R. & Adamowicz W.L. (2001) Effects of economic prosperity on numbers of threatened species. *Conservation Biology*, **15**, 1021-1029

Nesheim D.A. (2004) Who wants a buffalo? South dakota fenced herds and experiments in management, 1901-1952, Thesis University of Nebraska, [online] Available from: <http://digitalcommons.unl.edu/historydiss/10> [Accessed 30 May 2008]

New York Times (1924) *A Census of Buffaloes*, 3/2/1924; *Find Buffalo increasing* 3/3/1924, quoted in Nesheim (2004)

OPT (2007) Optimum Population Trust. *Too many people: Europe's population problem* [online] Available from: <http://www.optimumpopulation.org/opt.europe.html> [Accessed 19 Aug 2008]

Pautasso M. & Chiarucci A. (2008) A Test of the scale-dependence of the species abundance-people correlation for veteran trees in Italy, *Annals of Botany*, **101**, 709-715

Pautasso M. & McKinney M.L. (2007) The botanist effect revisited: Plant species richness, county area and human population size in the United States, *Conservation Biology*, **21**(5), 1333-1340

Pimm, S. L., Russell, G. J., Gittleman, H. L. & Brooks, T. M. (1995) The future of biodiversity. *Science*, **269**, 347–350

Popper D.E & Popper F.J. (2004) *The Great Plains and the Buffalo Commons*. In: Janelle D., Warf B. and Hansen K.(eds.), WorldMinds: Geographical Perspectives on 100 Problems, New York: Kluwer Academic Publishers, 2004 [online] Available from <http://policy.rutgers.edu/faculty/popper/WorldMinds.pdf> [Accessed 10 May 2008]

Rees, W. (1996) Revisiting Carrying Capacity, *Population and Environment*, **17**, 195-215

Rojstaczer, S., Sterling, S. M. & Moore, N. J. (2001) Human appropriation of photosynthesis products. *Science,* **294**, 2549–2552

Schmid K.P. & Tenbrock C. (2005) Die einsamen Inseln, *Die Zeit*, No. 40, [online] Available from: <http://www.zeit.de/2005/40/Ostdeutschland> [Accessed 30 June 2008]

Schofield, L. (2005) Public Attitude Toward Mammal Reintroductions: A Highland Case Study. MSc Thesis, Department of Environmental Science & Technology, Imperial College London

Scholes, R.J. & Biggs R. (2005). A biodiversity intactness index, *Nature,* **434**, 45-49

Seip K.L., Cobelas M.A., Doledec S., Fang J.H., Smith V.H. & Vorontsova O.S. (2005) Preferences for environmental issues among environmentally-concerned citizens in six countries. *Environmental Conservation*, **32**, 288-293

Sell R.S., Bangsund D.A. & Leistritz F.L. (1999) *Economic Contribution of the Bison Industry to the North Dakota Economy*, Agricultural Economics Department, North Dakota State University, Fargo [online] Available from: <http://www.ag.ndsu.nodak.edu/carringt/bison/impact.htm> [Accessed May 2008]

SEWTA (2005) South East Wales Transport Alliance, *The Environment Strategy for Wales* [online] Available from: <http://www.sewta.gov.uk/Board%20Meetings/September/Item7.doc> [Accessed 24 June 2008]

Shaw, L.M, Chamberlain, D. & Evans M. (2008) The House Sparrow *Passer domesticus* in urban areas: reviewing a possible link between post-decline distribution and human socioeconomic status, *Journal of Ornithology*, **149**(3), 293-299

StBA (2008) Statistisches Bundesamt, GENESIS Datenbank Wiesbaden [online] Available (to registered users only) from: <https://www-genesis.destatis.de/genesis/online/logon> [Accessed May-August 2008]

Steadman D.W. (1995) Prehistoric Extinctions of Pacific Island Birds: Biodiversity Meets Zooarchaeology, *Science*, **267**, 1123-1131

Stern (2006) news magazine article 10/7/2006: *Durchschnittseinkommen*, [online] Available from: <http://www.stern.de/wirtschaft/finanzen-versicherung/finanzen/:Durchschnittseinkommen-Zwischen-72.369-12.155-Euro/565700.html> [Accessed on 14/7/08]

Stokes, R.G. & Anderson A.B. (1990) Disarticulation and Human Welfare in Less Developed Countries. *American Sociological Review,* **55**, 63-74

Tagesspiegel, Berlin (2006) Newspaper article 10/6/2006: *Elche sind nicht ungewöhnlich* [online] Available from: <http://www.tagesspiegel.de/berlin/Berlin-Brandenburg-Elche;art114,2313266> [Accessed 10 May 2008]

Tagesspiegel, Postdam (2007) Newspaper article 15/9/2007: *Brandenburg besteht den Elch-Test* [online] Available from: <http://www.tagesspiegel.de/berlin/Brandenburg-Fauna;art128,2379792> [Accessed 10 May 2008]

Taylor, P. (2004a) Towards a wildland strategy (Editorial), *ECOS*, **25**(3/4), 1-3

Taylor, P. (2004b) Beyond conservation: A wildland strategy. Chapter 11- Targeted Habitat Creation, Earthscan, London, pg 218 (also see: <http://www.sharedspaces.nl/pagina.html?id=7348>)

The Population Institute (2004) *Population Issues: Population and Consumption* [online]. Available from: <http://www.populationinstitute.org/cms/modules/PopIssues/front/lib/pdf.php?id=8> [Accessed 3 May 2008]

The Population Institute (2006a) *Population and Environment: Biodiversity and Endangerment* [online]. Available from: <http://www.populationinstitute.org/population-issues> [Accessed 1 May 2008]

The Population Institute (2006b) *Population Challenges: The Basics* [online]. Available from: <http://www.populationinstitute.org/population-issues> [Accessed 1 May 2008]

The World Factbook (2008) *Germany: People – Age Structure* [online] Available from: <https://www.cia.gov/library/publications/the-world-factbook/geos/xx.html> [30 June 2008]

Thompson K. & Jones A. (1999) Human Population Density and Prediction of Local Plant Extinction in Britain, *Conservation Biology*, **13**(1) 185-189

Tremmel, J. (2005) Bevölkerungspolitik im Kontext ökologischer Generationengerechtigkeit, PhD dissertation Universität Stuttgart [online] Available from: <http://elib.uni-stuttgart.de/opus/volltexte/2005/2356/pdf> [Accessed 9 Aug 2008]

Umweltbundesamt (2007) Umweltdaten Deutschland Online, Gebiets- und Flächenschutz. [online] Available from: <http://www.umweltbundesamt-umwelt-deutschland.de/umweltdaten/public/theme.do;jsessionid= 9D60EDEEC575998F41DC051661DE9896?nodeIdent=2862> [Accessed 28 August 2008]

UN (2004) United Nations Department of Economic and Social Affairs, Population Division, *World Population To 2300,* Table 7 - Countries with the largest increases and decreases over 50-year periods (pg 59) [online] Available from: <http://www.un.org/esa/population/publications/longrange2/WorldPop2300final.pdf> [Accessed 23 Aug 2008]

UNDP (2007) United Nations Development Programme. *Development Challenges*. E-Newsletter: Youth Surge in the South: A Great Business Opportunity [online] Available from: <http://tcdc1.undp.org/enews/May2007 _enewsletter.html> [Accessed 9 Aug 2008]

UNESCO (2008) Deutsche UNESCO Kommission e.V., *Die 13 Biosphärenreservate in Deutschland* [online] Available from: <http://www.unesco.de/br_in_deutschland.html?&L=0> [Accessed 15 August 2008]

UNFPA (2001) United Nations Population Fund, *The State of World Population 2001*, Chapter 1: Overview. [online] Available from: <http://www.unfpa.org/swp/2001/english/ch01.html> [Accessed 10 Aug 2008]

UNFPA (2007) United Nations Population Fund, *State of the World Population*, Online Report, [online] Available from: <http://www.unfpa.org/swp/2007/english/introduction.html> [Accessed 1 June 2008]

UNPD (2007) United Nations Population Division, *World Population Prospects* [online] Available from: <http://www.un.org/esa/population/unpop.htm> [Accessed 28 June 2008]

US Census Bureau (2000a) Population and Housing Unit Counts, North Dakota, Available from: <http://www.census.gov/prod/cen2000/phc-3-36.pdf> [Accessed 26 May 2008]

US Census Bureau (2000b) Population and Housing Unit Counts, Minnesota, [online] Available from: <http://www.census.gov/prod/cen2000/phc-3-25.pdf> [Accessed 26 May 2008]

US Census Bureau (2000c) Population of the State, Earliest Census to 1980 - North Dakota, [online] Available from: <www.census.gov/population/www/documentation/twps0056.html> [Accessed 26 May 2008]

Vitousek, P.M., Mooney, H. A., Lubchenco, J. & Melillo, J. M. (1997) Human domination of earth's ecosystems. *Science*, **277**, 494-499.

Wackernagel M. & Yount J.D. (1998) The ecological footprint: An indicator of progress toward regional sustainability, *Environmental Monitoring and Assessment*, **51**, 511-529

Walter, N. F. (1995) The Evolving German Economy: Unification, the Social Market, European and Global Integration, *SAIS Review*, **15**, 55-81

Wolf A. & Appel-Kummer E. (2005) *Demografische Entwicklung und Naturschutz, Perspektiven bis 2015* Bundesamt für Naturschutz [online] Available from: <www.bfn.de/fileadmin/MDB/ documents/demografischerwandel.pdf> [Accessed 23 Aug 2008]

Woodroffe, R. (2000) Predators and people: using human desities to interpret declines of large carnivors. *Animal Conservation*, **3**, 165-173

World Bank (2007) *World Development Report 2007: Development and the Next Generation* [online] Available from: <http://econ.worldbank.org/wbsite/external/extdec/extresearch/ extwdrs/extwdr2007/> [Accessed 26 June 2008]

WWF (2006) Living Planet Report. *The Living Planet Index*, page 4 [online] Available from: <http://assets.panda.org/downloads/living_planet_report.pdf> [Accessed 3 May 2008]

WWF Deutschland (2006) *In Deutschland ausgestorbene, wiederangesiedelte oder eingewanderte Arten*. Hintergrundinformation September 2006 [online] Available from: <http://www.wwf.de/fileadmin/fm-wwf/pdf_neu/In_Deutschland_ausgestorbene_Arten_06_09.pdf> [Accessed 31 August 2008]

York, R (2006) Demographic trends and energy consumption in European Union Nations, 1960-2025, *Social Science Research*, **36**(3), pp 855-872

Young J., Richards C., Fischer A., Halada L., Kull T., Kuzniar A., Tartes U., Uzunow Y., Watt A. (2007) Conflicts between Biodiversity conservation and human activities in the central and eastern European countries. *Ambio*, **36**(7), pp 545-550

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Hartwig, Douglas A., USDA, National Agricultural Statistics Service. E-mail and personal communication, E-mail 3/6/08

Hermann, Frank, LJV (Hunting Association) Thüringen. E-mail 1/7/2008

Krüger, Irmgard, Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz. Personal communication 29/7/08

Lanz, Ulrich, Landesbund für Vogelschutz, Artenschutzreferat, E-mail 18/5/2008,

Matheson, Jim, Assistant Director of National Bison Association, Westminster, CO, E-mail 4/6/08

MDA, Minnesota Department of Agriculture, 2008. E-mail reply to question sent to: <http://www.mda.state.mn.us/about/askmdaresponse.htm> 6/6/2008

Niemetz, I. Hunting Association Sachsen. E-mail, 3/7/2008.

North Dakota Buffalo Association, Bismarck, ND. Personal communication June 2008

Quandel-Albring, Marita, StBA, Referat VIIA-4. Personal communication 28/7/08

Appendix A

Principal Component Analysis

Table A1: Demographics Variables for 13 German *Länder* (East German *Länder* in grey)

		popdens	households	agri-area	forest	cars	unempl	av-wages	GNP	md age
1	W-BW	300	4959	40.6	38.1	141	5.2	29617	350188	40.7
2	W-Bay	177	5927	46.3	34.9	132	5.7	28401	405988	41.9
3	E-BB	86	1238	45.1	35.1	147	15.7	22213	51897	43.9
4	W-Hess	288	2906	36.1	40.0	142	8.1	29920	197985	41.6
5	E-MV	73	845	58.2	21.3	157	17.3	20773	32222	43.8
6	W-Nie	168	3804	55.0	21.2	145	9.4	25683	213843	41.8
7	W-NrW	529	8524	44.8	24.9	156	10.0	27645	530435	41.4
8	W-RhPf	204	1895	35.6	41.5	136	6.9	26265	110946	41.0
9	W-Saar	406	504	30.1	33.4	137	8.8	26497	28287	43.2
10	E-Sachs	231	2207	49.6	26.8	156	15.6	21891	83998	44.8
11	E-SaA	119	1201	57.1	23.8	157	16.7	21569	46462	44.5
12	W-SchH	179	1369	64.4	9.9	146	9.0	24769	74977	41.9
13	E-Thü	143	1142	49.1	31.9	150	13.8	21508	45056	44.2
	average	***223***	***2809***	***47.1***	***29.5***	***146.3***	***10.9***	***25135***	***167099***	***42.7***

data sources: StBA, 2008 – data for 2006/2007
Kraftfahrzeugbundesamt (Federal Office for motor vehicles), 2008

Key to abbreviations:

1 = Baden-Württemberg
2 = Bayern
3 = Brandenburg (East Germany)
4 = Hessen
5 = Mecklenburg-Vorpommern (East Germany)
6 = Niedersachsen
7 = Nordrhein-Westfalen
8 = Rheinland-Pfalz
9 = Saarland
10 = Sachsen (East Germany)
11 = Sachsen-Anhalt (East Germany)
12 = Schleswig-Holstein
13 = Thüringen (East Germany)

popdens = population density (number of people per km²)
households = number of households in .000
agri-area = proportion of area in agricultural use
forest = proportion of forest area
cars = number of cars per 100 of population
unempl = unemployment rate
av wages = average wages per year in Euro, including all sectors and including part-time workers.
GNP = Gross National Product in million Euro
median age = midpoint of age distribution where 50% of population younger, 50% older

Table A2 - Summary statistics for each variable

Variable	Count	Mean	SE Mean	TrMean	StDev	Minimum	Q1	Median	Q3	Maximum
popdensity	13	223.3	36.1	209.2	130.1	73.0	131.0	179.0	294.0	529.0
households	13	2809	662	2499	2385	504	1172	1895	4382	8524
agri-area	13	47.08	2.76	47.05	9.96	30.10	38.35	46.30	56.05	64.40
forest	13	29.45	2.52	30.13	9.09	9.90	22.55	31.90	36.60	41.50
cars	13	146.31	2.37	146.64	8.55	132.00	139.00	146.0	156.00	157.00
unempl	13	10.94	1.19	10.88	4.31	5.20	7.50	9.40	15.65	17.30
av wages	13	25135	904	25096	3259	20773	21730	25683	28023	29920
GNP	13	167099	5606	146687	164435	28287	45759	83998	282016	530435
median age	13	42.67	0.39	42.66	1.43	41.50	40.70	41.90	44.05	44.80

Table A3 - Eigenanalysis of the Correlation Matrix

Eigenvalue	5.1813	1.9126	1.0582	0.5545	0.1892	0.0700	0.0294	0.0036	0.0011
Proportion	**0.576**	**0.213**	0.118	0.062	0.021	0.008	0.003	0.000	0.000
Cumulative	0.576	0.788	0.906	0.967	0.988	0.996	0.999	1.000	1.000

Table A4 shows the coefficient or weight given to each variable in each of the 9 principal components to account for the maximum amount of variation:

Table A4 – Principal Components

variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
popdensity	-0.294	-0.187	0.494	-0.632	0.120	-0.117	0.146	0.261	0.343
households	-0.306	-0.456	0.161	0.377	0.194	-0.165	-0.065	-0.602	0.314
agri-area	0.285	-0.431	-0.445	0.108	0.024	0.188	0.350	0.316	0.514
forest	-0.231	0.487	0.325	0.509	-0.241	0.050	0.367	0.197	0.333
cars	0.299	-0.391	0.405	-0.012	-0.583	0.196	0.315	-0.181	-0.288
unempl	0.401	-0.057	0.343	0.171	-0.122	0.051	-0.717	0.231	0.324
av wages	-0.423	-0.009	-0.098	-0.108	-0.119	0.850	-0.226	-0.085	0.066
GNP	-0.336	-0.408	0.109	0.374	0.176	-0.011	-0.065	0.573	-0.453
median age	0.378	0.106	0.351	0.082	0.700	0.397	0.222	-0.091	-0.108

The scores obtained by multiplying the first two Principal Components with the standarized data for each country are shown in Table A5:

Table A4 – PC1 and PC2

Variable	PC1	PC2
popdensity	-0.294	-0.187
households	-0.306	-0.456
agri-area	0.285	-0.431
forest	-0.231	0.487
cars	0.299	-0.391
unempl	0.401	-0.057
av-wages	-0.423	-0.009
GNP	-0.336	-0.408
median age	0.378	0.106

(x standardized data for each Land)

Table A5 – Scores

Land	score 1	score 2
W-BW	-3.04985	-0.06878
W-Bay	-2.55987	-0.13607
E-BB	1.71896	1.17582
W-Hess	-2.12232	0.99619
E-MV	3.22404	-0.47132
W-Nie	-0.15130	-0.99676
W-NrW	-2.52540	-3.10976
W-RhPf	-1.68240	1.88421
W-Saar	-0.98198	1.95905
E-Sachs	2.12521	-0.28078
E-SaA	2.97541	-0.40163
W-SchH	1.11885	-1.24647
E-Thü	1.91063	0.69631

Score 1 and score 2 are plotted in Figure 13

.

Table A6 – Long-hand version of standardizing the *Länder* data and calculating the scores Example of Baden-Württemberg

variable	*PC1*	actual data Baden-Wü	standardized: subtract mean, divide by StDev	PC1 x standardized data
popden	-0.294	300	300 – 223.3 / 130.1 = 0.59 x – 0.294 =	-0.17
households	-0.306	4959	4959 – 2809 / 2385 =	-0.27
agri-area	0.285	40.6	40.6 - 47.08 / 9.96 =	-0.19
forest	-0.231	38.1	38.1 - 29.45 / 9.09 =	-0.22
cars	0.299	141	141 - 146.31 / 8.55 =	-0.19
unempl	0.401	5.2	5.2 - 10.94 / 4.31 =	-0.54
av wages	-0.423	29617	29617 – 25135 / 3259 =	-0.58
GNP	-0.336	350188	350188 – 167099 / 164435 =	-0.37
median age	0.378	40.7	40.7 - 42.669 / 1.434 =	-0.52
			SUM score on PC1 axis	**-3.05**

APPENDIXB

MINITAB results for Stepwise Regression: each region / each bird species versus population density, unemployment rate, forest area, agricultural area, average wages, GNP

East Germany LINNET

```
Response is East G-LINNET on 6
predictors, with N = 15

Step               1        2        3
Constant      -879.7  -1426.4  -1262.2

pop              7.8     11.0     10.0
T-Value         6.53     4.17     4.47
P-Value        0.000    0.001    0.001

av wages              0.0068   0.0125
T-Value                 1.35     2.64
P-Value                0.203    0.023

unemp                             -8.1
T-Value                          -2.52
P-Value                          0.028

S               15.3     14.8     12.3
R-Sq           76.66    79.72    87.16
R-Sq(adj)      74.86    76.34    83.65
Mallows C-p      5.6      5.5      2.2
```

Hessen LINNET

```
Response is Hess-
LINNET on 6
predictors, with N =
15

Step                1
Constant        179.3

GNP_1        -0.00068
T-Value         -2.60
P-Value         0.022

S                17.5
R-Sq            34.24
R-Sq(adj)       29.18
Mallows C-p       3.1
```

NRW LINNET

```
Forward selection.  Alpha-
to-Enter: 0.25

Response is NRW-LINNET on 6
predictors, with N = 15

Step                1
Constant        294.9

GNP_2        -0.00046
T-Value         -4.14
P-Value         0.001

S                16.8
R-Sq            56.89
R-Sq(adj)       53.58
Mallows C-p      -1.7
```

East Germany TREE SPARROW

```
Forward selection.
Alpha-to-Enter: 0.25
Response is EG_tree_sparrow on 6
predictors, with N = 15

Step               1        2        3
Constant       620.3   1176.1  -7818.4

forest_km2    -0.088   -0.194    0.570
T-Value        -1.49    -2.26     3.01
P-Value        0.159    0.043    0.012

GNP_mill             0.00155  0.01006
T-Value                 1.62     4.77
P-Value                0.132    0.001

popden                            31.3
T-Value                           4.22
P-Value                          0.001

S               16.3     15.3     9.90
R-Sq           14.65    29.92    73.26
R-Sq(adj)       8.09    18.24    65.96
Mallows C-p     19.2     15.8      2.5
```

Hessen TREE SP

```
Forward
selection.
Alpha-to-Enter:
0.25
Response is
Hessen on 6
predictors, with
N = 15


No variables
entered or
removed
```

NRW TREE SP

```
Forward selection.
Alpha-to-Enter: 0.25
Response is NRW on 6
predictors, with N = 15

Step                1         2
Constant        261.7     208.9

GNP mill     -0.00041  -0.00045
T-Value         -5.10     -6.18
P-Value         0.000     0.000

unemp                       6.9
T-Value                    2.22
P-Value                   0.047

S                12.2      10.7
R-Sq            66.64     76.33
R-Sq(adj)       64.07     72.39
Mallows C-p       1.8       0.0
```

East G. SKYLARK

Forward selection. Alpha-to-Enter: 0.25
Response is East Germ on 6 predictors, N = 15

Step	1
Constant	991.1
forest km2	-0.146
T-Value	-5.71
P-Value	0.000
S	7.08
R-Sq	71.52
R-Sq(adj)	69.33
Mallows C-p	13.0

Hessen SKYLARK

Forward selection. Alpha-to-Enter: 0.25
Response is Hessen on 6 predictors, with N = 15

Step	1	2
Constant	-2131	-5841
agric km2_1	0.247	0.593
T-Value	6.74	2.26
P-Value	0.000	0.044
av wages_1		0.020
T-Value		1.33
P-Value		0.209
S	13.4	13.0
R-Sq	77.75	80.60
R-Sq(adj)	76.04	77.37

Nordrhein-Westfalen SKYLARK

Forward selection. Alpha-to-Enter: 0.25
Response is NRW on 6 predictors, with N = 15

Step	1	2	3
Constant	5635	2516	-1157
forest km2_2	-0.656	-0.359	-0.181
T-Value	-9.27	-2.42	-1.62
P-Value	0.000	0.032	0.134
agric km2_2		0.035	0.128
T-Value		2.20	4.78
P-Value		0.048	0.001
av wages_2			0.0213
T-Value			3.81
P-Value			0.003
S	8.40	7.38	5.07
R-Sq	86.85	90.63	95.96
R-Sq(adj)	85.84	89.07	94.85
Mallows C-p	19.6	12.8	2.4

East Germany GOLDFINCH

Forward selection. Alpha-to-Enter: 0.25
Response is East Germ on 6 predictors, with N = 15

Step	1	2	3
Constant	-879.7	-1426.4	-1262.2
popden	7.8	11.0	10.0
T-Value	6.53	4.17	4.47
P-Value	0.000	0.001	0.001
av wages		0.0068	0.0125
T-Value		1.35	2.64
P-Value		0.203	0.023
unemp			-8.1
T-Value			-2.52
P-Value			0.028
S	15.3	14.8	12.3
R-Sq	76.66	79.72	87.16
R-Sq(adj)	74.86	76.34	83.65
Mallows C-p	5.6	5.4	2.1

Hessen GOLDFINCH

Forward selection. Alpha-to-Enter: 0.25
Response is Hessen on 6 predictors, with N = 15

Step	1
Constant	-1416
agric km2_1	0.162
T-Value	5.30
P-Value	0.000
S	11.2
R-Sq	68.38
R-Sq(adj)	65.95
Mallows C-p	1.3

NRW Goldfinch

Forward selection. Alpha-to-Enter: 0.25
Response is NRW on 6 predictors, with N = 15

Step	1	2
Constant	3488	16998
agric km2_2	-0.188	0.837
T-Value	-3.28	1.71
P-Value	0.006	0.113
GNP mill_2		-0.0047
T-Value		-1.33
P-Value		0.207
S	63.5	61.7
R-Sq	45.33	52.39
R-Sq(adj)	41.12	44.46
Mallows C-p	23.6	21.1

East Germany – Yellowhammer

Forward selection. Alpha-to-Enter: 0.25
Response is EastG-YellHam on 6 predictors, with N = 15

Step	1	2	3	4	5
Constant	-106.1	-858.3	-976.2	-4875.1	8222.1
av wages	0.0149	0.0228	0.0186	0.0272	0.0216
T-Value	7.09	5.32	4.23	4.18	4.20
P-Value	0.000	0.000	0.001	0.002	0.002
popden		4.6	5.4	17.5	47.3
T-Value		2.04	2.59	2.34	4.24
P-Value		0.064	0.025	0.041	0.002
unemp			5.8	7.8	2.6
T-Value			1.96	2.61	0.93
P-Value			0.076	0.026	0.375
forest km2				0.36	0.73
T-Value				1.68	3.69
P-Value				0.123	0.005
agric km2					-1.54
T-Value					-3.07
P-Value					0.013
S	14.1	12.7	11.4	10.6	7.78
R-Sq	79.47	84.76	88.71	91.20	95.70
R-Sq(adj)	77.89	82.22	85.63	87.68	93.30
Mallows C-p	27.5	19.6	14.2	11.5	5.1

Hessen - Yellowhammer

Forward selection. Alpha-to-Enter: 0.25
Response is Hess-YellHam on 6 predictors, with N = 15

Step	1	2	3
Constant	5012	20425	26790
forest	-0.583	-2.455	-3.228
T-Value	-7.08	-1.82	-2.23
P-Value	0.000	0.094	0.048
GNP mill_1		0.0022	0.0030
T-Value		1.39	1.80
P-Value		0.191	0.099
unemp_1			1.9
T-Value			1.28
P-Value			0.228
S	6.42	6.21	6.05
R-Sq	79.42	82.26	84.55
R-Sq(adj)	77.84	79.31	80.34
Mallows C-p	0.4	0.8	1.5

Nordrhein-Westfalen - Yellowhammer

Step	1	2
Constant	3036	3159
forest km2_2	-0.347	-0.368
T-Value	-4.45	-5.60
P-Value	0.001	0.000
unemp_2		5.6
T-Value		2.57
P-Value		0.025
S	9.26	7.74
R-Sq	60.33	74.42
R-Sq(adj)	57.28	70.15
Mallows C-p	5.8	1.8

East Germany – Gr.sp.Woodpecker

Forward selection. Alpha-to-Enter: 0.25

Response is East G/Woodp on 6 predictors, with N = 15

Step	1
Constant	29.59
unemp	4.1
T-Value	2.87
P-Value	0.013
S	10.7
R-Sq	38.72
R-Sq(adj)	34.00
Mallows C-p	-1.4

Hessen - Gr.sp.WP

Response is Hess-Woodp on 6 predictors, with N = 15

No variables entered or removed

NRW - Gr.sp.WP

Forward selection. Alpha-to-Enter: 0.25

Response is NRW-Woodp on 6 predictors, with N = 15

Step	1
Constant	-29.79
unempl2	11.7
T-Value	4.11
P-Value	0.001
S	10.1
R-Sq	56.48
R-Sq(adj)	53.14
Mallows C-p	-1.2

East Germ - Lesser spotted WP

Forward selection. Alpha-to-Enter: 0.25
Response is EastG lssr WP on 6 predictors, with N = 15

Step	1
Constant	-217.6
popden	2.6
T-Value	1.77
P-Value	0.101
S	18.5
R-Sq	19.37
R-Sq(adj)	13.17
Mallows C-p	-2.0

Hessen – L sp. WP

Forward selection. Alpha-to-Enter: 0.25
Response is Hess-lssr WP on 6 predictors, with N = 15

Step	1
Constant	-18.70
unemp_1	34
T-Value	1.23
P-Value	0.240
S	151
R-Sq	10.43
R-Sq(adj)	3.54
Mallows C-p	-1.0

NRW – Lesser sp. WP

Forward selection. Alpha-to-Enter: 0.25
Response is NRW-lssr WP on 6 predictors, with N = 15

Step	1
Constant	-33357
forest km2_2	4.0
T-Value	2.93
P-Value	0.012
S	161
R-Sq	39.75
R-Sq(adj)	35.12
Mallows C-p	-1.0

East Ger. - Nuthatch

Forward selection. Alpha-to-Enter: 0.25
Response is EastG Nuth on 6 predictors, with N = 15

Step	1
Constant	-378.7
forest km2	0.081
T-Value	2.66
P-Value	0.020
S	8.46
R-Sq	35.26
R-Sq(adj)	30.28
Mallows C-p	5.7

Hessen - Nuthatch

Forward selection. Alpha-to-Enter: 0.25
Response is Hessen Nuth on 6 predictors, with N = 15

Step	1	2
Constant	4087	15465
agric km2_1	-0.42	-0.96
T-Value	-3.05	-2.62
P-Value	0.009	0.022
popden_1		-23
T-Value		-1.57
P-Value		0.142
S	50.6	47.9
R-Sq	41.76	51.70
R-Sq(adj)	37.28	43.65
Mallows C-p	-0.1	0.1

Nordrhein-Westfalen - Nuthatch

Forward selection. Alpha-to-Enter: 0.25
Response is NRW nuth on 6 predictors, with N = 15

Step	1	2	3	4
Constant	0.36	68.80	-2938.44	-7088.40
unemp_2	5.7	7.2	8.5	6.9
T-Value	1.73	2.31	2.84	2.19
P-Value	0.108	0.039	0.016	0.053
GNP mill_2		-0.00014	-0.00041	-0.00088
T-Value		-1.92	-2.34	-2.24
P-Value		0.079	0.039	0.049
forest km2_2			0.37	0.69
T-Value			1.68	2.14
P-Value			0.122	0.058
popden_2				3.2
T-Value				1.32
P-Value				0.215
S	11.8	10.7	9.99	9.66
R-Sq	18.64	37.70	50.37	57.76
R-Sq(adj)	12.38	27.32	36.83	40.87
Mallows C-p	5.5	3.6	3.0	3.6

East Germany- Coal tit

Forward selection. Alpha-to-Enter: 0.25
Response is EG- coal t on 6 predictors, with N = 15

Step	1	2	3
Constant	3295	9669	8232
agric km2	-0.258	-0.757	-0.647
T-Value	-4.94	-3.20	-2.78
P-Value	0.000	0.008	0.018
GNP mill		-0.0047	-0.0049
T-Value		-2.15	-2.37
P-Value		0.053	0.037
unemp			4.5
T-Value			1.62
P-Value			0.133
S	12.0	10.6	9.97
R-Sq	65.22	74.88	79.74
R-Sq(adj)	62.55	70.69	74.21
Mallows C-p	5.5	2.9	2.6

Hessen – Coal tit

Alpha-to-Ent: 0.25
Response Hess-coal t on 6 predictors, with N = 15

Step	1
Constant	-25806
popden_1	93
T-Value	3.30
P-Value	0.006
S	260
R-Sq	45.66
R-Sq(adj)	41.48
Mallows C-p	-2.1

NRW – Coal tit

Forward selection. Alpha-to-Enter: 0.25
Response is NRW-coal t on 6 predictors, N = 15

Step	1	2	3	4
Constant	188.6	5006.8	1011.6	-1049.3
GNP mill	-0.00022	-0.00190	-0.00242	-0.00249
T-Value	-2.47	-2.85	-4.22	-4.43
P-Value	0.028	0.015	0.001	0.001
agric km2_		-0.232	-0.251	-0.204
T-Value		-2.53	-3.36	-2.50
P-Value		0.026	0.006	0.031
forest km2_2			0.54	0.65
T-Value			2.70	3.04
P-Value			0.021	0.013
av wages_2				0.013
T-Value				1.25
P-Value				0.241
S	13.7	11.5	9.34	9.12
R-Sq	32.01	55.69	73.37	76.95
R-Sq(adj)	26.78	48.30	66.11	67.73
Mallows C-p	13.3	6.9	2.5	3.3

East Germ. - Tree creeper

Forward selection. Alpha-to-Enter: 0.25
Response is EG tree cr on 6 predictors, with N = 15

Step	1
Constant	436.9
forest km2	-0.059
T-Value	-1.58
P-Value	0.137
S	10.3
R-Sq	16.19
R-Sq(adj)	9.75
Mallows C-p	-0.7

Hessen – Tree creeper

Forward selection. Alpha-to-Enter: 0.25
Response is Hess-tree cr on 6

Step	1	2	3
Constant	177.32	79.82	569.54
unemp_1	-12.1	-18.4	-18.3
T-Value	-1.92	-2.51	-2.60
P-Value	0.077	0.027	0.025
GNP mill_1		0.00091	0.00478
T-Value		1.51	1.70
P-Value		0.156	0.117
av wages_1			-0.042
T-Value			-1.41
P-Value			0.187
S	34.5	32.9	31.6
R-Sq	22.04	34.53	44.51
R-Sq(adj)	16.04	23.62	29.38
Mallows C-p	1.6	1.6	2.0

NRW – Tree creeper

Forward selection.
Alpha-to-Enter: 0.25

Step	1
Constant	3055
popden_2	-5.74
T-Value	-6.45
P-Value	0.000
S	12.1
R-Sq	76.20
R-Sq(adj)	74.37
Mallows C-p	0.4

East Germany- House sparrow

Forward selection. A-to-E:0.25

Step	1	2
Constant	131.1	133.6
av wages	-0.0026	-0.0062
T-Value	-2.35	-3.34
P-Value	0.035	0.006
unemp		3.8
T-Value		2.26
P-Value		0.043
S	7.55	6.59
R-Sq	29.78	50.74
R-Sq(adj)	24.38	42.53
Mallows C-p	7.9	4.2

Hessen – House sparrow

Forward selection. Alpha-to-Enter: 0.25
Response is Hess-sparrow on 6 predictors, with N = 15

Step	1
Constant	21.33
unemp_1	3.1
T-Value	1.90
P-Value	0.079
S	8.78
R-Sq	21.82
R-Sq(adj)	15.81
Mallows C-p	4.4

NRW – House sparrow

Forward selection. Alpha-to-Enter: 0.25
Response is NRW-sparrow on 6 predictors, with N = 15

No variables entered or removed

Appendix B2 –

Demographic data used for stepwise regression

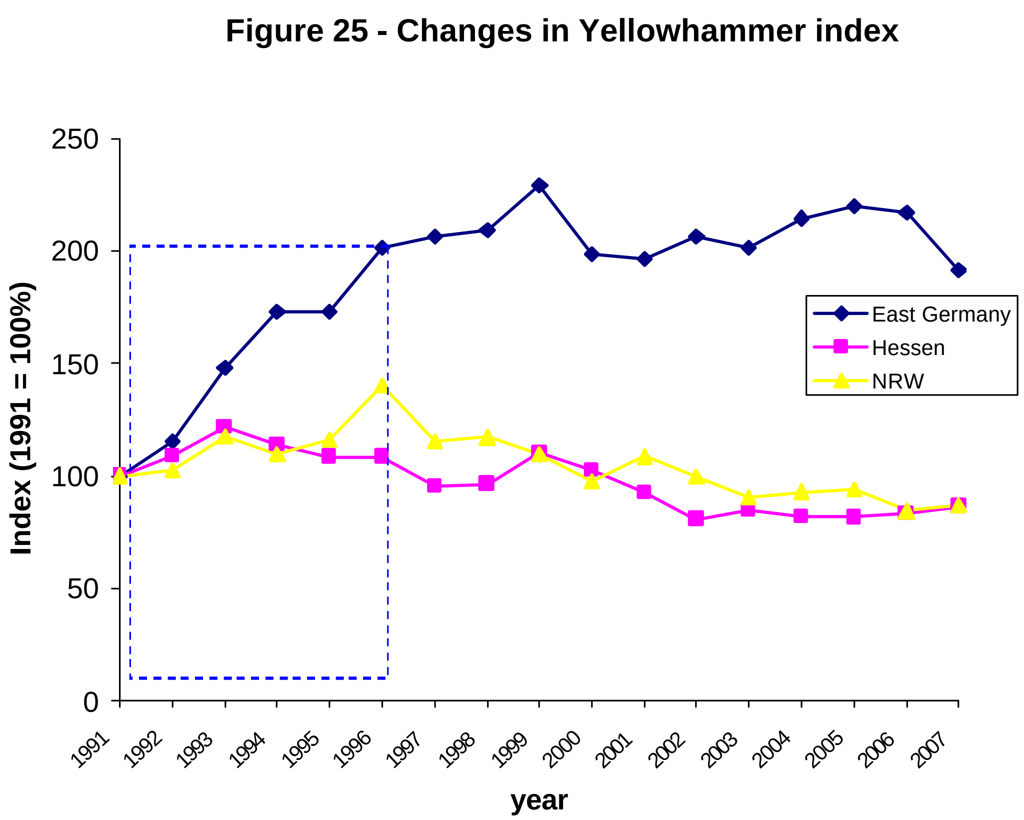
EAST GER	popden	unemp	forest km2	agric km2	av wages €	GNP mill €
1992	133.65	14.8	**5909**	**12416**	15668	35035
1993	132.80	15.8	*5909*	*12399*	17492	38290
1994	132.16	16.0	*5909*	*12382*	18376	41860
1995	131.64	14.9	*5909*	*12365*	19339	45226
1996	131.25	16.7	**5909**	**12350**	19705	46868
1997	130.79	19.5	*5913*	*12335*	19758	47594
1998	130.17	19.5	*5917*	*12319*	19953	48767
1999	129.54	19.0	*5921*	*12305*	20371	50195
2000	128.62	18.8	**5925**	**12293**	20738	51440
2001	127.50	18.9	*5958*	*12281*	21103	52833
2002	126.46	19.2	*5991*	*12269*	21390	53391
2003	125.60	20.1	*6024*	*12258*	21685	53795
2004	124.76	20.1	**6056**	**12246**	21775	55520
2005	123.93	20.6	*6089*	*12234*	21798	56017
2006	123.00	19.2	*6122*	*12222*	21946	57630

HESSEN	popden	unemp	forest km2	agric km2	av wages €	GNP mill €
1992	280.51	5.5	**8398**	**9252**	24295	140976
1993	282.62	7.0	*8403*	*9236*	25068	144040
1994	283.26	8.2	*8408*	*9211*	25427	149007
1995	284.64	8.4	*8413*	*9185*	26223	153448
1996	285.46	9.3	**8418**	**9159**	26523	156610
1997	285.67	10.4	*8422*	*9137*	26518	158821
1998	285.84	10.0	*8426*	*9144*	26802	161825
1999	286.63	9.4	*8430*	*9092*	27214	167104
2000	287.40	8.1	**8434**	**9070**	27658	171401
2001	287.86	7.4	*8439*	*9050*	28174	174910
2002	288.51	7.8	*8444*	*9031*	28585	177625
2003	288.41	8.8	*8449*	*9012*	29141	182398
2004	288.80	9.1	**8454**	**8993**	29217	189114
2005	288.55	10.9	*8460*	*8972*	29369	192418
2006	287.74	10.4	**8465**	**8952**	29608	197985

NRW	popden	unemp	forest km2	agric km2	av wages €	GNP mill €
1992	518.75	8.0	**8424**	**17905**	23685	396761
1993	521.11	9.8	*8424*	*17841*	24344	402342
1994	522.77	10.4	*8424*	*17778*	24683	415781
1995	525.03	10.5	*8424*	*17714*	25414	427641
1996	526.63	11.4	**8424**	**17651**	25704	430760
1997	527.42	11.9	*8427*	*17581*	25676	440707
1998	527.45	11.1	*8430*	*17512*	25700	449939
1999	528.16	10.8	*8433*	*17443*	25910	457158
2000	528.46	9.5	**8436**	**17374**	26039	468711
2001	529.70	9.4	*8450*	*17304*	26349	479005
2002	530.41	9.7	*8464*	*17235*	26726	482682
2003	530.51	10.5	*8478*	*17166*	26980	487971
2004	530.38	10.7	**8493**	**17097**	27140	504903
2005	529.87	10.6	*8500*	*17054*	27227	513803
2006	529.01	10.9	*8513*	**17009**	27275	530435

popden *= number of people per km², **unemp** = unemployment rate in %, **av wages** = average wages per person per year in Euro, **GNP mill €** = Gross National Product per year in million Euro*

Appendix C

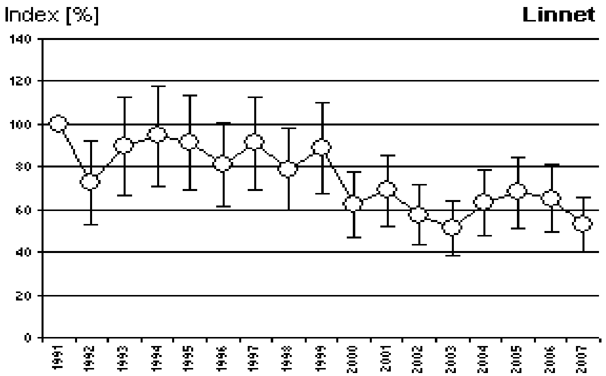


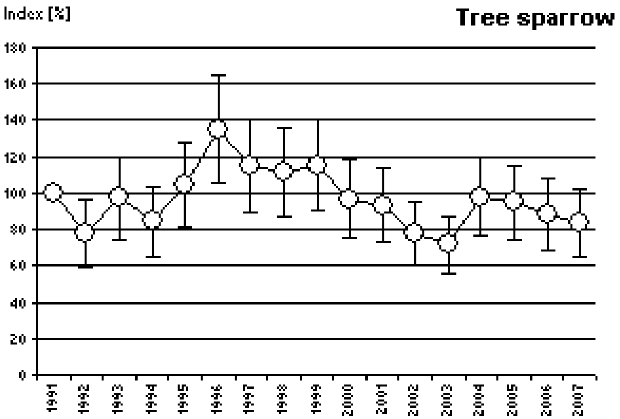
source: DDA bird index data

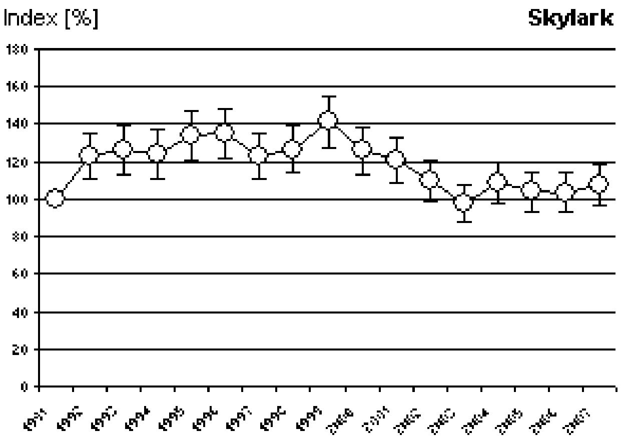
APPENDIX D

EAST GERMANY | HESSEN | NRW

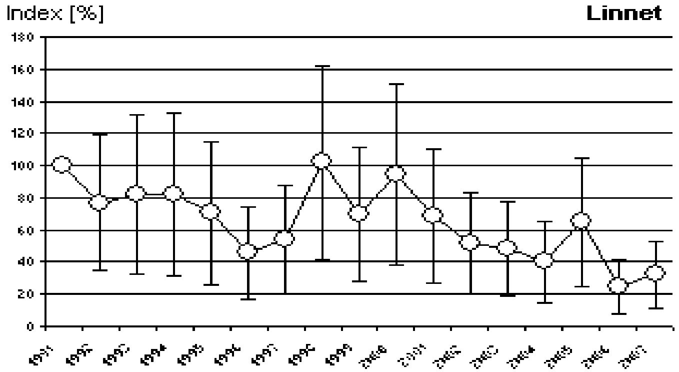
EAST GERMANY

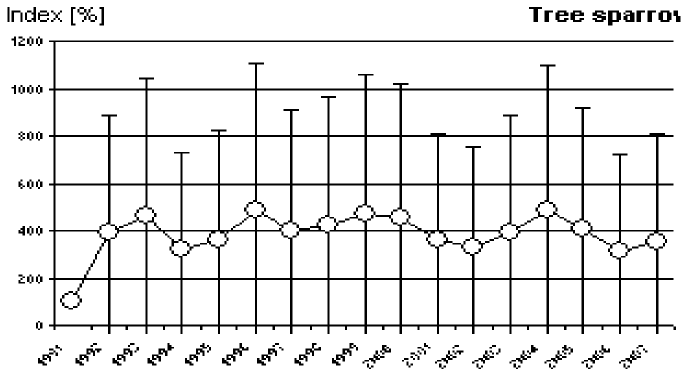


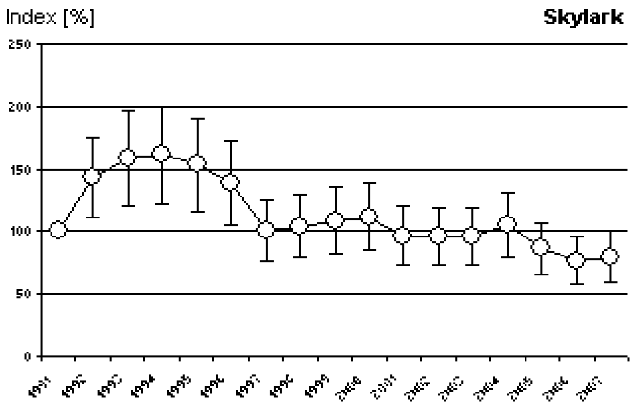




HESSEN







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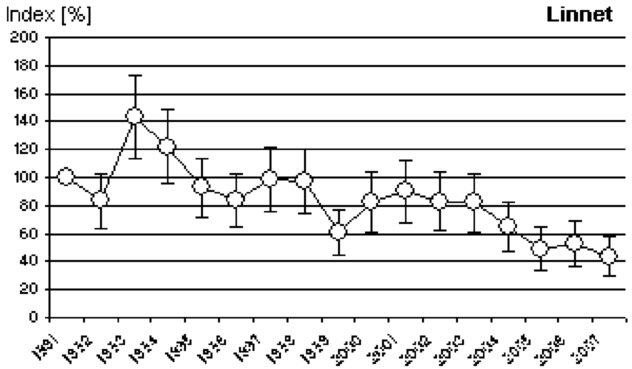
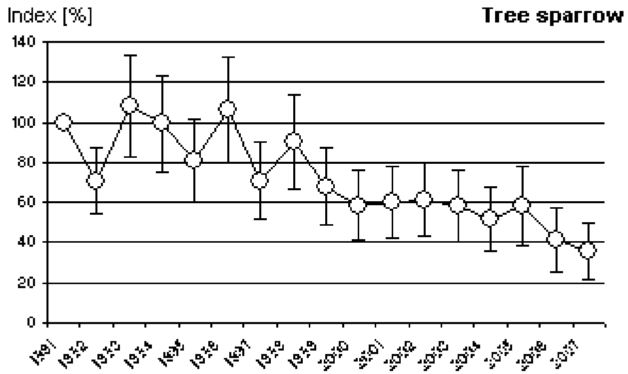
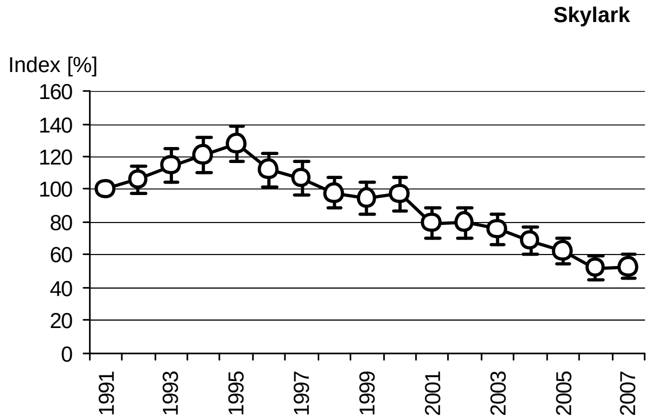
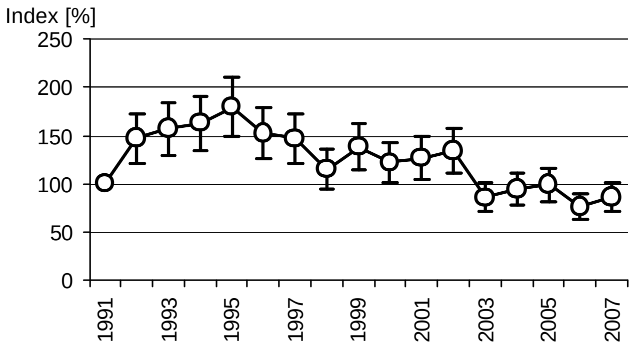






EAST GERMANY



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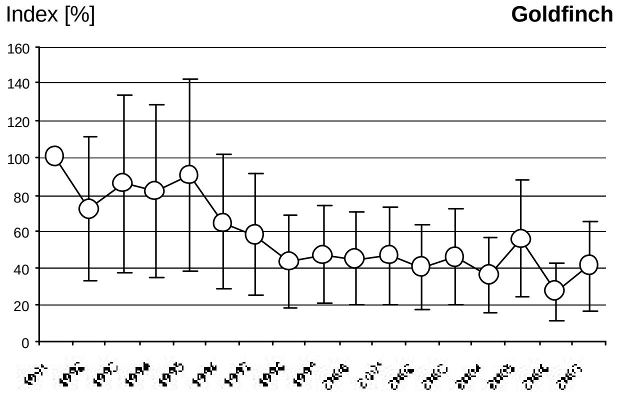

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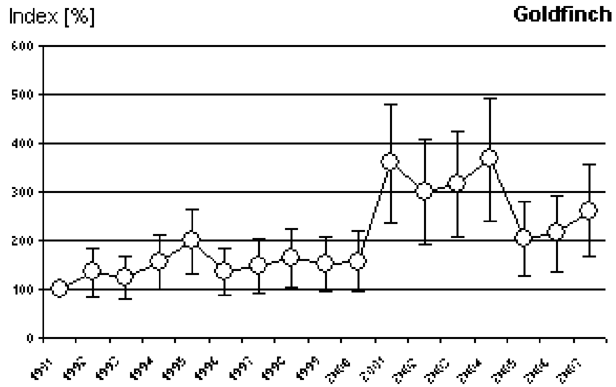
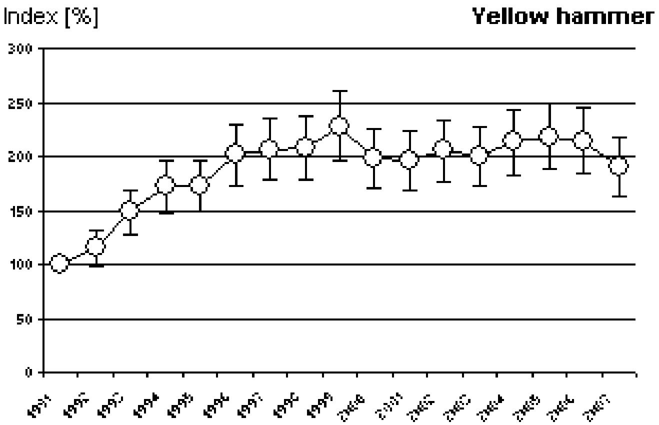
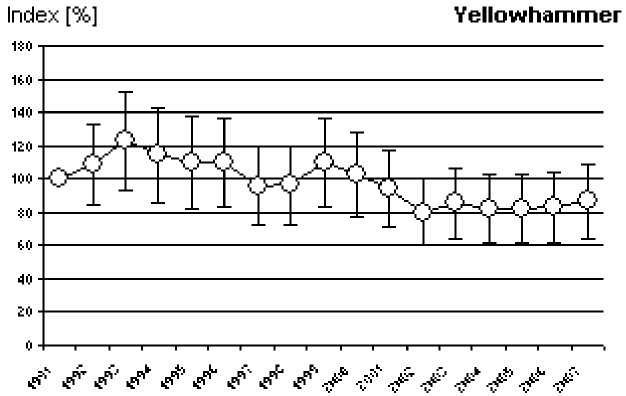
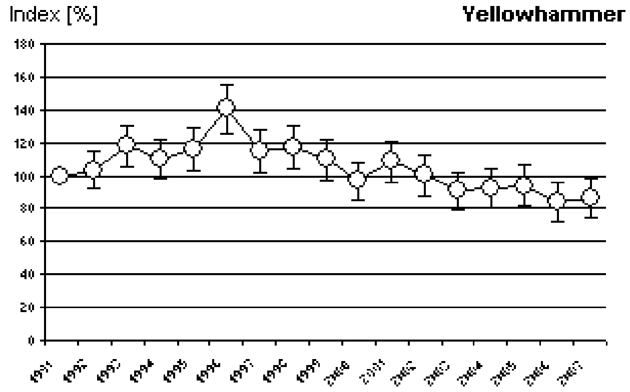
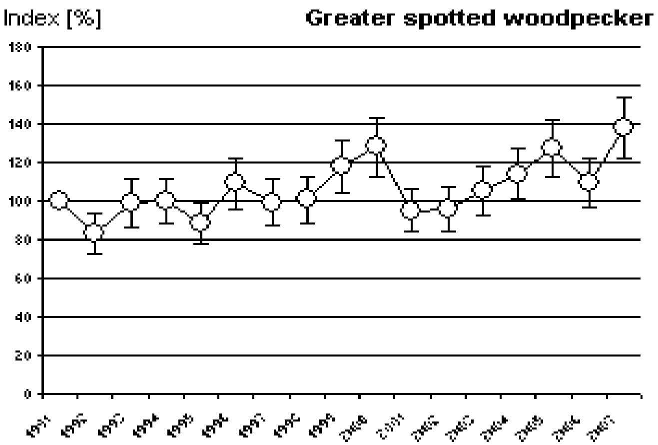
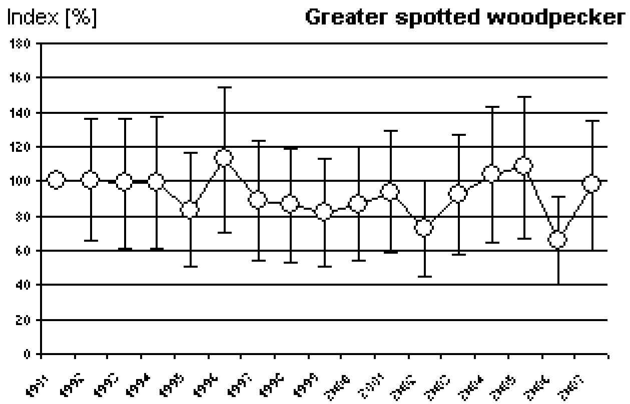


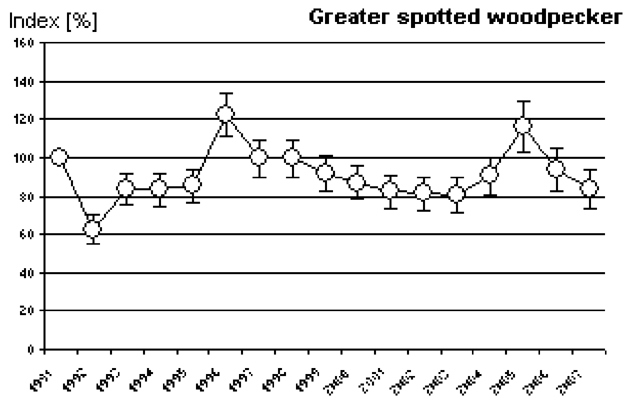




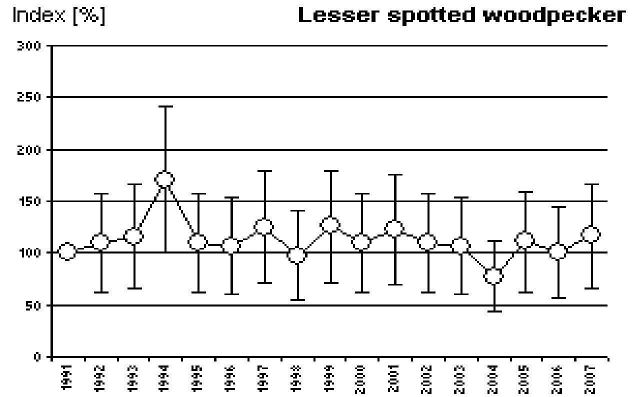


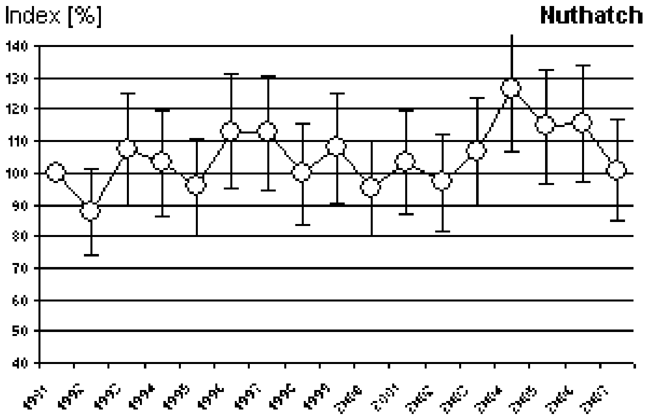


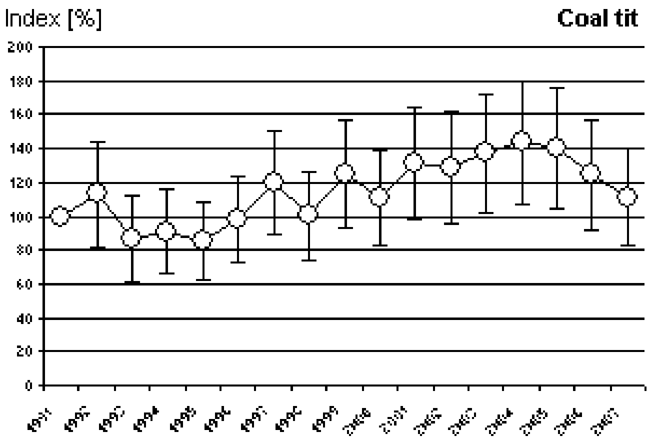




EAST GERMANY







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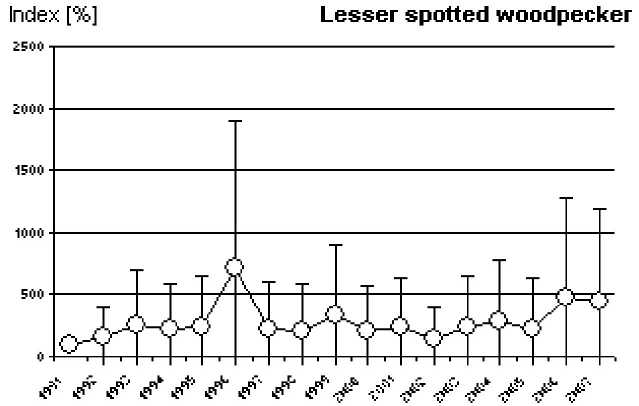

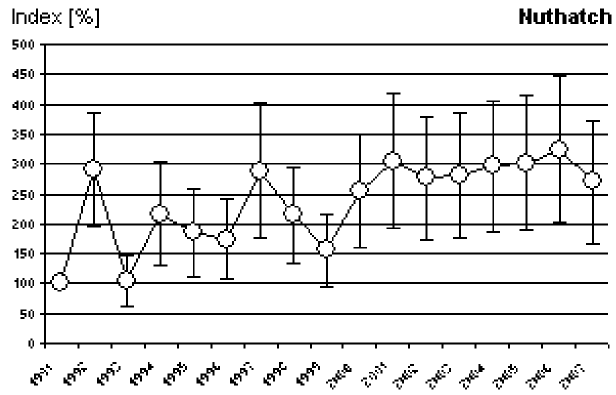

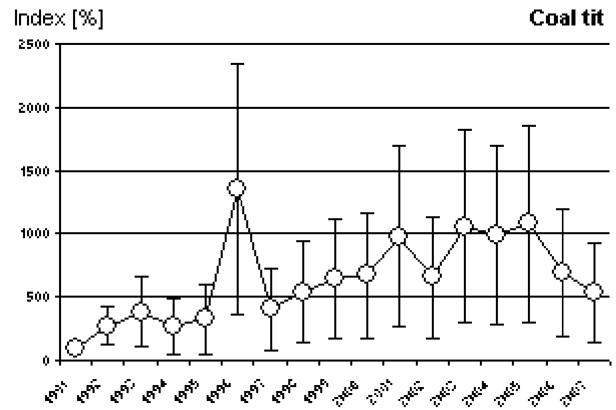

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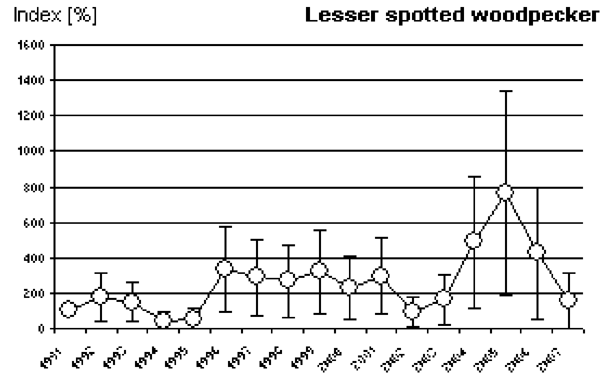

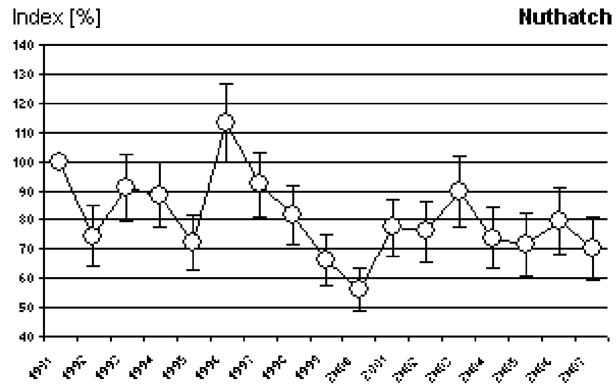

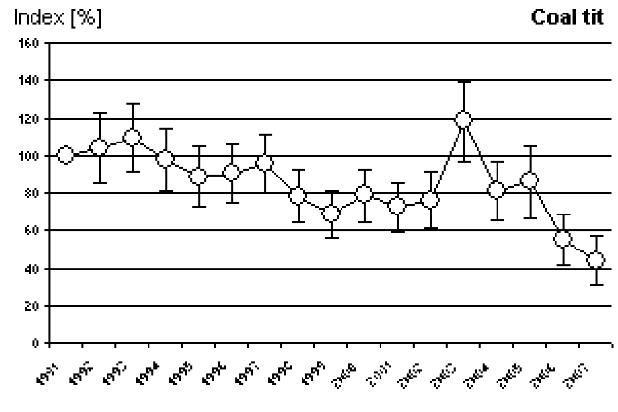

EAST GERMANY

HESSEN

NRW