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Range, population estimates and conservation recommendations for Baillon's Crake, Allen's Gallinule, African Swamphen and Red-chested Flufftail in South Africa

David A. Ehlers Smith[1, 2], *Sanjo Rose*[2, 3] and *Alan T.K. Lee*[1, 2, 3]
[1] *Centre for Functional Biodiversity, School of Life Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville 3209, South Africa.*
email: david.ehlers.smith@birdlife.org.za
[2] *BirdLife South Africa, Isdell House, Johannesburg 2193, South Africa.*
[3] *FitzPatrick Institute of African Ornithology, Department of Biological Sciences, University of Cape Town, Rondebosch 7701, South Africa.*

Abstract

Africa's herbaceous wetlands are vital ecosystems, which provide essential services such as water filtration, flood mitigation, and carbon sequestration, while supporting a diverse array of species, including Baillon's Crake (*Zapornia pusilla*), Allen's Gallinule (*Porphyrio alleni*), Red-chested Flufftail (*Sarothrura rufa*), and African Swamphen (*Porphyrio madagascariensis*). These species were chosen from the many that use wetlands as declines were inferred from citizen-science datasets and more detailed information was needed to aid in threat assessments for the IUCN Red Listing process. This study presents updated information on the distribution and population estimates of these four bird species in South Africa, utilising records from the BirdLasser mobile app and cross-verified with the Southern African Bird Atlas Project 2 (SABAP2) database. Species Distribution Modelling was conducted using MaxEnt, and South Africa's 2020 Land Use and Land Cover dataset was employed to identify and delineate suitable herbaceous wetland habitats. By extracting the habitat from the predicted niche over 0.5 likelihood of suitability, results indicated an area of occupancy of 497 km^2 for Baillon's Crake, 173 km^2 for Allen's Gallinule, 3 574 km^2 for Red-chested Flufftail, and 3 114 km^2 for African Swamphen. Estimated home-range sizes allowed for projected maximum populations of 43 736 individuals for Baillon's Crake, 17 128 individuals for Allen's Gallinule, 1 588 444 individuals for Red-chested Flufftail, and 249 120 individuals for African Swamphen. This study highlights the critical importance of herbaceous wetlands for these species and underscores the significant threats posed by habitat loss and degradation, pollution, and climate change. Based on the range sizes, and degradation of suitable wetland habitat, it is recommended that Baillon's Crake be considered regionally Endangered. Allen's Gallinule occurs peripherally in South Africa and may potentially meet regionally Vulnerable under the IUCN Regional Red List criteria, when considering potential rescue effects from the more extensive extra-limital population stronghold. Conservation measures, including habitat protection and restoration, pollution control, climate-adaptation strategies, community engagement, and ongoing research and monitoring, are essential to safeguard these species and their habitats.

Keywords: herbaceous wetlands; red listing; species distribution modelling; waterbirds.

Introduction

Herbaceous wetlands (wetland types dominated by herbaceous plants, such as marshes and flooded meadows), such as the iSimangaliso Wetland Park and the Okavango Wetland Complex, are among the most productive and valuable ecosystems on Earth. They provide a myriad of ecosystem services that are crucial for environmental health and human well-being (Zedler and Kercher 2005). These wetlands play a significant role in water filtration, flood mitigation, carbon sequestration, and supporting biodiversity (Mitsch and Gosselink 2015). The dense vegetation and complex hydrology of herbaceous wetlands create a unique habitat that supports a diverse array of flora and fauna, including many waterbird species (Ramsar Convention on Wetlands 2018).

Waterbirds rely heavily on these wetlands for breeding, feeding, and shelter. Herbaceous wetlands provide essential resources for a wide range of waterbird species, including crakes, rails, gallinules, and swamphens (Taylor and van Perlo 1998). These birds depend on the dense vegetation, shallow water and abundant invertebrate prey found in wetland habitats (Ma et al. 2010). Many waterbird species exhibit specialized adaptations and behaviours that allow them to thrive in these environments, such as long toes for walking on floating vegetation and long and narrow bills for probing in soft mud (Jenni 1970, Ripley 1977).

Despite their ecological importance, herbaceous wetlands and the waterbird species they support, face numerous threats. Habitat loss and degradation due to agricultural expansion, urbanization, and infrastructure development

are major concerns (van Asselen et al. 2013). Wetland drainage, filling and conversion to other land uses have led to significant declines in wetland extent and quality worldwide (Davidson 2014). Pollution from agricultural runoff, industrial discharges and sewage can degrade water quality and harm aquatic organisms, including waterbirds (Verhoeven et al. 2006). Climate change poses additional challenges, altering hydrological regimes, water availability, and vegetation composition, which can impact the suitability of wetland habitats for waterbirds (Erwin 2009, Junk et al. 2013).

In South Africa, it is estimated that 35–50% of herbaceous wetlands have been severely degraded or entirely lost because of agricultural and urban expansion, mining activities and alien invasive vegetation (Sieben et al. 2014). Many waterbird species are dependent on herbaceous wetlands, including Baillon's Crake (*Zapornia pusilla*), Allen's Gallinule (*Porphyrio alleni*), Red-chested Flufftail (*Sarothrura rufa*), and African Swamphen (*Porphyrio madagascariensis*). However, information is limited on the current distribution and population status of these species in the country. These species were chosen for study here as declines were inferred from citizen-science datasets and more detailed information was needed to aid in threat assessments for the IUCN Red Listing process. Given the ongoing threats to wetland habitats, we predicted that these waterbird species would have limited distributions and small population sizes in South Africa (including Lesotho and Eswatini). These countries are nested for Regional Red Listing purposes (Taylor et al. 2015) and for the purpose of this study. This study aims to provide updated information on the distribution, suitable habitat extent and population estimates of these four species in the region, using data from the BirdLasser mobile application (Lee and Nel 2020) and the Southern African Bird Atlas Project 2 (SABAP2) database (Brooks et al. 2022). By identifying key wetland habitats and estimating population sizes, we seek to inform conservation planning and management efforts for these species and their critical habitats.

Methods

Study species

Baillon's Crake is a small, secretive waterbird that inhabits marshes and wet meadows (Taylor et al. 2020). The species has a large global range, occurring in Africa, Europe, Asia and Australia (BirdLife International 2021). In Africa, the subspecies *Z. p. intermedia* is considered resident with local movements (Taylor et al. 2020). Baillon's Crake exhibits a highly adaptive diet, primarily consuming invertebrates such as coleopterans. It demonstrates flexible breeding and migration strategies that are influenced by environmental conditions and habitat availability (Seifert et al. 2018).

Allen's Gallinule is found in wetland habitats across sub-Saharan Africa and Madagascar (Taylor and van Perlo 1998). Allen's Gallinule is generally considered resident, with some local movements in response to rainfall and habitat conditions (Taylor and van Perlo 1998). In South Africa it may be considered peripheral and more strongly seasonal in its occurrence (Hockey et al. 2005). The species relies on dense wetland vegetation for cover and foraging, feeding on a variety of aquatic plants, seeds, and invertebrates (Taylor and van Perlo 1998).

Red-chested Flufftail is a small, cryptic bird that inhabits dense vegetation in wetlands (Taylor 1994). The species is distributed across sub-Saharan Africa (Taylor 1994). Red-chested Flufftails are generally resident, with some local movements in response to rainfall and habitat conditions (Taylor and van Perlo 1998). The diet includes earthworms, small gastropods and crustaceans, insects and their larvae (Hockey et al. 2005).

African Swamphen is a large, colourful waterbird found in wetlands and riverine habitats across sub-Saharan Africa and Madagascar (Taylor and van Perlo 1998). The species was previously considered a subspecies of the Western Swamphen (*Porphyrio porphyrio*) but is now recognized as a distinct species (García-R and Trewick 2015). African Swamphens are generally resident, with some local movements in response to rainfall and habitat availability (Taylor and van Perlo 1998). The species feeds on a variety of aquatic plants, seeds, and invertebrates and is known for its aggressive territorial behaviour (Hockey et al. 2005).

Data collection

Target-species location data were sourced from the BirdLasser mobile application (Lee and Nel 2020) and cover the period 2016–2024. These records were cross-verified using the Southern African Bird Atlas Project 2 (SABAP2) database (Brooks et al. 2022) to ensure data accuracy and completeness. The SABAP2 project collects species records in spatial units called pentads (5x5 minutes latitude, longitude) contributed by citizen-science birdwatchers, with spatial records vetted by regional experts. We present summary statistics for the target species from the SABAP2 database. These include the number of pentads across which the species was recorded between 2007 and 2023, and the reporting rate (a measure of relative abundance and detectability), which is the number of bird checklists from which a species was recorded divided by the total number of lists for the pentads within the species range, using a subset of pentads that had been sampled >4 times. The cross-verified locality data from BirdLasser were then used to train the habitat suitability models.

Habitat suitability modelling

Climate and habitat suitability for the target species was modelled using MaxEnt, a maximum entropy approach widely used for species distribution modelling (Phillips et al. 2006). MaxEnt was chosen for its effectiveness in handling presence-only data and its ability to provide robust predictions of species distributions. The environmental variables used are presented in Appendix 1.

Land cover and habitat identification

We utilised the South African 2020 National Land Use and Land Cover data layer (DFFE 2020) to identify suitable habitat for the target species. Specifically, herbaceous wetlands of both previously mapped, i.e., areas identified to be of herbaceous wetland type in the 2013–2014 National Land Cover product (DFFE 2015), and currently mapped herbaceous wetland (DFFE 2020) were extracted as the primary habitat of interest. The herbaceous wetland layer has an end-user accuracy assessment of 91.8% (DFFE 2020). The identified suitable habitat polygons were used to delineate the final range of occupancy for the target species in ArcPro (ESRI 2023).

Area of Occupancy calculation

The total area of suitable habitat was calculated from the polygons to estimate the Area of Occupancy (AOO) for each target species. This metric was derived by extracting previously and currently mapped herbaceous wetland habitat from the predicted niche of both species over 0.5 likelihood of suitability in ArcPro (ESRI 2023). This threshold was selected as it best represented the distribution of each species when overlain with available herbaceous wetland habitat. This is a frequently employed threshold to determine binary positive and negative outcomes used to subsequently test prediction accuracy. This was required to remove areas of overprediction from the MaxEnt model into unsuitable terrestrial habitat types and assumes the species are restricted to this habitat, which is a reasonable assumption for these habitat specialists.

Population estimation

Using the mean group size and estimated home-range sizes from the available literature, we calculated potential populations of each species within the identified suitable habitat. Where data were unavailable for a species, we used data from the literature of the closest sister taxon as a surrogate to imply population estimates. This projection provides an estimate of the number of individuals that the habitat can support under current conditions. To calculate the degree to which each species falls within the protected area network, the AOO was clipped by the South African national formal protected area (DFFE 2022) layer in ArcPro (ESRI 2023) and the area of each resultant polygon was calculated (Table 1).

Data collection and verification

A total of 601 location records for Baillon's Crake, 912 for Allen's Gallinule, 10 460 for Red-chested Flufftail and 25 852 records for African Swamphen were extracted from the BirdLasser mobile application. Cross-verification with the SABAP2 database and spatial rarefication to 500 m resulted in a final dataset of 464 records for Baillon's Crake, 853 records for Allen's Gallinule, 2 711 for Red-chested Flufftail and 3 335 records for African Swamphen (Table 1).

Results

Habitat suitability modelling

All the MaxEnt models (Fig. 1) showed high predictive performance with an Area Under the Curve (AUC) value of 0.987 for Baillon's Crake, 0.991 for Allen's Gallinule, 0.855 for Red-chested Flufftail, and 0.852 for African Swamphen, indicating robust model fit (Appendix 2). Key environmental variables contributing to the model are detailed in Appendix 1 and included distance to waterbodies and the South African National Biodiversity Institute biome layers.

Area of Occupancy calculation

Defining Area of Occupancy (AOO) as the area of herbaceous wetland where the species was predicted to occur from the MaxEnt models, the calculated AOO for Baillon's Crake was 497 km^2 of suitable habitat, 173 km^2

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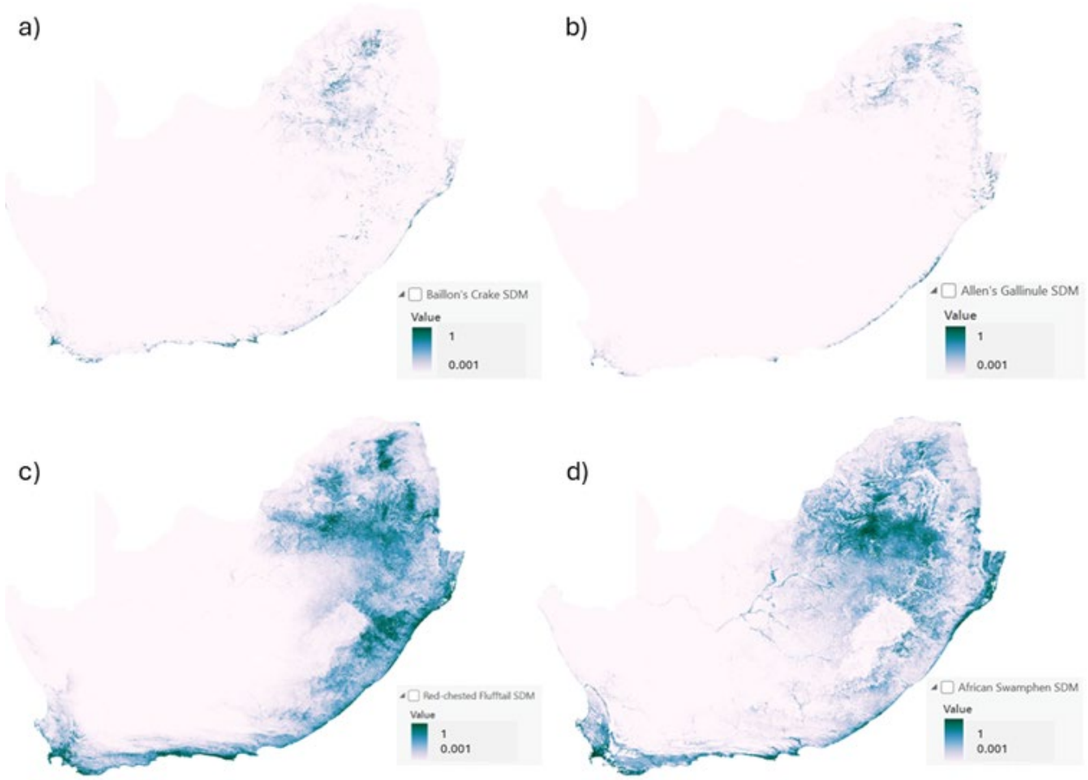

Figure 1. Modelled climate and habitat suitability probability maps for Baillon's Crake, Allen's Gallinule, African Swamphen and Red-chested Flufftail across South Africa, Lesotho and Eswatini. Darker colours represent regions with a higher probability of occurrence from the MaxEnt output, prior to clipping to herbaceous wetland land-cover types.

Table 1. Relative abundance measures from source and various other datasets for Baillon's Crake, Allen's Gallinule, African Swamphen and Red-chested Flufftail. Pentads describe the number of ca. 9x9 km^2 grids used by the SABAP2 project that each species is reported from. Reporting rate is the percentage of checklists within a species range from which a species was reported from, with the median across pentads provided for the periods 2007–2015 and 2016–2023. AOO is the area of occupancy calculated in this study, with the area of the AOO classified as predicted reported.

Species	Birdlasser records	Pentads	Reporting rate (%)	AOO (km^2)	Protected area (km^2)	Protected area (% of AOO)
Baillon's Crake	464	73	0.9, 0.6	497	63	12.7
Allen's Gallinule	853	64	0.0, 1.1	173	72	41.6
African Swamphen	3 335	973	6.7, 5.3	3 114	272	8.7
Red-chested Flufftail	2 711	625	1.7, 3.4	3 574	392	11.0

for Allen's Gallinule, 3 574 km^2 for Red-chested Flufftail and 3 114 km^2 for African Swamphen (Table 1). These figures represent the extent of suitable habitat available for each species within the study area.

Population estimation

A telemetry study from Senegal of tagged Baillon's Crake individuals calculated 1 individual/0.88 ha (Seifert et al. 2018). Using this estimate as a baseline, the maximum projected population size for Baillon's Crake in South Africa was 43 736 individuals based on an AOO of 497 km^2. On the Nyl River floodplain, density estimates for Allen's Gallinule are 3 pairs/ha; however, in the entire northern Kruger region, there are estimated to be fewer than 10 pairs (Hockey et al. 2005). This density estimate would indicate 103 800 individuals, which is unlikely given the species' status as uncommon. Given the fluctuations and uncertainty in the density range, inferences may be made from the home-range size of its sister taxon, the Purple Gallinule (*Porphyrio martinica*). Telemetry data from Louisiana, USA indicate a mean home range size of 1.03 ha (Matthews, 1983). The projected population for Allen's Gallinule based on this home range is 17 128 individuals in the South African subregion, given an AOO of 173 km^2.

Red-chested Flufftail are monogamous and highly territorial and have an estimated territory size of 0.05–0.45 ha in South Africa (Taylor and van Perlo 1998). Given occupancies may vary according to ecological conditions and therefore taking the upper territorial size limit of 0.45 ha (and assuming a territory contains an adult pair), applying this to the AOO of 3 574 km^2 provided an upper population size of mature Red-chested Flufftail 1 588 444 individuals.

Population density of the African Swamphen is estimated to be a pair of birds per 2.5 ha of suitable habitat (Hockey et al. 2005). Therefore, using the AOO of 3 114 km^2, the projected maximum population size for African Swamphen in South Africa was 249 120 individuals.

The degree to which the AOO of each species was located within the protected area network of South Africa varied from 41.6% for Allen's Gallinule to 8.7% for African Swamphen (Table 1).

Discussion

The results of this study highlight the importance of herbaceous wetlands for maintaining populations of the four study species in South Africa. Our findings align with previous studies that have emphasized the significance of wetland habitats for the conservation of rallid species. For instance, research on the Endangered Sakalava Rail (*Amaurornis olivieri)* shows that the species is closely associated with wetland vegetation and relies on these habitats for foraging and breeding (Pruvot et al. 2017). Similarly, studies on the Spotted Crake (*Porzana porzana*) in Europe highlight the importance of maintaining suitable wetland habitats for the species' persistence (Brambilla and Jenkins 2009). The current study contributes to this body of knowledge by providing quantitative estimates of suitable habitat extent and inferred maximum population sizes for the four study species in South Africa.

The limited areas of suitable habitat identified for Baillon's Crake (497 km²) and Allen's Gallinule (173 km^2) highlight their reliance on wetland ecosystems with specific climatic conditions and the urgent need for conservation initiatives. The larger areas of suitable habitat for Red-chested Flufftail (3 574 km^2) and African Swamphen (3 114 km^2) suggest that these species may be more resilient to wetland degradation but nonetheless depend on the availability of herbaceous wetlands for their ecological requirements.

The projected population sizes provide a baseline for further research into the population viability of the four species and offer potential insights into the current status of these waterbird species in South Africa. It is important to note the caveats that for all but the Red-chested Flufftail, species' population estimates were derived from other countries (and in the case of Allen's Gallinule, were provided by a sister taxon). These estimates therefore must not be interpreted as definitive but rather provide potential population sizes based on the best available data. They will hopefully motivate and inform future research and conservation planning. Further, the population estimates assume ideal habitat within the AOO and that all available habitat is occupied, which is unrealistic, and so the values presented here are maximum values.

The relatively small population sizes of Baillon's Crake (17 128 individuals) and Allen's Gallinule (24 714 individuals) highlight the need for targeted conservation efforts. All these species have very low SABAP2 reporting rates, indicating they are secretive and uncommon. Furthermore, the degree to which the protected area network represents each species' AOO varied, from almost half for Allen's Gallinule to less than 15% for the other three species, suggesting a vulnerability to threats outside of protected areas.

Indeed, the threats facing herbaceous wetlands, including habitat loss and degradation, pollution and climate change, pose significant challenges for the long-term survival of these waterbird species. Rapid urban expansion, agricultural intensification and infrastructure development have led to the loss and fragmentation of wetland habitats

in South Africa (Kotze and O'Connor 2000). Pollution from agricultural runoff, industrial discharges and improper waste management can degrade water quality and harm aquatic organisms, including waterbirds (Harmon and Wiley 2010). Climate change is expected to alter hydrological regimes, water availability and vegetation composition, further impacting the suitability of wetland habitats (Erwin 2009). Rallidae declines have been shown to be linked to habitat loss, with annual rates of declines from 2.2–3.3% for Virginia Rail (*Rallus limicola*) and Sora (*Porzana carolina*) respectively (Conway et al. 1994).

To address these threats and ensure the long-term survival of Baillon's Crake, Allen's Gallinule, Red-chested Flufftail and African Swamphen, a range of conservation measures are necessary. Protecting and restoring key wetland habitats is essential, as is strengthening pollution-control regulations and promoting sustainable agricultural practices (Verhoeven et al. 2006). Developing and implementing climate-adaptation strategies, such as enhancing water-management practices and conserving water resources, will be crucial for the resilience of herbaceous wetlands and the species they support (Reis et al. 2017).

Baillon's Crake, Allen's Gallinule, Red-chested Flufftail and African Swamphen have thus far not been assessed by the IUCN Regional Red List in South Africa. Range-size and population-size estimates from this study means that these species may now be assessed according to the IUCN Regional Red List Guidelines (IUCN 2012, v. 4.0). It is recommended that Baillon's Crake be considered regionally Endangered under the IUCN Red List criteria (IUCN 2021) based on the definitive projection of limited range size, 35–50% population decline and degradation of suitable habitat (Siebert et al. 2014, Kotze and O'Connor 2000), despite the uncertainty of the population estimate. The AOO is within the threshold of Endangered for Allen's Gallinule but considering "rescue effects" from a more extensive extra-limital population, whereby the likelihood of small or peripheral populations going extinct is mitigated by turnover or immigration from a stable metapopulation (Brown and Kodrick-Brown 1977, Hanski 1991), we recommend that this species be considered regionally Vulnerable. While the Red-chested Flufftails and African Swamphens have larger AOOs and potentially high population sizes, we emphasise the need for more research to verify these estimations. These assessments highlight the need for immediate conservation action to prevent further declines and ensure the long-term viability of all four species.

Engaging local communities and raising awareness about the importance of wetland conservation is critical for fostering a sense of stewardship and support for conservation efforts (Dolman et al. 2012). Ongoing research and monitoring are necessary to track population trends, assess habitat quality and evaluate the effectiveness of conservation interventions (Ma et al. 2010). This information may be used to adapt and improve conservation strategies over time, ensuring the long-term viability of these waterbird species and their habitats.

Acknowledgements

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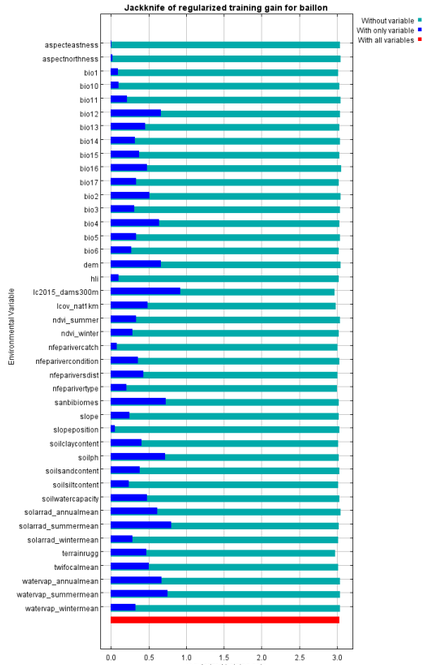
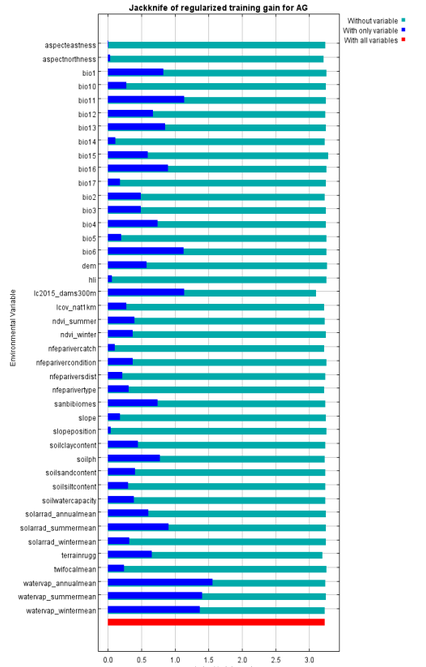
Appendices

Appendix 1. Results of the jackknife test of variable importance used to train the MaxEnt species distribution models for Baillon's Crake, Allen's Gallinule, African Swamphen and Red-chested Flufftail.



Baillon's Crake



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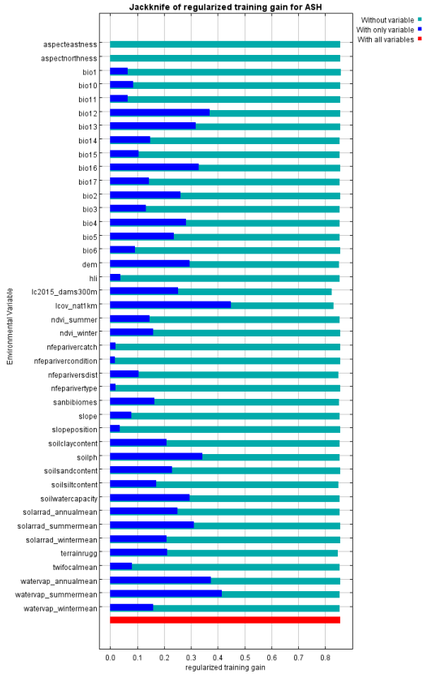
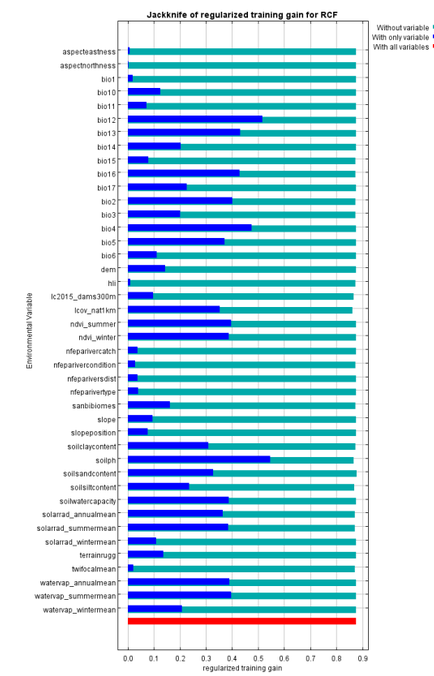
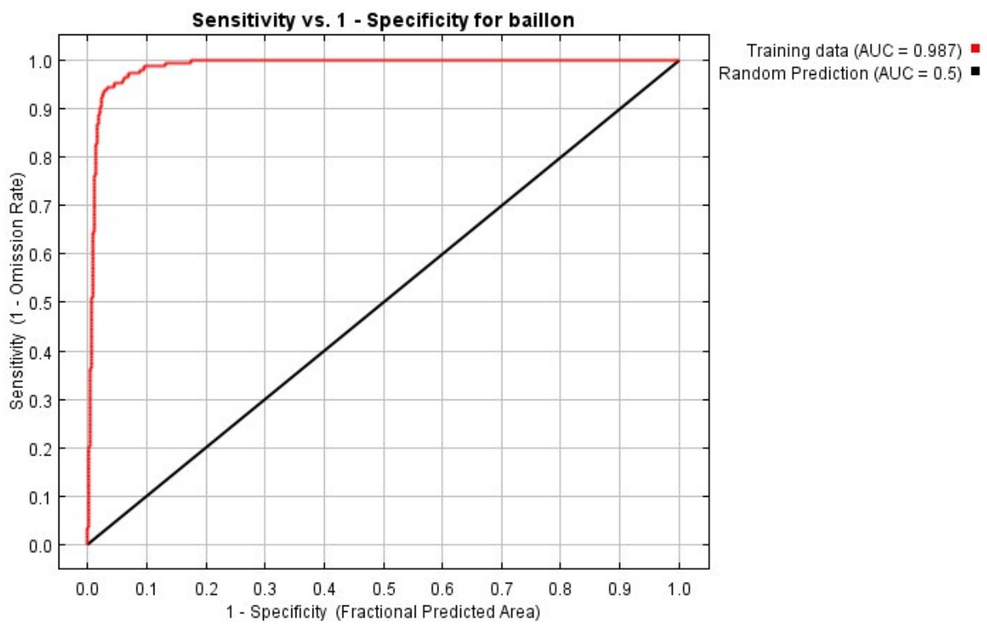


African Swamphen

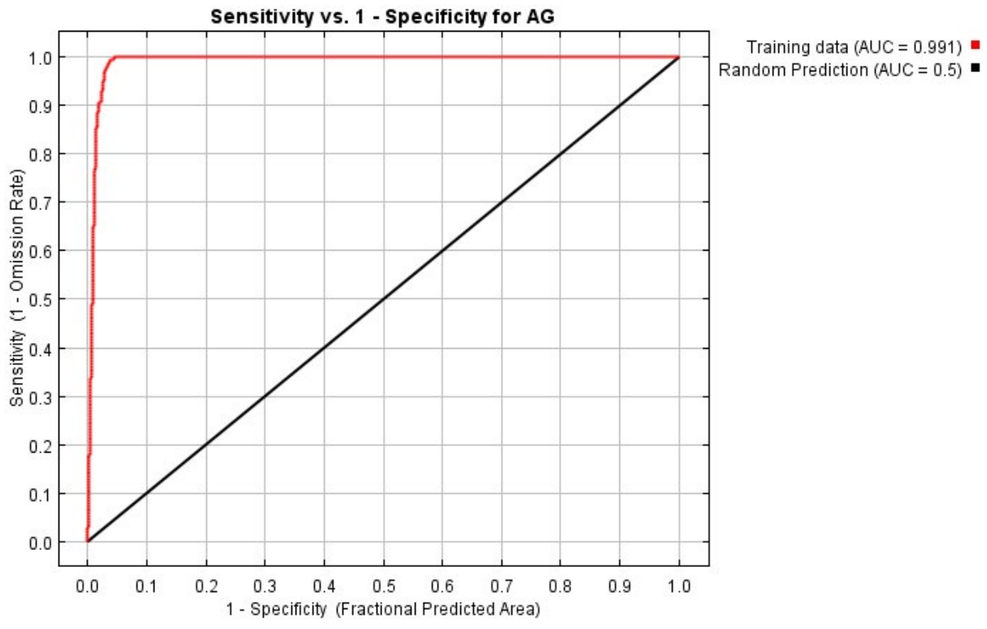


Red-chested Flufftail

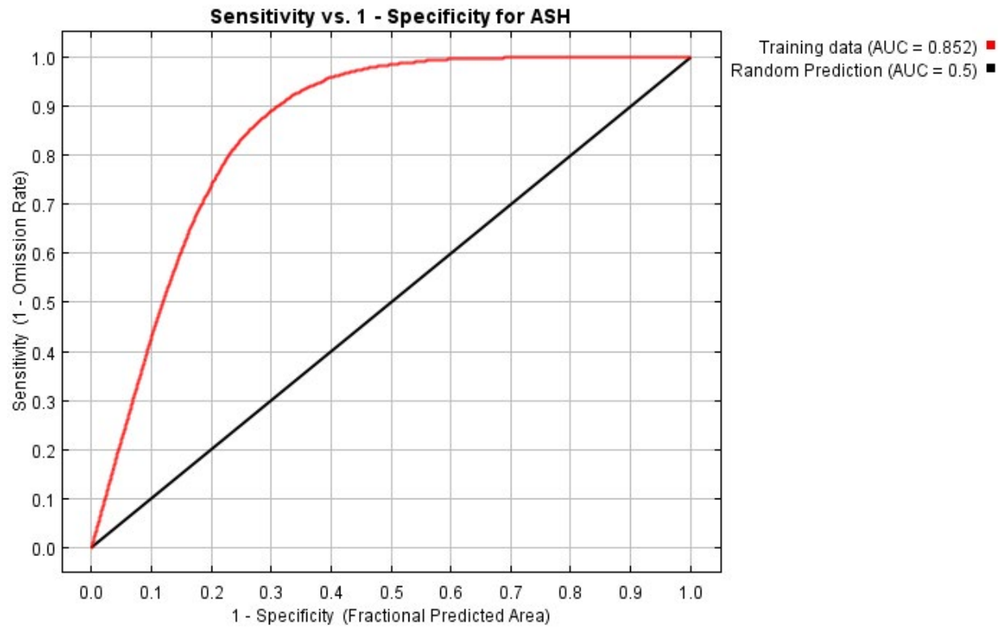
Appendix 2. Area Under Curve statistics for the MaxEnt species distribution models produced for Baillon's Crake, Allen's Gallinule, African Swamphen and Red-chested Flufftail.



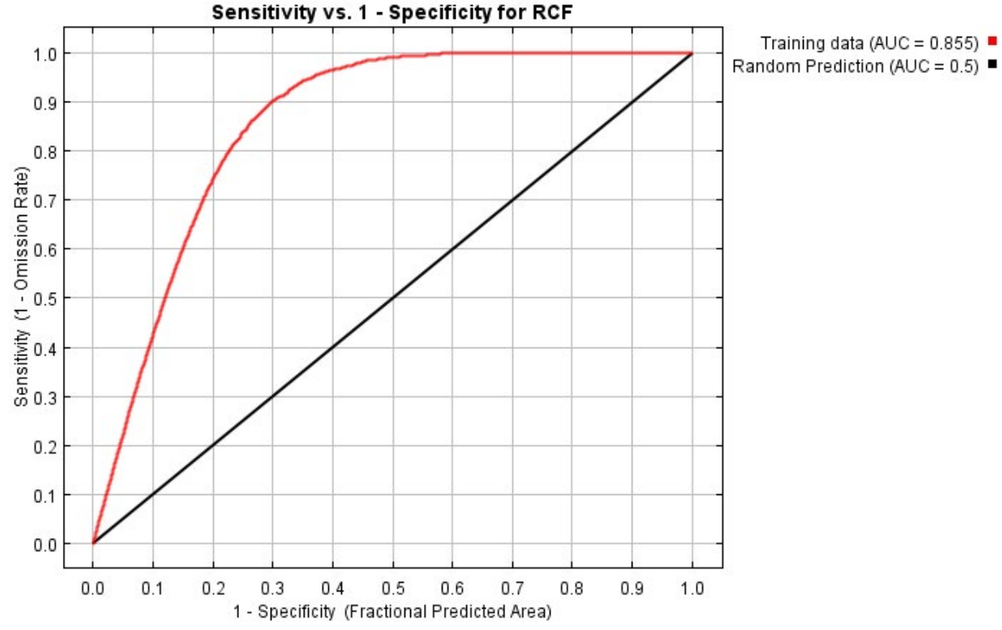
Baillon's Crake



Allan's Gallinule



African Swamphen



Red-chested Flufftail