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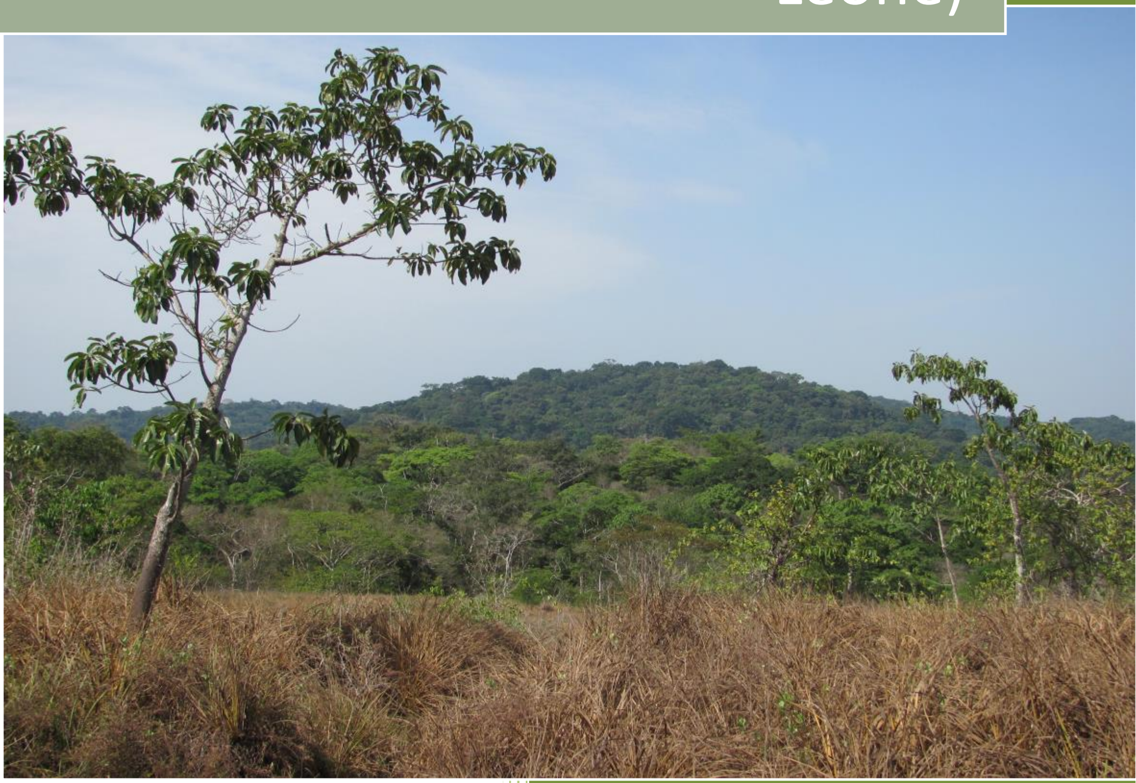
2015

Species monitoring recommendations for the Greater Gola Peace Park (Liberia and Sierra Leone)



ENGLISH

Jamie Carr

IUCN Global Species Programme

2015

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Executive Summary

This report is one in a series of five, and presents recommendations for strategies to monitor the impacts of climate change on species at the Greater Gola Trans-boundary Peace Park (GGTPP), which spans Liberia and Sierra Leone.

The development of these recommendations followed a three-step process:

1. The application of IUCN's climate change vulnerability assessment framework to all terrestrial and freshwater vertebrates of the West Africa region, to determine those species that are likely to be most vulnerable to climate change.
2. A GIS-based analysis, combining spatially explicit data on species' ranges (from the IUCN Red List) and protected areas (from the World Database of Protected Areas, or WDPA) to derive estimated species lists for the sites of interest.
3. A consultation with species experts with good knowledge of the site, wherein they were presented with the results from the above two steps and asked to provide specific monitoring recommendations based upon these.

The main recommendations given were as follows:

Although no amphibians at the site were specifically identified as being among the region's most vulnerable species, the group as a whole are known to excellent bio-indicators, and there is local expertise available in species identification and common survey techniques for this group. Species recommended for monitoring include: *Amietophrynus taiensis*, *Hylarana occidentalis*, *Phrynobatrachus annulatus*, *Phrynobatrachus alleni*, *Conraua alleni* and *Odontobatrachus* (*Petropedetes*) *natator*, several of which are already receiving monitoring.

Bird species recommended for monitoring were *Bycanistes cylindricus, Ceratogymna elata, Malimbus ballmanni, Picathartes gymnocephalus, Psittacus timneh* and *Scotopelia ussheri*, several of which are already receiving monitoring.

No specific freshwater fish were recommended for monitoring, although the assumed high sensitivity of this group as a whole to climate change, and the availability of baseline data for the site, means that this group remains a good candidate for monitoring. It is suggested that this group is better suited to monitoring at the community level, giving focus to key habitats.

Numerous mammals were suggested as candidates for monitoring, including large mammals such as *Cercopithecus Diana, Cephalophus jentinki, Cephalophus ogilbyi, Cephalophus zebra, Choeropsis liberiensis, Colobus polykomos, Loxodonta cyclotis, Pan troglodytes verus, Procolobus badius* and *Tragelaphus eurycerus*, smaller mammals such as *Graphiurus nagtglasii, Nandinia binotata, Phataginus tricuspis* and *Smutsia gigantea*, and the bat species Eidolon *helvum, Hipposideros ruber* and *Miniopterus schreibersii.*

No specific local expertise is known to be available for reptiles or invertebrate groups, although in the case of the latter, development of monitoring plans for Hymenoptera, Lepidoptera and Odonata was recommended as a priority.

Typically, recommendations for all groups included monitoring (in combination with the monitoring of relevant climatic factors) the availability (i.e. abundance and phenology) and quality of key habitats and microhabitats. For aquatic habitats and species the monitoring of factors such as flow rates and dissolved oxygen was also recommended.

This report also provides some more generic recommendations on developing monitoring schemes, including on the setting of objectives, the monitoring of climatic factors, and consideration of the timescales required in order to identify species' population trends and to determine whether these are attributable to climatic factors or are simply natural fluctuations. We also urge those developing species monitoring schemes to consider other factors, such as whether there is already a monitoring scheme in place; whether it is better to monitor one, several or many species; whether there are confounding factors (e.g. human hunting) which may disguise or falsely implicate the impacts of climate change; and whether or not the species proposed for monitoring is sufficiently observable to detect a population trend. For those wishing to develop a monitoring scheme for one or more bird species, additional information on the practicalities of doing so, provided by BirdLife International, is presented as an appendix.

1. Introduction

This report is one in a series of five, each of which presents recommendations for strategies to monitor the impacts of climate change on species at five trans-boundary pilot sites across the focal region of West Africa. Here we specifically consider the Greater Gola Trans-boundary Peace Park (GGTPP), which spans Liberia and Sierra Leone. The report contains information on the methods used to identify the species most vulnerable to climate change at both the regional and site scales, and presents results specific to the focal site. It also describes the methods and results of the consultation process used to identify species (or species groups) considered to be best suited and/or the greatest priorities for the monitoring of climate change impacts within the GGTPP.

Prior to this, we present information on the importance of monitoring species in the context of climate change.

2. Importance and basics of species monitoring under climate change

It is now widely accepted that rapid, anthropogenic climate change is having, and will continue to have, impacts on biodiversity. Although in some cases certain (typically more generalist) species may benefit from climate change, for many other species climate change will present a new threat, which could either act alone or in combination with existing threats to increase the risk of local or global extinction (Urban 2015). The general consensus among experts and the relevant literature is that the impacts of climate change on biodiversity (and the societies that depend on it) will be predominantly negative (Bellard *et al.* 2012).

Within their current ranges, some species may experience one or more of the following as a result of climate change: changes to their habitats or microhabitats; changes of environmental factors beyond tolerable thresholds; disruptions to important interspecific interactions (e.g. the loss of an important prey item, pollinator etc.); the emergence or increase of novel, negative interspecific interactions (including by humans); the disruption of important environmental cues or triggers and/or increases in the frequency of localised extinctions due to stochastic events (Foden *et al.* 2013). Species that are sensitive to such changes (and are exposed to significant climatic change in the first place) might be expected to respond in one of two ways: (1) to disperse to areas where the environment is more suitable, or (2) to adapt to change *in-situ* through genetic or behavioural microevolution. Species that are unable to respond in such a way (e.g. due to low genetic variability, low reproductive output, the presence of barriers that prevent dispersal and/or a low intrinsic capacity for dispersal) are those species that are considered to be the most vulnerable to climate change (Foden *et al.* 2013).

Biodiversity monitoring is widely conducted across the world as a means to detect changes in natural systems, and to assess the requirements and effectiveness of management actions. There is now an increasingly urgent need to monitor the impacts of climate change on species, so that managers may respond to this emerging threat in the most timely and effective manner.

In many cases, the monitoring of climate change impacts on biodiversity (and particularly of individual species) can and should build upon existing monitoring schemes. Nevertheless, certain additional steps and considerations must be made when developing a monitoring strategy to specifically look at climate change impacts. Although it is beyond the scope of this report to lay out the specifics of a monitoring strategy (though suggestions for further reading on this topic are provided at the end of the document, and more detailed information for those wishing to monitor birds is presented as an appendix), here we remind the reader of a few additional key points that are specific to monitoring in a climate change context:

1) It is essential to monitor over a long time period (ideally spanning several decades) as effects may only be detectable over many years (Yoccoz *et al.* 2001).

2) In addition to monitoring biodiversity, it is essential to monitor the actual climate. In some cases such data may be available from long-term weather stations, although one must remain aware of the uncertainties associated with these data, and particularly when making inferences about trends at locations farther away and/or at finer scales (e.g. at the microhabitat level). The ideal protocol is to monitor weather and climate at the exact location where any biodiversity sampling takes place, although this will often be highly restricted by the availability of resources and expertise.

3) Any monitoring effort needs to set its objectives prior to developing the sampling protocol, as the former will greatly influence the latter. Similarly, the sampling protocol (and anticipated analyses) should be clearly stated so that they can be implemented consistently by multiple people, as will typically be required over such a long timeframe.

4) When selecting the species (or species groups) that will form the subject of the monitoring strategy, several key considerations should be borne in mind:

    a. **Is there already a monitoring scheme in place**, which could be adapted to consider climate change? Making use of long term data sets can provide indication of trends much more rapidly than when setting out anew. However, do take time to consider the sampling protocol used (and whether it is appropriate) as well the other points that follow in this section.

    b. **Should I monitor one, several or many species?** It is generally little more work, and much more powerful, to monitor all (sufficiently common) species using whichever technique is chosen, rather than a subset of pre-selected species. Moreover, we encourage a holistic assessment of biodiversity trends wherever possible. Nevertheless, the following point describes why certain species could provide a misleading impression of how climate change is (or is not) having an impact. As such we do also recommend that specific attention is paid to species which are already suspected to be vulnerable to climate change, and for which there are no (or few) confounding factors (e.g. non-climatic threats) at work.

c. **Are there any other factors at work that may disguise the impacts of climate change?** For species that are already subject to ongoing, non-climatic pressures (e.g. human collection, pollution etc.), it may not be possible to determine the significance of additional pressures arising from climate change. As such, it is desirable to aim to monitor species that are otherwise unaffected. Where one wishes to focus upon a species that is already threatened, then it may be possible to focus efforts on a sub-population of the species which is stable and not subject to any other threats.

d. **Is my focal species sufficiently observable to detect a population trend?** Species that are not readily detected, perhaps because they are cryptic and/or rare, will not make good monitoring subjects as they will not provide sufficient data to detect a change in distribution or population. Managers should aim to focus on species that are sufficiently common and observable to provide a useful dataset.

3. Description of the transboundary pilot site

The GGTPP, which comprises Gola Rainforest National Park (GRNP) in Sierra Leone and the Gola Forest National Park (GFNP), soon to be established in Liberia.

A Memorandum of Understanding was signed in May 2011 between the governments of Sierra Leone and Liberia (Mano River Union) on the cooperation in management, research, protection and conservation of the Greater Gola Trans-boundary Peace Park. However, in order to be effective, the boundaries of the Gola Forest in Liberia need to be demarcated and the protected area gazetted as a National Park. It is expected that a new operational agreement will then be drafted in the future. A draft management plan has been drafted by Liberia, but the process is on hold until the Gola Forest is gazetted as a National Park in Liberia. A joint management plan will be drafted following the signing of the new agreement.

There is currently a biodiversity monitoring system in place for flagship species found in GRNP as part of the Gola REDD Project, such as Rockfowl (*Picathartes* sp.) and Pygmy Hippopotamus, but the monitoring does not take into account the impact of climate change on species.

4. Traits-based vulnerability assessments

In a process led by the International Union for Conservation of Nature's Global Species Programme (IUCN-GSP), almost all terrestrial and freshwater vertebrates of the West Africa region were assessed in terms of their vulnerability to climate change (see Carr *et al.* 2014 for the full report). Through two expert workshops, remote consultations, and using data available from previous projects, biological and ecological trait data were collated for 183 amphibians, 1,172 birds, 517 freshwater fish, 405 mammals and 307 reptiles. These data were used to infer, for each individual species, 'sensitivity' and 'adaptive capacity' to climate change and its impacts. Species distribution polygons, collated through the process of assessing species for the IUCN Red List of Threatened Species™, were overlaid with future climate projections provided by the UK Met Office Hadley Centre to determine the changes in the means and variability of temperature and precipitation that each species may be exposed to. Species that are both sensitive and poorly able to adapt to climate change, and are among the most severely exposed to climatic changes are described as 'climate change vulnerable'.

These data were used to derive estimates of the levels of species vulnerability at each site (see Table 1), as well as to guide experts on the selection of species for the monitoring strategy, as described in section 5.

Results for the GGTP

Using species distribution polygons collected through the assessment process for IUCN's Red List, in combination with a polygon representing the geographic boundaries of GGTPP, it was possible to derive a list of species considered likely to occur at the site. It is important to note that this list, which is presented as Appendix 1 at the end of this report, is likely to both include and omit species that may or may not actually occur at the site, due to the imprecise nature of the input spatial data. Nevertheless, it was widely agreed that this method of deriving species lists for each site was the best approach available, given the poor availability of alternative data sources and/or methods, and the wide taxonomic scope that we wished to consider.

The total numbers of species from each of the five taxonomic groups estimated to occur at the GGTPP is presented in Table 1. This table also presents, for each taxon, the number of species considered to be climate change vulnerable, as well as the number of species deemed to be 'biologically susceptible' to climate change (i.e. considered both sensitive and poorly able to adapt to climate change, but not necessarily expected to be exposed to large changes). It is important to note that the measures of overall vulnerability presented in this table are relative to all other species considered in the wider, regional assessment, while measures of biological susceptibility are not.

Table 1. Numbers of species, including climate change vulnerable and biologically susceptible species, estimated to occur at the GGTPP.

Taxon	Estimated number of species	Estimated number of climate change vulnerable species	Estimated number of biologically susceptible species
Amphibians	44	0	6
Birds	415	96	119
Freshwater Fish	106	23	56
Mammals	136	10	30
Reptiles	71	9	17

5. Expert consultations

In order to gather suggestions and recommendations for a climate change monitoring strategy, we consulted a wide range of local and international experts. More than 200 experts were approached, and a response rate of just over 10 percent was received (noting that some individuals opted to provide feedback following internal, group consultations). Experts were provided with three documents (in both French and English):

- The original, regional assessment report (Carr *et al.* 2014), which provides background information on the methods used to assess climate change vulnerability at the regional level.
- Lists of species derived for each of the five pilot sites, including indication of the specific vulnerability traits relevant to each species.
- A form on which to provide suggestions of candidate species for monitoring, as well as other comments and suggestions. This form requested three main types of information:
    - The name of the species (or species group) proposed.
    - Justification of why the species (or group) is considered a good and/or important species for monitoring under climate change.
    - A brief description of how the monitoring should be conducted.

The remainder of this document provides a summary of the feedback received, which was either specific or relevant to the GGTPP.

6. Expert recommendations

Table 2 contains the species-specific monitoring recommendations provided by experts through our consultation process.

Table 2. Monitoring recommendations for the Greater Gola Peace Park gathered through expert consultations

Taxon	Species	Taxonomic notes	Monitoring recommendations
Amphibians	*Amietophrynus taiensis**, *Hylarana occidentalis**, *Phrynobatrachus annulatus**, *Phrynobatrachus alleni*, *Conraua alleni**, *Odontobatrachus* (*Petropedetes*) *natator* * denotes species that are already receiving monitoring.	This taxonomic group includes several globally threatened and Near Threatened species that therefore should be monitoring priorities; they are part of ongoing monitoring and conservation efforts and baseline data and standardized monitoring techniques exist (plots). Amphibians are known to be excellent bio-indicators; due to their partly aquatic life cycle and relatively (among vertebrates) short generation times, climatic and environmental changes affecting populations can be observed within short timeframes. Furthermore, there is local expertise available in species identification and common survey techniques.	In combination with monitoring of climatic factors (temperature including water temperature for aquatic habitats and precipitation), the availability (i.e. abundance) of habitats and microhabitats that are suitable and essential for these species should be monitored, as should the abundance of the species within them. Across the site, habitat data should be collected in order to define present habitat types as well as population trends of species. Remote sensing can also help identify available habitat types and, if possible, species habitat modelling can help with identifying areas where species are more likely to occur. For particular aquatic habitats, measuring oxygen levels might show changes resulting from climatic changes.

Taxon	Species	Taxonomic notes	Monitoring recommendations
Birds	*Bycanistes cylindricus**, *Ceratogymna elata**, *Malimbus ballmanni**, *Picathartes gymnocephalus**, *Psittacus timneh**, *Scotopelia ussheri* * denotes species that are already receiving monitoring.	Most of the birds species listed are part of ongoing monitoring and conservation efforts and baseline data and standardized monitoring techniques exist (e.g. bird point counts). Furthermore, there is available in local expertise in species identification and used survey techniques. <u>*B. cylindricus*</u>: This species is conspicuous (large and noisy), and therefore relatively easily surveyed even by non-specialist ornithologists. Associated with relatively undisturbed high forest and large forest areas; also important for long-distance dispersal of canopy tree species, therefore both indicative of health of the system and significant for maintenance of that system. Given that two other large hornbill species are also listed (*B. fistulator* and *C. atrata*), with the same sensitivities, a programme monitoring all three together would be sensible. <u>*M. ballmanni*</u>: Species restricted to very few primary forest areas in the Upper Guinean Forest region, and likely vulnerable to climatic changes; Endangered and thus also a monitoring and conservation priority; easy to identify and first baseline data on distribution and habitat requirements exist.	In combination with monitoring of climatic factors (temperature and precipitation), the availability (i.e. abundance) of habitats and microhabitats that are suitable and essential for these species should be monitored, as should the abundance of the species within them. Across the site, habitat data should be collected in order to define present habitat types as well as population trends of species. Remote sensing can also help identify available habitat types and if possible, species habitat modelling can help with identifying areas where species are more likely to occur. Further general information on the practicalities of monitoring of birds under climate change is available in Appendix 2 (Guidance for monitoring birds in West African Protected Areas under Climate Change).

Taxon	Species	Taxonomic notes	Monitoring recommendations
		P. gymnocephalus: Species is Vulnerable and, therefore, monitoring and conservation is considered a priority. Specialised on particular microhabitat (builds nest colonies in rocks with particular features and close to water), distribution seems to be dependent on environmental and climatic features. Restricted to only few areas, easy to monitor. Baseline data on distribution and habitat requirements exist. *S. ussheri*: Species is Vulnerable and, therefore, monitoring and conservation is considered a priority. Specialised on a particular microhabitat along streams. Distribution seems to be dependent on environmental and climatic features. Restricted to only few areas, but detailed knowledge on distribution are lacking, with only very few records so far.	

Taxon	Species	Taxonomic notes	Monitoring recommendations
Fish	No specific species recommended for monitoring	Freshwater fish (and the aquatic systems that they inhabit) are believed to be highly sensitive to climate change, and although such sensitivity can vary between species, the group is typically better suited to monitoring at the community level, giving focus to key habitats. Baseline fish survey data exist for Gola Rainforest National Park.	In combination with monitoring of climatic factors (temperature and precipitation), the availability (i.e. abundance) and quality of key habitats and microhabitats for fish should be monitored. The monitoring of additional variables, such as flow rates and levels of dissolved oxygen, will also provide insights into the quality of aquatic habitats. Efforts should focus on key habitats and microhabitats, and it is suggested that stretches of river that are susceptible to becoming intermittently dry, as well as shallow areas important for spawning and/or juvenile development, should form priorities for monitoring. Regular sampling at these locations should monitor the overall diversity of fish communities, as well as the relative abundances of the species present. As with mammals, care should be taken to avoid attribution of species trends to climate change where other confounding threats could be having an influence. As such, a focus on species that are highly popular for human collection and/or consumption should be avoided.

Taxon	Species	Taxonomic notes	Monitoring recommendations
Mammals	Large mammals: *Cercopithecus Diana**, *Cephalophus jentinki**, *Cephalophus ogilbyi*, *Cephalophus zebra**, *Choeropsis liberiensis**, *Colobus polykomos**, *Loxodonta cyclotis**, *Pan troglodytes verus**, *Procolobus badius**, *Tragelaphus eurycerus* Smaller mammals: *Graphiurus nagtglasii*, *Nandinia binotata*, *Phataginus tricuspis*, *Smutsia gigantea* Bats: *Eidolon helvum*, *Hipposideros ruber*, *Miniopterus schreibersii* * denotes species that are already receiving monitoring.	Large mammals: Many of the large mammal species listed are part of ongoing monitoring and conservation efforts, and baseline data and standardized monitoring techniques (camera traps and transect surveys) exist for them. Furthermore, there is local expertise in species identification and common survey techniques. Nevertheless, all may be subject to additional (non-climatic) threats, and so care should be taken when inferring impacts from climate change. It may be useful to monitor levels of human harvesting of species in unison with climatic factors, to determine whether climate change impacts on human communities are influencing bushmeat hunting and trade. Smaller mammals: This group includes a small rodent, a small carnivore and the pangolins. Most are included due to their notable interspecific interactions and/or microhabitat associations, which may increase their sensitivity to climate change. *G. nagtglasii* is highly dependent on tree hollows. *N. binotata* is arboreal and mainly frugivorous, and may be sensitive to fruit ripening periods. Pangolins have highly specialised diets, feeding exclusively on termites and ants, and are noted as having inefficient thermoregulatory systems compared to other mammals. Pangolins are also subject	Large mammals: Monitoring should build upon existing schemes, and should aim to integrate additional elements such as the monitoring of climatic factors (temperature and precipitation), and the associated availability and quality of suitable habitats and microhabitats. Monitoring of species harvest levels by humans (e.g. at markets) in combination with climate change impacts to nearby human communities may highlight climate change-driven trends in bushmeat trade. Monitoring of large mammals in the context of climate change at this site must take into account other potentially confounding threats. For example, forest monkeys are often conspicuous and easily monitored, but can be subject to hunting pressures which may not be easily partitioned from climate-related trends. Smaller mammals: In combination with monitoring of climatic factors (temperature and precipitation), the availability (i.e. abundance and phenology) of essential habitats, microhabitats and food species should be monitored, as should the overall abundance of each species. Across the site, habitat data should be collected in order to define present habitat types, as well as population trends. As with larger mammals, above, monitoring of pangolin populations and exploitation levels with respect to impacts of climate change on humans could highlight climate change-driven trends in bushmeat trade.

Taxon	Species	Taxonomic notes	Monitoring recommendations
		to human hunting, and so the caveats and suggestions given under large mammals above also apply here. Bats: Bats were noted by several experts as being good candidates for the monitoring of climate change impacts, particularly as they are often easily surveyed, sensitive to environmental change and typically subject to less additional pressures than other mammals. Of particular note is the ongoing activities of the Eidolon Monitoring Network, which has responded to suggestions of Newson *et al.* (2009) that *E. helvum* is an especially good indicator of the impacts of climate change on migratory species. Implementers of the monitoring strategy are encouraged to liaise with this group to develop a robust database.	Bats: In combination with monitoring of climatic factors (temperature and precipitation), the availability (i.e. abundance) of habitats and microhabitats suitable for this species should be monitored, as should the abundance of the species within them. Across the site, habitat data should be collected in order to define present habitat types, as well as population trends. Records on the flowering and fruiting times of important food species should also be kept, as they may provide insights into the reason for any population or phenological trends observed.
Reptiles	No specific species recommended for monitoring	There is a notable lack of reptile expertise at this site, including a lack of baseline data and standardized survey techniques, making it problematic to plan monitoring for this group. Furthermore, in forested areas, encounters with reptiles are few, and are typically random, chance events, making the identification of long-term, climate-related trends very challenging.	No recommendations made.

Taxon	Species	Taxonomic notes	Monitoring recommendations
Invertebrates	No specific species recommended for monitoring	Although there is a notable lack of invertebrate expertise at this site (and indeed across the much of the continent), experts noted the importance of monitoring invertebrates in order to detect system changes, including those occurring at lower trophic levels. This site, given its established and successful management history, may be suitable for the monitoring of invertebrates. Potential candidate groups for monitoring include: Hymenoptera, Lepidoptera and Odonata.	See comments in column to the left.

5. Suggested additional reading

Bibby *et al.* (2000) Bird Census techniques (2nd ed). Academic Press, London.

Davies *et al.* (eds.) (2002) African Forest biodiversity: a field survey manual for vertebrates. Earthwatch Europe. [Available here]

Lepetz *al.* (2009) Biodiversity monitoring: some proposals to adequately study species' responses to climate change. *Biodiversity and Conservation* 18 (12): 3185-3203. [Available here]

6. References

Bellard *et al.* (2012) Impacts of climate change on the future of biodiversity. *Ecology letters* 15(4): 365-377.

Carr *et al.* (2014) A Climate Change Vulnerability Assessment of West African Species. UNEP-WCMC technical report.

Foden *et al.* (2013) Identifying the World's Most Climate Change Vulnerable Species: A Systematic Trait-Based Assessment of all Birds, Amphibians and Corals. *Plos One*. DOI: 10.1371/journal.pone.0065427

IUCN (2015) The IUCN Red List of Threatened Species. Version 2014.3.

Newson *et al.* (2009) Indicators of the impact of climate change on migratory species, Endangered species research 7 (2): 101-113.

Urban (2015) Accelerating extinction risk from climate change. *Science* 348 (6234): 571-573.

Yoccoz *et al.* (2001) Monitoring of biological diversity in space and time. *Trends in Ecology and Evolution* 16: 446–453.

7. Appendix 1: Species lists for the GGTPP

The following tables present species lists derived for the GGTPP using IUCN Red List species distribution maps and digital boundaries of the site. Tables include information on the threat status of each species according to the IUCN Red List of Threatened Species (IUCN 2014) and information on the perceived climate change vulnerability of each species according to the biological traits presented in Carr *et al*. (2014). Empty cells infer that a species is not sensitive, climate change vulnerable etc. We encourage making reference to Carr *et al.* (2014) in order to gain further information on the species traits investigated, and to gain a full understanding of the assessments process applied. Note that a question mark in the final columns of any of the following tables indicates that this species has undergone a taxonomic change since the original assessment, meaning that trait data are either not available or no longer valid. Finally, it should be noted that these lists are estimates based on desk-based GIS analyses, and should not be considered as exhaustive or complete. At best, we hope that they provide a reasonable indication of the species that are likely to occur at the focal site.

Amphibians

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Afrixalus dorsalis	LC	Yes	Yes	
Afrixalus fulvovittatus	LC	Yes	Yes	
Afrixalus nigeriensis	NT		Yes	
Afrixalus vittiger	LC	Yes	Yes	
Amietophrynus maculatus	LC			
Amietophrynus regularis	LC	Yes		
Amietophrynus togoensis	NT	Yes		
Astylosternus occidentalis	LC	Yes		
Chiromantis rufescens	LC	Yes		
Conraua alleni	VU (B2ab(iii))	Yes		
Geotrypetes seraphini	LC		Yes	
Hemisus guineensis	LC	Yes		
Hoplobatrachus occipitalis	LC			
Hylarana albolabris	LC	Yes		
Hyperolius chlorosteus	NT	Yes		
Hyperolius concolor	LC	Yes	Yes	
Hyperolius fusciventris	LC	Yes		
Hyperolius guttulatus	LC		Yes	
Hyperolius lamottei	LC	Yes		
Hyperolius nitidulus	LC	Yes		
Hyperolius picturatus	LC			
Hyperolius zonatus	NT	Yes	Yes	
Kassina cochranae	NT	Yes		

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Leptopelis macrotis	NT	Yes		
Leptopelis spiritusnoctis	LC		Yes	
Leptopelis viridis	LC	Yes		
Odontobatrachus natator	NT			
Phlyctimantis boulengeri	LC		Yes	
Phrynobatrachus alleni	NT			
Phrynobatrachus calcaratus	LC			
Phrynobatrachus fraterculus	LC			
Phrynobatrachus guineensis	NT	Yes	Yes	
Phrynobatrachus latifrons	LC			
Phrynobatrachus liberiensis	NT			
Phrynobatrachus phyllophilus	NT	Yes		
Phrynobatrachus tokba	LC			
Ptychadena arnei	DD			
Ptychadena bibroni	LC	Yes		
Ptychadena longirostris	LC		Yes	
Ptychadena mascareniensis	LC			
Ptychadena pumilio	LC	Yes		
Ptychadena superciliaris	NT			
Ptychadena tournieri	LC	Yes		
Xenopus tropicalis	LC			

Birds

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Accipiter badius	LC		Yes	
Accipiter erythropus	**LC**	**Yes**	**Yes**	**Yes**
Accipiter melanoleucus	LC		Yes	
Acrocephalus arundinaceus	LC			
Acrocephalus schoenobaenus	LC	Yes		
Acrocephalus scirpaceus	LC	Yes		
Actitis hypoleucos	LC		Yes	
Actophilornis africanus	LC			
Agapornis swindernianus	LC	Yes		
Agelastes meleagrides	VU (A2cd+3cd+4cd)	Yes		

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Alcedo quadribrachys	LC	Yes		
Alethe diademata	LC	Yes	Yes	
Alethe poliocephala	LC		Yes	
Amandava subflava	LC			
Anastomus lamelligerus	LC		Yes	
Andropadus ansorgei	**LC**	**Yes**	**Yes**	**Yes**
Andropadus curvirostris	LC	Yes		
Andropadus gracilirostris	LC	Yes		
Andropadus gracilis	**LC**	**Yes**	**Yes**	**Yes**
Andropadus latirostris	**LC**	**Yes**	**Yes**	**Yes**
Andropadus virens	LC		Yes	
Anhinga rufa	LC		Yes	
Anthreptes collaris	LC			
Anthreptes fraseri	LC	Yes		
Anthreptes gabonicus	LC	Yes	Yes	
Anthreptes rectirostris	**LC**	**Yes**	**Yes**	**Yes**
Anthus cervinus	LC		Yes	
Anthus leucophrys	LC			
Anthus similis	LC			
Anthus trivialis	LC	Yes		
Apalis sharpii	LC	Yes	Yes	
Apaloderma narina	LC	Yes	Yes	
Aplopelia larvata	LC		Yes	
Apus affinis	LC		Yes	
Apus apus	**LC**	**Yes**	**Yes**	**Yes**
Apus barbatus	LC	Yes	Yes	
Apus batesi	**LC**	**Yes**	**Yes**	**Yes**
Aquila africana	**LC**	**Yes**	**Yes**	**Yes**
Ardea alba	LC		Yes	
Ardea cinerea	LC		Yes	
Ardea goliath	LC		Yes	
Ardea melanocephala	LC		Yes	
Ardea purpurea	LC		Yes	
Ardeola ralloides	LC		Yes	
Aviceda cuculoides	LC	Yes	Yes	
Baeopogon indicator	**LC**	**Yes**	**Yes**	**Yes**
Bathmocercus cerviniventris	NT	Yes		
Batis occulta	LC	Yes		
Bias musicus	**LC**	**Yes**	**Yes**	**Yes**
Bleda canicapillus	LC	Yes	Yes	
Bleda eximius	**NT**	**Yes**	**Yes**	**Yes**
Bleda syndactylus	**LC**	**Yes**	**Yes**	**Yes**

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Bostrychia hagedash	LC		Yes	
Bostrychia olivacea	**LC**	**Yes**	**Yes**	**Yes**
Bubo leucostictus	**LC**	**Yes**	**Yes**	**Yes**
Bubo poensis	**LC**	**Yes**	**Yes**	**Yes**
Bubo shelleyi	**NT**	**Yes**	**Yes**	**Yes**
Buccanodon duchaillui	**LC**	**Yes**	**Yes**	**Yes**
Burhinus senegalensis	LC		Yes	
Buteo auguralis	LC	Yes	Yes	
Butorides striata	LC			
Bycanistes cylindricus	**VU (A2cd+3cd+4cd)**	**Yes**	**Yes**	**Yes**
Bycanistes fistulator	**LC**	**Yes**	**Yes**	**Yes**
Bycanistes subcylindricus	LC	Yes	Yes	
Calherodius leuconotus	LC		Yes	
Calidris alba	LC		Yes	
Calidris canutus	LC		Yes	
Calidris ferruginea	LC		Yes	
Calidris minuta	LC		Yes	
Calidris pugnax	LC	Yes	Yes	
Calidris temminckii	LC		Yes	
Calyptocichla serina	LC	Yes		
Camaroptera brachyura	LC			
Camaroptera chloronota	**LC**	**Yes**	**Yes**	**Yes**
Camaroptera superciliaris	LC	Yes		
Campephaga lobata	VU (A2c+3c+4c)	Yes		
Campephaga quiscalina	LC		Yes	
Campethera caroli	LC	Yes		
Campethera maculosa	LC	Yes		
Campethera nivosa	**LC**	**Yes**	**Yes**	**Yes**
Canirallus oculeus	**LC**	**Yes**	**Yes**	**Yes**
Caprimulgus climacurus	LC		Yes	
Caprimulgus europaeus	**LC**	**Yes**	**Yes**	**Yes**
Caprimulgus inornatus	LC		Yes	
Caprimulgus longipennis	LC		Yes	
Caprimulgus pectoralis	LC	?	?	?
Caprimulgus tristigma	LC		Yes	
Centropus grillii	LC			
Centropus leucogaster	**LC**	**Yes**	**Yes**	**Yes**
Centropus senegalensis	LC			
Ceratogymna atrata	**LC**	**Yes**	**Yes**	**Yes**
Ceratogymna elata	VU (A2cd+3cd+4cd)	Yes	Yes	

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Cercococcyx mechowi	LC	Yes		
Cercococcyx olivinus	LC	Yes		
Ceryle rudis	LC			
Ceuthmochares aereus	LC			
Charadrius alexandrinus	LC			
Charadrius dubius	LC			
Charadrius forbesi	LC			
Charadrius hiaticula	LC	Yes	Yes	
Charadrius marginatus	LC		Yes	
Chlidonias hybrida	LC		Yes	
Chlidonias leucopterus	LC		Yes	
Chlorocichla simplex	**LC**	**Yes**	**Yes**	**Yes**
Chrysococcyx caprius	LC			
Chrysococcyx cupreus	LC			
Chrysococcyx flavigularis	LC	Yes		
Chrysococcyx klaas	LC			
Cinnyricinclus leucogaster	LC			
Circaetus cinereus	LC		Yes	
Circus aeruginosus	**LC**	**Yes**	**Yes**	**Yes**
Circus macrourus	**NT**	**Yes**	**Yes**	**Yes**
Cisticola aberrans	LC			
Cisticola anonymus	LC	Yes		
Cisticola brachypterus	LC			
Cisticola erythrops	LC			
Cisticola galactotes	LC			
Cisticola lateralis	LC	Yes		
Clamator glandarius	LC			
Clamator levaillantii	LC			
Columba iriditorques	**LC**	**Yes**	**Yes**	**Yes**
Columba unicincta	**LC**	**Yes**	**Yes**	**Yes**
Coracias abyssinicus	LC			
Coracina azurea	LC	Yes		
Corvus albus	LC		Yes	
Corythaeola cristata	**LC**	**Yes**	**Yes**	**Yes**
Corythornis leucogaster	**LC**	**Yes**	**Yes**	**Yes**
Cossypha cyanocampter	**LC**	**Yes**	**Yes**	**Yes**
Cossypha niveicapilla	LC			
Crex egregia	LC			
Crinifer piscator	LC			
Criniger barbatus	LC	Yes		
Criniger calurus	**LC**	**Yes**	**Yes**	**Yes**
Criniger olivaceus	VU (A2c+3c+4c)	Yes		

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Cuculus canorus	**LC**	**Yes**	**Yes**	**Yes**
Cuculus clamosus	LC		Yes	
Cuculus solitarius	LC		Yes	
Cypsiurus parvus	LC		Yes	
Delichon urbicum	LC	Yes		
Dendrocygna viduata	LC	Yes		
Dendropicos fuscescens	LC	Yes		
Dendropicos goertae	LC	LC		
Dendropicos pyrrhogaster	LC	Yes		
Dicrurus adsimilis	LC			
Dicrurus atripennis	**LC**	**Yes**	**Yes**	**Yes**
Dicrurus ludwigii	LC			
Dryoscopus gambensis	LC		Yes	
Dryoscopus sabini	LC	Yes		
Dryotriorchis spectabilis	**LC**	**Yes**	**Yes**	**Yes**
Egretta ardesiaca	LC		Yes	
Egretta garzetta	LC		Yes	
Egretta gularis	LC		Yes	
Elminia longicauda	**LC**	**Yes**	**Yes**	**Yes**
Elminia nigromitrata	**LC**	**Yes**	**Yes**	**Yes**
Eremomela badiceps	LC	Yes		
Erythrocercus mccallii	LC	Yes		
Erythropygia leucosticta	LC	Yes		
Estrilda astrild	LC			
Estrilda melpoda	LC	Yes		
Euplectes afer	LC			
Euplectes ardens	LC			
Euplectes hordeaceus	LC			
Euplectes macroura	LC			
Eurystomus glaucurus	LC	Yes		
Eurystomus gularis	LC	Yes		
Falco cuvierii	LC	Yes	Yes	
Falco peregrinus	**LC**	**Yes**	**Yes**	**Yes**
Falco tinnunculus	LC	Yes		
Ficedula hypoleuca	LC	Yes		
Fraseria cinerascens	**LC**	**Yes**	**Yes**	**Yes**
Fraseria ocreata	LC	Yes		
Gallinago gallinago	LC	Yes		
Gallinago media	NT	Yes		
Gallinula angulata	LC			
Gelochelidon nilotica	LC		Yes	
Glareola nuchalis	**LC**	**Yes**	**Yes**	**Yes**
Glareola pratincola	LC		Yes	

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Glaucidium tephronotum	LC	Yes		
Gymnobucco calvus	**LC**	**Yes**	**Yes**	**Yes**
Gymnobucco peli	**LC**	**Yes**	**Yes**	**Yes**
Gypohierax angolensis	LC		Yes	
Halcyon badia	LC	Yes		
Halcyon leucocephala	LC			
Halcyon malimbica	LC	Yes		
Halcyon senegalensis	LC	Yes		
Haliaeetus vocifer	LC		Yes	
Heliolais erythropterus	LC			
Hieraaetus ayresii	LC	Yes	Yes	
Himantornis haematopus	LC	Yes		
Hippolais polyglotta	LC			
Hirundo abyssinica	LC			
Hirundo fuligula	LC			
Hirundo nigrita	LC	Yes		
Hirundo preussi	LC			
Hirundo rustica	LC			
Hirundo semirufa	LC			
Horizocerus albocristatus	LC	?	?	?
Horizocerus hartlaubi	LC	?	?	?
Hydroprogne caspia	LC		Yes	
Hylia prasina	LC		Yes	
Hyliota violacea	LC	Yes		
Illadopsis cleaveri	**LC**	**Yes**	**Yes**	**Yes**
Illadopsis fulvescens	**LC**	**Yes**	**Yes**	**Yes**
Illadopsis puveli	LC	Yes	Yes	
Illadopsis rufescens	NT	Yes	Yes	
Illadopsis rufipennis	**LC**	**Yes**	**Yes**	**Yes**
Indicator exilis	LC	Yes		
Indicator indicator	LC	Yes		
Indicator maculatus	LC	Yes		
Indicator minor	LC	Yes		
Indicator willcocksi	LC	Yes		
Ispidina lecontei	LC	Yes		
Ispidina picta	LC			
Ixobrychus minutus	LC	Yes		
Ixobrychus sturmii	LC			
Ixonotus guttatus	**LC**	**Yes**	**Yes**	**Yes**
Jubula lettii	DD	Yes		
Jynx torquilla	LC	Yes		
Kaupifalco monogrammicus	LC		Yes	

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Lagonosticta rubricata	LC			
Lagonosticta rufopicta	LC			
Lamprotornis cupreocauda	NT	Yes		
Lamprotornis splendidus	**LC**	**Yes**	**Yes**	**Yes**
Laniarius aethiopicus	LC			
Laniarius leucorhynchus	LC		Yes	
Laniarius turatii	LC		Yes	
Lanius collaris	LC			
Larus cirrocephalus	LC		Yes	
Limosa lapponica	LC		Yes	
Limosa limosa	NT		Yes	
Lonchura bicolor	LC	Yes		
Lonchura cucullata	LC			
Lonchura fringilloides	LC	Yes		
Lophoceros camurus	LC	?	?	?
Luscinia megarhynchos	LC	Yes		
Lybius vieilloti	**LC**	**Yes**	**Yes**	**Yes**
Lymnocryptes minimus	**LC**	**Yes**	**Yes**	**Yes**
Macheiramphus alcinus	LC	Yes	Yes	
Macronyx croceus	LC			
Macrosphenus concolor	LC	Yes		
Macrosphenus kempi	LC	Yes		
Malaconotus cruentus	LC	Yes		
Malaconotus lagdeni	NT		Yes	
Malimbus ballmanni	EN (A2c+3c+4c)	Yes		
Malimbus malimbicus	LC	Yes		
Malimbus nitens	LC	Yes		
Malimbus rubricollis	LC	Yes		
Malimbus scutatus	LC	Yes		
Mandingoa nitidula	LC			
Megabyas flammulatus	LC	Yes		
Megaceryle maxima	LC			
Melaenornis annamarulae	VU (A2c+3c+4c)	Yes		
Melichneutes robustus	LC	Yes		
Melignomon eisentrauti	DD	Yes		
Melocichla mentalis	LC			
Merops albicollis	LC		Yes	
Merops gularis	**LC**	**Yes**	**Yes**	**Yes**
Merops mentalis	NT			
Merops persicus	LC		Yes	
Merops pusillus	LC		Yes	

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Microcarbo africanus	**LC**	**Yes**	**Yes**	**Yes**
Milvus migrans	LC		Yes	
Motacilla aguimp	LC			
Motacilla alba	LC	Yes		
Motacilla flava	LC	Yes		
Muscicapa caerulescens	LC			
Muscicapa cassini	**LC**	**Yes**	**Yes**	**Yes**
Muscicapa comitata	**LC**	**Yes**	**Yes**	**Yes**
Muscicapa epulata	**LC**	**Yes**	**Yes**	**Yes**
Muscicapa olivascens	**LC**	**Yes**	**Yes**	**Yes**
Muscicapa striata	LC	Yes		
Muscicapa tessmanni	DD	Yes		
Muscicapa ussheri	LC	Yes		
Mycteria ibis	LC		Yes	
Myioparus griseigularis	**LC**	**Yes**	**Yes**	**Yes**
Myioparus plumbeus	LC		Yes	
Neafrapus cassini	**LC**	**Yes**	**Yes**	**Yes**
Nectarinia adelberti	LC	Yes		
Nectarinia chloropygia	**LC**	**Yes**	**Yes**	**Yes**
Nectarinia coccinigaster	LC	Yes	Yes	
Nectarinia cuprea	LC		Yes	
Nectarinia cyanolaema	**LC**	**Yes**	**Yes**	**Yes**
Nectarinia johannae	**LC**	**Yes**	**Yes**	**Yes**
Nectarinia minulla	**LC**	**Yes**	**Yes**	**Yes**
Nectarinia olivacea	LC		Yes	
Nectarinia seimundi	**LC**	**Yes**	**Yes**	**Yes**
Nectarinia superba	**LC**	**Yes**	**Yes**	**Yes**
Nectarinia venusta	LC		Yes	
Nectarinia verticalis	**LC**	**Yes**	**Yes**	**Yes**
Neocossyphus poensis	LC	Yes		
Nettapus auritus	LC	Yes	Yes	
Nicator chloris	**LC**	**Yes**	**Yes**	**Yes**
Nigrita bicolor	LC		Yes	
Nigrita canicapillus	LC			
Nigrita fusconotus	LC	Yes		
Nigrita luteifrons	LC			
Numenius phaeopus	LC		Yes	
Onychognathus fulgidus	LC	Yes		
Oriolus brachyrhynchus	**LC**	**Yes**	**Yes**	**Yes**
Oriolus nigripennis	LC	Yes		
Oriolus oriolus	LC	Yes		
Otus icterorhynchus	LC	Yes		
Otus scops	LC	Yes		

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Pachycoccyx audeberti	LC			
Pandion haliaetus	LC		Yes	
Parmoptila rubrifrons	NT	Yes		
Parus funereus	LC	Yes		
Passer griseus	LC			
Pelecanus rufescens	LC		Yes	
Peliperdix lathami	LC		Yes	
Pernis apivorus	**LC**	**Yes**	**Yes**	**Yes**
Phoenicopterus roseus	LC		Yes	
Pholidornis rushiae	**LC**	**Yes**	**Yes**	**Yes**
Phyllanthus atripennis	LC	Yes	Yes	
Phyllastrephus albigularis	**LC**	**Yes**	**Yes**	**Yes**
Phyllastrephus icterinus	**LC**	**Yes**	**Yes**	**Yes**
Phylloscopus trochilus	LC	Yes		
Picathartes gymnocephalus	VU (A2c+3c+4c;C2a(i))	Yes	Yes	
Pitta angolensis	LC			
Platalea alba	LC		Yes	
Platysteira blissetti	LC		Yes	
Platysteira castanea	**LC**	**Yes**	**Yes**	**Yes**
Platysteira concreta	**LC**	**Yes**	**Yes**	**Yes**
Platysteira cyanea	LC		Yes	
Plectropterus gambensis	LC		Yes	
Ploceus albinucha	LC	Yes		
Ploceus cucullatus	LC			
Ploceus nigerrimus	LC	Yes		
Ploceus nigricollis	LC			
Ploceus preussi	LC	Yes		
Ploceus tricolor	LC	Yes		
Pluvialis squatarola	LC		Yes	
Podica senegalensis	LC		Yes	
Poeoptera lugubris	LC	Yes		
Pogoniulus atroflavus	**LC**	**Yes**	**Yes**	**Yes**
Pogoniulus bilineatus	**LC**	**Yes**	**Yes**	**Yes**
Pogoniulus scolopaceus	**LC**	**Yes**	**Yes**	**Yes**
Pogoniulus subsulphureus	**LC**	**Yes**	**Yes**	**Yes**
Pogonornis bidentatus	**LC**	**Yes**	**Yes**	**Yes**
Poicephalus robustus	LC		Yes	
Polyboroides typus	LC		Yes	
Porphyrio alleni	LC			
Porphyrio porphyrio	LC			

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Prinia subflava	LC			
Prionops caniceps	LC		Yes	
Prodotiscus insignis	**LC**	**Yes**	**Yes**	**Yes**
Psalidoprocne nitens	**LC**	**Yes**	**Yes**	**Yes**
Psalidoprocne obscura	LC		Yes	
Pseudhirundo griseopyga	LC			
Psittacus timneh	VU (A2abcd+3bcd+ 4abcd)			
Pternistis ahantensis	LC	Yes		
Pternistis bicalcaratus	LC			
Pteronetta hartlaubii	**LC**	**Yes**	**Yes**	**Yes**
Pycnonotus barbatus	LC			
Pyrenestes sanguineus	LC			
Pytilia hypogrammica	LC			
Quelea erythrops	LC			
Rhaphidura sabini	LC	Yes	Yes	
Rynchops flavirostris	NT		Yes	
Sarothrura elegans	LC			
Sarothrura pulchra	**LC**	**Yes**	**Yes**	**Yes**
Scopus umbretta	LC		Yes	
Scotopelia ussheri	**VU (C2a(i))**	**Yes**	**Yes**	**Yes**
Sheppardia cyornithopsis	**LC**	**Yes**	**Yes**	**Yes**
Smithornis capensis	LC			
Smithornis rufolateralis	**LC**	**Yes**	**Yes**	**Yes**
Spermophaga haematina	LC	Yes		
Spilopelia senegalensis	LC		Yes	
Stephanoaetus coronatus	NT	Yes	Yes	
Stiphrornis erythrothorax	**LC**	**Yes**	**Yes**	**Yes**
Stizorhina fraseri	**LC**	**Yes**	**Yes**	**Yes**
Streptopelia semitorquata	LC		Yes	
Strix woodfordii	LC		Yes	
Sylvia atricapilla	LC	Yes		
Sylvia borin	LC	Yes		
Sylvietta brachyura	LC		Yes	
Sylvietta denti	**LC**	**Yes**	**Yes**	**Yes**
Sylvietta virens	**LC**	**Yes**	**Yes**	**Yes**
Tauraco macrorhynchus	**LC**	**Yes**	**Yes**	**Yes**
Tauraco persa	**LC**	**Yes**	**Yes**	**Yes**
Tchagra australis	LC			
Tchagra senegalus	LC			
Telacanthura melanopygia	**LC**	**Yes**	**Yes**	**Yes**

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Telophorus multicolor	LC			
Telophorus sulfureopectus	LC		Yes	
Terpsiphone rufiventer	LC			
Terpsiphone viridis	LC			
Thalasseus maximus	LC		Yes	
Thescelocichla leucopleura	**LC**	**Yes**	**Yes**	**Yes**
Threskiornis aethiopicus	LC		Yes	
Treron calvus	LC		Yes	
Tricholaema hirsuta	**LC**	**Yes**	**Yes**	**Yes**
Tringa erythropus	**LC**	**Yes**	**Yes**	**Yes**
Tringa glareola	LC		Yes	
Tringa nebularia	LC		Yes	
Tringa ochropus	LC			
Tringa stagnatilis	LC	Yes		
Tringa totanus	**LC**	**Yes**	**Yes**	**Yes**
Trochocercus nitens	**LC**	**Yes**	**Yes**	**Yes**
Turdoides reinwardii	LC		Yes	
Turdus pelios	LC		Yes	
Turnix sylvaticus	LC			
Turtur afer	LC		Yes	
Turtur brehmeri	**LC**	**Yes**	**Yes**	**Yes**
Turtur tympanistria	LC		Yes	
Tyto alba	LC		Yes	
Urotriorchis macrourus	**LC**	**Yes**	**Yes**	**Yes**
Vanellus albiceps	LC		Yes	
Vanellus senegallus	LC		Yes	
Veles binotatus	LC	Yes		
Vidua macroura	LC			
Vidua togoensis	LC			
Zapornia flavirostra	LC			
Zoothera princei	LC	Yes	Yes	
Zosterops senegalensis	LC			

Freshwater fish

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Amphilius atesuensis	LC	Yes	Yes	
Amphilius platychir	LC	Yes	Yes	
Amphilius rheophilus	LC	Yes	Yes	
Anomalochromis thomasi	**LC**	**Yes**	**Yes**	**Yes**
Aplocheilichthys spilauchen	LC		Yes	
Archiaphyosemion guineense	LC	Yes	Yes	
Auchenoglanis occidentalis	LC		Yes	
Awaous lateristriga	NE		Yes	
Barbus ablabes	LC		Yes	
Barbus liberiensis	**EN (B2ab(iii))**	**Yes**	**Yes**	**Yes**
Barbus macrops	LC		Yes	
Barbus parawaldroni	NT	Yes	Yes	
Barbus trispiloides	DD		Yes	
Barbus wurtzi	LC	Yes	Yes	
Bathygobius soporator	NE		Yes	
Bostrychus africanus	LC		Yes	
Brienomyrus brachyistius	LC	Yes	Yes	
Brycinus longipinnis	LC			
Brycinus macrolepidotus	LC		Yes	
Brycinus nurse	**LC**	**Yes**	**Yes**	**Yes**
Callopanchax monroviae	**VU (B1ab(iii)+2ab(iii); D2)**	**Yes**	**Yes**	**Yes**
Callopanchax occidentalis	**NT**	**Yes**	**Yes**	**Yes**
Chrysichthys johnelsi	LC	Yes	Yes	
Chrysichthys maurus	LC	Yes	Yes	
Chrysichthys nigrodigitatus	LC		Yes	
Clarias buettikoferi	LC			
Clarias gariepinus	NE			
Clarias salae	LC			
Ctenopoma kingsleyae	**LC**	**Yes**	**Yes**	**Yes**
Dalophis boulengeri	LC		Yes	
Dormitator lebretonis	LC		Yes	
Eleotris daganensis	LC		Yes	
Eleotris senegalensis	LC		Yes	
Eleotris vittata	NE		Yes	
Epiplatys annulatus	**LC**	**Yes**	**Yes**	**Yes**
Epiplatys barmoiensis	**LC**	**Yes**	**Yes**	**Yes**
Epiplatys fasciolatus	LC	Yes	Yes	

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Epiplatys lamottei	**VU (B1ab(ii,iii)+2ab(ii,iii); D2)**	**Yes**	**Yes**	**Yes**
Epiplatys njalaensis	**EN (B1ab(iii)+2ab(iii))**	**Yes**	**Yes**	**Yes**
Epiplatys roloffi	**EN (B1ab(ii,iii)+2ab(ii,iii))**	**Yes**	**Yes**	**Yes**
Gobioides sagitta	LC		Yes	
Hemichromis bimaculatus	LC	Yes	Yes	
Hemichromis fasciatus	LC	Yes	Yes	
Hepsetus odoe	LC			
Heterobranchus isopterus	LC			
Heterobranchus longifilis	LC			
Hippopotamyrus paugyi	**LC**	**Yes**	**Yes**	**Yes**
Hydrocynus forskahlii	LC		Yes	
Isichthys henryi	LC		Yes	
Kribia kribensis	LC		Yes	
Kribia leonensis	**EN (B1ab(iii)+2ab(iii))**	**Yes**	**Yes**	**Yes**
Kribia nana	LC		Yes	
Labeo coubie	LC			
Labeo parvus	**LC**	**Yes**	**Yes**	**Yes**
Laeviscutella dekimpei	LC			
Lates niloticus	LC			
Leptocypris guineensis	NT	Yes		
Malapterurus barbatus	NT		Yes	
Malapterurus punctatus	**NT**	**Yes**	**Yes**	**Yes**
Malapterurus stiassnyae	NT		Yes	
Marcusenius mento	LC	Yes	Yes	
Marcusenius thomasi	LC	Yes	Yes	
Marcusenius ussheri	LC	Yes	Yes	
Mastacembelus liberiensis	LC	Yes	Yes	
Mormyrops anguilloides	LC	Yes		
Mormyrops breviceps	LC			
Mormyrus tapirus	LC	Yes		
Nannocharax fasciatus	LC	Yes	Yes	
Nematogobius maindroni	NE		Yes	
Neolebias unifasciatus	LC		Yes	
Papyrocranus afer	LC			
Paramphilius trichomycteroides	NT	Yes	Yes	
Pellonula leonensis	NE		Yes	
Pellonula vorax	LC			

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Pelmatochromis buettikoferi	LC	Yes	Yes	
Pelvicachromis humilis	**LC**	**Yes**	**Yes**	**Yes**
Pelvicachromis roloffi	**NT**	**Yes**	**Yes**	**Yes**
Periophthalmus barbarus	LC		Yes	
Petrocephalus pellegrini	LC	Yes	Yes	
Petrocephalus tenuicauda	LC	Yes	Yes	
Polypterus palmas	LC			
Poropanchax normani	LC		Yes	
Raiamas nigeriensis	NT	Yes	Yes	
Raiamas steindachneri	LC	Yes	Yes	
Rhabdalestes septentrionalis	LC		Yes	
Sarotherodon caudomarginatus	LC	Yes	Yes	
Sarotherodon occidentalis	NT	Yes	Yes	
Schilbe intermedius	LC	Yes		
Schilbe micropogon	LC	Yes		
Schilbe mystus	LC	Yes		
Scriptaphyosemion bertholdi	**EN (B2ab(ii,iii))**	**Yes**	**Yes**	**Yes**
Scriptaphyosemion brueningi	**EN (B1ab(iii)+2ab(iii))**	**Yes**	**Yes**	**Yes**
Scriptaphyosemion liberiense	**NT**	**Yes**	**Yes**	**Yes**
Scriptaphyosemion roloffi	**NT**	**Yes**	**Yes**	**Yes**
Sierrathrissa leonensis	LC		Yes	
Synodontis thysi	**LC**	**Yes**	**Yes**	**Yes**
Synodontis waterloti	LC	Yes	Yes	
Tilapia brevimanus	LC	Yes	Yes	
Tilapia buttikoferi	LC	Yes	Yes	
Tilapia guineensis	LC	Yes	Yes	
Tilapia joka	**VU (B2ab(iii))**	**Yes**	**Yes**	**Yes**
Tilapia louka	LC	Yes	Yes	
Tylochromis intermedius	LC	Yes	Yes	
Tylochromis jentinki	LC	Yes	Yes	
Tylochromis leonensis	LC	Yes	Yes	
Yongeichthys thomasi	LC		Yes	

Mammals

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Anomalurus beecrofti	**LC**	**Yes**	**Yes**	**Yes**
Anomalurus derbianus	LC	Yes	Yes	
Aonyx capensis	LC			
Arvicanthis rufinus	LC			
Atherurus africanus	LC	Yes		
Atilax paludinosus	LC			
Caracal aurata	NT			
Cephalophus dorsalis	LC			
Cephalophus jentinki	EN (C1)	Yes	Yes	
Cephalophus niger	LC	Yes	Yes	
Cephalophus ogilbyi	**LC**	**Yes**	**Yes**	**Yes**
Cephalophus silvicultor	LC	Yes		
Cephalophus zebra	VU (A2cd; C1)	Yes	Yes	
Cercocebus atys	VU (A2cd)		Yes	
Cercopithecus campbelli	LC		Yes	
Cercopithecus diana	VU (A2cd)	Yes	Yes	
Cercopithecus petaurista	LC	Yes	Yes	
Chlorocebus sabaeus	LC		Yes	
Choeropsis liberiensis	EN (C1)	Yes	Yes	
Civettictis civetta	LC		Yes	
Colobus polykomos	VU (A2cd)		Yes	
Cricetomys emini	LC			
Crocidura crossei	LC	Yes		
Crocidura denti	LC	Yes		
Crocidura jouvenetae	LC	Yes		
Crocidura muricauda	LC	Yes		
Crocidura nimbae	NT	Yes	Yes	
Crocidura obscurior	LC	Yes		
Crocidura olivieri	LC	Yes		
Crocidura poensis	LC			
Crocidura theresae	LC	Yes		
Crocuta crocuta	LC		Yes	
Crossarchus obscurus	LC	Yes		
Dasymys rufulus	LC			
Dendrohyrax dorsalis	LC	Yes		
Dephomys defua	LC	Yes		
Eidolon helvum	NT	Yes	Yes	
Epixerus ebii	LC	Yes		
Epomops buettikoferi	LC	Yes	Yes	
Funisciurus pyrropus	LC			
Galagoides demidovii	LC		Yes	
Galagoides thomasi	LC		Yes	

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Genetta bourloni	NT	Yes		
Genetta johnstoni	VU (A2cd)	Yes	Yes	
Genetta pardina	LC			
Genetta thierryi	LC			
Gerbilliscus kempi	LC		Yes	
Glauconycteris poensis	LC	Yes		
Grammomys buntingi	DD	Yes		
Graphiurus lorraineus	LC			
Graphiurus nagtglasii	LC			
Heliosciurus punctatus	DD	Yes		
Heliosciurus rufobrachium	LC			
Herpestes ichneumon	LC			
Herpestes sanguineus	LC			
Hipposideros abae	LC	Yes	Yes	
Hipposideros beatus	**LC**	**Yes**	**Yes**	**Yes**
Hipposideros caffer	LC	Yes	Yes	
Hipposideros cyclops	**LC**	**Yes**	**Yes**	**Yes**
Hipposideros fuliginosus	**LC**	**Yes**	**Yes**	**Yes**
Hipposideros jonesi	NT	Yes	Yes	
Hipposideros ruber	**LC**	**Yes**	**Yes**	**Yes**
Hybomys planifrons	LC	Yes		
Hybomys trivirgatus	LC	Yes		
Hyemoschus aquaticus	LC	Yes		
Hylochoerus meinertzhageni	LC	Yes		
Hylomyscus alleni	LC			
Hypsignathus monstrosus	LC	Yes		
Hystrix cristata	LC			
Kerivoula lanosa	LC	Yes		
Lemniscomys striatus	LC			
Leptailurus serval	LC		Yes	
Lophuromys sikapusi	LC			
Loxodonta africana	VU (A2a)	Yes	Yes	
Lutra maculicollis	LC			
Malacomys edwardsi	LC	Yes		
Mastomys erythroleucus	LC			
Mastomys natalensis	LC			
Megaloglossus woermanni	LC	Yes		
Mellivora capensis	LC		Yes	
Micropteropus pusillus	LC	Yes		
Mimetillus moloneyi	LC	Yes		
Miniopterus schreibersii	**NT**	**Yes**	**Yes**	**Yes**
Mungos gambianus	LC			

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Mus musculoides	LC			
Mus setulosus	LC			
Myonycteris torquata	LC	Yes		
Nandinia binotata	LC			
Nanonycteris veldkampii	LC	Yes		
Neotragus pygmaeus	LC	Yes	Yes	
Nycteris arge	LC	Yes		
Nycteris gambiensis	LC	Yes		
Nycteris grandis	**LC**	**Yes**	**Yes**	**Yes**
Nycteris hispida	LC	Yes	Yes	
Nycteris macrotis	LC	Yes		
Nycteris thebaica	LC	Yes		
Oenomys ornatus	LC	Yes		
Orycteropus afer	LC	Yes		
Pan troglodytes	EN (A4cd)		Yes	
Panthera pardus	NT		Yes	
Paraxerus poensis	LC			
Perodicticus potto	LC		Yes	
Phataginus tetradactyla	VU (A4d)			
Phataginus tricuspis	**NT**	**Yes**	**Yes**	**Yes**
Philantomba maxwellii	LC		Yes	
Pipistrellus brunneus	NT	Yes		
Pipistrellus nanulus	LC	Yes		
Pipistrellus nanus	LC	Yes		
Pipistrellus rendalli	LC	Yes		
Pipistrellus somalicus	LC	Yes		
Pipistrellus tenuipinnis	LC	Yes		
Potamochoerus porcus	LC			
Praomys rostratus	LC			
Praomys tullbergi	LC			
Procolobus badius	EN (A2cd)	Yes	Yes	
Procolobus verus	NT	Yes	Yes	
Protoxerus aubinnii	DD	Yes		
Protoxerus stangeri	LC			
Rhinolophus landeri	LC	Yes		
Scotophilus dinganii	LC	Yes		
Scotophilus nux	LC	Yes		
Smutsia gigantea	NT	Yes		
Suncus megalura	LC			
Syncerus caffer	LC		Yes	
Tadarida brachyptera	LC	Yes		
Tadarida condylura	LC			
Tadarida nanula	LC	Yes		

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Tadarida pumila	LC			
Tadarida spurrelli	LC	Yes		
Tadarida thersites	LC	Yes		
Thryonomys swinderianus	LC			
Tragelaphus eurycerus	**NT**	**Yes**	**Yes**	**Yes**
Tragelaphus scriptus	LC		Yes	
Trichechus senegalensis	VU (A3cd; C1)	Yes	Yes	
Uranomys ruddi	LC			
Xerus erythropus	LC			

Reptiles

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Afronatrix anoscopus	NE	Yes		
Agama africana	LC	Yes		
Agama agama	NE	Yes		
Aparallactus modestus	**NE**	**Yes**	**Yes**	**Yes**
Aparallactus niger	LC	Yes	Yes	
Atheris chlorechis	LC	Yes		
Atractaspis corpulenta	**NE**	**Yes**	**Yes**	**Yes**
Atractaspis irregularis	NE	Yes		
Bitis arietans	NE			
Bitis nasicornis	NE			
Bitis rhinoceros	LC	Yes		
Boaedon fuliginosus	NE	Yes	Yes	
Boaedon lineatus	NE	Yes	Yes	
Boaedon olivaceus	**NE**	**Yes**	**Yes**	**Yes**
Boaedon virgatus	**NE**	**Yes**	**Yes**	**Yes**
Calabaria reinhardtii	**NE**	**Yes**	**Yes**	**Yes**
Causus lichtensteinii	**NE**	**Yes**	**Yes**	**Yes**
Causus maculatus	NE	Yes		
Chamaeleo gracilis	NE	Yes		
Chamaelycus fasciatus	NE	Yes	Yes	
Cophoscincopus durus	LC	Yes		
Cophoscincopus greeri	LC	Yes		
Cophoscincopus simulans	LC	Yes		
Crotaphopeltis hotamboeia	NE			
Cynisca liberiensis	LC	Yes	Yes	
Dasypeltis fasciata	NE	Yes		
Dendroaspis viridis	LC	Yes		

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Dipsadoboa brevirostris	LC	Yes		
Dipsadoboa underwoodi	NE	Yes		
Dipsadoboa unicolor	NE	Yes		
Gonionotophis grantii	NE	Yes		
Gonionotophis guirali	NE	Yes		
Gonionotophis poensis	NE	Yes		
Grayia smithii	NE	Yes	Yes	
Hapsidophrys lineatus	NE	Yes		
Hapsidophrys smaragdina	NE			
Hemidactylus angulatus	NE	Yes		
Hemidactylus fasciatus	**NE**	**Yes**	**Yes**	**Yes**
Hemidactylus mabouia	NE	Yes		
Holaspis guentheri	NE	Yes		
Hormonotus modestus	NE	Yes		
Lepidothyris fernandi	NE			
Lycophidion semicinctum	NE	Yes		
Lygodactylus conraui	NE		Yes	
Meizodon regularis	NE			
Mochlus guineensis	NE			
Naja melanoleuca	NE	Yes		
Natriciteres olivacea	NE			
Natriciteres variegata	NE			
Philothamnus carinatus	NE	Yes		
Philothamnus heterodermus	NE			
Philothamnus irregularis	NE	Yes		
Philothamnus nitidus	NE			
Philothamnus semivariegatus	NE	Yes		
Polemon acanthias	**LC**	**Yes**	**Yes**	**Yes**
Psammophis phillipsi	NE			
Pseudohaje nigra	LC			
Python regius	NE	Yes	Yes	
Python sebae	NE	Yes		
Rhamnophis aethiopissa	NE	Yes		
Telescopus variegatus	NE	Yes		
Thelotornis kirtlandii	NE			
Thrasops occidentalis	LC	Yes		
Toxicodryas blandingii	NE			
Toxicodryas pulverulenta	NE			
Trachylepis affinis	NE	Yes	Yes	
Trachylepis bensonii	LC	Yes	Yes	
Trachylepis maculilabris	NE	Yes	Yes	

Species	Red List Category and Criteria	Sensitive?	Low adaptability?	Climate change vulnerable (baseline)?
Trachylepis paucisquamis	**LC**	**Yes**	**Yes**	**Yes**
Varanus exanthematicus	NE			
Varanus ornatus	NE			

Appendix 2: Guidance for monitoring birds in West African protected areas under climate change

Compiled by Stuart Butchart, BirdLife International

Summary

Monitoring biodiversity is important in order to detect changes and assess the effectiveness of management actions. Monitoring is particularly important under climate change given the expected shifts in species' abundance and distribution, and the uncertainty over these.

Birds are useful as indicators for biodiversity more broadly because they are relatively easy to observe, identify and count, widely distributed in most habitats, responsive to environmental change and popular (so there are many potential people available with the skills to monitor them).

Establishing a monitoring scheme requires setting objectives, defining a sampling strategy, selecting appropriate techniques, training and motivating surveyors, analysing data and using the results. Guidance is provided here on each step.

Sampling units are typical defined as 2x2 km or 10x10 km squares. Squares can be selected for surveying using a random sampling approach, regular sampling, or semi-random sampling, but free choice should be avoided as it introduces bias.

Three main alternative survey techniques are described: line-transects, point counts and Timed Species Counts, which have different pros and cons and are suitable for different situations.

It is generally little more work, and much more powerful, to monitor all (sufficiently common) species using whichever technique is chosen, rather than a subset of pre-selected species.

Adequately training and motivating surveyors is essential to ensure accurate and consistent results.

Population trend indictors can be relatively easily calculated from the data generated, and these can be used to meet the monitoring objectives by identifying species that are declining, assessing the accuracy of climate projections, informing management actions and assessing the effectiveness of adaptation responses.

1. Introduction

1.1 Why monitor biodiversity?

It is important to monitor the state of biodiversity in order to detect changes (e.g. increases or decreases in population abundance, species' distributions, community composition etc) and to determine the effectiveness of management actions (for example, aimed at increasing or decreasing the abundance of particular species or habitats). In protected areas, monitoring helps to establish if the biodiversity the area was designated to protect is being maintained, and to inform and track management interventions (e.g. those aimed at reducing poaching, or boosting numbers of a particular iconic species).

1.2 Monitoring under climate change

Under climate change, monitoring is particularly important, because substantial shifts are expected in the species for which individual sites are likely to support suitable habitat in future, owing to changing climatic conditions. For example, in West Africa, many species currently occurring in particular protected areas are not expected to persist in future because of projected changes in the climatic conditions within them. By contrast, other species of conservation concern are expected to colonise particular protected areas in future. Management of individual sites will therefore need to be adjusted through the coming decades. Monitoring will be critical to: (a) detect if projected changes in species' abundance and occurrence happen (and within the projected time-frames), (b) detect if any unexpected shifts in species abundance and distribution occur, and (c) determine if the adaptation actions and management interventions implemented are effective.

1.3 Why monitor birds?

Monitoring all types of wildlife would be extremely expensive and is impractical for a range of reasons. Fortunately, birds are often useful indicators of trends in the state of nature, and thus of the sustainability of human use of landscapes and resources. This is because they are relatively conspicuous, easy to identify, sufficiently diverse yet not overwhelmingly speciose in any particular location, widely distributed, occur in most habitats but with many species being quite specialised in their requirements, responsive to environmental change and popular (so there are many potential people available with the skills to monitor them). It is therefore often feasible and affordable to monitor birds, and valid to use the results to infer trends in the broader environment.

1.4 The guidelines

To facilitate monitoring of birds in West African protected areas under climate change, guidance is provided here on the following topics:

- Setting objectives for monitoring
- Sampling design
- Survey techniques
- Training and motivating surveyors
- Analysing data and using the results
- Additional sources of information

The guidance builds on the extensive experience of BirdLife Partners, their collaborators, and on-going monitoring efforts in Africa, Europe, North America and elsewhere, and draws heavily on Senyata (2007). Note that there is no blue-print for monitoring, and approaches will need to be tailored for the local context, taking into account the resources available, habitats, bird abundance, infrastructure, management structures and monitoring objectives.

2. Setting objectives

The first step in establishing monitoring efforts is to determine the objectives of the monitoring, as it will be impossible to design a scheme or determine its effectiveness unless the objectives it is trying to achieve are clear.

- Examples of questions that could potentially be answered or informed by monitoring include:
- Are the species in a particular protected area being impacted by climate change?
- How are species being impacted?
- Which species are most severely impacted?
- Which are benefitting from climate change? Which are negatively impacted?
- Are the ranges and abundance of species shifting as predicted by climate change vulnerability assessments (e.g. species distribution models, or trait-based assessments of

climate change vulnerability), in terms of the magnitude, rate, timing, and relative impacts across species

- How should management of the protected area change?
- Are climate change adaptation efforts effective?

The objectives chosen will then determine what sort of data needs to be collected, how much of it, how often and so on.

3. Sampling design

Once it is clear what the objectives of monitoring are, it is important to design a monitoring scheme systematically. Resources rarely allow all individuals of all species to be counted throughout a particular protected area. However, a systematic sampling approach can require vastly less effort and cost, yet provide data that can be taken as representative of the protected area as a whole. It necessitates pre-determining the locations within the protected area where data will be collected, and the timing and frequency of data collection.

The basic principle is for the same set of locations, ideally spread throughout protected area, to be surveyed on a regular basis, preferably each year. As it is difficult to predict the future, and because there is considerably uncertainty associated with projected impacts of climate change on species, it generally makes sense to collect data on all bird species recorded (or at least all common species). It is also important to use a standardised methodology (see below), preferably implemented by the same observers between years (with repeated training to ensure consistency within and between observers; see below). Trends in the abundance of each species may then be calculated by assessing changes between years in counts at each survey location.

3.1 Defining and selecting sampling units

It is important to standardize the ‘sampling units’, i.e. locations from which data will be collected. The best approach is to divide the entire protected area into grid squares of a standard size, for example, 2x2 km or 10x10 km squares, rather than using irregularly shaped areas such as wetlands or particular patches of forest.

Then a sample of these squares needs to be selected at which data will be collected. It is extremely important, as much as is practicable, to avoid bias in the selection of sampling units. Such bias might arise from choosing only squares that contain particular habitat types (e.g. wetlands and forest, but not agricultural land or urban areas), or only areas that are known to be good for birds, or only areas with a geographical bias (e.g. from the north of a protected area, or from close to the park headquarters). One approach that should be avoided, if at all possible, is that of 'free choice'. Allowing observers to decide where they survey is almost certain to result in a biased sample. These locations will not be representative of the protected area as a whole, and counts and trends of birds from them will not necessarily be indicative of trends in species across the protected area.

Instead, it is better to select squares through random or regular sampling. The former involves selecting squares entirely at random from the entire sample, whereas the latter involves selecting every 10th, or 20th, or 100th square to ensure an even spread of survey squares across the protected area (with the interval and hence total number of squares being determined by the resources available and heterogeneity of the habitats in the protected area). Both approaches should help to ensure an unbiased and hence representative sample.

In reality, it may not be possible to use a fully random or regular sampling design if the number of potential surveyors is few, the sites too distant, remote, difficult or unsafe to access, or for other practical reasons. In such cases, it is better to adopt a more pragmatic, semi-random approach which allows potential surveyors to define the general area that it is practical to survey within (encouraging this to be set as large as possible). The survey squares are then selected at random from within this area. This ensures that while there may be some biases at a large spatial scale, at a smaller scale the squares selected should be unbiased.

3.2 Dealing with imperfect sampling

Often, for the reasons already outlined, the sample of squares surveyed may be unrepresentative of the entire protected area. However, some major sources of bias can be controlled for when analysing the results by weighting the trends obtained from individual sites. The two most obvious ways to do this are by region, to account for a greater density of survey sites in some parts of the protected area than others, or by habitat, to correct for unrepresentative sampling of habitats. The latter requires at least a basic assessment of habitat within survey squares, and knowledge of habitat cover over the protected area as a whole.

3.3 Setting the number of samples

The number of samples (i.e. squares surveyed) will, to a large extent, depend on both the availability of surveyors, and the method used. As a general rule it is desirable to have as many samples as possible, e.g. ten counts made at two different sites will be preferable to twenty counts made at one site. Similarly, many samples taken using a simpler method are preferable to few samples with more detailed and time-consuming methods.

4. Survey techniques

After deciding the sampling design and where to monitor birds, the next step is to decide the method to be used. There are a number of publications that describe in detail the different techniques that can be used to survey birds (see below). Considering the likely resources available for monitoring biodiversity in West African Protected Areas, three alternative approaches are recommended here: line transects, point counts and timed species counts, which are described in turn below.

4.1 Line transects

This method involves counting birds along a predefined route within a predefined sampling square. A regular approach to placement of the route within the square is best: most schemes use straight transects that run north-south, or east-west, through the centre of a square. In reality, certain land uses (roads, watercourses etc.) might limit access, resulting in modifications to the ideal routes. It is important to document or demarcate the route so that exactly the same one can be used in repeat surveys in future.

At its simplest, the technique involves walking along the transect and recording all individual birds (seen or heard) within a fixed distance on either side of the observer. For analysis purposes, it is crucial to decide several factors before starting, such as a) if recording will be done in units (i.e. counting in sections, such as 200 m lengths) rather than totals for the whole transect, b) when and how to score habitat condition (which allows comparisons of bird numbers to changes in the habitat available to them), c) if there is any distance beyond which birds should not be counted and d) the speed with which the transects will be walked, which is often dictated by the terrain, the number of birds present, and any difficulties in recording these birds. All these should be standardised.

The length of the transect requires consideration of total bird abundance and diversity, the degree to which bird activity is dependent on the time of day, and the degree to which data quality will decline with observer fatigue. If transects are walked, remember that observers will usually want to end up near where they started, for practical reasons, so a transect in one direction followed by another, returning on a parallel route (but far enough away to avoid double-counting) is a sensible approach.

4.2 Point transects

This technique involves standing still at a pre-determined point and recording all birds heard or seen from it. A point count approach is often preferable when counting less mobile species, and in closed habitats (e.g. forests), where observer mobility is more limited. As with line transects, once the sampling unit (square) has been randomly chosen, it is not necessary for the census stations to be randomly selected; if possible, a regular approach that ensures the entire sampling unit is covered is preferable. Compared to line transects, point counts may be easier where access is an issue, as the series of points can be accessed by whatever route is most convenient, rather than having to follow a set route.

The number of point counts to use within a sampling square depends primarily on the size of the square, although most schemes aim for 10-20 points per square, noting that the precision of the counts at points can be increased by repeating them, but at the detriment of total area surveyed. This balance also has implications for how long the count periods at each point should be: periods of 5-10 minutes are widely used. In addition, it is a good idea to have an initial 'settling in' period before counting (usually 2 minutes). It will also need to be decided whether all birds seen or heard from a count station will be recorded, or only those within a fixed radius (e.g. 100 m, 200 m) of the point.

Table 1 summarizes some of the main issues to consider when choosing between line transects and point counts, relating to effectiveness (i.e. which best provides answers for the questions posed), efficiency (which provides the required data most cost-effectively) and appropriateness for the surveyors available.

Table 1. Advantages and disadvantages of line and point transects

Line transect	Point transect
Relatively efficient at low bird densities and in species-poor habitats (e.g. deserts, farmlands etc.)	More suitable at high bird densities, especially in species-rich habitats (e.g. forests)
Good for open habitats	Suits dense habitats
Suitable for large and conspicuous species	Suitable for skulking or cryptic species
Suitable for easily accessible areas	Suitable in areas where accessibility is poor

4.3 Timed Species Counts

Timed Species Counts (TSCs) are lists of the species seen within a particular habitat (habitats are not mixed, as these usually have obviously different bird communities), recording the time when a species is first recorded. Thus a one hour-long survey may be divided into ten-minute blocks, and for each species, the block in which it was first recorded is noted. A score of 6 is given to any species first recorded in the first 10 minutes, a score of 5 to any species first recorded in the second 10 minutes, a score of 4 to any species recorded in the third 10 minutes etc. and so on, with a score of 0 given to all species not recorded within that hour.

These TSCs are then repeated as many times and as widely as is possible within the habitat, and for each species the mean score across all 1-hour counts gives a relative measure of abundance. The assumption is that the more common species will be recorded more frequently and quickly, and so would have a higher cumulative score. Often, surveyors are allowed to wander everywhere, but it is also possible to designate a fixed route (randomly selected), which may be more useful in terms of repeated observations along a specific stretch of a particular habitat. Consequently, if habitat conditions along that stretch are also recorded, the TSC scores could then be correlated to any observed habitat changes.

However, the results of TSC should be interpreted with caution, because the scores of each TSC event (i.e. a score 6, 5, 4, 3, 2, 1, or 0) measure relative abundance of a species at that time, and a cumulative score of these over several sites and deduction of trends from these indices over years (or repeated counts) is not simply the arithmetic sum.

Table 2: Suitability of point counts, line transects and Timed Species Counts for various bird groups. Adapted from Gibbons and Gregory (2005). Two asterisks indicate greater suitability.

Method	Waterbirds	Raptors	Gamebirds	Passerines
Point count	*	*	*	**
Line transect	**	**	**	**
Timed Species Count	*	**	**	**

4.4 Overarching considerations

It is important to note that all three techniques are highly influenced by detectability: counts will be a lot lower for small, cryptic, quiet species than for large obvious vocal species present at a similar density. Similarly, habitat will also have an impact on the numbers detected (higher in more open habitats, lower in denser habitats). However, this may not be problematic, given that monitoring should be repeated (ideally annually) at the same sites and using the same methods, so relative change between counts is unbiased. The difficulty in detecting some species may mean, however, that they are recorded insufficiently frequently for adequate data to be collected to monitor trends.

These techniques also permit the estimation of population densities (and therefore population size estimates), if the distance from the observer to each bird is recorded, and if detectability of birds decline with distance (section below for references on 'distance sampling'). Although 'distance sampling' is relevant for population estimates, it is not required for trend analyses. However, if surveyors can handle the added complexity of recording the distance (in bands) to each bird recorded, this maximises the utility of the data collected.

It is important to highlight that once a technique (line transects, point transects or TSCs) has been selected, it should not be changed over time, in order to ensure comparability. Further issues to consider include the following:

How often to do counts? For points and transects, multiple visits are desirable, as it is easy to miss species or obtain unusually high or low counts on a single visit. Many schemes use two visits per year, and take the highest count from either visit for each species for analytical purposes. TSCs are far less robust, and so more counts would be needed.

What time of year to count? This will depend on the time of year when breeding activity peaks or when birds are most readily detected. For some tropical countries, it may be best for counts to be spread across the whole year (e.g. 2 counts 6 months apart, 3 counts 4 months apart, or 4 counts 3 months apart).

What time of day to count? Early morning is always best because of higher bird activity, but this requirement may have to be relaxed given travel times to some sites.

Whether to count all species, or fixed subset? The latter is not desirable because it restricts the scope of the monitoring, loses data and is not future-proof (we do not know which species it may be important to monitor in future, so may not have an adequate baseline if we decide to add additional species in future). However, monitoring a subset of species may make a monitoring scheme more accessible, feasible and practical for specific audiences, depending on their capabilities, the intended use of the data etc.

5. Training and motivating surveyors

Once the sample design and survey techniques have been defined, careful consideration has to be made of the practical considerations of implementing the monitoring. This may be done by protected area staff (e.g. park rangers) and/or volunteer observers (e.g. from conservation NGOs). Hence it is vital that good management practices are employed to recruit, train and retain participants by ensuring their involvement with the scheme is enjoyable and rewarding. In addition, it is important to ensure that there is sufficient support, guidance and training so that the data collected is robust, reliable and consistent.

Training

Good training is an essential component of successful monitoring, in order to build capacity for designing surveys, managing surveyor networks, analysing data, communicating results and using them to inform management and decision-making. This is likely to involve both face-to-face training (e.g. through workshops) and the dissemination of training materials.

Training workshops should aim to:

- Describe the rationale behind establishing monitoring, and its value for a protected area
- Give a basic grounding in survey design and methods
- Fully describe the survey method to be used
- Include sessions on identification, filling in forms correctly, health and safety issues
- Use a mixture of practical and theoretical sessions, and opportunity for participants to exchange experience and opinions.

As well as a detailed workshop at the initiation of monitoring, repeat training should be held when needed (and at least annually).

Providing supporting materials

To maximise participation, accuracy and consistency in the data collected, some or all of the following materials may be produced:

Data capture forms – which should be easy to read and allow for all the required data to be recorded on them in the field

Survey protocols – which should describe in detail the methods to be used so that everyone understands what is to be done, and data collection is consistent

Field guides – if these are too expensive then modified identification kits illustrating only the species most likely to be encountered can be considered

Posters, leaflets, brochures etc – to provide appropriate information for the surveyors and other stakeholders involved

Incentives

Recruitment, retention and maintained motivation of surveyors may be greatly helped by offering incentives (noting that long-term sustainability is also critical). These might include recognition (e.g. named awards), prizes (e.g. a free field guide, or binoculars), additional training, or travel opportunities. If volunteers are involved in monitoring, then regular personal contact is important, or at least regular communications.

The results of monitoring should be reported to surveyors as promptly as possible, for example through newsletters, websites, annual reports, brochures etc. This enables surveyors to see the results of their efforts and hence helps to maintain motivation.

6. Analysing the data and using the results

Before launching a monitoring scheme, it is important to consider how the data collected will be analysed. Rules may be needed for identifying, checking and if necessary, removing erroneous records (e.g. likely misidentifications, vagrants, implausibly high counts etc). Data need to be entered into a spreadsheet or appropriate database, and then analyses conducted. In the first year of a scheme, these will be simple descriptive statistics such as the number of species, and their relative abundance. After three or four consecutive years, it will be appropriate to develop species trends for those more frequently recorded species for which there is sufficient data. The production of trends requires analysing changes in counts at each site between years, and can be achieved by a number of modelling approaches. A recommended approach is to use the freely available bespoke analysis software TRIM (Trends and Indices for Monitoring data: www.ebcc.info/trim.html).

Population trend indices can be calculated for individual species (e.g. iconic species or those of conservation concern for which a protected area has been designated), suites of similar species (e.g. vultures, waterbirds), sets of species characteristic of particular habitats within a protected area (e.g. forest species, savannah species), those species projected to be negatively impacted by climate change, or those species targeted by management actions (including adaptation interventions).

These can help diagnose a problem (through identifying a suite of species that are declining), assess the accuracy of climate projections (in terms of the species projected to decline or shift their distributions, or the timing of such changes), inform management actions and assess the effectiveness of responses.

7. References and additional sources of information

Bennun, L. and Howell, K. (2002): *Birds*. In: Davies, G. and Hoffmann M., eds., *African Forest biodiversity: a field survey manual for vertebrates*. Earthwatch Europe. Available at:

www.earthwatch.org/atf/cf/{BD9A05BF-0860-451E-AA867FBF37574C00}/african_forest.pdf

Bibby, C.J., Burgess, N.D., Hill, D.A. and Mustoe, S.H. (2000) *Bird Census techniques* (2nd ed). Academic Press, London.

Bibby C., Jones M. and Marsden S. (1998) *Expedition Field Techniques: Bird Surveys*. Expedition Advisory Centre, Royal Geographical Society, London.

Eaton, M.A., Gregory, R.D. and Farrar, A. (2002) Bird conservation and citizen science: counting, caring and acting. *Ecos* 23: 5-13.

Freeman, S.N., Pomeroy, D.E. and Tushabe, H. (2003) On the use of Timed Species Counts to estimate avian abundance indices in species-rich communities. *African J. Ecol.* 41: 337-348.

Gibbons D.W. and Gregory R.D. (2005): *Birds*. In: Sutherland W.J., ed.,: *Ecological Census Techniques: a handbook*. Cambridge University Press, Cambridge. Free to conservation biologists and institutions in developing countries: http://www.nhbs.com/Conservation/gratis-books.html.

Gilbert, G., Gibbons, D.W. and Evans, J. (1998) *Bird monitoring methods, a manual of techniques for key UK species*. RSPB, Sandy, UK.

Greenwood, J.J.D. and Robinson, R.A. (2005a) Principles of sampling. In: Sutherland W.J., ed., *Ecological Census Techniques: a handbook*. Cambridge University Press, Cambridge.

Greenwood, J.J.D. and Robinson, R.A. (2005b) General census methods. In: Sutherland W.J., ed., *Ecological Census Techniques: a handbook*. Cambridge University Press, Cambridge.

Gregory R.D., Gibbons D.W. and Donald P.F. (2004) *Bird census and survey techniques*. In: Sutherland W.J., Newton I. and Green R.E., eds., *Bird ecology and conservation; a handbook of techniques.* Oxford University Press, Oxford.

Jones, J. P. G., Asner, G. P., Butchart, S. H. M. and Karanth, K. U. (2013) The ‘why’, ‘what’ and ‘how’ of monitoring for conservation. Pp. 327-343 in MacDonald, D. W and Willis, K. J., Eds. Key Topics in Conservation Biology 2. Cambridge: Wiley-Blackwell.

Pomeroy, D. (1992) *Counting birds: a guide to assessing numbers, biomass, and diversity of Afrotropical birds*. African Wildlife Foundation, Nairobi, Kenya.

Senyatso, K. (2007) Guidelines for the development of Common Bird Monitoring in Africa. BirdLife International, Cambridge, UK.

Freely available software

Distance. A software package for estimating bird population density. Available at: www.ruwpa.st-and.ac.uk/distance.

TRIM (Trends and Indices for Monitoring data). An easy-to-use software package for producing species population trends from monitoring data. Available at: www.ebcc.info/trim.html.