#BESMove2023: Animal and human movements and their interactions

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Keynotes

Human-wildlife Interactions: Insights from Movement Ecology

Marlee Tucker- Department of Environmental Science, Radboud University, the Netherlands

Marlee Tucker is an Assistant Professor in the Department of Environmental Science at Radboud University, the Netherlands. She is interested in large scale patterns in ecology, biogeography and evolution that can aid our understanding of species vulnerability to changing environments that can be utilised for conservation. Her research encompasses macroecological questions related to allometric scaling, predator–prey interactions and animal behaviour. Her recent projects combine macroecology and movement ecology to examine how humans have altered animal behaviour and the consequences of these changes for populations and ecosystem processes.

Human Mobility Analysis and Response to the Covid-19 Pandemic

Tao Cheng- Department of Civil, Environmental & Geomatic Engineering, University College London, UK

Tao Cheng (HDR, PhD, FICE, CEng) is a Professor in GeoInformatics, Fellow of Turing Institute, the Founder and Director of SpaceTimeLab for Big Data Analytics (www.ucl.ac.uk/spacetimelab) at University College London, a multi-disciplinary research centre that aims to gain actionable insights and foresights from geo-located and time-stamped data for government, business and society. Her research interests span AI and Big Data, network complexity, urban analytics (modelling, prediction, clustering, visualisation and simulation) with applications in transport and mobility, safety and security, business intelligence, and natural hazards prevention. She has secured more than £25M research grants in the UK and EU, working with government and industrial partners in the UK including Transport for London, the London Metropolitan Police Service, Public Health England and Arup, to name a few. She has published over 300 research articles and received numerous international best paper awards.

Big brother biology - marine human-wildlife interactions using animal-tracking technology

Sascha Hooker- School of Biology, University of St Andrews, UK

Professor Sascha Hooker is a marine scientist with wide interests in wildlife ecology, conservation, and environmental sustainability. Using technological tools such as animal-attached tags or analyses of tissue isotope signatures, she studies how and where animals feed, the physiology underpinning this, and implications for marine conservation decision-making. Sascha received the ZSL Marsh Award for Marine and Freshwater Conservation (2018) and became a Fellow of the Royal Society of Edinburgh (2023). She has worked half-time since 2004, becoming a passionate advocate for Equality, Diversity, and Inclusion within academia, and directing her department to Gold Athena Swan Award status.

Human and vultures crossroads: when our movements match the movements of the obligate scavengers

Eneko Arrondo- University of Granada, Spain

Eneko Arrondo carried out his PhD thesis at the Estación Biologica de Doñana. He currently works as a postdoctoral researcher at the University of Granada. His general line of research involves the study of carrion ecology and scavengers from different perspectives. More specifically, research usually focuses on movement ecology of Iberian vultures and its conservation consequences.

St Andrews Talks

Movement ecology in the School of Geography & Sustainable Development / Bell-Edwards Geographic Data Institute- Studying migratory bird navigation with spatial data science

Urška Demšar- Bell-Edwards Geographic Data Institute, SGSD, University of St Andrews

Dr Urška Demšar is Senior Lecturer (Associate Professor) at the University of St Andrews in Scotland, UK and an established international leader in Geographic Information Science (GIScience). She is Associate Editor of the International Journal of GIScience and leads a research group as part of the Bell-Edwards Geographic Data Institute in St Andrews, which she co-chairs. She specialises in movement analytics, by developing new methods for animal movement and human mobility. Her current research vision is to bring a spatial data science perspective to difficult data problems in movement ecology, which traditional methods may not be able to address.

Movement ecology in the School of Biology / Building a future where humans and wildlife can coexist

Christian Rutz- Schools of Biology, University of St Andrews, UK

Professor Christian Rutz FRSE has broad interests in animal conservation, cutting-edge research methods, and policy making. The challenges of observing tool-using New Caledonian crows prompted him to push the boundaries of terrestrial bio-logging, leading the teams that pioneered the use of video-loggers and proximity-loggers on wild birds. Christian is Founding President of the International Bio-Logging Society, and Chair of the COVID-19 Bio-Logging Initiative – a UN-endorsed global research consortium investigating changes in animal movement patterns during pandemic lockdowns. A Professor at the University of St Andrews, Christian has received numerous honours, including a Rhodes Scholarship at Oxford, a Radcliffe Fellowship at Harvard, and most recently, an Explorers Club 50 Award ('Fifty people changing the world, the world needs to know about').

Contributed Talks

Aerial Movement

Predicting anthropogenic food supplementation from individual tracking data

Steffen Oppel- Swiss Ornithological Institute, Switzerland

To understand the effect of anthropogenic food subsidies on wildlife populations, we first need to quantify where and when individuals can access such food sources. The Red Kite Milvus milvus is an opportunistic raptor species and uses both inadvertent and deliberate food subsidies provided by members of the public. Here we present a new approach using GPS tracking data to identify where anthropogenic food subsidies occur. We tracked 235 individuals at hourly intervals over an average of 2.9 breeding seasons in Switzerland, and combined these data with locations of 125 known feeding stations obtained through interviews. We used two sequential random forest models, at both individual movement and population levels, to predict where anthropogenic food subsidies are exploited by red kites. The first model classified locations that were frequently and regularly revisited, and successfully predicted 96.2% of locations that were within a 50 m radius of a known feeding site. These predicted locations were aggregated in 500 m grid cells to calculate the proportion of individuals and locations associated with predicted food subsidy. A second model related the presence of known food subsidies to the aggregated predictions. In our study area, 83.2% of known anthropogenic food provision locations could be correctly identified using red kite tracking data, and we show how the locations of such anthropogenic food subsidies can be predicted across the landscape. Biologging data can therefore identify ephemeral food sources, and facilitate an assessment of the importance of anthropogenic food subsidies on tracked populations.

The Global Anthropause Raptor Research Network: How raptor research during the COVID-19 pandemic provides invaluable opportunities for conservation biology

Petra Sumasgutner- University of Vienna, Austria

Research is underway to examine how animals have responded to reduced levels of human activity during the COVID-19 pandemic. Raptors are particularly well-suited for investigating potential ‘anthropause’ effects: sensitive to environmental perturbation and affected by various human activities, they include many threatened species. Lockdowns altered extrinsic factors that normally limit raptor populations. These environmental changes influence in turn the intrinsic (demographic) factors that ultimately determine raptor population levels and distributions, and are mediated by behavioral and physiological responses. Using this population-limitation framework, we present a range of research opportunities and conservation challenges that have arisen during the pandemic, related to changes in human disturbance, light and noise

pollution, collision risk, road-kill availability, supplementary feeding, and persecution levels. Within the “Global Anthropause Raptor Research Network” (GARRN) we aim to tackle ambitious analyses across geographic regions, ecosystems, species, and gradients of lockdown perturbation. We operate an inclusive collaboration model where data owners are offered co-authorship on publications featuring their data contributions to mobilize the international raptor community. We have partnered with the Raptor sub-project of the Bio-Logging Initiative to build onto their findings on raptor movement worldwide (including vultures, owls and corvids) and the Peregrine’s Fund “Global Raptor Impact Network” to manage data submissions and organizations for analyses. With these strong partnerships, we will ensure that any hard-earned data set will help to examine effects of anthropogenic disturbance on raptors.

Citizen science data unveils hummingbird movement in the Andes Mountains

Cristina Rueda Uribe- University of Aberdeen, UK

Species records in citizen science databases may reveal understudied patterns of animal movement, particularly for those species that are difficult to track or in locations lacking monitoring schemes. In the Andes Mountains of South America, there is almost no information on how animals move along mountain slopes throughout the year, despite the importance of the region as a biodiversity hotspot and the prevalence of altitudinal movement across many taxa. Using citizen science data, we modeled monthly changes in altitudinal distribution and ecosystem use for Andean hummingbirds, a group of animals with seasonal changes in abundance that seem to respond to flowering pulses yet remain largely unknown. We found widespread patterns of altitudinal movement and changes in ecosystem use for 55 hummingbird species at a continental scale by applying analytical tools to deal with implicit spatiotemporal biases and machine learning methods to model species distributions. In addition, our results show that natural landscapes have greater hummingbird seasonality in comparison to anthropogenic land covers, and hummingbirds with seasonal ecosystem use tend to exhibit decreasing populations. Consequently, our study shows the importance of ecological connectivity between different ecosystem types to protect hummingbird populations and their key ecological role as avian pollinators. It also exemplifies how citizen science data may be used to increase our understanding of animal movement, which in the future could also inform landscape management and conservation.

Anthropogenic disturbances at high tide roosts

Sjoerd Duijns- Sovon Dutch Centre for Field Ornithology, the Netherlands

Intertidal areas support a rich benthic fauna across the world and are a vital habitat for staging, breeding and wintering (migratory) waterbirds. At low tide these birds forage at the intertidal mudflats and during high tide, these waterbirds congregate in large numbers at high tide roosts. These large concentrations of birds are very susceptible to (anthropogenic) disturbances, impacting their energetic budget due to increased costs of flying, but also avoidance of the roost or sites within the roost. Here we

examined the effectivity ‘dynamic zoning’ (opening and closing the area depending on environmental sensitivity), by means of a dynamic information pillar to reduce human-wildlife conflicts at an important high tide roost. This important high tide roost hosts in Autumn on average 70.000 birds and is accessible to humans. By using field observations and wi-fi counters we were able to assess the number of visitors in the area, the number of disturbances and the number and position of six bird species before and after the pillar was placed. Most disturbances occurred in the middle of the day during the high tide period, with most visitors present in the weekend. Some species such as Curlew and Avocet already avoid the most central place of the roost and were disturbed most and had the additional energetic costs were highest for these species. The information pillar did not result in a decrease in disturbances, hence other measures should be considered when dealing with these conflicts.

How does anthropogenic disturbance affect vampire bat roost abandonment and foraging activity?

Rita Claudia Cardoso Ribeiro- Glasgow University, UK

In Latin America, rabies is one of the most important zoonoses threating human and animal health, and the common vampire bat Desmodus rotundus is the main reservoir. Decades of efforts to reduce the burden of lethal rabies infections in humans and livestock by culling bats have had limited success. Recent work hypothesized that the social perturbation associated with culls may exacerbate viral spatial spread by promoting bat dispersal or altering foraging ranges, but empirical demonstration of disturbance-induced changes in bat behaviour are lacking. Here, we used GPS tracking data from 60 adult D. rotundus (31 males and 29 females), captured between 2022-2023 from five colonies in three regions in the south of Peru to characterize the normal foraging behaviour of this species. Specifically, we characterized how vampire bat foraging area and distance from the roost were influenced by region, season, bat gender, cattle density, and proximity to human settlements. Future work will assess changes in foraging area and roost abandonment after an experimental cull. Results of this study provide new insights into the foraging patterns of a colonial bat with a complex social system are of prime importance to guide rabies prevention and control strategies.

Human-Wildlife Interaction in Terrestrial Environments

Brown bear multi-scale response to human presence and mobility in the Italian Alps

Andrea Corradini- Fondazione Edmund Mach, Italy

In an increasingly human-dominated world, wildlife is constrained by human presence and activity, inducing behavioural adjustments as a consequence. Large mammals are especially sensitive to such changes, questioning the potential of their behavioural

flexibility to cope with human disturbance. Using brown bears in the Italian Alps as a study case, we investigated their response to changes in human presence over different temporal scales. Combining human mobility data with bear tracking and activity data spanning from 2006 to 2019, we analysed bears' behaviour and movement as a function of human activities. We observed that over the years bear activity and daily movement length have increased, while diurnality and range size have decreased. While tourism has grown in parallel, this was not identified as the main driver of such responses. Rather, it was mostly due to the increase in bear population, whose space is nonetheless limited by human infrastructure. At a weekly scale, we observed no difference in daily movement lengths between weekdays and weekends. This might perhaps be because of the continuous human disturbance in the area overall. Finally, at the daily scale, we found that individuals roamed in places more intensively exploited by humans at night compared to daytime, especially when ranging in heavily disturbed areas. Our results highlight how humans are indirectly, by hampering connectivity, and directly, through disturbance, shaping brown bear behaviour and movement. In view of a growing volume of outdoor human activity, we analyze the implications of such responses and present challenges for human-wildlife coexistence.

Human impact on movement patterns of far-ranging ungulate species – the need for integrative and global conservation measures

Steffen Mumme- University of Wyoming, USA

At global scale ungulate migrations are disappearing at a fast rate and long-distance movements of ungulates and many other taxa are declining. It remains challenging to identify the detailed factors driving the observed changes in movement patterns in many cases. We used 1206 GPS trajectories from 28 elk and red deer populations and measuring their movement patterns along a steep gradient of human activity. We found that human activity (Human Footprint Index) had a stronger effect on movement characteristics than other key environmental characteristics as topography and predictability of resource availability. With increasing level of human activity long-distance and directed movements (as seasonal migrations) decreased, instead patterns of restricted and more tortuous movement increased in population exposed to higher human pressure. Interestingly, we detected a relatively low threshold of human activity beyond which movement patterns (Intensity of Use) remained unchanged, potentially indicating that animals were not able to further adapt their movement behavior after the threshold was reached. Facing globally increasing human pressure, it can be expected that ungulate movements will be further restricted and effects of lost migrations cascading through other trophic levels of the ecosystem will increase. One main hinderance to conservation efforts is that many migratory populations have never been mapped, therefore we promote our Global Initiative on Ungulate Migration, in which together with the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and under the United Nation Environmental Program (UNEP), we are building an integrative approach to map and conserve ungulate migrations.

Unveiling the impact of outdoor activity on the formation of home range in a wide-ranging species

Aida Parres Lluch- Institute of Nature Conservation, Polish Academy of Sciences, Poland

Background: Outdoor activities in natural habitats are becoming increasingly popular, and conserving spatial behaviours of wide-ranging species is becoming a major challenge. Taking a European large carnivore population as a model, we explored the patterns of home range (HR) formation and investigated whether the protection status and outdoor activity influenced these patterns. Between 2013 and 2020, we monitored the day-to-day HR expansion over a year in brown bears (Ursus arctos) from the north-western Carpathian Mountains and measured the effect of outdoor activity inside and outside protected areas.
Results: Our analyses revealed that outdoor activities, both inside and outside protected areas, have an impact on the formation of HR in bears. In half cases, bears' day-to-day HR expansion stabilised before winter, between one and three times during a given year. Most HRs encompassed protected areas, but their area rarely fit completely within protected sites, and in all cases, HRs were densely covered by hiking trails. Our results indicate that day-to-day HR expansion was, on average, one-third larger in areas with outdoor activities than in protected undisturbed areas. In addition, our findings indicate that HRs that covered a higher proportion of areas with outdoor activities had delayed stabilisation.
Conclusion: The marked alterations in the HR formation suggest that bears expand their HR area to cope with anthropogenic pressures in the habitat, in search of patches unoccupied by humans. These results highlight that existing protected areas were insufficient to support the bears' spatial needs and emphasize the need to regulate outdoor activities to successfully conserve wide-ranging species.

Landscape level analysis of lion conservation interventions in the Amboseli ecosystem, Kenya; an actor-network theory perspective

Margaret Muriuki- Mawazo Institute, Kenya

The African lion population has declined by 43% and is estimated to occupy about 25% of the historical range. Retaliatory killing due to livestock predation is a major contributory factor. The problem is acute in the human-populated areas of Southern Kenya. Conservation interventions have therefore been introduced. Evaluation of interventions often focuses on human agency. However, non-humans including animals and devices influence conservation goals and outcomes. Using the Actor-Network Theory we trace the development of the complex relations that underpin lion conservation. Data was generated using key informant interviews, field observation, and literature review. Results show that lions represent a heterogeneous entity with individual identities that get embedded in relations that are in themselves multiple and apparent in the realities of actors. The relational agency is realized in the motion of a network formed of lions, humans, policy documents, dollars, collars, spears, and poison. Although Conservation Organizations establish themselves as the representative of this network that realizes a decline in lion killing, power is seen to be

associative. Evaluating the agency inherent within the network bonds is necessary to reinforce those with positive agency and break the smaller networks or tame the agency that is likely to destabilize the network. The context of place through which these more-than-human relations are created is important in shaping the way forward.

Migratory Navigation

Geomagnetic night vision: A data-driven approach to study geomagnetic navigation in a migratory bird

Beate Zein- University of St Andrews, UK

Geomagnetic bird navigation is widely debated and it remains uncertain to what extent birds use the Earth's magnetic field. We used step-selection analysis to study geomagnetic navigational strategies of a long-distant migrant, the Eurasian Curlew (Numenius arquata), as a model species. Biologging tracking data of 170 migrational flights were annotated with measured geomagnetic satellite data for step-selection analysis. Additionally, we used this data-driven approach to study daytime and seasonal effects on geomagnetic navigational strategies during migration. To our knowledge, our results are the first empirical evidence for the effect of nighttime and the effect of the angle between the two navigational cues involved (intensity and inclination), on geomagnetic navigation, which is in line with previous theories. Our data also support previous findings that taxis navigation based on the geomagnetic field intensity showed the best model fit, which suggests that this geomagnetic navigational strategy is the most likely one used by these birds. This approach can be further extended to study interaction effects of different navigational mechanisms, environmental factors like wind and for comparing different navigational mechanisms between different species and geographical areas and has therefore important implications for future research.

Nature's Seismic Sensor: Unraveling the Potential of Migratory Birds as Bio-Indicators for Earthquake Precursors

Sinan Robillard- Utrecht University, the Netherlands

Migratory birds such as White Storks (Ciconia Ciconia), renowned for their magneto-receptive capabilities, utilize geomagnetic cues to navigate extensive distances. Previous evidence has highlighted their propensity for disorientation in response to both natural and artificially induced magnetic variations. With this in mind, our study theorized that a detectable disruption in their behavior could occur up to ten days prior to a substantial seismic event (M>6), the period during which magnetic alterations are released. To test our hypothesis, we leveraged GPS and accelerometer data from eight White Storks, procured from the MoveBank database. The accelerometer data was classified into four distinct flight behavior categories: sitting, standing, passive flight, and active flight. We fed daily sequences of these behaviors into a B-LSTM model, aiming to predict their temporal proximity to earthquakes. Our findings yielded

an accuracy of .81 and a ROC Area-Under-the-Curve of .87 and a Brier Score of .15. These results suggest a noticeable change in Stork behavior beginning ten days before an earthquake. Although our model does not yet meet the precision necessary for real-time implementation, these initial results lay a promising groundwork for the future development of a multi-species natural disaster forecasting model.

Animal Movement in Marine Environments

Inferring Fishing Activity from Vessel Monitoring System (VMS) data: a comparison of conventional speed threshold methods with a hidden Markov model (HMM) approach

Maria Clara Iruzun Martins- Sea Mammal Research Unit, University of St Andrews, UK

All UK fishing vessels ≥ 12m have a satellite-based vessel monitoring system (VMS) for marine and fisheries compliance purposes. However, VMS data can also provide ecologists with valuable insight into the activity of fishing vessels at sea. Typically, different movement modes are inferred from VMS data using a threshold of speed between successive location fixes, where movement above or below this threshold is classed as travelling or fishing respectively. This approach is based on the knowledge that fishing activity, especially trawling, cannot occur at high speeds, but does not consider the tortuosity and the directionality of vessel movements. Hidden Markov models (HMMs) have been used on animal movement data and have often outperformed more simplistic methods of inferring behavioural states when ground-truthed with direct metrics of activity. Here we compare the conventional speed threshold approach with a 2-state multivariate HMM which considers both step length and turn angles between points. Our key findings show that the HMM inferred c.10% less overall fishing activity and a smaller overall fishing area for trawling gears in the North Sea across all years studied. Our findings clearly demonstrate that different methods can provide different results and that considering tortuosity and the markov property as well as speed does affect the inference of fishing activity. These differences in estimation of fishing activity have implications in policy and management decisions for example in marine spatial planning. Therefore, it is evident that further work is needed to ground-truth both approaches with direct metrics of vessel activity such as observer data.

Studying seals with sonar: preliminary results from a tidal turbine marine mammal monitoring system

Jessica Montabaranom- Sea Mammal Research Unit, University of St Andrews, UK

Marine mammals forage in tidally energetic locations, which are of interest to the tidal energy industry. To understand the risks of collisions between wildlife and tidal turbines, fine-scale movements of animals around the rotor blades must be studied.

Recent research has shown that harbour porpoises effectively avoid turbine rotors, but current technologies such as animal-borne tags can only monitor seal behaviours at a larger scale than is required. Development of the Marine Mammal High-Current Underwater Platform (HiCUP) – a combined sonar and hydrophone system – has allowed fine-scale 3D tracking of sound-producing animals (e.g. porpoise) and non-sound-producing animals (e.g. seals) around an operational tidal turbine in the Pentland Firth. Using bespoke movement detectors in the software PAMGuard, that extract tracks of interest, and manual review to assign a likely species identification, we have tracked marine animals around the turbine for 12 months. Animals identified to date include seals, fish, elasmobranchs, and birds. Approximately one seal was detected within 30m to the turbine per day; further analysis will allow us to understand animal presence in relation to environmental variables and track 3D movements in the water column.

Natural and anthropogenic features shape the foraging behaviour of grey seals in the North Sea

Matt Carter- Sea Mammal Research Unit, University of St Andrews, UK

Grey seals are top predators in the North Sea, encountering a range of different habitat types on foraging trips which can extend hundreds of kilometres from coastal haulouts. Previous work has revealed individuals using both natural and anthropogenic features (seabed geomorphology, wind turbines, oil and gas platforms) for foraging, but what characterises important foraging habitat remains largely unknown. Here we analysed movement data from 112 grey seals tagged in four areas of the North Sea. We used hidden Markov models to infer transit and area restricted search (ARS) behaviour at two spatial scales: encamped and broad. Behavioural state was then modelled as a function of habitat covariates in a hierarchical framework. We show for the first time that seals display individual differences in spatial scale of ARS. The highest probability of ARS occurred when encountering peaks and steep slopes on the seabed. Seals hauling-out in southern North Sea areas selected stratified and frontal water bodies, as well as regions of freshwater influence, while well-mixed waters were selected in northern areas. Although anthropogenic structures had no overall effect on behaviour, a substantial increase in probability of ARS associated with platforms was detected for ~16% of individuals that frequently encountered them, suggesting the presence of individual foraging specialisms. These results contribute valuable information to our understanding of the ecological significance of different habitat features in the North Sea. Additionally, they provide insight into the influence of anthropogenic structures on the behaviour of top predators that will help to inform management decisions.

Multiple tag-types reveal longer-term behavioural responses of Atlantic bluefin tuna to catch and release angling

Jessica Rudd- Exeter University, UK

Catch and release (C&R) fishing is increasingly popular, particularly for large pelagic species such as sharks and tuna. In the UK and in northern Europe, catch and release fishing for Atlantic bluefin tuna (Thunnus thynnus) have been introduced following a significant increase in sightings over the last decade. However, little is known about

the effects of angling and handling on the post-release behaviour of captured fish. We used eight high-resolution tags (triaxial acceleration at 20 Hz) deployed for 21 - 94 hours and 12 additional fish tagged with MiniPATs (0.2 Hz) deployed for 110 - 366 days to compare initial behavioural responses after capture with long-term trends. Immediately post-release, fish displayed a long deep dive that increased significantly in duration with fight time. Activity, tailbeat amplitude and frequency were greater within the first hour post-release than the subsequent 48 hours, stabilising at lower levels within 6 - 8 hours. The long-term deployments revealed that fish maintained reduced activity for ~ 6 days, with fish allocating less than 1% of each day to putative feeding. By day 15, fish regained higher activity levels, resumed diel vertical migration and were significantly more active during daylight hours. By day 21, the time allocated to burst energy events was comparable to foraging behaviour recorded a year later. This work highlights the impacts of capture and tagging on Atlantic bluefin tuna behaviour are lasting and complex. Longer-term tag deployments for C&R studies are necessary to understand how target species respond to fishing and tagging practices.

Animal Movement in Terrestrial Environments

Use and selection of agricultural farmland by a partially migratory ungulate

Tilde Hjermann- University of Oslo, Norway

Wildlife foraging on agricultural farmland causes human-wildlife conflicts. Understanding the factors influencing their habitat choices can improve mitigation strategies. Theories of sexual segregation and partial migration may help predict the use and selection of farmland across multiple spatial and temporal scales. We quantified seasonal variation in use and selection of farmland in partially migratory red deer (Cervus elaphus) using 16 years of data from 446 individuals, analysing the use of farmland and how use is determined by selection on two different levels; selection within home ranges (third order selection), and broad-scale selection within the landscape (second order selection). Farmland was more selected in winter and by residents on both selection levels. Females also selected farmland more than males. Increased population densities increased broad scale selection but had little effect on home range scale. On home range scale, increased farmland availability decreased selection of farmland (i.e., a functional response). Use of farmland was also highest in winter. Resident females used farmland more than migrant females in summer, while their use was similar in winter. For males, migrants used farmland more than residents in both seasons. Population density had contrasting effects, with less use at higher densities in summer and more use in winter. Our study emphasises how theories of individual heterogeneity in behaviour can enhance our understanding of ungulate use and selection of agricultural farmland and the importance of disentangling behaviour at different scales, which can be essential for effective population management.

Seasonal dynamics impact habitat preferences and protected area use of the critically endangered Kordofan giraffe (Giraffa camelopardalis antiquorum)

Rachael Clark- University of Aberdeen, UK

Understanding animal's habitat selection and movement behaviours relative to human activities is important for evaluating resource requirements and ensuring effective conservation management. Over two-thirds of the world's remaining population of Kordofan giraffe (Giraffa camelopardalis antiquorum) reside in Zakouma National Park, Chad. However, it is unclear if park boundaries encompass the full range of this population's preferred habitats. We used GPS telemetry data from sixteen female giraffe over multiple years to better understand landscape and seasonal factors that influence their home range patterns and habitat preferences at multiple spatial scales. Kordofan giraffe seasonal ranges and core seasonal ranges were larger during the wet season and core utilisation distributions had greater overlap with the national park in the dry season. The importance of shifts in seasonal habitat use, attributed to the flooding and drying that occurs within the park, necessitates giraffe to move beyond the park's boundaries. Giraffe selected for open grasslands, and increased their tortuosity of movement in these areas. Conversely, with Vachellia savannas as the reference level for land cover variables, giraffe avoided anthropogenic areas, barren

lands, Combretaceae savannas and forests. We advise increased community-based co-learning projects and awareness of giraffe outside the park. In addition, by identifying key habitat types that giraffe selected, we advise enhanced monitoring in preferred habitats during the wet season to protect these areas from being encroached by human settlement or agricultural expansion, with the support of the legal framework of the Bahr Salamat Wildlife Reserve and other agreements that protect wet season wildlife corridors.

Fire and development impacts on wildlife movement at the Wildland-Urban Interface

Kirby Mills- University of Michigan, USA

Increases in the frequency and severity of wildfires – spurred by climate change – have drastically modified wildlife habitats around the world. These changes are most pronounced in the growing Wildland-Urban Interface (WUI), where human impacts and environmental change create a hotbed of wildfire ignitions that can restructure wildlife behaviors and interactions across trophic levels. To explore how wildfire activity influences wildlife behaviors and interactions, we integrate measures of wildfire impacts with a high-resolution, long-term wildlife telemetry dataset representing nearly 4,000 individual animals – specifically mule deer, black bear, and cougars – located over 21 million times over 20 years and 500,000 km^2 in the American Intermountain West. We developed integrated step-selection functions to assess how wildlife severity and legacy alter habitat selection and movement characteristics in all three species inside and outside of the WUI. We also evaluated how fires can impact predator-prey interactions by comparing fire metrics to a dataset of cougar cache sites for mule deer kills across the region, allowing us to assess how fire-related changes to movement behaviors cascade to restructure wildlife interactions. Our results shed light on how wildlife navigating increasingly urbanized landscapes adapt their movement behaviors to respond to the dynamic impacts of fire in wildland habitats. As wildfire severity and frequency continue to increase around the world, especially in the WUI, the survival of many wildlife species depends on their ability to adapt to novel environmental conditions created by human-caused environmental change.

Predicting animal responses to the loss of thermal shelters by deforestation: scaling up step selection functions

Érika Garcez- Swansea University, UK

The giant anteater, Myrmecophaga tridactyla, is a large mammal which uses the forest as a thermal shelter, as it has a low capacity for internal thermoregulation. However, forest loss is an increasing threat to biodiversity mainly due to human-induced deforestation. In this study, we aim to investigate how to reduce the impacts of the loss of thermal shelters due to deforestation on giant anteaters. We GPS-tracked 14 giant anteaters in Brazil and performed an integrated step selection analysis (iSSA) to estimate habitat selection parameters for the forest, environmental temperature and time of the day. Firstly, we developed five individual-based models (IBMs) to simulate the space use of these individuals by combining differently the covariates from habitat selection. The IBMs were parametrized with the coefficients extracted from the

integrated step selection analysis (iSSA). Then, we produced predicted spatial occurrence distribution (OD) for each individual and compared it with the observed data. As this is an ongoing study, we have performed some tests on the parameters and settings of the IBMs to evaluate the efficiency of the models to predict space use, which will be the preliminary results to be presented in this talk. The next steps, include simulating different scenarios of deforestation and performing simulations to evaluate how the loss of forest might affect space use of these animals. In addition to that, we aim to expand this study to others mammals species in Brazil.

Scentscape - integration of spatial information from long-range detection during dispersal

Kamil Bartoń- Institute of Nature Conservation, Polish Academy of Sciences, Poland

During dispersal, animals often move across a novel and unfamiliar landscape. There is growing body of evidence suggesting that dispersal is not a blind process, with many species having complex perceptual and cognitive abilities, such as spatial memory, that they employ during dispersal when moving long distances. One way to acquire long-range information is through olfactory cues, and information collected by an individual during movement can be incrementally integrated into a complex mental spatial representation of the surrounding landscape. We propose a model to show how directional information (such as scent) can be integrated during a movement process to provide an increasingly accurate representation of the surrounding landscape. We modelled the process by which an animal builds a cognitive map using odour cues from the environment. In our simple model, the individual creates a representation of the environment based solely on information on the strength and direction of cues, which is done iteratively from a series of locations. Finally, we demonstrate the properties of the model using real data on the long-distance dispersal of a large predator, the brown bear.

Pigs in blankets: The ecology of sleep in wild boar

Euan Mortlock- Queen's University Belfast, UK

Sleep is a fundamental behaviour that serves vital physiological functions, yet how sleep in wild animals is influenced by environmental conditions and varies within populations is poorly understood. Using an accelerometer-based, minimally-invasive approach we monitored and quantified multiple dimensions of sleep in a population of wild boar for periods up to a full annual cycle. In support of the hypothesis that environmental conditions determine thermoregulatory challenges, which regulate sleep, we show that on warmer, longer, and more humid days sleep quality and quantity are reduced, whilst greater snow cover and rainfall promote sleep quality. Importantly, our study reveals large inter-and intra-individual variation in sleep. We test the hypothesis that such differences in sleep, are the product of differences in individuals' approach to sources of potential human disturbance in selection of sleeping sites.

Poster Session

Air

Moving towards coexistence: understanding behavioural responses of eagles to human activity

Jain Varalika- University of Vienna, Austria

Human activities are driving population declines in over half of the world's raptor species, including eagles. Eagles, as large-bodied apex predators, fulfil a crucial stabilising role in ecosystems. However, their slow maturity and reproductive rates make them particularly vulnerable to human activity, namely spatial landscape modification (e.g., deforestation, infrastructure) and its associated temporally pulsing disturbances (e.g., road traffic). To mitigate these threats and preserve ecological functioning, it is essential to develop a finer-scaled understanding of how eagles respond to the growing impacts of human activity. In this project, we will analyse the movement and accelerometer- inferred behaviours of eagles in relation to human activity across different landscapes and disturbance regimes. Firstly, we will investigate the individual responses of golden eagles in the Alps to recreational infrastructure and mobility, with a focus on the influence of weather on both eagles and human activity patterns in outdoor areas. Secondly, we will assess the movement responses of multiple eagle species, differing in their reliance on scavenging and predation, to human pressures inside versus outside protected areas in Kenya. Lastly, we will detail the high-resolution hunting strategies of crowned eagles in Durban City, South Africa, to assess how they navigate the costs and benefits of an urban landscape. Our research aims to facilitate the development of effective conservation strategies for mitigating human impacts on eagles, and to move towards coexistence of eagles and humans in our shared environment.

Raptors respond to global changes in human activity patterns: a community-driven, global-scale analysis

Robert Patchett- University of St Andrews, UK

The COVID-19 Bio-Logging Initiative (https://doi.org/10.1038/s41559-020-1237-z) conducts large-scale collaborative analyses of how animals responded to altered levels of human activity during the COVID-19 pandemic. One of its sub-projects is an ambitious collaboration with the Global Anthropause Raptor Research Network (GARRN) (https://doi.org/10.1016/j.biocon.2021.109149) and The Peregrine Fund that aims to understand how lockdowns affected raptor movements and activity patterns. Many raptor species are sensitive to human activities, making them ideal models for examining potential 'anthropause' effects. Through the combined efforts of the international raptor research community, we have built a database of studies that tracked raptors before, during and after lockdowns, comprising data from over 3,000 tagged individuals across 65 species (from Africa, Asia, Europe and North and South

America). COVID-19 lockdowns have created, under the most tragic of circumstances, an opportunity to separate the effects of direct human disturbance from human-made landscape modifications, with adequate control and replication, providing critical insights into anthropogenic impacts on raptor movement patterns. We are carrying out global-scale comparative analyses across species, ecosystems and geographic regions. The resulting insights will provide much-needed impetus for global conservation efforts, inspiring innovative management strategies for raptor species that are locally or globally threatened. Here we present our most recent findings from this work, and sketch our vision for a follow-on project that will examine human-raptor interactions more generally by pooling tracking data over the past 15 years.

Combining capture-recapture, multievent models, and reverse-GPS tracking to infer pathogen-induced effects on population dynamics and movement behaviour

Marius Grabow- Leibniz-Institute for Zoo and Wildlife Research (IZW), Germany

Understanding the links between movement and pathogens has profound implications on our ability to forecast epidemics and to predict how host populations are affected by pathogen dynamics. Pathogens are powerful ecological drivers, determining animal behaviour including movement. By altering the ways in which hosts allocate energy, either as an adaptive strategy of the host or by parasitic manipulation, pathogens can dramatically alter movement behaviour, leading to implications for host fitness and pathogen transport. Although parasites regularly gain attention during disease outbreaks or invasions, there is a lack of knowledge of how host populations, which coevolved with cosmopolitan parasites, are impacted by subclinical, sublethal, and often benign infections. We hypothesize that pathogens are crucial to determining individual movement behaviour, inducing feedbacks on physiological traits and population dynamics. Here, we use high-throughput animal tracking (ATLAS) to follow the daily movement decisions of two sympatric swallow species, barn swallows (*Hirundo rustica*) and house martins (*Delichon urbicum*). We found that infected individuals, albeit showing no clinical signs of infection, reduced their daily foraging time and increased their resting behaviour, excluding infected animals from high-quality foraging grounds. We argue that those altered movement decisions are linked to the decreased survival probabilities between years and are important for shaping the host-pathogen dynamics in our study system.

Insights into breeding season foraging movements of Alpine swift Tachymarptis melba tracked with GPS loggers

Alexandra Brighten- University of Aberdeen, UK

Insectivorous birds rely on resource patches that fluctuate in time and space and may be influenced by weather and environmental factors, such as land use and landscape features. Much of what is known about aerial insectivore movement relates to their impressive migratory flights, whereas less is known about fine-scale non-migratory movement due to past size limitations of tracking devices. Biologging technology advancements have enhanced our understanding and, importantly, also revealed

significant individual variation in strategies. However, we know little about how such individual-level differences can drive variation in key demographic metrics including survival and reproduction. Insectivorous species have declined due to insecticide use and this combined with the forecast increase in unpredictable weather conditions from anthropogenic climate change means it is important to understand aerial insectivore resource and habitat use. We deploy GPS loggers on Alpine swifts to investigate the breeding season movements of individuals, mated pairs, and members of four breeding colonies asking whether there is overlap in foraging routes and habitats. In addition, we aim to investigate how different times of day, nest stages, individual morphology and physiology, and environmental and climatic variables influence foraging movements and prey selection. This study forms part of my PhD, which harnesses multi-decadal data from colonies in Switzerland combined with biologger tracking and dietary DNA-metabarcoding to better understand carry-over effects of individual variation in movement strategies and diet on survival and reproductive success in the context of changing prey availability and an increasingly unpredictable climate.

Tracking resistance: exploring Laridae as a reservoir of antimicrobial resistant bacteria

Paige Petts- University of Exeter, UK

Antimicrobial resistance (AMR) in bacterial pathogens is a global risk generating significant human and animal health concerns and economic challenges. Despite clinically relevant AMR bacteria being detected in wildlife for over three decades, minimal AMR surveillance in either wildlife or environmental sources has been conducted. By contrast, efforts have focused on human clinical environments and domestic livestock, subsequently neglecting the potential diversity of natural reservoirs or sentinels. Urban wildlife species, including gulls (family Laridae), are recognised for their opportunistic behaviour paired with adaptability to utilise anthropogenically modified habitats. Given the proliferation of anthropogenic nesting and feeding resources, for example landfills, wastewater treatment plants, and coastal towns, the dispersal of gulls throughout such sites facilitates the spread of pathogens between marine, freshwater, and anthropogenic ecosystems. This association epitomises the increasing threat of disease at the human-wildlife interface. Although identified globally to harbour AMR bacteria, the acquisition pathway of AMR in gulls and gull's role as reservoirs (i.e., having the ability to disseminate and transmit AMR to con- and heterospecifics) remains poorly understood. This study therefore aims to address the knowledge gap affiliated with the Laridae family and their role within the dissemination of AMR. Project C-Gull have established an extensive study system and colour-ringing programme focusing on urban herring gulls (*Larus argentatus*) within Cornwall. Using this system, in combination with advanced satellite tracking and full bacterial genome sequencing, this study proposes to track 90 individuals to establish the local origins of AMR and their role in AMR dispersal.

Herring gull (Larus argentatus) juvenile movement and habitat use

Emma Inzani- University of Exeter, UK

Herring gulls' increasing use of urban areas is creating human-wildlife conflict through what is perceived as anti-social behaviours, such as scavenging rubbish, stealing food from people, defecating on buildings and loud calling. However, due to their cliff-nesting populations decreasing by 40% in the last 20 years, herring gulls are a species of high conservation concern. The cause of their decline in their natural habitat is likely associated with anthropogenic activities, such as land development and overfishing, which reduce the availability and/or quality of natural resources, but conclusive evidence is lacking. As a result of advances in technology, studies are increasingly tracking adult gull movement to understand their use of urban habitats. However, little is known about juvenile and immature gull dispersal, movement and habitat use in the UK. Our study is the first in the UK to GPS-track thirty juvenile gulls. Twenty of these juvenile gulls were reared in wildlife rescue centre while the other ten were tagged in the wild. We aim to determine if the wild and rescued gulls differ in their movements, habitat use and likelihood of foraging in urban areas. We will also test whether behaviour traits measured during the development of the rescued juveniles predict their movements and urban habitat use, where bolder and less aggressive birds are predicted to use urban areas more. Our findings may increase our understanding of gulls' natural population decline and increase in urban areas.

Water

Colony and individual-level variation in foraging behaviour

Danni Thompson- University of Aberdeen, UK

Individual-level mechanisms are important for understanding ecological, demographic and evolutionary processes. Phenotypic differences can lead to individual specialisation, particularly regarding resource use, with both behavioural and physiological variation affecting the ability of individuals to detect, capture, handle, and digest prey. This variation between individuals, if sustained, results in individual specialisation across the dietary niche. Both competitive interactions and environmental heterogeneity drive the prevalence of individual specialisation within populations, but few studies consider these drivers together. The Falkland Islands shag *Leucocarbo atriceps albiventer* is an understudied nearshore, colonial species. Their widespread distribution across the archipelago in colonies of varying size, and with access to either oceanic or more inshore waters, allows for a natural experiment to differentiate between the effects of environmental heterogeneity and intraspecific competition as drivers of individual specialisation. By deploying GPS and TDR tags on breeding adults at multiple differently sized colonies, this study system provides a novel opportunity to identify the strength and extent of interactions between these key drivers. Here we present preliminary results from three colonies, revealing high levels of individual variation in foraging travel behaviours resulting in significant colony-level differences in space use. Such information is central to informing the development of

Falkland Islands Marine Managed Areas by identifying key foraging locations and, ultimately, prey species of importance for an important but poorly known nearshore predator.

Increasing biological realism in individual-based models of seabirds used to predict the impacts of offshore wind farms

Christopher Pollock- UK Centre for Ecology & Hydrology (UKCEH), UK

Predicting the sub-lethal impacts of offshore renewable developments (ORDs) on seabird populations can prove a complex challenge. For example, it is important to try and estimate the consequences of having to avoid wind farms footprints by flying around them ("barrier effects") on consecutive foraging trips throughout the breeding season by linking behavioural processes to changes in time-activity and energy budgets. Taking an individual-based approach to this task through scaling up to population size allows us to predict the demographic consequences of prospective developments, posing a leap in the sophistication of techniques used to estimate sublethal effects of offshore wind farms compared to current industry standards. As part of the PrePARED research project (Predators and Prey Around Renewable Energy Developments, funded by OWEC in the UK), we are improving the biological realism of the individual-based model (IBM) 'SeabORD', to better capture behavioural mechanisms of foraging trips and flight patterns in a range of seabird species, and how these changes are linked to redistribution of seabird prey around operational ORDs. The project will also deliver new methodologies for increasing the realism of foraging tracks for a range of seabird species. By analysing biologging data for five seabird species in the model we show how it is possible to decompose foraging trips into different behaviours, and to identify key parameters for capturing the internal structure of trips. By using contemporary Bayesian methods, we can then generate more biologically plausible foraging trips for seabirds, including their response to environmental covariates and ORDs.

Do seabirds alter their movement in the vicinity of wind farms?

Charlotte Regan- UK Centre for Ecology & Hydrology (UKCEH), UK

Seabirds around the world are contending with an increasing array of human activities and infrastructure within the marine areas they rely on for their day-to-day activities. UK seabird colonies are currently facing a large expansion of offshore renewable developments in areas they heavily rely on whilst breeding. Though work has focused on understanding the direct impacts of such developments on seabird populations via the morality caused by direct collisions between birds and the turbines, understanding of how such developments might impact populations by altering movement patterns and thus individual energetics is far less understood. In this poster, I will detail our plans to understand how a newly operational wind farm within the foraging range of a seabird colony impacts on individual movement behaviour. We will combine GPS data collected for four species of seabird (black-legged kittiwake, common guillemot, Atlantic puffin, razorbill) breeding on the Isle of May, Scotland, with Barrier Behaviour Analysis (BaBA) to compare movements made outside of the wind farm area (i.e., unimpacted) to those made within an impact zone around the wind farm boundary to

understand how birds respond to this novel stressor. Such work is a critical piece of the puzzle in understanding the potential impacts of renewable developments on seabirds both around the coast of the UK and further afield.

Estimating the quantity and spatial distribution of seabird prey offtake for marine impact assessments

Oliver Leedham- UK Centre for Ecology & Hydrology (UKCEH), UK

Each year, the British Isles host globally important populations of breeding seabirds. In these species, breeding adults forage at sea, often travelling great distances from the colony. This central place foraging modality—combined with an increased foraging burden for chick provisioning—mean that patterns of at-sea space use are central to understanding recruitment in these critical periods. An increasingly important issue for the conservation of seabirds is the development of offshore renewable energy infrastructure, which may impact the accessibility of prey to foraging seabirds via displacement and barrier effects. I present a new method to estimate the spatial distribution of prey offtake by chick-rearing seabirds to improve applied impact assessments of marine industrial activities on protected seabird populations. We use energetic and demographic data to estimate total prey offtake by focal populations and combine these estimates with measures of foraging space use to produce predation maps for key seabird species. Predation maps for species or assemblages can be applied to diverse contexts and offer versatile outputs. These include evaluation of the degree of protection afforded by marine protected areas, or the impact of predator exclusion via displacement from proposed offshore windfarms. Predicted losses of foraging opportunities can be input into demographic modelling to explore population-level consequences of offshore developments. I detail the stages of calculation involved in this novel predation mapping approach, and present examples to illustrate its application to impact assessments of anthropogenic activities on protected seabird populations.

Foraging movements of humpback whales relate to the lateral and vertical distribution of capelin in the Barents Sea

Emma Vogel- UiT- The arctic university of Norway, Norway

Understanding how individual animals modulate their behaviour and movement patterns in response to environmental variability plays a central role in behavioural ecology. Marine mammal tracking studies typically use physical environmental characteristics that vary, and/or proxies of prey distribution, to explain predator movements. Studies linking predator movements and the actual distributions of prey are rare. Here we analyzed satellite tag data from ten humpback whales in the Barents Sea (north-east Atlantic) to examine how their movement patterns are influenced by the geographic and vertical distribution of capelin, which is a key prey species for humpback whales and other predators. We used capelin density estimates based on direct observations from a trawl-acoustic survey as well as sun elevation to examine changes in movement patterns in response to changes in light levels. We found that humpback whales consistently reduced speed and directionality (associated with a low move persistence index) where capelin density was the highest. While horizontal

movements showed both positive and negative individual relationships with sun elevation, humpback whale dive depth was always positively correlated with diurnal variations in the vertical distribution of capelin. This suggests that in addition to whales foraging in regions of high capelin density, they also target the densest shoals of capelin at a range of depths, throughout the day and night. Overall, our findings suggest that regions of high capelin density are important foraging grounds for humpback whales, highlighting the central role capelin plays as prey for a range of predators in the Barents Sea marine ecosystem.

Quantifying activity profile of critically endangered big-headed turtles (Platysternon megacephalum) using an open source, low-cost accelerometer

Wing Sing Chan- The University of Hong Kong, Hong Kong

Increasing anthropogenic pressures from overharvesting, land use change, invasive species and climate change are menacing the life of many freshwater turtles and tortoises across the globe. Making informed management strategies in accordance with the life history of individual turtle species are thus critical to equip them with greater resistance against these multitude of threats. Here, using an open source, low-cost tri-axial accelerometer, we collected high resolution acceleration data from five free-ranging individuals of a critically endangered species of freshwater turtles, the big-headed turtles (*Platysternon megacephalum*) in Hong Kong, to inform conservation management of the species. Through individual-specific hidden Markov models (HMMs) built on acceleration data, we quantified activity profiles of *P. megacephalum* for the first time and accessed how individual's activities were modulated across the diel cycle, seasons, and environmental constraints. Both behavioural state transitions probabilities and time budgets estimated from the resulting HMMs demonstrated distinct patterns across the diel and seasonal cycles, with a significant temporal segregation across the diel cycle observed between sexes. Additionally, we observed greater time budget for being active during periods with increased precipitation and temperature. This result hinted a positive direct influence of climate and weather events on freshwater turtle's activity pattern and movement-associated energetic costs. Yet, further investigation is required to evaluate how such environmental constraints on movement and energetic costs of freshwater turtles may translate into actual fitness consequences.

Understanding predator-prey interactions: movement modelling of marine top predators and their prey

Katherine Whyte- Biomathematics and Statistics Scotland, UK

The movements and activities of marine top predators are typically challenging to understand, due to their high mobility and the difficulty in observing behaviours directly. The expansion of biologging tags has substantially improved our understanding of predator movements in recent decades; however, establishing direct links between these predators and their prey is often hindered by a lack of available concurrent data. Prey is likely to be a key driver of movements for many species, but many studies

have instead had to rely on environmental proxies when investigating predator-prey interactions. The PrePARED Project (Predators and Prey Around Renewable Energy Developments) is, for the first time, collecting concurrent data on the distribution and behaviour of marine predators (seabirds, marine mammals) and their prey (fish) on the east coast of Scotland. The aims of the project are to improve understanding of predator-prey interactions before, during, and after offshore wind farm construction, providing critical insights for predicting the potential impacts of future renewable energy developments, and in understanding the fundamental marine ecology within these habitats. In this talk, I will introduce the PrePARED Project, highlight the different types of data being collected, and discuss current work on modelling the movement behaviour of seabirds in relation to their prey.

Spatiotemporal overlap of baleen whales and krill fisheries in the Antarctic Peninsula region

Ryan Reisinger- University of Southampton, UK

In Antarctica, abundant consumers rely on Antarctic krill for food, but krill are also subject to commercial fishing. The fishery overlaps in time and space with the foraging areas of these consumers, making potential competition between krill fisheries and krill consumers a major management concern. Krill catches have become increasingly spatially concentrated in a small number of hotspots, raising concerns about the impact of localised krill depletion on consumers. Such concentrated catches indicate a mismatch between the spatial and temporal scales at which krill fisheries are currently managed, and those at which fisheries operate and consumers forage. We analysed the spatio-temporal distribution of two major krill consumers - humpback and minke whales - and the krill fishery off the Western Antarctic Peninsula. We used whale tracking data to develop spatial random forest models to predict the monthly distribution of whale foraging areas (January-July). We calculated the spatio-temporal explicit geographic overlap between whales and fisheries, the latter represented by krill fishing effort and catch data. Over the course of the krill fishing season, fishing effort and catch hotspots shifted southwest into Bransfield Strait, where effort and catch were highest. Predicted humpback whale foraging areas in Bransfield Strait increased over the same period, while predicted minke whale foraging areas showed the opposite trend. For both, we predicted a hotspot of whale-fishery interactions in the Bransfield Strait, strongest in April and May. Our results highlight the need for fisheries management to better match the spatio-temporal scale of likely predator-fishery interactions.

A novel approach to using seabed geomorphology as a predictor of habitat use in highly mobile marine predators: implications for ecology and conservation

Hannah Wyles- Sea Mammal Research Unit, University of St Andrews, UK

Identifying important ecological areas at-sea is essential for conservation management. Tracking mobile marine predators, such as seals, can aid in identification of such areas. However, an understanding of what characterises suitable foraging habitat is lacking for many species. This study demonstrates how geomorphological features can be classified from bathymetry data using a pattern recognition algorithm commonly applied in terrestrial geology, and how such features can be incorporated into models of animal movement to elucidate how behaviour relates to geomorphology. We used Hidden Markov Models to infer foraging and travelling behaviour from tracking data from grey seals (Halichoerus grypus) tagged in the southern North Sea, an area undergoing rapid anthropogenic habitat change. We found that all seals showed an increased probability of transitioning from travelling to foraging when encountering slopes, footslopes, and hollows. We hypothesise that such features may host prey aggregations or lead to increased prey capture success. This approach could be used to improve estimates of predator distribution, predict consequences of habitat change from climate change, and inform marine spatial planning.

Land

Sensory ecology of foraging in large African mammals and the importance of wind

Sara Gomez- Montpellier University, France

Understanding the link between the use of memory and the response to sensory stimuli in the environment is a key objective if we are to gain a better understanding of how animals use, and respond to, their environment. While the role of memory has received renewed interest in recent years, partly due to the recent availability of data on movements acquired over a long period of time, the use of these same data to question the importance of perception has not followed. It is clear, however, that even in familiar places, animals remain partly reactive to their perceptions. In large terrestrial mammals, it is not known to what extent olfaction and hearing are mobilized in the search for food and the avoidance of the risk of predation when the animal is exploiting a familiar area. In particular, wind is an important abiotic factor known to modulate the olfactory and hearing information detected. The role of wind, its strength and direction, as an important environmental factor in determining the movements of these species, is thus central to the project and provides an original perspective on the impact of climate change, which is expected to lead to changes in wind regimes. Using biologging data (GPS, accelerometers, magnetometers, audiometers) recorded on

wildebeest and lions, this project aims to evaluate the importance of olfaction and hearing in foraging or avoiding the risk of predation, providing tangible evidence to assess which stimuli animals respond to, and on what spatial and temporal scales.

Spatial behaviour of an Alpine marmot population within a high human activity area in eastern Alps

Alessandro Forti- Fondazione Edmund Mach, Italy

Strong relationships exist between species and ecosystem. Human activity and environmental changes are known to affect rodent behaviour. The ecology of Alpine marmot (*Marmota marmota*) has been well investigated in the past, however information on its home range characteristics is still lacking, particularly in eastern Alps. In this work we investigated the spatial behaviour of marmots in the Paneveggio-Pale di San Martino Natural Park, in the southeastern Italian Alps. The study area is affected by human activities (outdoor recreation, agricultural practices, rescue exercises, etc.). We analysed the home ranges size in relation to age, sex, Normalised Difference Vegetation Index and habitat types. During Spring, marmots were captured and marked with coloured ear-tags. In Summer, six family groups were scanned every 5 minutes with spotting scopes. The position of 23 marmots was drawn on a high-resolution map, obtained with drone flight. We calculated the size of each individual home range by perturbative hybrid residual maximum likelihood estimation of continuous-time movement models in R. A total of 4028 fixes were collected. Individual home range varied from 0.88 to 4.74 ha for males and from 0.44 to 4.59 ha for females (median 1.97 and 1.04, respectively). Our results revealed that males use a larger area compared to females, but the home range size did not differ between sexes. As the number of individuals per family group increased, the estimated home range size also increased. Our findings provide the first useful information on the spatial behaviour of alpine marmot in the easter Italian Alps.

Nagging Nuances. Exploring Inter- & Intra-specific Variation in Movement Among Four Coocuring South African Ungulate Species

Liam Kirwan- Swansea University, UK

Under current rapid global change, discerning animal movements and drivers thereof, on both individual and ecological levels, is increasingly coveted to provide improved evidence and guidance for key conservation actions, such as establishing migration corridors and creating reserves of sufficient size. Herein we explore intra- and inter-specific spatio-temporal variation in the movements of four major South African ungulate species (zebra, wildebeest, buffalo, sable antelope), using data on 47 individuals GPS-tagged (1-hour intervals) between 2003-2012 in the Kruger National Park. These grazers range greatly in body mass (180 – 800 kg) and differ in feeding habits (bulk and selective grazers), water dependency, trends in population dynamics and changes in distribution within the park. We relate these to differences in annual and seasonal movement types, space use and residence time, variation in hourly speed and turning angle distributions, and static and dynamic interactions among concurrently tracked individuals. While challenges remain great, understanding these

nagging nuances of species behaviour may hold the keys to more effective conservation efforts.

Fox on the run - cheaper camera traps fail to detect fast-moving mesopredators. Assessing the differences in mesopredator detection efficacy among different camera trap models

Robert McHenry- Environmental research institute, UHI Northwest Highland, UK

The use of camera trapping for detecting wildlife is increasingly emerging as a primary method of non-invasive wildlife monitoring. Yet consensus among researchers and conservationists on how to best undertake camera trap surveys for wildlife monitoring is scarce. For example, it isn't clear which camera trap makes and models are best to use, or in the case of older models, re-use or what specifications and parameters are essential for capturing target species within their study area. Here we present a comparison of predator and herbivore detection efficacy of three makes and models of camera trap at differing price ranges, vintage and specifications. We undertook this comparison in a passive monitoring survey design at six sites in open field conditions across the Flow Country, Northern Scotland. Camera traps were stationed along forestry access roads within forest stands in wider areas of open peatland. We found that detection efficacy varied substantially between grades and vintages of camera traps as well as between species. Older models of camera with lower trigger speed and night vision range performed particularly poorly for nocturnal predatory mammal detection. We discuss how researchers, conservationists and policymakers should apply these results to experimental design and analyses and caution against the comparison between results of one or more camera trap studies using different makes and models or vintages of cameras to their own experimental design or policy interventions.

Space use and movement of grazers, browsers, and mixed feeders at tropical savanna – forest ecotone

Pavla Hejcmanová- Czech University of Life Sciences Prague, Czechia

Ecotones represent highly diverse environment providing spatial mosaic of properties of neighbouring ecosystems, i.e. specific niches. In this pilot study we explore the space use and movement through a tropical savanna – forest ecotone of large herbivores of different feeding types, i.e. browsers, grazers, and mixed feeders. Feeding type is one of key animal functional traits that is inherently linked to the animal's behaviour and determine the functional niche. We used data from collared Giant elands (browser, 8 individuals), roan antelope (mixed feeder, 2 individuals), and lelwel hartebeest (grazer, 3 individuals) in the Chinko Nature Reserve, Central African Republic and we investigated the home range size of each feeding type, selection for specific habitats (savanna vs. closed forest), and their movement through the habitats to understand the functional niche for each feeding type group and to reveal the specifics of niche partitioning in the that area. While home range sizes corresponded to previous studies, i.e. browsers had significantly larger areas, followed by mixed

feeders and with grazers having comparatively small home range, the grazers moved faster and at longer step distances. Regarding the habitats, the browsers showed positive selection towards savanna, while grazers and mixed feeders remained unselective in regard to savanna vs. forest habitat. To understand further the association of feeding types to habitats, we will further explore the behaviour through path segmentation and more detailed view on ecosystem structure, in particular the patchiness of specific habitats and resources.

How plastic are African herbivore responses to climate-induced changes?

Melinda Boyers- University of Glasgow, UK

Recent climate change scenarios suggest that most regions in Africa are expected to increase in temperature at a much faster rate than predicted globally. Animal movements are relatively sensitive to environmental change, and therefore provide a possible early-warning system of perturbations to ecosystems, particularly if we can determine the mechanistic components driving movement decisions. But understanding whether the movements are species specific or climate driven, we need to comparatively assess the movement patterns of a single species across multiple regions. This comparison across multiple regions will allow us to understand whether differences in movement patterns across populations suggest phenotypic plasticity or simply a response to underlying environmental conditions. For this study we focused on using integrated Step-selection Functions (iSSF's) to discern how animals contend with different seasonal and spatial patterns of availability and paucity, and their ability to track these at different scales. GPS data from collared wildebeest collated by AfriMove from Serengeti southwards to South Africa will be statistically linked to field weather stations and radar satellite imagery. Our goal is to understand whether apparent plasticity in movement across individuals and populations are driven by local temperature and environment versus intrinsic differences in populations.

Fox in the City: Preliminary Insights into the Movement and Feeding Behaviour of Dublin's Urban Foxes (Vulpes vulpes)

Holly English- University College Dublin, Ireland

The red fox (*Vulpes vulpes*) thrives in diverse landscapes through adapting its foraging behaviour, which frequently implicates this species in human-wildlife conflict. Foxes can provoke extreme and disparate reactions in city-dwellers, with some people seeing fox presence as an opportunity to connect with nature while others consider them a pest. Using accelerometers and magnetometers recording at infra-second frequencies in conjunction with GPS tracking, we are investigating fox space use and foraging strategies across different habitats within an urban landscape through behaviour classification and dead-reckoning. We discuss preliminary insights into fox behaviour gleaned from GPS data (n = 5) and biologging data (n = 3), highlighting the heavy use of gardens and common reports of intentional feeding of foxes by people in Dublin. We outline how these methodologies can be directly translated into ecological insights relevant to wildlife management, specifically a city council biodiversity office

in Ireland. We prioritise behaviours related to foraging and space use due to their relevance to human-wildlife conflict. Further, we consider how both capture success and fox welfare can be optimised through refinements to capture protocols.

Tiger activities and movements

Ansha Pradham- Swansea University, UK

Human-wildlife conflict is a rapidly emerging issue, due to human population growth, land use and climate change. This problem is of particular concern regarding the conservation of large carnivores in human-dominated landscapes. Large carnivores typically range over very large areas, especially during dispersal and their conservation and management cannot rely uniquely on protected areas and close interactions between humans and large carnivores are unavoidable in many areas. Here we focus on the case of tigers in the Indian sub-continent, which hosts approximately 75% of the world's tigers in one of the most densely populated areas by humans. I analyse GPS and activity data collected by the Wildlife Institute of India, including one of the longest recorded dispersal tracks of tigers, investigating changes in movement and activity/resting periods, contrasting the behaviour of tigers in forested and human-dominated areas (‘landscape of risk’) and protected and non-protected areas, as well as between dispersing and non-dispersing individuals.