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Mapping a Future for Southeast Asian Biodiversity

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1. Introduction

1.1 Global conservation priorities

Globally, biodiversity levels are currently changing at an unprecedented rate due to a myriad of anthropogenically induced factors (Sala et al., 2000). Over the next century these negative trends in biodiversity are set to continue, and therefore the identification of areas for conservation prioritisation are necessary in order to best protect areas of greatest diversity (Brook et al., 2006). Though studies have used different criteria in prioritisation of areas, some studies have combined a number of criteria (Myers et al., 2000) which have led to the identification of 25 global hotspots of biodiversity and species endemicity, which only comprise 1.4% of the global land surface, but contain 44% of all known plant species and 35% of currently described vertebrates.

In this chapter I will principally dwell on three of these biodiversity hotspots, which join to form Southeast Asia (SEA). The following section details the biodiversity present through the region, followed by a brief discussion of the threats to biodiversity. To effectively conserve species present, knowledge of distributions and identification of species is essential, and thus appropriate techniques will be discussed and demonstrated. This will be followed by an analysis of methods to quantify the impacts of such threats, and thus develop the most suitable strategies to effectively conserve the maximum number of species throughout the region.

Though this chapter focuses predominantly on Southeast Asia many regions round the world currently face similar situations. The techniques and approaches discussed here will be broadly applicable to other regions, and species, than those discussed here.

1.2 The biodiversity of Southeast Asia

Southeast Asia (SEA) contains a number of the biodiversity hotspots identified by Myers et al. (2000) and has some of the richest biodiversity and endemicity on the planet (Gaston, 1995a). The area consists of a number of biotas including the Indo-Burmese region, Wallacea, Sundaland and the Philippines. When considering the number of endemic plants and vertebrates, three Southeast Asian regions rank in the global top ten (Sundaland-2nd, Indo-Burma-8th, Philippines-9th) and when the ratio of endemic species relative to area are considered these three are in the top 5 (Phillipines-2nd, Sundaland-3rd, Indo-Burma-5th) (Myers et al., 2000). SEA also contains high endemic evolutionary diversity at species, family and clade levels. On a global ranking Sundaland is in 2nd place, Wallacea 3rd and Indo-Burma 5th in terms of unique evolutionary history, with between 65 - 40 My (million years) of unique evolutionary history in each region (Sechrest, et al., 2002). Therefore SEA contains irreplaceable biodiversity and thus represents a priority area for conservation. Indeed, the forests of SEA have been deemed among the highest of all conservation priorities for biologists (Laurance, 2007).

The landscape of SEA is also diverse and varied and comprises a large number of ecoregions (Olson et al., 2001). Stibig (2007) categorised sixteen native forest types, in addition to woodland, savannah, two types of thorn scrub and forest, alpine grassland and cold desert among the native vegetation types. Such diversity in vegetation cover also creates very varied ecosystems with very different animal and plant communities. Karsts (limestone outcrops) make up around 400,000 km^2 of SEA, and though they only make up one percent of the land area, around two percent of Malaysian species are endemic to karst landscapes (Clements et al., 2006). Globally karsts also harbour a great proportion of endemic species, and therefore contribute significantly to landscape diversity and heterogeneity throughout SEA.

One reason for the high levels of diversity and endemicity in SEA is the dynamic and complex geo-physical history of the region, which has been described as a biogeographic theatre (Woodruff, 2003). Some of the landmasses that form SEA only joined as little as 15 Mya (Million years ago), and the addition of new landmasses caused faults and regional instability in many regions (Hall, 2002), which in turn contributed to the formation of unique biotas. Even at only five Mya SEA had not taken its present shape and landmasses within it were still subject to small but significant movements (Hall, 2002). Since this time glacial cycles have periodically transformed SEA, both in terms of shape and vegetation cover (Woodruff, 2003). During successive glaciations mainland and insular areas of SEA have been joined, and glaciers existed as recently as 10 Kya (thousand years ago) in Borneo and Sumatra (Morley & Flenley, 1987). This dynamic geophysical history has led to a highly complex pattern of species distributions and the area contains no less than three zoo/floro–geographic boundaries: Wallace's line, the Kangar-Pattani line and the Isthmus of Kra (Whitmore, 1981; Baltzer, 2008; Cox & Moore, 2010; A.C.Hughes et al., 2011). Therefore the region has a rich and highly varied biota, and thus represents a priority region for conservation.

2. Threats to biodiversity

Southeast Asia has been stated by many to be facing a crisis in terms of biodiversity loss (Laurance, 2007). SEA has the highest global rate of deforestation, with rates over double those documented elsewhere (Laurance, 2007). Despite possessing extensive biodiversity, Thailand only has around 17.6% of its potential forest remaining, and Peninsula Malaysia around half (Witmer, 2005). Rates of change in vegetation cover in SEA between 1981 and 2000 were the highest globally (Lepers et al., 2005) and what is more these rates of change are accelerating (Hansen & DeFries, 2004).

Loss of habitat and deforestation are not the only threats to the biodiversity of SEA. The Convention on International Trade in Endangered Species (CITES) listed that at least 35 million animals in addition to 18 million pieces of coral (and 2 million kg live coral) were exported from SEA between 1998 and 2007 (Nijman, 2010). Many species are also hunted for recreation (Epstein et al., 2009) in addition to bushmeat (Brodie et al., 2009). Furthermore the Chinese medicine trade is stated to be the "single major threat" for some species (EIA, 2004; Ellis, 2005). These problems are not limited to "unprotected areas" as even National Parks fail to offer protection from either illegal logging (Sodhi et al., 2010) or high levels of hunting (Brodie et al., 2009).

The above mentioned factors affecting biodiversity loss are further complicated by the effects of climate change (Figs.1-2), which may act to amplify other threats, and which itself may be amplified by other threat factors (such as wood burning and subsequent release of greenhouse gases-Brook et al., 2006). Fires present a major threat to biodiversity in the region, and during the past decade major fires have started progressively further north in response to climate change (Taylor et al., 1999). Even without considering of many of these factors, projections of the number of extinctions have been made, which project the extinction of 43% of endemic Indo-Burmese fauna within the next century (Malcolm et al., 2006). Thus despite harbouring considerable biodiversity, few areas in SEA have sufficient levels of protection, and with many new species still to be found (as demonstrated by the rapid rate of discovery (Giam et al., 2010)) it is currently almost impossible to determine the most effective means of conservation prioritisation within SEA given the level of knowledge of much of the fauna, and high levels of corruption (Global Witness, 2007).

Some conservation biologists have advocated the use of "indicator species" to monitor more general threats to biodiversity (Carignan & Villard, 2002). Chosen species must obviously be sensitive to the potential threats in the area, and such species must be possible to monitor in a standardised and repeatable way to generate meaningful and comparable data over large spatial and temporal scales. Indicator species can also be used to indicate trends in overall biodiversity (Mace & Baillie, 2007) and therefore provide a gauge of biodiversity change at large regional scales over time. Bats provide an ideal indicator group (G. Jones et al., 2009), and their diversity means that species can be susceptible to a wide variety of different threats. Bats form a large component of bush-meat through SEA (Mickleburgh et al., 2009), and many of these species often perform vital roles within ecosystems and their loss could have negative implications for a wide range of interacting taxa (Mohd-Azlan et al., 2001). A number of ecosystem services are provided by bat species, including pollination, seed dispersal and insect control, and therefore bats are frequently keystone species (Myers, 1987; Fujita and Tuttle, 1991; Hodgkison et al., 2004). Effective conservation of these keystone species is crucial not only for their survival, but for the ecosystems dependent upon them. Furthermore many bat species are either dependent on forests or caves for foraging and roosting, and some species have limited dispersal ability (Kingston et al., 2003), suggesting that their status may be indicative of destruction and consequent fragmentation of both karst and forest areas.

To try to reduce impacts of the Southeast Asian biodiversity crisis requires a number of steps: quantification of how species are distributed and their distribution changes, analysis of the threats each species faces and determination of the probable impact of threats they are likely to face. Only once these initial steps have been achieved is it possible to formulate effective impact mitigation strategies. Though in this chapter bats will provide the main case study (due to their potential as indicator species) most of what will be discussed here is broadly applicable for the conservation of biodiversity throughout SEA, and in developing strategies for mitigating species loss in other regions of the world which faces similar issues to those discussed here.

3. Identifying species and distributions

Although over 320 species of bat are currently described from SEA (Simmons, 2005; Kingston, 2010) research in the area has been sporadic and the rate of species discovery is now high for not only bats (Bumrungsri et al., 2006), but across many other taxa (Duckworth & Hedges, 1998; Bain et al., 2003; Giam et al., 2010). Recent research has revealed that many bats previously regarded as one species are in reality complexes, comprising a number of cryptic species (Soisook et al., 2008, 2010; Francis et al., 2010). Therefore before any conservation measures can be put in place the distribution and status of current species must first be established. SEA has some of the highest diversity of bats on the planet in addition rate of species discovery (Simmons & Wetterer, 2011). A projection of the species richness of 171 species throughout SEA (Fig.1) shows that most forested regions still retain high species richness, and therefore present priority regions for research.

However recent research has clearly demonstrated that currently known SEA bat species only represent a fraction of total species numbers (Francis et al., 2010; Giam et al., 2010; A.C.Hughes et al., in prep a). Both recent taxonomic and genetic research show that much further work is needed in order to identify all species in the region, and similar trends are liable to exist across biotic groups. Species identification is clearly a priority, because it is impossible to try to develop effective conservation strategies when there is little understanding of the true ranges of many species; and when species currently classified as showing large distributions are in actuality made up of a number of cryptic species with small ranges and much smaller populations (A.C.Hughes et al., in prep a). Both taxonomic (Soisook et al., 2008, 2010) and genetic work (Francis et al., 2010) demonstrate that there are many currently undescribed and potentially cryptic species throughout SEA.

Methods used to determine species present obviously involve detailed taxonomic surveys (as advocated by Webb et al., 2010), in addition to genetic analyses where possible. However other protocols for species identification and monitoring may also be valuable components of species discovery in some taxa, such as the use of call analysis to identify cryptic bat species (e.g. G. Jones & Van Parijs, 1993). In such cases the identification of potentially cryptic species may begin with call analysis, as was recently found to be the case in Hipposideros bicolor, (Douangboubpha et al., 2010). Acoustic monitoring also provides a means of potentially monitoring population trends as well as identifying possible cryptic species (K. E. Jones et al., 2011). Two protocols have recently been developed which describe the potential for using localised call libraries for identifying bat species in SEA (A.C.Hughes et al., 2010, in press). Once acoustic identification libraries have been developed then acoustic surveys and inventories of surrounding regions (e.g. 1^{o} of the areas used to develop the library) can be made to identify species present (using discriminant function analysis) and the presence of species outside their known range. The presence of novel call variants could cue and promote further research to determine if sub-species or cryptic species are present, and the spatial distributions of call variants of some species suggests spatial segregation which could denote cryptic species (A.C.Hughes et al., in prep a). Monitoring surveys are also essential to determine distribution and population trends, however funds and specialists are not always available to carry out this valuable work when it requires repeated taxonomic surveys and specialist knowledge. Acoustic analysis and monitoring only requires specialists initially, during the creation of acoustic libraries, and surveys can then be carried out by non-specialists or automated software programs (K.E. Jones et al., 2011). Thus protocols such as these provide a viable means of both identifying species present and subsequently monitoring trends, and may be able to detect variation over shorter periods than in trapping-based monitoring which has been previously been advocated (Meyer et al., 2010). Acoustic surveys are currently limited in species coverage, and are biased towards bat taxa that use high-intensity echolocation calls. Acoustic surveys are therefore best used side-by-side with conventional survey techniques such as using mist-nets and harp traps in a standardised manner (MacSwiney G et al., 2008). However invasive trapping techniques are expensive and require highly trained experts, whereas acoustic surveys can be carried out with little training and recordings can then be forwarded to highly trained researchers for analysis, or analysed by software to provide standardised and comparable data for any region. If initially surveys combine both trapping and acoustic techniques to establish acoustic libraries within a given area then those libraries can subsequently be employed to monitor trends in many species across wide areas. The use of common species as indicators for abundance and distribution of rarer species has been found to be accurate in previous studies, as correlations have been found in the trends of common species with other species present (Pearman et al., 2010). Therefore even if acoustic surveys cannot cover all species, the trends in the distributions and populations of common species may still be more widely applicable.

Logistical constraints also mean that it is not always possible to survey all areas in a region, and thus methods which determine range based on limited spatial knowledge of an organism's total distribution provides a valuable tool when applied properly (i.e. predictive modelling approaches, Box 1, Fig. 1). Former distributions of species and zoogeographic constraints must also be considered and included in analyses of species distributions. Within SEA the geophysical history is to a large extent responsible for the current patterns of diversity and species' distributions, and thus analyses of present species distributions cannot be conducted without by making reference to the past (Woodruff, 2003). The connections and separations of the various parts of SEA during past time periods not only influence current distributions but further constrain possible responses to future change. A zoogeographic transition in the distributions of some animal groups centred around the Isthmus of Kra has persisted for over a million years (De Bruyn et al., 2004). Recent analyses (A.C. Hughes et al., 2011) show that although breaks in the distribution patterns of bats are apparent along the Thai peninsula, they occur not only at the Isthmus of Kra and are influenced by climatic discontinuities in conjunction with biogeographic consequences associated with the narrow breadth of the peninsula; and it is probable that these circumstances have also caused divisions known to occur in the distributions of other taxa in the region (J.B. Hughes, et al., 2003). Zoogeographic transitions have persisted over long time periods along the peninsula because the position of climatic boundaries appears remarkably constant. Climatic discontinuities continue to affect the distributions of species, and will also affect how effectively species can respond to climatic change in the future.

Identification of species present, their ranges and trends in distribution and population form an important first step in the development of effective conservation plans. Once these steps have been fulfilled then threats to current distributions and diversity can be analysed (Fig. 1) and necessary conservation actions planned.

3.1 Assessing and quantifying threats to current diversity, and determining impacts

Analyses have previously shown that species richness is negatively related to human population density (A.C. Hughes et al., in prep b), and therefore further increase in human population size is likely to have detrimental effects on bat biodiversity. Projections suggest that human populations will continue to increase until at least 2050 and further urbanisation is likely throughout SEA (CIESEN, 2002; Gaffin et al., 2003; United Nations Population Division, 2008; Seto et al., 2010). Larger human populations impinge on biodiversity in a number of ways: through increased demand for wild-sourced products and via higher pollution (Corlett, 2009; Peh, 2010). Urbanisation and increasing deforestation also increase the potential for invasive species to spread throughout SEA (Riley et al., 2005) and further work is necessary to determine the effects of invasive species on the native fauna.

Forest fragment size correlates positively with bat species richness (Struebig et al., 2008; A.C. Hughes et al., in prep b). As deforestation is projected to increase throughout most of SEA, including in "protected areas" (Fuller et al., 2003), this trend is likely to lead to progressive loss of species richness in many areas due to the increased fragmentation of large forest patches. Currently many protected areas fail to offer protection, and are subject to both high hunting pressure (Steinmetz, et al., 2006) and deforestation (Fuller et al., 2003). Heightened accessibility of parks and involvement of rangers may indeed lead to greater pressures within National Parks than in other forested regions. Many regions were predicted to have high species richness during this study, however many forests have been described as showing "empty forest syndrome" (Redford, 1992; Tungittiplakorn & Dearden 2002). Therefore although many areas may be suitable for certain species, they are overexploited by humans, and do not contain the native fauna previously held. Empty forest syndrome and overexploitation have serious implications for a wide range of species: rodents are the most "harvested" taxa, followed by bats, and almost all bat species in SEA are eaten (Mickleburgh et al., 2009). The loss of species due to hunting has implications for the entire ecosystem. Frugivorous and nectarivorous bats, large bodied mammals and birds all have essential functions in seed dispersal and pollination and fulfil vital ecosystem services, yet such species are often the most threatened by human hunting activities. If such species are lost, there may be negative consequences for the entire ecosystem. Yet these animals are among the most hunted organisms in the region (Wright, et al., 2007; Corlett, 2008; Brodie et al., 2009).

When projections of the distribution of bats under future climatic scenarios are made, three broad outcomes can be noted (Fig. 2) (A.C. Hughes et al., in review). First almost all species are projected to show reductions in original range under future scenarios and second, most species are projected to move north. The third probable outcome is the large projected loss of species (up to 44) from areas currently predicted to have the highest levels of species richness (figs 1-2). Though some species were projected to show expansions in original range, this is unlikely to be logistically possible due to the limited dispersal abilities of many species (Struebig et al., 2008). This loss in species richness is based on climate change alone, and therefore is a conservative projection, and though it is possible to prevent the loss of species due to deforestation in protected areas it is not possible to prevent species loss due to climatic change. Forest is becoming increasingly fragmented even within "protected areas", and mining rates in SEA are the highest in the tropics (Day & Ulrich, 2000). Mining not only destroys important roost sites (Clements et al., 2006), but also degrades areas and increases accessibility to previously remote areas (which in turn facilitates deforestation, McMahon, et al., 2000; Laurance, 2008a). Therefore not only are current suitable habitat and roosts being destroyed, but the distance between suitable areas may actually be increasing for the same reasons. Other factors such as fires are also prevalent through SEA, and fires have increasingly been found to move north in response to climatic change, therefore posing an increasing threat to the biodiversity of SEA (Taylor et al., 1999). Projections of total biodiversity loss currently estimate the extinction of up to 85% of current biodiversity in SEA within this century (Sodhi et al., 2010). However the estimates of undiscovered species show that we may potentially have only discovered around half of the species in many orders (Giam et al., 2010) and only around 40% of bat species (A.C. Hughes et al., in prep a). Groups containing cryptic species are likely to have particularly high numbers of undiscovered species, and this is highlighted in bats by recent genetic work (Francis et al., 2010). Species with smaller distributions are more likely to have specialist requirements (limiting overall distribution), and will be more susceptible to loss of range and therefore have a higher probability of extinction (Kotiaho et al., 2005). Hence many species currently regarded as widespread, and thus of "Least Concern" by the IUCN may comprise a complex of cryptic species each of which will show higher categories of threat. As almost all species analysed here (fig. 2) showed a loss in original habitat in all scenarios, and many of those species may be species complexes it is likely that impacts for many of the species will be worse than estimated during this study (fig. 2). Projections here (Fig. 2) only account for climate change, but cannot consider hunting, fires, mining and the plethora of other threats. Fungal diseases have recently devastated populations of North American bats (Blehert et al., 2009), in addition to South American frogs (Berger et al., 1999). Moreover the spread of pathogens has been associated with temperature change, for example the spread of chytrid fungus is believed to be related to global warming (Pounds et al., 2006; Boyles & Willis, 2010). Therefore the effect of climate change on species is dynamic and complex, as it has both direct and indirect implications for distributions and populations of all species. Furthermore climatic changes have already been shown to cause changes to the distribution of different biomes (Salazar et al., 2007), and hence has profound implications for species within those biomes.

SEA is currently in the midst of a biodiversity crisis which has been described as a 6th mass extinction (Myers, 1988). There are some undeniable implications of the current threats, and others such as the possibility of 'no-analogue' communities (Stralberg et al., 2009) and the effect of invasive species, which are less certain. However native species are likely to attempt to either migrate north spatially, or move to higher altitudes (Malcolm et al., 2006). Continued decreases in the patch sizes of rainforest will decrease species richness, and increasing accessibility for humans will increase the probability of hunting within areas. Increases in human population will negatively affect biodiversity, if current unsustainable practices continue. Not only is the modification of human activities necessary to decrease further species loss, but human intervention is necessary to allow species any opportunity to respond effectively to climatic changes. The methods to mitigate possible threats require detailed evaluation to try to curb species extinctions.

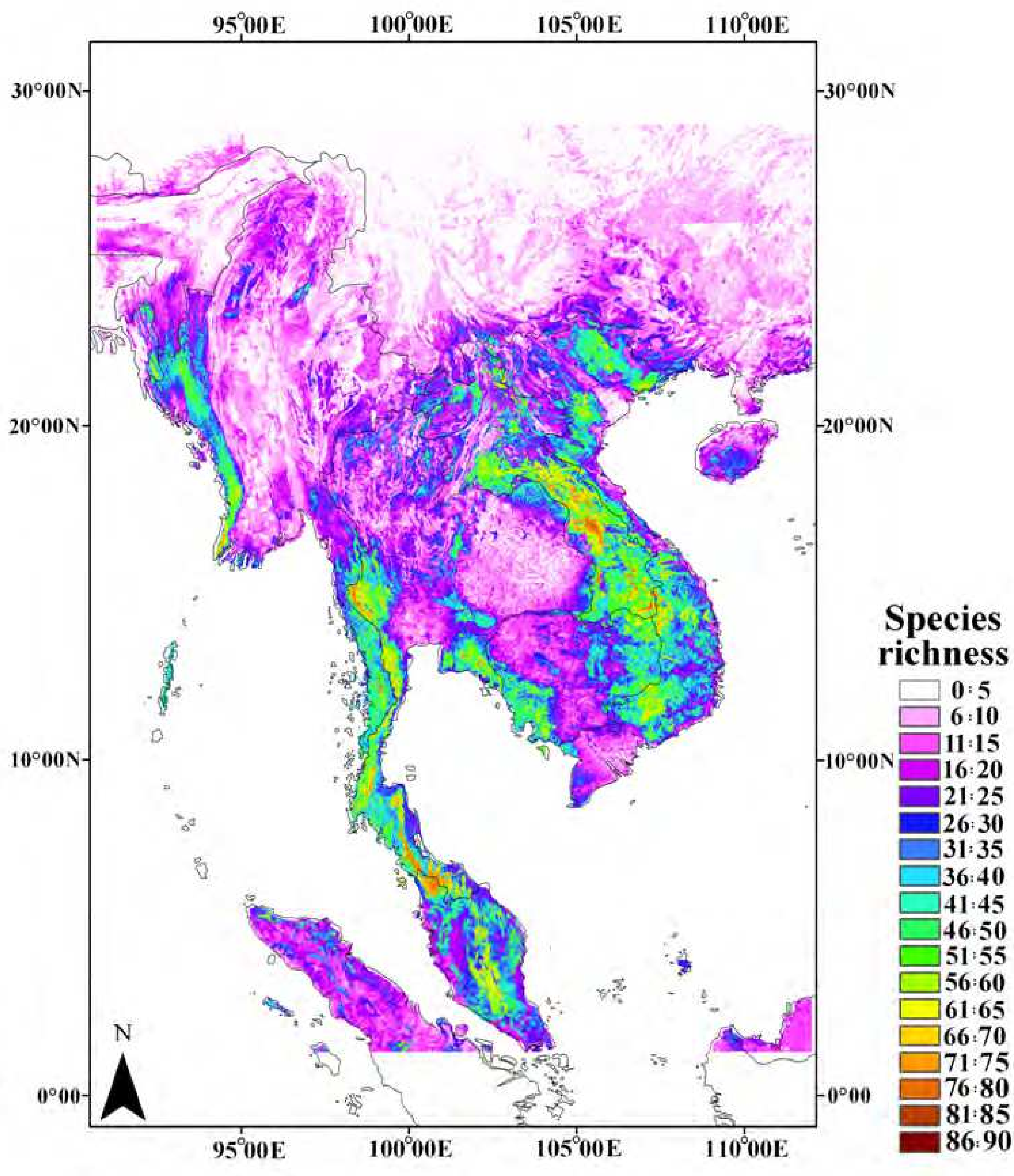

Fig. 1. The current projected species richness for 171 Southeast Asian bat species on a km^2 basis. Projections were generated using Maxent, methods are shown in Box 1. Environmental variables used in projections are included in Appendix 1.

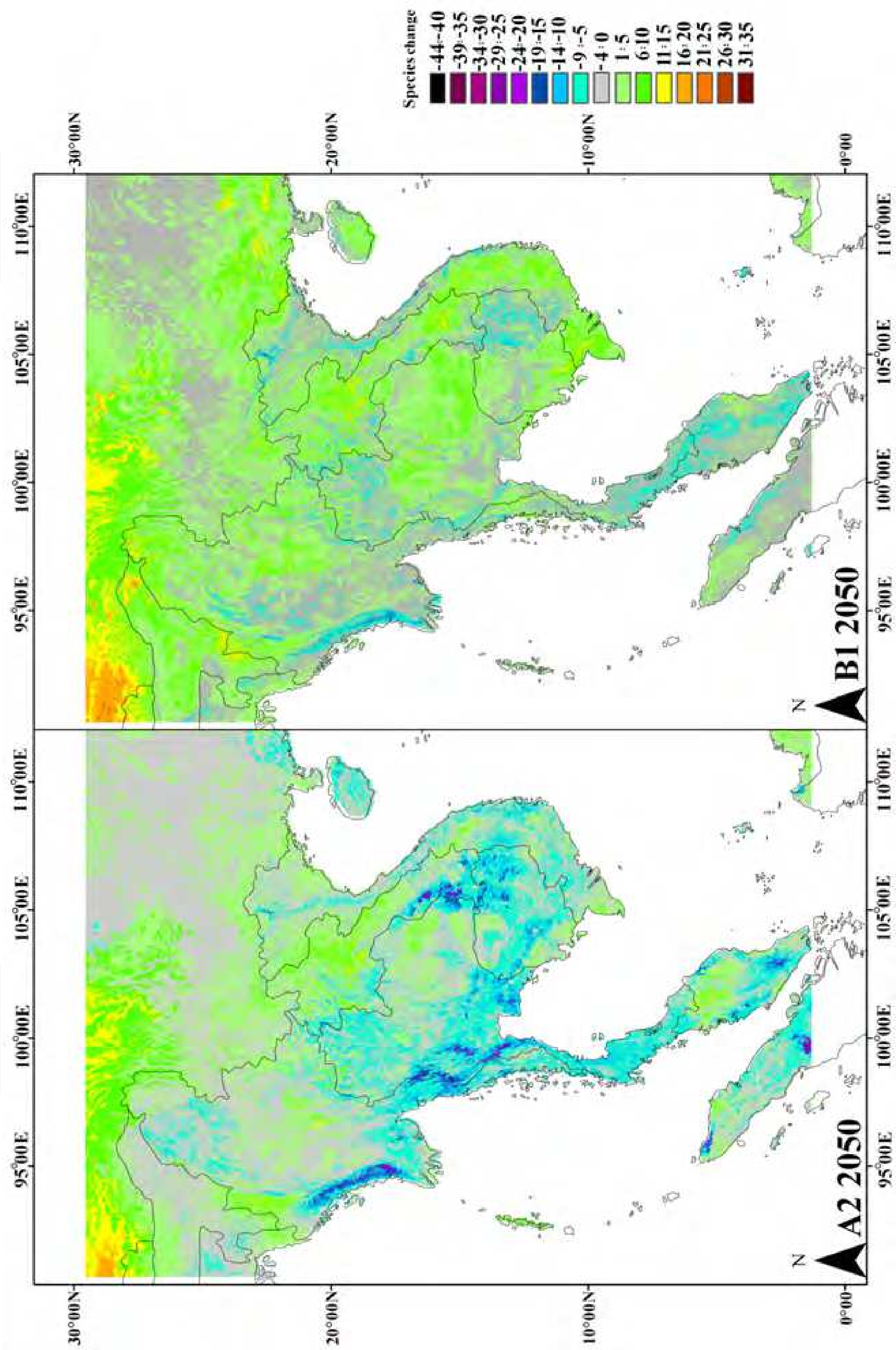
A2 2050
B1 2050
N
Species change
-44-40
-39-35
-34-30
-29-25
-24-20
-19-15
-14-10
-9-5
-4-0
1-5
6-10
11-15
16-20
21-25
26-30
31-35
30°00N
20°00N
10°00N
0°00
95°00E
100°00E
105°00E
110°00E

Fig. 2. A-B.

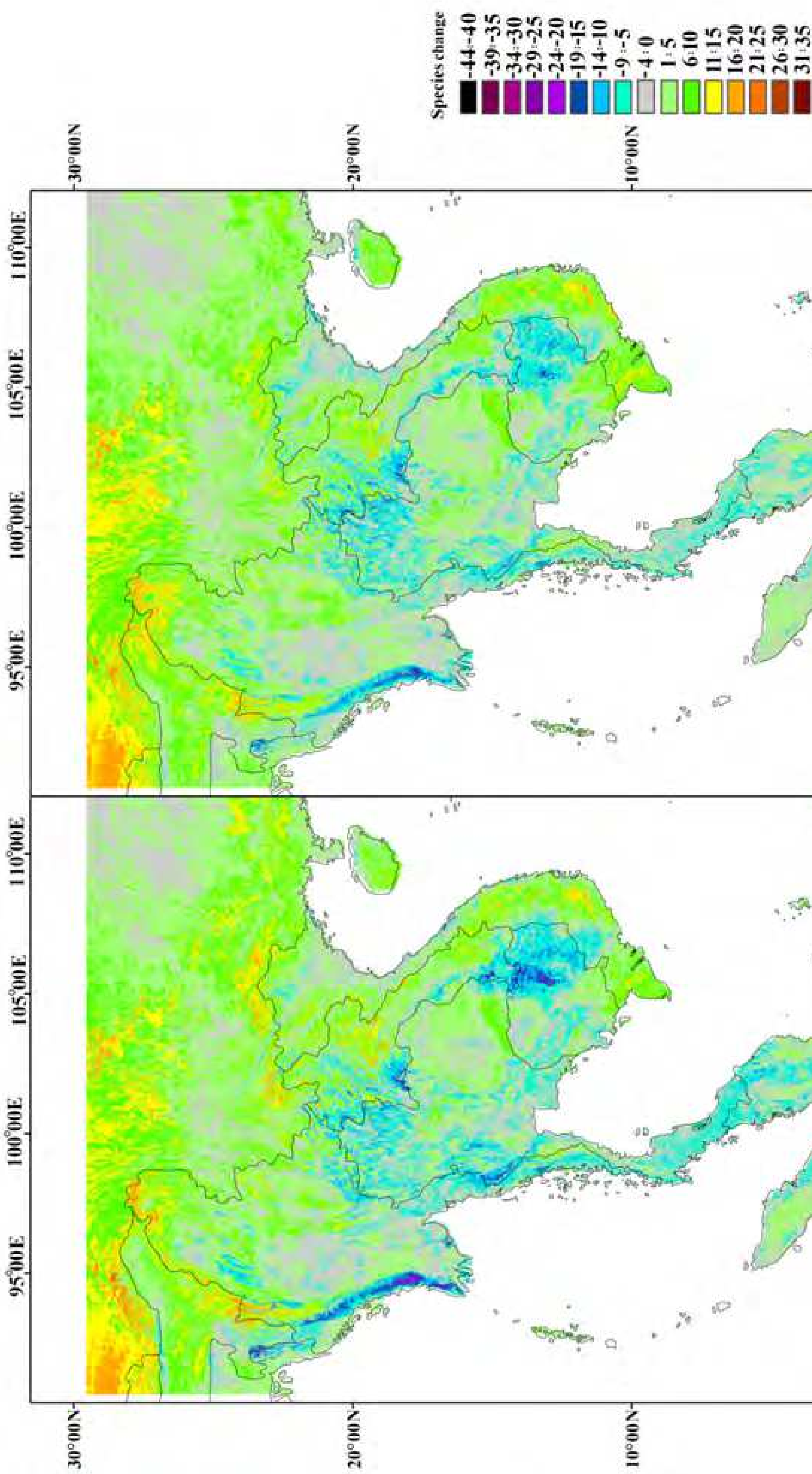

Fig. 2. C-D. These maps display the projected change in the number of bat species under the A2 and B1 climate change scenarios produced by the IPPC. A2 represents the most severe of the climate change scenarios and B1 the mildest. Many regions are projected to lose between five to nineteen species, with some regions projected to lose up to forty-four species.

Predicting species richness by pairing the known distribution of each species with environmental parameters to determine the habitat requirements of each species, (and thus distribution) can help inform and target research and conservation (Box 1). Such models can also aid conservation planning under probable future scenarios, but are targeted to specific questions and can only incorporate some dimensions of ecosystems and must therefore only be interpreted while acknowledging inputs, assumptions and limitations. Models are a powerful tool for predicting the effects of climatic, land-cover and direct anthropogenic change on species richness (if these anthropogenic drivers have been projected). What such models are less good at is incorporating the biotic dimension, the inter-dependence of some species, and temporal interactions such as the flowering of trees and breeding of organisms (L. Hughes, 2000) which can cause resource asynchrony. More complicated ecological interactions and phenomena cannot yet be incorporated in the building of models, but should be included in the interpretation of results; and thus both dimensions of possible ecosystem change can be used to inform and develop appropriate conservation strategies.

Figure 2 shows projections of the effects of climatic change under two potential climate change scenarios (the mildest, and the most severe). Extensive regions are projected to lose between five to nineteen species, with some regions projected to lose up to forty-four species. Though some regions, especially in Northern regions are projected to increase in the number of species, this result should be interpreted with caution for a number of reasons. Firstly these projections only include climatic change, and do not reflect changes in land-cover, and secondly many species are dispersal limited and therefore will not to show the expansions projected here. Also the Northern areas of the projection, which are predicted to gain species here are liable to lose species which were not included in these projections, (which include predominantly tropical dwelling species). These projections are highly conservative, for they only show climate mediated loss of species, this is only one driver of species loss and thus the loss of species in these scenarios is liable to represent a fraction of that when all factors are considered.

4. Mitigating species loss

There are at least three issues that must be addressed if biodiversity is to be most effectively conserved throughout SEA: identification of species and their distributions (Section 3), decreasing the impacts of current threats, and creating ways to allow species to respond to climate change (because halting further climate change is considered impossible, Bowen & Ranger, 2009; Vistor et al., 2009). Each issue requires different actions in order to respond effectively.

As stated previously, accurate species identification requires thorough systematic surveys, taxonomic and acoustic studies, and where possible genetic research. However the scale of this work requires the use of university researchers, students and park rangers. The use of citizen science for survey and monitoring has been advocated by some researchers (Webb et al., 2010). However citizen science is plagued with potential problems in SEA: not only is hunting exceedingly popular, but in many taxonomic groups' cryptic species and the lack of adequate taxonomic knowledge precludes species surveys by non-specialists. However education, and enthusing of the population could allow some citizen science in distinct and recognisable species. School children in some parts of SEA also must complete science projects whilst at high school, and with little training such projects could contribute to this knowledge pool (Sara Bumrungsri pers. comm.). However for successful citizen science to be conducted, people must be educated to the importance of species such as bats (as throughout SEA bats are generally viewed negatively by the public, Kingston et al., 2006). Nature recreation has been implemented in schools, and provides an important means of enthusing the next generations about biodiversity and engendering greater respect for the environment (Pergams & Zaradac, 2008). Education is of paramount importance in the realisation of any level of conservation or mitigation. Without the support and backing of local people no changes to current activities will take place. Projections of species distributions, like those within this study - and subsequent ground truthing (validation and testing) by trained surveyors - can also provide a focus for further research and conservation activity.

Many strategies have attempted to decrease anthropogenic impacts on biodiversity. Recent studies have projected the species richness patterns of bats throughout SEA (Fig 1) (Hughes et al., in review; in prep b), and the regions of high species richness obviously provide a focus for conservation efforts. However within the scientific community there is great dispute as to what criteria should be used to assign conservation priorities. There is debate as to whether regions, species richness, evolutionary uniqueness and richness, numbers of threatened species or specific species should be used in area prioritisation (Corlett, 2009). Under the current circumstances it is not feasible to conserve on a single species basis, because this approach is financially unviable, and it ignores interactions within ecosystems. Furthermore there is currently inadequate knowledge to reliably designate IUCN threat levels for many species throughout SEA, due to the lack of knowledge about the distributions and population sizes of many species, and the presence of cryptic species. However SEA is regarded as an area of both evolutionary, and species richness (Gaston, 1995b; Sechrest, et al., 2002). Most currently species-rich areas are also liable to contain high levels of intraspecific genetic diversity as populations of most species have been predicted to have expanded during the last glacial maximum (LGM), and because current ranges may be restricted compared with ranges occupied during the LGM in tropical areas and may overlie former glacial distributions (Woodruff, 2010). Current species populations within areas of former glacial refugia often contain high genetic diversity in comparison to those in non-refugial areas (Anthony et al., 2007), and genetic heterogeneity and diversity is known to make populations more robust to environmental change and therefore to increase the capacity of such populations to adapt (Aitken et al., 2008). Therefore former refugial areas, many of which fall within current National Parks deserve prioritisation on all grounds. However the current system of National Parks fails to function in many regions (Fuller et al., 2003), and with the high levels of corruption (Global Witness, 2007; EIA/Telepak, 2008) the enforcement of laws such as those governing reserves is difficult.

A variety of schemes and approaches have been developed to try to promote biodiversity conservation and decrease deforestation. The following section evaluates some of these methods in an attempt to formulate a viable method of mitigating biodiversity loss.

Paying for Environmental Services (PES) is one scheme suggested for conservation (Blackman & Woodward, 2010). PES schemes use money generated by environmental service users to pay people who own an area which is (in part) responsible for the service, in order to maintain forest/ biodiversity within the area responsible for that service. For example, forest cover in watersheds may be preserved by using the income generated by hydro-electric dams. Such approaches have potential but must be closely tailored to each site and country, to be economically viable both for those responsible for the maintenance of the area which provides the ecosystem service and those who profit from the service. These schemes have a great number of potential pitfalls which have prevented their success in some areas (Wunder, 2006, 2007). PES-type schemes are obviously unsuitable when the service users earn less than the ecosystem service users, such as the cases of guano miners and durian growers (both of whom have income streams dependent on cave bat populations) and people whom mine karsts (and therefore are responsible for the resource). In situations involving the mining of karsts, determining who should pay for environmental services is difficult, as the income of the miners (who may own the karst) may be higher than those who benefit from bat related services (Wunder, 2006). However when PES-type schemes are well-tailored and targeted to specific areas, they can effectively protect forests, and stipulations can place more emphasis on biodiversity rather than solely forest, as in the case of some "engineered PES" schemes (Wunscher et al., 2006).

Carbon offsets (carbon credits) and the REDD (Reduced Emissions from Deforestation and Forest Degradation) systems also provide a means to fund forest protection (Laurance, 2008b). Afforestation can also be part of such schemes, but in some existing schemes this has included the use of non-native trees. If biodiversity is to be protected it is important that afforestation uses only native species (Corlett, 2009). Afforestation schemes are currently the subject of much debate, however when well applied they have the potential to both decrease rates of biodiversity loss and to mitigate climate change (Canadell & Raupach, 2008). Biodiversity offsets have also been used in some regions (i.e. Uganda), however in some areas (i.e. the USA) the heightened protection of one area has led to greater biodiversity declines elsewhere and thus yielding no net benefit to conservation overall (Ten Kate et al., 2004). Therefore education is necessary alongside offset schemes in order to attempt to prevent greater pressures being deflected elsewhere as a result of conservation within one area (conservation leakage, Gan & McCarl, 2007). Problems also arise when it comes to prioritising areas for conservation based on current risks alone. Hence it is valuable to predict future scenarios based on land cover and climate in assessing conservation priorities (Fig. 2). Although future risk should be part of any assessment criterion, assessment must also analyse other factors, so even if environmental pressure is deflected to other areas as a result of conservation in a particular area: that the most important areas (in terms of biodiversity/uniqueness) are adequately protected (Laumonier et al., 2010). Risk and enforcement can also be projected together and the combined effects predicted to generate the most effective means of minimising deforestation or biodiversity loss within an area (Linkie et al., 2010).

The protection of specific areas still requires funding, as National Parks are currently ineffective in many regions of SEA (Fuller et al., 2003; Steinmetz, et al., 2006). In other countries (i.e. Costa Rica) ecotourism has provided a highly successful means of funding biodiversity protection and educating local people about the value of biodiversity (Jacobson & Robles, 1992; Aylward et al., 1996). Currently although ethnotourism is popular (Zeppel, 2006), ecotourism in mainland SEA is mainly dominated by bird watching tours (Mollmann, 2008). Ecotourism has been shown to work well in parts of Malaysia and Indonesia (Hill et al., 2007, Pearce et al., 2008), and if it were to develop throughout SEA it could provide a viable means of conservation.

Multiple models exist to spatially project species probable distributions used limited spatial data, and in recent years the use of such models has increased dramatically; in 1999-2004 only 74 published studies used species/niche distribution models, however between 2005-2010 this increased to over 850 (Beale and Lennon, in review). Clearly such models represent useful tools for projecting species distributions, and can further allow targeted conservation to either species habitat requirements or the prioritization of areas for research or conservation (Pawar et al., 2007; Sergio et. al., 2007). Recent developments in habitat suitability modelling allow the prediction of a species' potential distribution based on presence-only records (e.g. Hirzel et al., 2002; Phillips et al., 2006). Presence-only modelling is a valuable tool in contemporary conservation biology, and has been applied to a wide range of taxa, from bryophytes (Sergio et. al., 2007) to reptiles (Pawar et al., 2007). Presence-only modelling may be more reliable than presence-absence models for species in which absence records cannot be reliably gathered (i.e. failure to capture a species at a site does not necessarily mean the species is absent- Wintle et al., 2004; MacKenzie, 2005; Elith et al., 2006; Jime´nez-Valverde et al., 2008). One presence-only modelling method that is used widely (Maxent – Phillips et al., 2006) involves maximum entropy modelling and has been used successfully to predict the distributions of bat species in both present day conditions (e.g. Lamb et al., 2008; Rebelo and G. Jones, 2010) and under projected climate change scenarios (Rebelo et al., 2010). Additionally Maxent has been found to be robust to changes in sample size, and still have good predictive ability at low sample sizes, making it the ideal model for the prediction of distributions for rare species (Hernandez et al., 2006; Wisz et al., 2008).

Figures 1 and 2 both use Maxent to project the distributions of 171 bat species for a number of time periods. By pairing known distribution coordinates each species has been recorded at with appropriate environmental variables it is possible to project the probable distribution of each species for any time period for which spatial data exists, and to combine these to calculate species richness (see Hughes et al., In review, for a full account of methods used).

Using projections of future climatic change it is possible to project the probable impacts and develop targeted solutions and effective conservation methods (Prentice et al., 1992; Beerling et al., 1995; Huntley et al., 1995; Sykes et al., 1996; Berry et al., 2001, 2002; Hannah et al., 2002; Midgley et al., 2002). Though improvements in modelling approaches in the future will allow further insights to be generated, such models will take time to be developed and refined. In many areas (such as Southeast Asia) with rapid rates of deforestation, prioritisation of key areas is required to protect areas of high conservation value from deforestation and modelling can facilitate the determination of these priority areas in a region of high conservation importance (Pawar et al., 2007; Sergio et. al., 2007; Gibson et al., 2010).

Box 1. Mapping species distributions using distribution models.

Other countries (e.g. Brazil) with large export markets have also started to produce certified wood for a large proportion of their exports, however few certifications have sufficient biodiversity emphasis (McNeely, 2007). Attempts at certification programs throughout much of SEA have met with little success, as most logged wood is used within the country, and people are not prepared to pay increased prices involved with establishing and maintaining certification (Cashore, et al., 2006; Laurance, 2008b). Until local people value the natural environment, or exports increase, certification will remain an unsuitable scheme for much of SEA. It may be for similar reasons that previous integrated conservation and development projects have met with little success (in terms of impact) despite large-scale investment throughout SEA (Terborgh et al., 2002; McShane & Wells, 2004). Community-based conservation schemes have also been little used outside marine national parks, and their use may be unsuitable for many areas (Gray et al., 2007).

Certification is unlikely to work within SEA, and logging is liable to continue within natural forests (Fredericksen & Putz, 2003). The use of "reduced impact logging" could at least provide a means of providing both humans and biodiversity with a means of existence (Sessions, 2007; Putz et al., 2008). Reduced impact logging would require less human behavioural modification than stopping altogether or certification, and if local people can be educated to perceive it as an efficient way of logging, which preserves ecosystem services then it may provide a means of conservation. However as most logging which takes place in SEA is illegal, enforcement of laws is first essential (EIA/Telepak, 2008). Enforcement is also necessary to restrict hunting, and requires not only education but an enforced system of permits to control it. Logging programmes must also consider that the removal of the most mature trees may have negative consequences for those bat species that roost under bark and in other species which dwell in holes of mature tree (Gibbons & Lindenmayer, 2001; Kunz & Lumsden, 2003; Barclay & Kurta, 2007). As these forest-dwelling species are often the most limited in dispersal abilities, they are liable to suffer most from deforestation (Kingston et al., 2003).

Therefore in the protection of existing highly biodiverse areas, and to prevent an increasingly fragmented landscape further reducing biodiversity (A.C. Hughes et al., in prep b) education and law enforcement are paramount. Well considered funding systems also provide a good opportunity for decreasing biodiversity loss, and ecotourism if well developed could remedy both habitat destruction and overhunting. These are the primary means for protecting areas from anthropogenic direct threats.

4.1 Mitigating the effect of climatic changes on biodiversity

Recently developed models predicted that bat species would both lose areas of suitable habitat in their original range, and would often need to move north if they were to remain in similar niches in response to climatic change (A.C. Hughes et al., in review). However in order to adapt, species must be able to reach suitable habitat. Translocation, and assisted migrations are often put forward as ways of accomplishing this (McLachlan et al., 2007). However many species face the same threats, and so how could species be selected for translocation: by uniqueness, charismatic mega fauna, ecological role or extinction risk? Too many species face the same situation, and too little information exists on many to make translocation a viable solution. Even for species selected as candidates for translocation, (due to IUCN status, or other factors) some species react poorly and show poor survival following translocation (Weinberger et al., 2009). Consequently translocation is not a practicable solution, both due to the number of species that face threat and the variability in the reaction to translocation in particular species, in addition to the financial cost. Human-mediated adaptive strategies should allow species to shift ranges in response to climate change (similar changes have occurred naturally during previous periods of climate change (Hickling et al., 2006; Lenoir et al., 2008)). Movements can be assisted by increasing landscape connectivity, by creating corridors of native forest between existing forest patches particularly in a north-south orientation (Heller & Zavaleta, 2008). These areas must be wide enough so not to act as population sinks, and must contain heterogeneity of both species and genetic variation in order to be viable and sustainable (Lamb et al., 2008, Lamb & Erskine, 2008; Kettle, 2010). Hence there is a need for careful matching of tree species to soil type and area between sites, and corridors should also contain site-appropriate plants including nitrogen-fixing legumes to increase canopy density (Siddique et al., 2008; Suzuki et al., 2009). Afforestation has begun in many countries (UK, Vietnam; McNamara, et al., 2006; McNamara, et al., 2008), and if it is used to connect areas it will give species a higher probability of responding effectively to climatic change, by allowing the species to expand their ranges north as detailed in predictive models (fig.2) and studies in other regions (Malcolm et al., 2006) and therefore not suffer severe reductions in overall range.

5. Conclusion

SEA represents one of the most biodiverse regions on the planet, yet throughout SEA species are at risk due to dynamic interactions between numerous threats, including both direct and indirect drivers of human mediated biodiversity loss. In order to have any chance of preserving a fraction of the current fauna, major changes are needed in human activities, which requires education of people throughout SEA and the minimisation of corruption at all levels. Only if people can gain from the preservation of current biodiversity can it remain, and therefore schemes that use the environment in a sustainable manner present ways for affecting change. Even under fairly minimal impact scenarios modelled, almost all bat species lost original habitat (up to 99%), and many will be unable to reach new suitable areas (A.C. Hughes et al., in review). To allow species to respond to climate change without going extinct will require not only the cessation of destructive activities, but the active intervention of humans to create forested corridors between current forests to allow species an opportunity to reach suitable habitat under changing conditions.

There is no doubt that even with direct conservation action, climatic change and direct environmental change will lead to the loss of species, some as yet undescribed. What cannot yet be quantified is the number of species which will become extinct during the next century, because the number of extinctions is under the direct control of human choices and actions made now. At this point in time humans do have an opportunity to reduce the impacts of destructive human activities and mitigate the effect of climatic change through effective and considered conservation activities, but with further inaction we as a species increase the total number of other species that will become extinct due to our unsustainable human activities.

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7. Appendix 1.

Variables included in species distribution models:
Vegetation cover: Globcover-Ionia (http://ionia1.esrin.esa.int/)
Mean annual temperature, minimum and maximum annual temperature, minimum and maximum mouthy precipitation, total annual precipitation, isothermality: www.worldclim.org
Humidity: New et al. 1999 (http://atlas.sage.wisc.edu/)
Elevation: NGDC http://www.ngdc.noaa.gov/mgg/topo/globe.html)
Soil pH :ISRIC-WISE (www.isric.org/)
Distance from waterways and distance from roads: Edited from U.S. Geological Survey (USGS- www.usgs.gov/)
Karsts: Karst portal- School of Environment, University of Auckland, (http://web.env.auckland.ac.nz/our_research/karst/)
Geology :CCOP-Coordinating Committee of Geoscience Programmes in Asia and Southeast Asia (www.ccop.or.th/),Prince of Songkla University's GIS centre, Ministry of Mining in Myanmar.
Human population density: Ciesen (Grump v1: http://sedac.ciesin.columbia.edu/gpw/)
A2 and B1 future climate scenarios: CIAT-GCM (Centro Internacional de Agricultura Tropical-Global Climate Model, - CSIRO-Mk2.0 model: http://ccafs-climate.org/)

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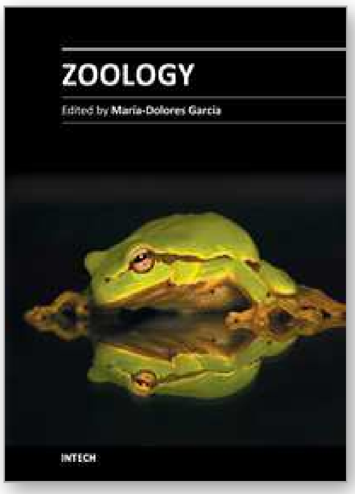

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The present book is not a classical manual on Zoology and the reader should not expect to find the usual treatment of animal groups. As a consequence, some people may feel disappointed when consulting the index, mainly if searching for something that is considered standard. But the reader, if interested in Zoology, should not be disappointed when trying to find novelties on different topics that will help to improve the knowledge on animals. This book is a compendium of contributions to some of the many different topics related to the knowledge of animals. Individual chapters represent recent contributions to Zoology illustrating the diversity of research conducted in this discipline and providing new data to be considered in future overall publications.

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