Why birth and death matter for bird conservation

RHYS GREEN
RSPB, Department of Zoology, University of Cambridge, UK

Email: reg29@hermes.cam.ac.uk

Identification of external causes of bird population declines is valuable to conservationists who want to reverse them. Such diagnoses can often be accomplished using just information on population trends and candidate causes and the comparative method, so why do ornithologists bother to measure demographic rates for conservation purposes? In this talk I propose some reasons and illustrate them with examples. Measuring demographic rates can assist the diagnosis of causes of population declines by identifying their most likely demographic mechanism. This narrows the field when searching for the external cause. Demographic rate estimates also allow stringent checks of the diagnosis to be made, including assessments of whether the magnitude of the effect of the candidate cause is sufficient to account for the observed population change.

Rhys Green undertakes research in animal population ecology and applies it to solving biodiversity conservation problems. He is Honorary Professor of Conservation Science, Department of Zoology, University of Cambridge and Principal Research Biologist at Royal Society for the Protection of Birds. His research interests are studies of interactions between birds and agricultural management, interactions between birds and forest management, global monitoring of trends in biodiversity, global patterns in land use change and their impacts on biodiversity, effects of climate change on geographical range and population processes, habitat and food selection by birds, population processes in threatened birds, practical management of habitats and manipulation of demographic rates of threatened birds and modelling effects of disturbance on birds.

Field estimation of over-winter survival rates

GAVIN SIRIWARDENA
British Trust for Ornithology, The Nunnery, Thetford, Norfolk, IP24 2PU, UK

Email: gavin.siriwardena@bto.org

Demographic and ecological studies of passerines commonly indicate, directly or indirectly, that over-winter survival is the critical demographic rate underlying population change. Survival probabilities are difficult to measure, however: they are population parameters with no measurable values for individuals or pairs and are only tractable across samples of greater than a certain size. In practice, this means that most studies of survival use national-scale ring-recovery data or more local (networks of) constant- or controlled-effort mark-recapture trapping. These approaches provide perfectly good data for many applications, but are often limited in terms of temporal resolution and geographical and habitat coverage. When evidence is needed about local survival rates

and the ways in which they are influenced by environmental variation, ring-recovery data tend not to exist at a suitable spatial scale. Similarly, many habitats do not facilitate constant-effort trapping because vegetation structure inhibits mist-netting. These problems tend to mean that the responses of survival to environmental management remain unknown and effects on breeding success are more prominent in the evidence base simply because they are relatively easy to study. If demographic effects of management action are to be separated from simple redistributions, local survival information may be critical to elucidate the mechanisms behind local changes in abundance.

I present a tractable mark-resighting protocol, using individually colour-ringed birds, using a case study of the responses of yellowhammer and chaffinch populations to experimental and control supplementary feeding in farmland. Birds were generally only caught once during the three-year study, during winter ringing sessions across ten "fed" and ten "unfed" 2×2km tetrads in East Anglia. Resighting (and, opportunistically, recapture) then took place in subsequent breeding seasons and winters, and standard Cormack-Jolly-Seber models allowed estimation of annual and seasonal survival probabilities.

The best estimates of survival rates for yellowhammer were comparable in magnitude and precision to those calculated from national ring-recovery data, but those for chaffinch were considerably lower, showing bias due to "emigration" of the winter migrant portion of the sample. Seasonal survival showed trends to be considerably higher between spring and winter than between winter and spring, despite the greater length of the former period, consistent with negative mortality effects of late winter food shortages. Although the differences fell short of statistical significance, there were trends for survival to be higher in fed areas, consistent with the results of tests of variation in population growth rate. Population models showed that the apparent differences in survival could have driven the differences in population growth.

This study demonstrates that intensive mark-resighting fieldwork provides a viable approach to estimating survival for open-country species at a spatial scale at which experimental management can take place. A significant investment of fieldwork time is required, but this is small in relation to the amounts spent on management such as winter seed options in agri-environment schemes, so represents a worthwhile use of monitoring resources.

Gavin Siriwardena is Head of Land-Use Research at the BTO and has been engaged in research into the causes of farmland bird decline and the design and performance of agri-environment measures to address the problem for 16 years. He has led both field-based and analytical research projects, as well as doing regular bird surveys as a volunteer, and has published more than 20 papers in journals such as the Journal of Applied Ecology and Ibis. Gavin sits on BOU Council (until 2013) and the Evidence and Monitoring Group of the Campaign for the Farmed Environment.

Occupancy estimation on winter grounds: Integrating process-observation occupancy models with automated acoustic sampling

JOHN E. QUINN[1,*], AMY ODEN[1] & JAMES R. BRANDLE[2]
[1] Furman University, 3300 Poinsett Highway, Greenville, SC 29613, US
[2] University of Nebraska-Lincoln, 3310 Holdrege Street, Lincoln, NE 68583, US

* Email: john.quinn@furman.edu

Understanding the spatial distribution of populations has important implications for conservation action and policy. However, at this time our understanding of patch occupancy during the non-breeding season and, more specifically, on winter grounds is limited by low detection probabilities. Thus, estimates of patch occupancy may be inaccurate. An improved understanding of patch occupancy would contribute to greater understanding of winter dispersal and survival of rare and common species.

In this paper, we demonstrate how we use process-observation models alongside new technology in the Song Meter acoustic recorder to sample occupancy patterns of winter birds in the Central Great Plains of North America. We focus here on the occupancy patterns and detection probability of the Black-capped Chickadee *Poecile atricapillus*, a small passerine common in forest patches embedded in cropland. During our sampling period (December-January), the larger landscape matrix around each patch is bare soil and no-till cropland.

The Song Meter is a unique sampling platform that allows for automation of repeated sampling across a broad spatial area. With this digital platform, we sampled ten sites in December and January 2011-2012. Each unit was programed to record for 10 minutes on the hour between 8:00 and 17:00. We visited each site once to deploy the recorder, a second time mid-season to change batteries and download the collected data, and third time to retrieve the recorder. After collected, we combined the 10 count periods in a day into a single count period. We analyzed the data with the software Song Scope, using recorded vocalizations to document species presence in a patch. To compare the effectiveness of this method with traditional field sampling, we identified observations from the 1st and 15th of the month to represent four visits to each site by a researcher, an economically viable sampling frequency. Estimations of occupancy and detection probability were calculated for both data sets in the unmarked package for Program R.

Occupancy estimates from the 62-day data set suggest that all sites were used by chickadees. In contrast, the 4-day data set estimated only two sites occupied. Detection probability also differed between data sets. The 4-day sampling program overestimated detection probability when compared to the 62-day data set.

These data are from a single year, but the integration of technology and modeling demonstrate the potential to make winter measurements of population dynamics more accurate. Results suggest first, that accurate estimates of patch occupancy on a species' winter grounds may require a high frequency of sampling and second, that sampling programs, based detection probabilities incorrectly estimated, may lead to over-confidence of subsequent predictions.

The combined use of technology and population models can provide accurate measures of occupancy and dispersal on winter grounds. To improve the accuracy of our predictions and to tie these data into land use patterns, we will expand this program in the Great Plains and replicate this design in a new location (South Carolina, USA) during the winter of 2012 and 2013.

John Quinn is an Assistant Professor of Biology at Furman University in South Carolina, USA. His research addresses concerns related to biodiversity conservation and sustainability, in particular avian ecology, agroecology, and conservation in working landscapes. His current work focuses on changes in avian populations over space and time while integrating social and economic parameters to identify effective conservation solutions. He received a Ph.D. from the University of Nebraska-Lincoln in 2010.

A method for deriving time-variable avian re-nesting probability functions for use in seasonal productivity models

PATRICK J. C. WHITE[1]*, CHRIS STOATE[2], JOHN SZCZUR[2], NICHOLAS J. AEBISCHER[3] & KEN NORRIS[4]
[1] Game and Wildlife Conservation Trust, Drumochter Lodge, Dalwhinnie, Inverness-shire, PH19 1AF, UK
[2] Game and Wildlife Conservation Trust, Loddington House, Loddington, LE7 9XE, UK
[3] Game and Wildlife Conservation Trust, Burgate Manor, Fordingbridge, SP6 1EF, UK
[4] Centre for Agri-environmental Research, University of Reading, PO Box 237, Reading, RG6 6AR, UK

* Email: pwhite@gwct.org.uk

The demographic parameters productivity, survival and migration ultimately determine local avian population trends. Their measurement is essential in bird conservation, for diagnosing proximate causes of population declines and for testing responses to management. It is ultimately seasonal productivity (productivity-per-female-per-season) that is required for demographic simulation or quantification of individual fitness.

But measuring seasonal productivity is difficult in multi-brooded species without labour-intensive studies of marked birds. Dynamic models have been developed that do not require knowledge of the number of attempts made, but they have often had to use simplified re-nesting probability (φ_R) step-functions instead of more biologically intuitive time-variable functions. This has implications for how models simulate inter-individual variation in productivity, the relative contributions of early/late nests and re-nesting compensation.

For Blackbird *Turdus merula*, Chaffinch *Fringilla coelebs* and Yellowhammer *Emberiza citrinella* we demonstrate a modelling approach to derive time-variable φ_R functions where not all attempts can be located and females are unmarked. For yellowhammer we test their performance (relative to simpler step-functions) within a dynamic simulation model.

Derived φ_R functions approximated reverse sigmoid shapes, matching expectations. Specified with the time-variable function, the simulation model better matched observed seasonal distribution of first egg-dates. In all outputs (productivity, attempts and season length) time-variable functions allowed for intermediate inter-individual variation compared with the step-functions.

The φ_R function used had implications for the strength and form of re-nesting compensation specified by the model, being linear using a time-variable function and non-linear using step-functions.

The method demonstrated is less resource-intensive than continuous monitoring of marked birds and thus potentially increases the availability of time-variable φ_R functions to researchers. Though not proven superior in estimating productivity, they widen the functionality of dynamic seasonal productivity models and thus provide an additional tool for demography studies in multi-brooded species.

Patrick White studied BSc Ecological Science at the University of Edinburgh and then for a PhD on farmland songbird breeding in the Centre for Agri-environmental Research at the University of Reading. Over this period he also had short-term research assistant posts at Rothamsted Research (Plant and Invertebrate Ecology division) and Glasgow University Zoology Department. He currently works on black grouse within the Upland Research Group at the Game & Wildlife Conservation.

The use of stochastic re-nesting models to measure fecundity in birds

ROSEMARY SETCHFIELD[1,*], NORMAN RATCLIFFE[2], DAVE BUCKINGHAM[1], RHYS GREEN[1,3] & WILL PEACH[1]
[1] RSPB, The Lodge, Sandy, Bedfordshire, SG19 2DL, UK
[2] BAS, High Cross, Madingley Road, Cambridge, CB3 0ET, UK
[3] University of Cambridge, UK

* Email: Rosemary.Setchfield@rspb.org.uk

Ornithologists and conservationists often require a measure of season-long reproductive success (or fecundity) in birds. For species that re-lay after failure or are multi-brooded it is often difficult to locate and determine the fates of all breeding attempts for any given female, and data collection is often only feasible at the level of individual nesting attempts.

Stochastic re-nesting models involve the probabilistic integration of the various components of reproductive success (laying date, clutch size, egg survival, hatching rate, chick survival, intervals between successive nesting attempts etc). Simulation of nesting histories is achieved through the random sampling of observed or assumed distributions of the various components of reproductive success. Re-nesting models allow the user to identify the components of reproductive success that have the most influence on overall fecundity. Moreover, when the component demographic data are collected with respect to covariates, they allow the impact of those

covariates to be assessed on overall fecundity. This allows a wide range of potential management scenarios to be tested without the need for expensive and logistically difficult experiments. For example, for birds nesting in grass fields, knowing the impact of grazing intensity or mowing on nest survival allows us to predict fecundity under a wide range of potential management scenarios in which the timing and intensity of grazing and mowing are manipulated.

We briefly review the development of re-nesting models since the early pioneering work of Albert Beintema through to modern boot-strapping approaches, and consider their application to real conservation problems. We consider methods, implementation, assumptions and minimum data requirements. We show how the approach can be used to refine study design and data collection, and to estimate population size based on counts of active nests.

Sex-biased survival in a declining long-distance migratory bird: implications for population dynamics

CATRIONA A. MORRISON[1,*], ROBERT A. ROBINSON[2], JACQUIE A. CLARK[2] & JENNIFER A. GILL[1]
[1] School of Biological Sciences, University of East Anglia, Norwich Research Park, Norwich, NR4 7TJ, UK
[2] BTO, The Nunnery, Thetford, IP24 2PU, UK

* Email: catriona.morrison@bto.org

Over the past 40 years there have been rapid declines in the abundance of many migratory bird species which breed in Europe and winter in Africa. In many declining bird species, higher rates of mortality among females than males have led to biased population sex ratios, which may have feedback effects on population abundance. Quantifying the impact of sex-biased mortality on population sex ratios and productivity may therefore be critical in understanding the processes driving the population dynamics of Afro-Palaearctic migrants. Since the mid-1990s, the abundance and productivity of one of Britain's most abundant passerine migrants, the Willow Warbler *Phylloscopus trochilus* has declined in the south-east of the country while slightly increasing in the north-west. We use national-scale bird ringing data to investigate variation in the survival rates of adult male and females willow warblers breeding in these two regions of the UK. We then explore the consequences of survival rates for adult sex ratios and trends in productivity and abundance, in order to identify processes potentially limiting population recovery.

Catriona Morrison has recently completed her PhD at the University of East Anglia, using BTO long-term datasets to explore the demographic drivers of population change in willow warblers. She is currently working as a research ecologist within the demography unit at the BTO.

Sub-lethal and indirect effects of mammalian predators on urban birds

KARL EVANS[1]*, COLIN BONNINGTON[1] & KEVIN GASTON[2]
[1] Department of Animal and Plant Sciences, University of Sheffield, UK
[2] Environment and Sustainability Institute, University of Exeter, UK

*Email: karl.evans@sheffield.ac.uk

Urban areas support high densities of some non-native predators, which in the UK include the domestic cat *Felis catus* and the grey squirrel *Sciurus carolinensis*. The direct predation effects of domestic cats on prey populations attract intense debate, and concern has been expressed regarding the impacts of nest-predatory grey squirrels. Ecological theory, however, predicts that sub-lethal and indirect effects are more important at limiting avian population size than direct predation events. Empirical evidence for such sub-lethal and indirect effects on avian populations is generally very scarce, and currently lacking with regard to domestic cats and grey squirrels. Controlled model presentation experiments at active urban Blackbird *Turdus merula* nests were used to quantify potential sub-lethal and indirect effects of predators (domestic cat and grey squirrel) on avian reproductive success. The results are discussed in the context of assessing the relative impacts of different predator species on urban bird assemblages, and mitigating their impacts.

Karl Evans is a conservation biology lecturer at the University of Sheffield. His research focuses on how biodiversity responds to natural environmental gradients and human activities, with a focus on climate change and urbanisation. He is an associate editor of *Global Ecology and Biogeography* and *Animal Conservation*.

Reversal of anti-predator response to predation risk under changing environmental conditions and its implications for population dynamics

ROSS MACLEOD
University of Glasgow, UK

Email: Ross.MacLeod@glasgow.ac.uk

Within population ecology, it has long been established that direct mortality due to predation can be a major force in population dynamics. Recently it has also been shown that the indirect or risk effects of predators and predation (also known as non-lethal or non-consumptive effects) can have as great, or even greater, an impact on population dynamics. This study focuses on a well-known avian response to predation risk, body mass change, to ask how this indirect predator effect may change in response to changing environmental conditions. The use of innovative RFID monitoring technology allowed an experimental approach to test how a wild bird species (the Great Tit *Parus major)* responds to perceived changes in predation risk and allowed the following questions to be answered: 1) can identical experimental heightening of perceived predation risk produce

opposite anti-predator responses under different environmental conditions?, 2) can predator response in a single local population change over a small geographic scale (less than a km)?, 3) over what time scale can change in predator response occur (years to weeks)? The results show that great tits can strategically alter their mass response to predators and that they can do so over short temporal and spatial scales. Starvation-predation risk trade-off theory is used to interpret the results and predict that climate change will make such changes in individual predation risk response widespread and this is likely to significantly change population dynamics of the species through changing winter survival rates.

Ross Macleod currently holds a Royal Society of Edinburgh Scottish Government Research Fellowship at the University of Glasgow's Institute of Biodiversity, Animal Health & Comparative Medicine. His research uses a combination of individual based starvation-predation risk trade-off theory, experiments and long-term datasets to understand how behavioural responses to environmental conditions are linked to and might drive future changes in bird populations. Ross also runs two overseas research programmes investigating 1) how biodiversity responds to rainforest regeneration in the Peruvian Amazon and 2) how conservation management of tropical savannah ecosystems effects threatened bird species, including the Critically Endangered Blue Throated Macaw.

Living in a wormy world: do gut parasites impact demography of the European Shag *Phalacrocorax aristotelis*?

SARAH BURTHE[1,*], MARK A. NEWELL[1], HANNA GRANROTH-WILDING[2], TOM REED[3], GIDONA GOODMAN[4], ADAM BUTLER[5], THOMAS BREGNBALLE[6], EILEEN HARRIS[7], SARAH WANLESS[1], EMMA J.A. CUNNINGHAM[2] & FRANCIS DAUNT[1]

[1] Centre for Ecology & Hydrology, Bush Estate, Penicuik, Midlothian, EH26 0QB, UK

[2] I nstitute for Evolutionary Biology, University of Edinburgh, Kings Buildings, Edinburgh, EH9 3JT, UK

[3] Netherlands Institute for Ecology, Wageningen, the Netherlands

[4] Royal (Dick) School of Veterinary Studies, University of Edinburgh, Easter Bush, Midlothian, EH25 9RG, UK

[5] Biomathematics and Statistics Scotland, Kings Buildings, Edinburgh EH9 3JZ, UK

[6] Department of Bioscience, Aarhus University, Kaloe, Grenaavej 14, DK-8410 Roende, Denmark

[7] Department of Zoology, Natural History Museum, London, SW7 5BD, UK

*Email: sburthe@ceh.ac.uk

Parasites are ubiquitous in wild animal populations and considered to be a key driver of evolutionary processes. However, parasites comprise an overlooked component of ecological communities with relatively few studies having considered the impact of parasites on wild animals. This is in part because assessing parasite burdens can be difficult, particularly for endoparasites. Collection of faecal samples can be problematic, faecal egg counts may not always be a reliable indicator of infection intensity, and destructive sampling of hosts is not possible if the animal is of conservation importance or part of a long-term study.

In this study we focus on understanding the impacts of endoparasites (nematodes *Contracaecum rudolphii*) in a breeding wild seabird host, the European Shag *Phalacrocorax aristotelis* on the Isle of May, Scotland. Shags in this population have been intensively studied since the 1980s, with parasites having been studied since 2005.

We provide an overview of the parasite work, reporting on the development of new methodology to monitor parasites and also revealing how experimental manipulations have aided our understanding of the impacts of parasites on shag demography. We successfully developed endoscopy as a method of quantifying endoparasite burdens in the field. The aims of this method were to i) measure natural variation in endoparasite burdens and ii) to show that treatment with a suitable dose of ivermectin removed parasites. Endoscopy proved to be a rapid, reliable and repeatable method. Parasite burdens were scored into categories and found to be consistent within naturally infected birds throughout the breeding season. All birds were found to be naturally parasitised. However there was significant variation in burdens, with late breeding males having the greatest burdens and early breeding females the lowest. Testing of a suite of doses of ivermectin found that a dose of 4mg/kg bird weight resulted in complete removal of parasites, with birds remaining worm free for at least three weeks.

Parasites are known from experimental manipulations to impact shag demography. Survival of male offspring, the larger more costly sex, was shown to be higher for late breeding pairs where the adults were treated with ivermectin relative to controls. Shags have asynchronously hatched young resulting in the last hatched chick being smaller than its siblings. Dosing of chicks with ivermectin altered the patterns of growth within a brood: the last-hatched chick consistently responded to treatment more strongly than its older siblings, and this varied across years. Last-hatched chicks' growth rate increased with treatment in years of low productivity but decreased in the most productive year, whereas older siblings' growth rates were not affected by treatment. Whole-brood growth rates did not change with treatment, suggesting that differences between individuals could be underpinned by interactions within the brood rather than changes in total parental provisioning. We also considered the longer term impacts of anti-parasite treatment of chicks and adults by examining the return rates to the breeding colony, annual survival and subsequent breeding success compared to controls. Negative impacts of parasites on demography, particularly if interacting with food availability, may have long term consequences for population growth rates.

Sarah Burthe's research aims to understand the processes and factors driving animal population dynamics and demography, with a particular focus on parasites and disease. She has been employed as an ecologist with the Isle of May seabird group at CEH Edinburgh since 2008, where she has been investigating the impacts of macroparasites on seabird demography, developing new methodologies for monitoring endoparasites and also examining evidence for phenological change, trophic mismatch and regime shifts in North Sea food-webs. Her PhD research and post-doctoral work focused on determining the negative impacts of endemic microparasites on wild rodent survival and population growth rates, and elucidating the factors that determine individual risk of infection, especially in relation to pathogen interactions and coinfection.

Climate change and survival in Long-tailed Tits *Aegithalos caudatus*

PHILIPPA GULLETT[1]*, ROBERT ROBINSON[2], BEN HATCHWELL[1] & KARL EVANS[1]
[1] University of Sheffield, Western Bank, Sheffield, UK, S10 2TN, UK
[2] British Trust for Ornithology, The Nunnery, Thetford, Norfolk, UK, IP24 2PU, UK

* Email: p.gullett@sheffield.ac.uk

Recent amelioration of winter climates in temperate regions is thought to enhance the survival of small-bodied resident passerines. This is supported by the observation that particularly cold winters cause reduced survival and associated population crashes. However, less attention has been paid to the link between survival and climate during less severe winters, when rainfall rather than temperature may be the primary determinant of over-winter survival if higher rainfall reduces foraging opportunities and increases thermoregulatory demands. Similar effects may occur during the breeding season, when wet weather may reduce parental survival by increasing the costs of reproductive investment. This is important because, in addition to the virtually certain increases in future winter temperatures, it seems likely that winter and spring precipitation will increase in the future across most of the UK. Future climate change may thus have negative impacts on passerine survival, rather than positive impacts as often assumed. We provide a rare empirical test of this hypothesis using a 19-year capture-mark-recapture study of a population of Long-tailed Tits *Aegithalos caudatus* in the Rivelin Valley, Sheffield. We construct climatic models of survival rates in this local population, and use these local models to develop predictions of future survival rates under a range of climate change scenarios.

Philippa Gullet is a PhD student at The University of Sheffield, funded by NERC with the BTO as a CASE partner. She is investigating the mechanisms driving avian demographic and population responses to climate change, using long-term local and national datasets as well as collecting new data on the timing of budburst and the timing of spring food peaks (caterpillar/insect abundance). Her enthusiasm for conservation and natural history has previously seen me measuring trees in the Pyrennees and tracking babblers in Australia; during her PhD, she is keeping a hold on reality by leading a Wildlife Trust nature club for children.

The relative roles of nest boxes and immigration on the growth of a Peregrine Falcon *Falco peregrinus* population

RES ALTWEGG[1,*], FITSUM ABADI[1,2] & ANDREW JENKINS[3]

[1] South African National Biodiversity Institute, and Animal Demography Unit, University of Cape Town, South Africa

[2] CEFE-CNRS, Montpellier, France

[3] AVISENSE consulting and Percy FitzPatrick Institute, University of Cape Town, South Africa

*Email: res.altwegg@gmail.com

The effectiveness of conservation interventions is often difficult to assess because a number of potentially interacting drivers generally determines changes in population size. Some of these drivers may act through demographic processes that are difficult to observe, such as immigration. Populations may further be small and subject to strong demographic stochasticity, which further complicates linking population trends to management actions taken in the past. We studied the urban Peregrine *Falco peregrinus* population in the vicinity of Cape Town, South Africa, that increased from 3 pairs in 1997 to 18 pairs in 2010 where nest boxes had been installed to manage the interface between new urban pairs of falcons and the human users/occupants of colonised buildings, and incidentally to improve breeding success We used integrated population models (IPM) to formally combine information from a capture-mark-recapture study, monitoring of reproductive success, and counts of the population size. Since all local demographic processes were directly observed, the IPM approach also allowed us to estimate immigration. The provision of nest boxes, as a possible stimulant of population growth, improved breeding success, but the population increased mainly due to immigration. Despite low sample sizes, the IPM approach allowed us to obtain relatively precise estimates of the population-level impact of deploying nest boxes in this population. The goal of conservation interventions is often to increase population size and the effectiveness of conservation interventions should therefore ideally be assessed at the population level. IPMs are powerful tools for combining demographic information that may be limited due to small population size or practical constraints on monitoring.

Res Altwegg is an ecologist interested in population and statistical ecology. His recent work has focused on demography and population dynamics of various birds, including raptors, seabirds, blue cranes, and the range expanding Hadeda Ibis. His other main interest is to understand range dynamics for which he is currently analysing bird atlas data.

Linking dispersal strategies with population dynamics: a case example with the Eurasian Eagle Owl *Bubo bubo*

MARIA DEL MAR DELGADO[1,2]* & VINCENZO PENTERIANI[1]

[1] Department of Conservation Biology, Estación Biológica de Doñana, CSIC, c/Américo Vespucio s/n, 41092 Seville, Spain

[2] Metapopulation Research Group, Department of Biosciences, University of Helsinki, Viikinkaari 1, 00014 Helsinki, Finland

*Email: mmdelgado@ebd.csic.es; maria.delgado@helsinki.fi

During the last decades, dispersal studies have mainly focused on the cues used in the first step (i.e. when individuals take the decision to leave their natal site) and the last stage (i.e. when dispersing select a settlement area), while little is still unknown about the intermediate, wandering phase. A greater understanding of this phase can be achieved by approaching it under the perspective of the animal movement analyses. Understanding how animals make movement decisions during dispersal is an important step for predicting the trajectories of population dynamics. This is because the movement behaviour during natal dispersal has important consequences on the dynamics of spatially structured populations, influencing how populations can respond to substantial environmental stress (e.g. human alteration and climate warming) and local catastrophes. However, many movement models still tend to fail when longer time horizons are taken into consideration, mainly due to not considering the occurrence of behavioural changes during the life-span of an individual and their influences on movement patterns, as well as the possible changes of movement patterns when different habitat conditions are encountered. Moreover, much of metapopulation ecology is still assuming that individuals disperse in a rather passive or random fashion. This is, perhaps defendable for certain systems, but for animals with good sensory and cognitive capabilities dispersal decisions can be much more goal-oriented. Here I will talk about the natal dispersal process of a long-lived species, the Eagle Owl. By summarising the results of a 10-year study I will show that, when considering an animal searching for suitable habitat patches while dispersing through a matrix landscape, we have to take into account that, during the travel from the natal to the breeding patch, the movements will be influenced by e.g. matrix habitat variability, density, competition, predation and food availability. All these factors may generate different movement behaviours and search strategies. That is, animal movement ability and therefore, the dispersal process, is the result of multiple complex interactions of external and internal factors acting at various spatial and temporal scales. Importantly, because dispersal is frequently risky or otherwise costly, individuals may disperse less than would be ideal for population performance. Following this idea, I will provide some insights on how natal dispersal might influences the demographic and evolutionary dynamics of spatially structured populations, and conversely how ecological and evolutionary dynamics provide the context against which individuals make their dispersal decisions.

Maria Delgado undertook her degree in Biology at the University of Seville (Spain), and then a PhD in ecology at Doñana Biological Station (CSIC, Spain). She then moved to Finland (University of Helsinki) where she spent her first postdoctoral period (two years) with Hanna Kokko and the second one (three years) with Otso Ovaskainen.

By combining fieldwork with statistical analyses and modelling she aimed to gain an integrated understanding of how natal dispersal influences the demographic and evolutionary dynamics of spatially structured populations, and conversely how ecological and evolutionary dynamics provide the context against which individuals make their dispersal decisions.

Patterns of spatial variation in morphology, life-history and genetic structure at small spatial scales: a case study of European Common Starlings *Sturnus vulgaris*

JESSICA WALKUP*, PETER EVANS & JANE REID
Department of Zoology, University of Aberdeen, Aberdeen, AB24 2TZ, UK

* Email: j.walkup@abdn.ac.uk

Spatial variation in morphology, life-history and allele frequencies can occur within natural populations. Such variation can profoundly influence population and evolutionary dynamics. The understanding of population and evolutionary dynamics can therefore be aided by quantifying variation in these traits at a range of biologically relevant spatial scales. Patterns of variation are frequently observed over large spatial scales that exceed individual dispersal distances, but could have equally important and complex consequences where they occur at much smaller spatial scales. Despite their importance, the degree to which morphology, life-history and allele frequencies can actually vary at small spatial scales within populations of highly mobile species has rarely been quantified. We quantified small scale morphological, demographic and genetic variation within an apparently continuous population of European starlings across a very small spatial scale (<5 km). Surprisingly, we detected spatial variation in morphology within the population, and also substantial and temporally consistent variation in reproductive success. Starlings are philopatric within Fair Isle, raising the possibility of local adaptation and source-sink dynamics at very small spatial scales. In addition, analyses of microsatellite genotypes revealed very weak genetic structure within Fair Isle. We discuss the potential causes of this very small-scale variation in morphology and life-history, and the importance of considering variation occurring at such small spatial scales in understanding population dynamics.

Jessica Walkup is studying for a PhD at the University of Aberdeen and is due to complete her thesis in population and evolutionary ecology this summer. She graduated from the University of York in 2009 after completing a biology degree that incorporated a year working at FERA in their Wildlife and Ecology Management team. A fascination with wildlife, in particularly birds, developed in childhood combined with a passion for science led Jessica to pursue a career in ecology and to jump at the opportunity to study the charismatic European starling during her PhD. She spends much of her spare time outdoors and is currently training to be a bird ringer.

Individual variation and winter site fidelity in a partially migratory seabird

HANNAH GRIST[1,*], FRANCIS DAUNT[2], SARAH WANLESS[2] & JANE REID[1]
[1] Department of Zoology, University of Aberdeen, Aberdeen, AB24 2TZ, UK
[2] Centre for Ecology & Hydrology, Bush Estate, Penicuik, EH26 0QB, UK

* Email: hgrist@abdn.ac.uk

Population dynamics stem from temporal and spatial variation in demography across population members, and consequently from heterogeneity in individual life-histories. A major step towards understanding population dynamics is therefore to quantify individual life-history variation and the degree to which such variation is repeatable or plastic within or across years.

In partially migratory populations, an individual's migration strategy and location could influence its over-winter survival and subsequent reproduction, and thereby profoundly affect its entire life-history. However few studies have tracked individuals across the annual cycle across multiple years, or consequently quantified the degree to which individual variation in migration strategy and winter location is repeatable within or across years.

We used nearly 5000 resightings of individually colour-ringed adult European Shags *Phalacrocorax aristotelis* over three winters to demonstrate that individuals winter in a range of locations spanning nearly 600km of coastline, including the breeding colony. Winter locations and hence migration strategies vary among individuals, but repeatability analysis demonstrated that individuals remain in a single location each winter and are also highly consistent across years.

Strong site fidelity has a range of implications for individual survival and carry-over effects into the breeding season, and therefore on the demography of the population as whole. In addition, with increasing pressure on land use planning, knowledge of the patterns of occupation of protected species can be vital for evidence based conservation management.

Hannah Grist is a PhD student based at the University of Aberdeen. She graduated in Biological Sciences from the University of Oxford in 2007, and gained an MRes from the University of York in 2009. Between degrees, she worked with NGOs both in the UK and overseas, and as a research assistant at the Royal Veterinary College, London. Her main research interests are in avian ecology and conservation, and her current project involves working in partnership with the Centre for Ecology and Hydrology and the Scottish Ornithologists Club to investigate population ecology using a long-term study of European Shags.

Settlement decisions of juvenile shorebirds: implications for seasonal interactions

TÓMAS GUNNARSSON[1,*], JOSÉ ALVES[2], WILLIAM J. SUTHERLAND[3], PETER M. POTTS[4] & JENNIFER A. GILL[2]
[1] University of Iceland
[2] Dept of Biological Sciences, University of East Anglia, Norwich, NR4 7TJ, UK
[3] Cambridge University, UK
[4] Farlington Ringing Group, UK

* Email: tomas@hi.is

The quality of the habitats that organisms occupy is a major driver of their fitness. For long-lived vertebrates, such as many birds, high levels of adult philopatry is the norm, largely independent of whether individuals occupy higher or lower quality habitats. Natal philopatry is thought to be a useful rule-of-thumb for settlement decisions in the absence of higher resolution information on which to base decisions, and indeed most birds disperse non-randomly when returning to their breeding grounds for the first time as adults. In migratory birds the situation is more complex as juvenile individuals also have to make settlement decisions on the wintering grounds and the quality of the habitat occupied in one season can have profound effects on fitness measures in the other seasons through carry-over effects. The process of settlement decisions in migratory systems where juveniles migrate without parents is however, notoriously difficult to study at the relevant spatial and temporal scales. A population-wide, long-term tracking study of Black-tailed Godwits *Limosa limosa* which breed in Iceland and winter in W-Europe has shown strong seasonal links at the individual level. The same individual godwits tend to use either higher quality habitats both in winter and summer or poorer quality habitats in both seasons, a pattern termed *seasonal matching*. This pattern has profound implications for population dynamics and evolutionary processes by means such as increasing fitness variance. Since 1999, over 500 godwits chicks have been individually marked in Iceland and many of them have subsequently been seen on their wintering grounds in W-Europe. These sightings allow us to reconstruct the process of juvenile settlement and to explore the factors influencing the initiation and maintenance of seasonal matching of habitat quality. In the presentation, we will link the fate of individuals, from hatching to adulthood, to the quality of their natal habitat, the subsequent choice of winter habitat and to population and evolutionary processes driven by seasonal interactions.

Tómas Gunnarsson completed his BSc and MSc in biology from the University of Iceland in 2000 and his PhD from the University of East Anglia in 2005. During the PhD he studied seasonal interactions in migrants using Icelandic Black-tailed Godwits as a study system. He carried out post-doctoral work on the same system at UEA and Cambridge University in 2006-2008. He is currently a research professor at the University of Iceland and the director of the University's South Iceland Research Centre.

Carry-over effects on trans-Saharan migrant phenology and fecundity

TOM FINCH[1,2]*, JAMES PEARCE-HIGGINS[3], DAVID LEECH[3] & KARL EVANS[1],
[1] Dept. Animal and Plant Sciences, Alfred Denny Building, University of Sheffield, Western Bank, Sheffield, UK, S10 2TN, UK
[2] School of Biological Sciences, University of East Anglia, Norwich, UK, NR4 7TJ, UK
[3] British Trust for Ornithology, The Nunnery, Thetford, IP24 2PU, UK

*Email: tom.finch@uea.ac.uk

The decline of long-distance migrant birds is well documented, but the underlying mechanisms are generally poorly understood, in part due to the exposure of migrants to processes operating across wide geographical areas. Environmental change on wintering and passage grounds can reduce migrant numbers directly, through lethal effects, and indirectly through non-lethal 'carry-over effects'. Currently, these carry-over effects have been quantified for only a limited number of species, but evidence is accumulating that poor non-breeding conditions can delay breeding and reduce productivity. There is a further need to understand how non-breeding conditions influence breeding date in the context of trophic mismatch, which could reduce migrant productivity if breeding phenology does not advance to the same extent as peak resource availability. Here, we use data from the BTO's long-term nest record scheme to quantify the effect of climate at winter, passage and breeding grounds on the breeding phenology and fecundity of three trans-Saharan migrants: Common Redstart *Phoenicurus phoenicurus*, Spotted Flycatcher *Muscicapa striata* and Wood Warbler *Phylloscopus sibilatrix*. The results are discussed in relation to the effects of climate change on avian demography.

Tom Finch graduated from the University of Sheffield in 2011 with an MBiolSci in Biology. After spending an autumn at North America's flagship bird observatory, and the following spring on Skomer Island, he is now in the first year of a PhD at the University of East Anglia. Supervised by Simon Butler, he is studying intra-specific variation in the breeding ecology and population dynamics of the European Roller. His final year undergraduate project, looking into carry-over effects on migrant breeding and supervised by Dr Karl Evans.

Demographic consequences of migration stopover: linking of Red Knot *Calidris canutus* populations to horseshoe crab spawning and harvest in Delaware Bay

CONOR McGOWAN
USGS, Alabama Cooperative Fish and Wildlife Research Unit, Auburn University, Auburn, AL 36849, US

Email: cpmcg00@gmail.com

Migratory bird species exhibit complex annual cycles and often face complex management problems. Conservation issues at one location in the annual cycle may have significant demographic and population consequences for other phases of the annual cycle. Explanations for the *rufa* Red Knot apparent, steep

population declines since the late 1990s have focused primarily on horseshoe crab harvest in the mid-Atlantic region of the U.S,. where Knots stopover during northward, spring migration and consume large quantities of Horseshoe crab eggs. However, uncertainty persists in understanding how Red Knot demographics are related to horseshoe crab populations and harvest management decisions. Through concepts of structured decision making and adaptive management, we developed projection models to explicitly link Red Knot populations to crab population dynamics. The model was a two species model with dual sex components that could evaluate harvest management strategies with respect Red Knot population growth and abundance. The model was parameterized using mark-recapture/resight data from the expansive annual trapping a resighting effort that occurs in Delaware Bay. Through a multistate analysis, the probability of transitioning above a mass threshold of 180g and the subsequent annual survival of birds that reach, or fail to reach the 180g threshold were estimated. The transition probabilities from the light mass state (<180g) to the heavy mass state (>180g) were linked to estimated horseshoe crab spawning abundance each year and survival was dependent upon what state each bird was in at their time of departure from the Bay. Results indicate strong support for the hypothesis that mass state transition probabilities are correlated with crab spawning and that survival is somewhat dependent on mass state at the time of departure. Light mass birds survival was on average ~1% lower than heavy bird survival. Alternative models linking Knot survival to snow depth in the arctic breeding grounds garnered more support, indicating that deeper snow was associated with higher survival, but the model selection results retuned significant model uncertainty. These results somewhat contradict previous analyses, and heighten rather than reduce ecological uncertainty in this management system. From these contradictory analyses competing projection models, capturing three alternative hypotheses of species interactions, were incorporated into an adaptive management plan for horseshoe crab harvest. The plan includes a unified objective statement, an agreeable set of harvest alternatives, and the three alternative systems models. The approach uses an optimization analysis to identify the optimal management action, given both Red Knot and horseshoe crab abundance under model uncertainty. The approach effectively incorporates competing stakeholder objectives and significant ecological uncertainty but still enables effective decision making to allow for learning through management and directed research.

Conor McGowan is a native of New York. He completed a BS at Wake Forest University in 2000. After several field based avian conservation jobs, he completed an MS at N.C. State University studying reproductive ecology of American Oystercatchers under Dr. Ted Simons, and a Ph.D. from the University of Missouri, studying Piping Plover population modelling under Dr. Mark Ryan. Following a two year post-doc position at the USGS Patuxent Wildlife Research Center, he began working as the Assistant Unit Leader for Wildlife at the USGS Alabama Cooperative Fish and Wildlife research unit in 2010.

Identifying links between environment and demography: a methodological overview

MORTEN FREDERIKSEN
Aarhus University, Denmark

Email: mfr@dmu.dk

One of the most important goals of demographic research is to identify environmental drivers of population change. In order to provide robust diagnosis and prediction of population change in a changing environment, it is critical that available demographic data are analysed carefully to obtain reliable results. In this talk, I will provide an overview of the state of the art of demographic methods in ornithology, with an emphasis on tools for identification of environmental drivers. A central theme is the need to use mixed models in order to avoid pseudoreplication and the associated risk of spurious findings. I will also focus on true replication as the only way to increase power when time series are often too short.

Morten Frederiksen is an experienced avian ecologist and demographer, with special expertise in the use of capture-mark-recapture modelling to analyse data from long-term studies of marked individuals. Most of his work has been on seabirds, including cormorants in Denmark and the long-term multi-species data from the Isle of May. His work is increasingly focused on understanding and predicting the effects of global change on seabird populations, and this involves an emphasis on large-scale patterns and processes in distribution, demography and population dynamics.

The impact of transients on variation in population dynamics

THOMAS H G EZARD[1,*] and PETER H BECKER[2]
[1] Centre for Biological Sciences, University of Southampton, Life Sciences Building 85, Highfield Campus, Southampton, SO17 1BJ, UK
[2] Institut für Vogelforschung 'Vogelwarte Helgoland', An der Vogelwarte 21, D-26386 Wilhelmshaven, Germany

*Email: t.ezard@soton.ac.uk

Age-related improvements in breeding success are one of the most ubiquitous patterns in avian population biology, which demands structured demographic models to accurately model population growth. Population projection matrices are one common way of investigating links between demographic processes and population dynamics in structured populations. A large amount of very useful theory pivots on the assumption of equilibrium dynamics, i.e., no change in total population size and no change in the relative abundances of each age class. The preceding transient is, however, of genuine conservation concern as it encompasses the short-term impact of natural or anthropogenic disturbance on the population.

What consequences do these assumptions have on the understanding we glean from population projection matrix models of avian population dynamics? Here, we'll compare and contrast equilibrium and transient, deterministic and stochastic analyses of the male and female components of an increasing Common Tern *Sterna hirundo* population.

The three main results are: (1) a large contribution to population growth does not imply a large contribution to variation in population growth; (2) sex-specific differences are clearest when studying covariation between vital rates; (3) the breeding performance of older age classes is more influential on long-term population growth than that of younger age classes, but the opposite is true when studying short-term, transient measures of population growth.

We show how short-term, transient effects can leave clear signatures on long-term population dynamics and highlight how a dynamic age structure in analysis can bring results from deterministic analysis closer to those from stochastic approaches. By considering short-term population responses to perturbations, especially in long-lived species, population biologists can obtain a more comprehensive understanding of the drivers of population growth without making further mathematical assumptions.

Tom Ezard completed his PhD (Interactions between Structure and Stochasticity in Demographic Models) in 2007 at Imperial College London, before one empirical and one theoretical postdocs on more explicitly evolutionary themes. He is now a NERC Advanced Research Fellow at the University of Southampton, investigating the bridge between micro- and macroevolution.

Effects of climate change on stochastic demography in a population of Eurasian Oystercatchers *Haematopus ostralegus*

MARTIJN VAN DE POL [1,3], YNGVILD VINDENES[2,3]*, BERNT-ERIK SÆTHER[3], STEINAR ENGEN[4], BRUNO J. ENS[5], KEES OOSTERBEEK[5] & JOOST TINBERGEN[6]

[1] Evolution, Ecology and Genetics, Research School of Biology, The Australian National University, Australian Capital Territory 0200, Canberra, Australia,
[2] Department of Biology, Centre for Ecological and Evolutionary Synthesis, University of Oslo, 0316 Oslo, Norway
[3] Department of Biology, and [4] Department of Mathematical Sciences, Centre for Conservation Biology, Norwegian University of Science and Technology (NTNU), 7491 Trondheim, Norway;
[5] SOVON Dutch Centre for Field Ornithology, 6573DG Nijmegen, The Netherlands
[6] Animal Ecology Group, University of Groningen, 9750AA Haren, The Netherlands

*Email: yngvild.vindenes@bio.uio.no

Climate change affects the mean, variability and autocorrelation of climatic variables, but their relative impact

on the dynamics and persistence of populations is still largely unexplored. The effects of a climate variable on population dynamics depend on the vital rates affected, and on how they are affected. More specifically, the functional relationship between a vital rate and the climatic variable affects how variability and noise color in the environment is translated into variability and noise colour of the vital rates and population dynamics. Based on a long-term study of the demography of a declining Eurasian Oystercatcher *Haematopus ostralegus* population, we constructed a stage structured matrix model to evaluate the relative impacts of changes in the mean, variability and autocorrelation of a key environmental variable: winter temperature. The model also includes residual environmental variation and covariation, density dependence through a limited number of breeding sites, and demographic stochasticity affecting the dynamics at small population sizes. In the geographical region of the study population the mean winter temperature is predicted to increase, the variability is predicted to decrease, and the autocorrelation is predicted to become more positive in the near future. Our results show that winter temperature has opposite effects on survival (positive) and reproduction (negative). The persistence time of the population is likely to increase both due to an increased mean temperature and a decrease in the variability of temperature. Increasing the autocorrelation has a negative effect on the population persistence, but this is very small compared to effects of changes in the mean and variability. We discuss general mechanisms by which climatic variability and autocorrelation can increase or decrease population viability and how this might depend both on species' life histories and on the vital rates affected. This study illustrates that it is crucial to estimate the impacts of climate change across the entire life cycle, and to explicitly include key environmental variables. The data needed for such studies are unfortunately rare for most species of conservation concern.

Yngvild Vindenes is a researcher at CEES (University of Oslo), with a PhD from the Norwegian University of Science and Technology in Trondheim. Her research is both theoretical and applied, and focuses on the dynamics of structured populations in a varying and changing environment. To study the consequences of climate change she uses demographic models such as matrix models and integral projection models (IPM) that infer population dynamics resulting from processes occurring at the individual level (survival, reproduction, movement, growth etc). Currently she is working with integral projection models for size-structured fish populations, considering simultaneous changes in population dynamics and size structure caused by climate change, harvesting and other impacts.

Can we predict population changes in the Eurasian Oystercatchers *Haematopus ostralegus*?

BRUNO J. ENS[1], MARTIJN VAN DE POL, KEES OOSTERBEEK[1] & KEES RAPPOLDT
[1] Sovon Dutch Centre for Field Ornithology, The Netherlands

*Email: Bruno.Ens@sovon.nl

In a companion paper, Yngvild Vindenes will discuss how changes in the mean, variance, and autocorrelation (noise colour) of winter temperature affect the median time to extinction of a declining Eurasian Oystercatcher

Haematopus ostralegus population, breeding on Schiermonnikoog. The population decline is at least partly caused by an increase in the probability that the nesting area on the saltmarsh is flooded during the breeding season. Whereas projections for winter temperature are available, current climate models are insufficiently detailed to predict future changes in the magnitude and timing of flooding events in summer.

A second problem for predicting population changes is that only a minority of Oystercatchers breeds on saltmarshes. In the Netherlands, the vast majority of Oystercatchers breeds inland in agricultural areas. Here, they are also declining rapidly (the population more than halved in two decades), but the birds seem more affected by changes in agricultural practices than climate change. A small proportion breeds in urban areas, and this may be the only breeding habitat where reproduction may still be sufficient to maintain population size.

During the nonbreeding season the inland breeding birds join the coastal birds on the intertidal flats in the Delta area and the Wadden Sea. In the Delta area, the tidal flats erode as a delayed effect of the storm surge barrier. In the Wadden Sea, mussel beds were overfished around 1990, have only partly returned and are overgrown by Pacific oysters *Crassostrea gigas*. Furthermore, the stocks of Baltic tellin *Baltic tellin*, an important alternative food, have declined, possibly as a result of climate change. Mechanized fishery of cockles *Cerastoderma edule* was banned in the Wadden Sea in 2004, but is still allowed in the Delta area. Opportunities for gathering cockles by hand were increased in the Dutch Wadden Sea.

Thus, a third problem for predicting population changes is that a variety of processes affect different parts of the Oystercatcher population at different parts of the year. We have developed distribution models to investigate how climate change and different human activities impact the carrying capacity of intertidal areas during the nonbreeding season. Our aim is to develop a metapopulation model linking the different Oystercatcher populations during the breeding and the nonbreeding season.

Bruno Ens's scientific career is tightly linked to the study of career decisions and competition among shorebirds, most notably the Oystercatcher. From 1992 to 2006 he worked at RIN/IBN-DLO/Alterra/IMARES, where he studied the impact on shorebird populations of climate change, shellfish fishery, soil subsidence due to gas extraction, disturbance etc. He strongly believes that the dynamics of populations must be understood from the behaviour of individuals, and remain heavily committed to continuing the Oystercatcher population study on Schiermonnikoog, that was initiated by Jan Hulscher in 1983. Since 2006, he has continued his studies from Sovon Dutch Centre for Field Ornithology, the Dutch version of the BTO.

Avian demographic responses to a warming world

JAMES PEARCE-HIGGINS[1,*] & RHYS GREEN[2, 3]
[1] British Trust for Ornithology, The Nunnery, Thetford, Norfolk, IP24 2PU, UK
[2] Royal Society for the Protection of Birds, Sandy, SG19 2DL, UK
[3] Conservation Science Group, Department of Zoology, University of Cambridge, Cambridge, UK

* Email: james.pearce-higgins@bto.org

Climate warming is anticipated to result in significant impacts on bird populations around the world. These are projected to result in significant latitudinal shifts in the distribution of species, particularly towards the poles, and a general tendency towards range contractions. For this reason, climate change is regarded as a significant long-term threat to many bird species. Whilst there is increasing evidence for latitudinal range shifts to have occurred as expected, there is much less of a coherent picture about the impacts of recent climate change at the level of individual populations, which is what is of greatest interest to conservationists. To fill this gap, we reviewed the literature examining how variation in both temperature and precipitation influences the survival, productivity and population growth of birds around the world.

Firstly, we tested the extent to which the effects of temperature and precipitation vary with latitude, with the expectation that populations in the tropics may be more sensitive to variation in precipitation, whilst those towards the poles may be more sensitive to temperature. This is the pattern we observed. Populations at high latitudes tended to be positively influenced by temperature (i.e. showing improved productivity, survival or growth rates in warm years), whilst responses in the tropics were more equivocal. Conversely, the survival, productivity and growth of populations at low latitudes tended to be positively correlated with variation in precipitation. Thus, below about 30° latitude, precipitation appeared to be a stronger driver of bird demography than temperature.

The effects of temperature and precipitation upon populations also varied between taxa and according to different ecological traits. In particular, positive effects of non-breeding season temperature appeared greatest in invertivorous, carnivorous or omnivorous species, whilst positive effects of non-breeding season precipitation were greatest for piscivorous and invertivorous species. During the breeding season, effects of precipitation tended to have a negative effect on carnivorous raptors and owls. Migratory status also influenced the sensitivity of populations to non-breeding season precipitation. Populations of long-distance migrants which primarily winter in tropical areas tended to be most positively correlated with measures of variation in precipitation in those wintering areas.

These patterns are important to help understand how effects of future warming may impact on bird populations around the world, and illustrate how developing a demographic understanding of the drivers of individual populations can help understand the likely vulnerability of particular populations to change. However, these results may not tell the whole story, and a number of examples will be presented to illustrate some of the potential complexities and challenges of modelling the impacts of climate change on populations, by way of conclusions.

James Pearce-Higgins is a principal ecologist with the British Trust for Ornithology where he takes a lead on developing climate change research across the organisation and manages the Population Ecology and Modelling team. He has had a long-standing interest in understanding drivers of avian populations, which began during his PhD on golden plovers, undertaken at the University of Manchester, and was developed through a wide-range of research projects on upland birds during the 11 years he worked for the RSPB.

Integrating landscape simulation and population modelling for Black Grouse *Tetrao tetrix* in a changing upland landscape

MATTHEW GEARY[1]*, ALAN H. FIELDING[1], PHILIP J.K. MCGOWAN[2] & STUART J. MARSDEN[1]

[1]Division of Biology & Conservation Ecology, School of Science & the Environment, Manchester Metropolitan University, Chester St. Manchester, M1 5GD, UK

[2]World Pheasant Association, Biology Field Station, Newcastle University, Close House Estate, Heddon-on-the-Wall, NE15 0HT, UK

* Email: matthew.geary@stu.mmu.ac.uk

Accurate predictions as to the impacts of future land use change on species of conservation concern help to inform policy-makers and improve conservation measures. However, exploring these impacts, and especially their spatiality, has been at or beyond the limits of methodological capabilities. We investigated the effects of alternative land use change scenarios on suitability of a working landscape for Black Grouse *Tetrao tetrix*, a species that has experienced recent declines attributed to detrimental land use changes (Sim et al. 2008). Expert opinion was used to construct five near-future scenarios, including changes to the extent of grazing and forestry, for an 800 km^2 study site in upland Scotland. For each scenario, the landscape was altered from 20 random starting points and changes in habitat suitability assessed by projecting a MaxEnt suitability model onto each simulated landscape over 30 runs. The 'reduced grazing' scenario was the most beneficial for Black Grouse, and 'increased grazing' the most detrimental. Importantly, a scenario could result in either increases or decreases in suitability depending on positioning of changed land use within the landscape. Change in suitability under some scenarios was dependent on the pixel size modelled and the threshold used to define habitat as suitable. Increasing the area of open canopy forestry added to the landscape caused a proportional decrease in suitability, but suitability gains for the 'reduced grazing' scenario were nonlinear.

This landscape simulation model is currently being used to create habitat simulations for a spatially explicit population model in order to assess the effects on Black Grouse population structure and their distribution within the landscape over a 50-year period. The model is based on demographic rates from Baines *et al.* (2007). Models in which demographic parameters are constrained by habitat quality appear to represent the population more accurately and early indications suggest that the population responds spatially as well as demographically to landscape change in a similar way to the actual response of the Black Grouse population in Perthshire over the last 20 years (see Geary *et al.* 2012).

Landscape simulation models using open source software can be applied in planning or policy-based assessments of the impacts of land use change both on individual species and also on diversity/community measures, or ecosystem services. We recommend that policy which places incentives on grazing reduction would benefit Black Grouse and that landscape level change is assessed in terms of population structure in order to prioritise areas for conservation action in the future.

Matthew Geary has recently completed his PhD in "The long term viability of Black Grouse populations in a changing upland landscape" at Manchester Metropolitan University. Prior to this he obtained a BSc (Hons) in Biology from Newcastle University and an MRes in Ecology and Environmental Management at the University of York. Previous research projects have included investigating nestling diet in Tawny Owls, modelling a reintroduced raptor population and modelling the impacts of climate change on giant pandas. Born in Manchester, he now lives in Somerset but regularly returns to the Scottish Highlands.

Population dynamics and demographic processes in a reintroduced population of the Mauritius Kestrel *Falco puncatus*

MALCOLM NICOLL[1]*, DEBORA ARLT[1&2], MALCOLM BURGESS[1], SAM CARTWRIGHT[1], CARL JONES[3&4], MARIE NEVOUX[1&5], DEEPA SENAPATHI[1], VIKASH TATAYAH[4] & KEN NORRIS[1]

[1] Centre for Agri-Environmental Research, School of Agriculture, Policy and Development, University of Reading, Earley Gate, PO Box 237, Reading RG6 6AR, UK

[2] Present address: Department of Ecology, Swedish University of Agricultural Sciences, Box 7044 750 07 Uppsala, Sweden

[3] Durrell Wildlife Conservation Trust, Les Augres Manor, Trinity, Jersey, Channel Islands

[4] Mauritian Wildlife Foundation, Grannum Road, Vacoas, Mauritius

[5] Present address: Mammal research Institute, Department of Zoology and Entomology, University of Pretoria, Private bag X20, Hatfield, 0028, South Africa

*Email: m.a.c.nicoll@reading.ac.uk

In 1974 the Mauritius Kestrel *Falco puncatus* was reduced to just four known individuals in the wild. In 1987, as part of a species recovery programme, the Kestrel was reintroduced into the Bambous and Creole mountain ranges on the east coast of Mauritius, more than 30 years after its extirpation. Since then the population has been intensively monitored, with demographic and ecological data collected systematically each year. This 20+ year data set has enabled us to (i) describe detailed patterns in key demographic parameter, (ii) explore the processes that might be driving these patterns, (iii) examine the relative importance of these processes in the population's regulation, (iv) examine the effectiveness of the reintroduction programme and (v) guide management activities aimed at ensuring the long-term viability of this population. Here we briefly describe the reintroduction and establishment of the population, then summarise our understanding of the demographic processes (survival, breeding success & dispersal) operating in this closed population and the implications for future management. Between 1987 and 1996, 123 Kestrels were released and a network of over 60 nest boxes was established. The population developed rapidly stabilising at around 45 pairs by 2002. Each breeding season breeding pairs were located, individuals identified and breeding success monitored and this has been accompanied by the development of a digitised habitat map of the study area and the collation of daily rainfall data. Mauritius Kestrel ecology is strongly influenced by both habitat composition and seasonal rainfall conditions, with; breeding occurring later in wetter springs and at higher altitudes, agricultural encroachment reducing breeding success and wetter austral summers reducing first year survival. Most Kestrels breed within

2km of their natal site, but on average females disperse further than males. Females dispersed further when the availability of local breeding sites was limited and female fitness was lower when they dispersed longer distances compared to settling close to home. This Kestrel population is strongly regulated, primarily through density-dependent juvenile survival (via interference competition) and secondarily through density-dependent reproductive success (via spatial heterogeneity), which provide an apparent buffer against changing climate conditions. We suggest that the maintenance of a network of artificial nest sites and the restoration of native forest areas, particularly at agriculture/forest boundaries, are considered when planning future conservation strategies.

Malcolm Nicoll is a senior research fellow at the Centre for Agri-Environmental Research, University of Reading. Over the last 20 years he has been involved with a range of threatened species recovery programmes, which has led naturally to a research focus on understanding the ecology and dynamics of small populations and the implementation and refinement of applied management techniques. His experience has centred on threatened, endemic terrestrial bird populations in the Western Indian Ocean, but more recently has expanded to include threatened raptors in Oman and Cambodia, endangered mammals in the Dominican Republic and seabirds in the Indian Ocean.

Using Mark-Recapture methods to assess contributions to population growth rate in the endangered Pink Pigeon *Nesoenas mayeri*

LIANNE CONCANNON[1], CARL G. JONES[2, 3], MALCOLM. A.C. NICOLL[1], VIKASH TATAYAH[3], NICOLAS ZUËL[3], KEN NORRIS[1]

[1] Centre for Agri-Environmental Research, School of Agriculture, Policy and Development, University of Reading, Reading, RG6 6AR, UK

[2] Durrell Wildlife Conservation Trust, Les Augres Manor, Trinity, Jersey, Channel Islands

[3] Mauritian Wildlife Foundation, Grannum Road, Vacoas, Mauritius

* Email: l.concannon@pgr.reading.ac.uk

The Pink Pigeon *Nesoenas mayeri*, endemic to Mauritius, is a conservation success story, having recovered from the brink of extinction to a current population of 350 birds as a result of a reintroduction programme and on-going intensive conservation management. The population undergoes pronounced periodic fluctuations which is preventing the achievement of the recovery programme's target of a wild population of 600 birds. It is hoped that gaining an understanding of the demographic drivers of these fluctuations will inform the management programme and so aid in promoting the further recovery of the species.

There are currently six subpopulations; five on the mainland and one on Ile aux Aigrettes (IAA), a 25ha predator-free island off the south-eastern coast of Mauritius. Dispersal occurs between the mainland subpopulations, but dispersal between IAA and the mainland does not take place. The current paper focusses on the IAA subpopulation. Using a detailed individual-based 15-year dataset spanning 1994 to 2009, we used Pradel's

Temporal Symmetry Capture Recapture models to estimate apparent survival (ϕ), recruitment (F) and population change (λ) of adult birds. The 'seniority parameter' (γ) derived from these models allows an assessment to be made of the relative importance of recruitment and mortality to λ. The analysis showed that adult survival is more influential to population change than recruitment. The apparent survival rate has periodically decreased sharply, driving the population declines. The recruitment rate has decreased over the duration of the study. Future work and implications for management are discussed.

Lianne Concannon is a final year PhD student at the Centre for Agri-Environmental Research at the University of Reading. Her PhD involves working with a long-term dataset to explore the population dynamics and demography of the Pink Pigeon in order to understand the drivers of the population fluctuations in this endangered species. The results will inform future population monitoring and management led by the Mauritius Wildlife Foundation. Prior to her PhD, Lianne has worked for environmental NGOs Earthwatch and Wildscreen, and in local government as a Biodiversity Officer.

Red Kites *Milvus milvus* flying high or caught in mid-air?

JENNIFER SMART[1]*, ARJUN AMAR[2,3], INNES M.W.SIM[3], BRIAN ETHERIDGE[4], DUNCAN CAMERON[5], GEORGE CHRISTIE[6] & JEREMY D. WILSON[3]

[1] Royal Society for the Protection of Birds (RSPB), The Lodge, Sandy, SG19 2DL, UK

[2] University of Cape Town, South Africa

[3] RSPB, 2 Lochside View, Edinburgh Park, Edinburgh, EH12 9DH, UK

[4] RSPB, Etive House, Beechwood Park, Inverness, IV2 3BW, UK

[5] RSPB, 10 Park Quadrant, Glasgow, G3 6BS, UK

[6] RSPB, The Old School, Crossmichael, Castle Douglas, DG7 3AP, UK

*Email: jennifer.smart@rspb.org.uk

This paper brings to fruition long-term work by RSPB staff dedicated both to long-term monitoring of Red Kite *Milvus milvu*s populations in the field, and to ensuring that conservation action is founded upon the best available scientific evidence.

The reintroduction of Red Kites to the UK has been a phenomenal success story but not all reintroduced populations are increasing at the same rate. In particular, there has been a marked contrast in the fortunes of the two initial release populations in North Scotland and the Chilterns. Since releases began in 1989, populations in North Scotland reached only 41 pairs in 2006 compared to 320 pairs in the Chilterns, and many of the later released populations exceeded the number of pairs in North Scotland in a much shorter timescale. Clearly, there is something limiting the population size of the North Scotland kites and anecdotal evidence suggested that illegal poisoning could be a problem. Fortunately, Red Kite enthusiasts across several populations in England, Scotland and Wales had collected long-term demographic data on productivity, survival of marked individuals and causes of mortality. This paper brings together these datasets to model the

population dynamics of several Red Kite populations. We were able to demonstrate that illegal killing of Red Kites in North Scotland is the cause of the poor population growth and models that exclude the effect of illegal mortality predicted a population growth rate similar to the Chilterns, a rapidly growing population in south-east England. This study demonstrates the value of long-term demographic monitoring in establishing the cause of a conservation problem and the challenge now is to find ways to eliminate these illegal activities.

Jennifer Smart is a Senior Conservation Scientist at the RSPB. Much of her career in avian research has been focused on the ecology of breeding waders and developing conservation solutions, including mitigating the impacts of predators. Following her PhD and a short post-doc at the University of East Anglia, she moved to the RSPB in 2006. Although breeding waders are her first love, she has worked on other species including red kites. The work on red kites she is presenting here was awarded the Watson Raptor Science Prize for the most outstanding paper published in Europe on raptor science in 2011.

Was cock robin killed? Application of bayesian integrated population models to national bird monitoring

ROBERT A ROBINSON*, CATRIONA A MORRISON & STEPHEN R BAILLIE
British Trust for Ornithology, The Nunnery, Thetford, Norfolk, IP24 2PU, UK

*Email: rob.robinson@bto.org

Many countries have instituted a national bird population monitoring scheme to track annual fluctuations in abundance over time. Understanding the environmental causes behind the fluctuations in a particular species, however, requires knowledge of variation in demographic rates: recruitment, survival and dispersal. These too may be monitored at large spatial scales through ringing and nest-recording schemes. Although each of these parameters may analysed individually, much greater insight should come from analysing the data in combination, since each observed dataset may contain information on more than one parameter. We make use of recent developments in state-space (hidden-process) modelling to construct population models for a number of species with a range of life-history and ecological strategies. We fit these models to census, productivity and survival data collected by volunteers participating in national monitoring schemes organised by the BTO. By analysing demographic variation in species that share common habitats or ecological niches we expect to be able to provide better guidance to policy makers and others on pressures affecting our environment.

Rob Robinson is a Principal Ecologist at the BTO, where he has worked for the last 12 years following a brief spell with the JNCC Seabirds Team. He works on a range of topics, mostly in relation to understanding how and why our bird populations are changing using the BTO's brilliant volunteer-collected datasets. This usually involves getting computers to do complicated statistics, so he tries to get out of the office as often as possible, mostly to ring birds (on five continents so far), but frequently just for the opportunity to get wet and/or muddy.

Citizen science and integrated goose population monitoring

TONY FOX
Department of Bioscience, Aarhus University, Kalø, Grenåvej 14, DK-8410 Rønde, Denmark

Email: tfo@dmu.dk

Twelve populations of sedentary or migratory geese occur naturally, ferally or as reintroduced stock in significant numbers in the United Kingdom, all of which show contrasting population trends and present different conservation management challenges at the present time. Some of these populations are increasing, some of which create conflict with agricultural or amenity interests, others show no significant trends and create few management problems, while yet others are showing declining population trends, giving cause for conservation concern. In the latter case, the reasons for the declines may lie outside of the influence of UK agencies, making concerted international actions essential if these populations are to be restored to favourable conservation status. Effective management of such migratory bird populations requires international co-ordination, a sound scientific basis for policy formulation and effective monitoring to determine the outcome of management actions. Fortunately, there has been a long (more than 60 year) tradition of "citizen science" involvement and international coordination of the monitoring of goose populations that occur in the UK to provide such long-term information on their status and distribution. Here, the case of the Greenland White-fronted Goose *Anser albifrons flavirostris* is presented as just one example of how citizen science contributions support monitoring and scientific research to provide insight into changes in the annual distribution and abundance of this highly winter site loyal population. Perhaps more importantly, this contribution from a coordinated network of largely volunteer observers also provides an annual perspective on the key demographic drivers of these trends, namely reproductive success, survival and dispersal and how these are affected by anthropogenic factors, such as changes in agriculture and hunting kill, and macro-environmental factors, such as weather. Such information has proved vital to the drafting of the single species international action plan for the population which was adopted at the meeting of parties to the African Eurasian Waterbird Agreement at their meeting in France in May 2012. This process used the existing available scientific and monitoring information gathered over more than 30 years to establish priorities for actions agreed during the drafting of the plan, as well as contributing to shaping conservation actions in the future and monitoring their effects.

Tony Fox After a BSc and a PhD obtained up to his knees in quaking peat in mid-Wales, Tony worked for the Nature Conservancy Council there for many years, before moving to NCC in Inverness in 1984. After two expeditions to Greenland, he returned to research at the Wildfowl and Wetlands Trust at Slimbridge in an NCC-funded research position, where he eventually became Acting Head of Research in 1992. He has lived in Denmark since 1993 where he is Professor of Waterbird Ecology at the Department of Biosciences at Aarhus University and visiting professor at the Chinese Academy Sciences in Beijing.

Impacts of fisheries on the population dynamics of albatrosses

RICHARD A. PHILLIPS[1]*, GEOFFREY N. TUCK[2], ANDREW G. WOOD[1] & JOHN P. CROXALL[3]
[1] British Antarctic Survey, Cambridge, UK
[2] CSIRO Marine and Atmospheric Research, Hobart, Australia
[3] BirdLife International, Cambridge, UK

*Email: raphil@bas.ac.uk

Climate change, and over-harvesting of target and non-target (bycatch) species in fisheries are widely-acknowledged as major threats to marine biodiversity, with the potential for major long-term impacts on ocean ecosystems world-wide. Although declines in many albatrosses and large petrels have been attributed to incidental mortality on longlines or trawl warp cables, without detailed information on demography and distribution, it is rarely possible to determine which component of the population is at particular risk from which fisheries, and hence where to best target conservation efforts. The most vulnerable seabirds are albatrosses and large petrels, which possess a suite of extreme life-history characteristics: females lay a single egg; the breeding season is prolonged; chicks grow slowly; sexual maturity is delayed for many years; breeding frequency is low (several species breed biennially if successful); adults show exceptionally high survivorship under natural circumstances, and; divorce rates are very low. As a consequence, populations are poorly buffered from impacts of any additive mortality. As foraging ranges are extensive, they often overlap with multiple fisheries, including those on the High Seas. Using the example of a recent assessment of the impact of Atlantic tuna fisheries on seabirds, this talk will illustrate the processes involved, including the development of detailed population models, and the outcomes for management. The focal populations included Wandering Albatross *Diomedea exulans* and Black-browed Albatross *Thalassarche melanophrys* from South Georgia, which have shown major decreases (2-4% per annum) since the 1960s and 1970s, and, in the Wandering Albatross, an acceleration of the downward trend since the late 1990s. There have also been dramatic drops in recruitment rates (proportion of fledged chicks that return to breed), despite increasing breeding success in the wandering albatross, suggesting that environmental conditions may have improved. The assessment model incorporated components on population dynamics and fisheries bycatch, and accommodated either annual or biennial breeding schedules. Birds were categorized as actively breeding, failed, non-breeding adults that were either successful or unsuccessful in their previous breeding attempt, juveniles or chicks, and by sex. It incorporated detailed information (from tracking studies) on at-sea distribution of birds of each life-stage and sex in each month. The numbers of birds caught were modelled as a function of fishing effort, bird numbers, the catchability for each fleet (which relates fishing effort to bycatch), and the spatial overlap of birds and fisheries. A statistical best fit was then made between the observed and model-estimated annual breeding population size, numbers of fledglings, adult and juvenile survival rates, observed bycatch rates and, where available, the population age distribution. Projected population dynamics were based on scenarios assuming stable bird and fisheries distributions, and different degrees of spatial management of bycatch mitigation (e.g., in known bycatch hotspots), increased fishing effort and total elimination of bycatch. The results provided little doubt that fisheries are having detrimental impacts on black-browed and wandering albatrosses from South Georgia.

Richard Phillips is a seabird ecologist based at British Antarctic Survey since 2000. He is actively involved in international initiatives using results from scientific research to promote seabird conservation, including in his roles as member of the Advisory Committee and convenor of the working group on Populations and Conservation Status of the Agreement on the Conservation of Albatrosses and Petrels (ACAP). He is also a member of the Scientific Committee on Antarctic Research Group of Experts on Birds and Marine Mammals, and worked recently with the Atlantic tuna commission to assess the impact of their fisheries on seabirds.

Conservation, conflicts & stakeholder engagement

STEVE REDPATH
Aberdeen Centre for Environmental Sustainability, University of Aberdeen, Tillydrone Avenue, Aberdeen, AB24 2TZ, UK

Email: s.redpath@abdn.ac.uk

Conservation in our crowded, climate-affected world is becoming increasingly challenging. There is increasing awareness that to be effective, conservation needs to work closely with people. This talk will start by exploring the valuable role that stakeholders can play in conservation projects. I will then move on to consider the more difficult issue of how conservation engages with those people who have different objectives. This is most obviously the case in conservation conflicts, where the objectives of conservation clash with other parties and where one party is perceived to assert its interests at the expense of the other. I will explore how conservation engages with stakeholders with conflicting objectives, the barriers to stakeholder engagement and consider how alternative strategies are likely to affect success.

Steve Redpath is an applied ecologist who has worked extensively on bird populations in the UK uplands. He got his PhD from Leeds University, then worked for the Institute of Terrestrial Ecology / Centre for Ecology & Hydrology for 17 years before moving to the University of Aberdeen in 2007, where he became Director of the Aberdeen Centre for Environmental Sustainability. His work on predation led me into the field of human-wildlife conflicts and he is increasingly interested in how we can effectively link natural and social sciences together with policy makers and stakeholders to tackle issues in environmental sustainability.

Making Space for Nature: the science-policy interface

JOHN LAWTON
The Hayloft, Holburns Croft, Heslington, York, YO10 5DP, UK

Email: dandj@snotrag.fsnet.co.uk

Making Space for Nature (the 'Lawton Review'), published in September 2009, made 24 recommendations to government about improving the performance of England's protected area network of terrestrial and fresh-water habitats. In the report's own words what is needed are: *More* protected sites, *Bigger* sites, *Better* managed sites and more *Joined* up sites. Recommendation 3, that there should be a national competition to establish 12 Ecological Restoration Zones, or ERZs – very large scale habitat restoration and re-creation projects – has attracted the most attention. Government responded to *Making Space* in June 2011 in the Natural Environment White Paper (*The Natural Choice*), where it accepted some (but not all) of its recommendations. But it did accept the idea of a national competition to establish 12 ERZs, but called them *Nature Improvement Areas* (NIAs) instead, and made £7m available to pump-prime their establishment. The lecture will briefly review this history, and current progress with establishing the NIAs, and then go on to consider why governments of all political shades sometimes rapidly embrace the recommendations of expert committees (e.g. the NIAs), but all too often ignore or reject other recommendations (including several others in *Making Space*). Many scientists hold the view that the problem lies in government not really understanding the issue (the so-called 'deficit model'). Sometimes this is indeed the case, but usually it is not. Politics is not science, and there are all kinds of reasons (some legitimate, others less so) why governments wilfully ignore or contradict what 'the evidence' says.

Sir John Lawton is an ecological scientist. He was Chairman of the Royal Commission on Environmental Pollution until 2011, and formerly Chief Executive of the Natural Environment Research Council (1999-2005). He is a passionate natural historian, and enjoys walking, gardening and cooking. He trained as a zoologist at the University of Durham, and subsequently held posts at Oxford and York Universities, and Imperial College London. He was elected FRS in 1989, awarded a CBE in 1997 and knighted in 2005. He has been awarded numerous other national and international prizes. He is married to Dot, with two grown up children and five grandchildren.