Species Threat Abatement and Recovery in Cameroon and Kenya

Findings from a STAR assessment to support biodiversity conservation using high-resolution data

Joshua Schneck, Frank Hawkins, Neil Cox, Louise Mair, Alison Thieme and Joe Sexton





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Executive summary

This report presents findings from an assessment of the biodiversity conservation potential of project sites in Cameroon and Kenya[1], developed using the **Species Threat Abatement and Recovery (STAR)** metric[2]. This assessment is a follow-up to an earlier "low-resolution" STAR assessment done in June of 2020 on the same project sites and was performed using higher-resolution imagery and a revised approach to modeling species Area of Habitat (AOH)[3] among other enhancements and changes. The work was undertaken to better inform conservation planning and work at the partner project sites, and as part of a wider effort to pilot and enhance the use of STAR as a tool for conservation practitioners, communities, investors and policymakers.

A principal difference in findings between the low- and high-resolution assessments concerns the overall STAR score. **The high-resolution assessment indicates lower total STAR scores at the project sites: 76.2 total STAR score (all sites) in the high-resolution assessment vs 245 total STAR score from the low-resolution assessment.** The likely reasons for this sizable difference are discussed in the Findings section below, and include:

1. less inclusion in the high-resolution assessment of non-project site areas that overlap (wholly or partially) with the larger 5-km grid cells of the low-resolution assessment;
2. differences in the distribution of AOH for the assessed threatened species using the new land cover map developed for the high-resolution assessment; and
3. lack of re-calibrated global AOH values for assessed species when calculating the estimated STAR values at the project site.

Results suggest the need for globally consistent, high-resolution AOH and land cover mapping using regularly-updated imagery, and an approach to land cover classification and threat mapping closely tailored to that used by the IUCN Red List of Threatened Species™ when developing STAR assessments.

For project partners, this high-resolution assessment report provides information potentially of use in supporting conservation efforts at project sites including: (a) maps showing areas of relatively higher STAR values that can be helpful in prioritizing conservation efforts within project sites; b) overall STAR scores at each site that can help in prioritizing conservation work among the different project sites; (c) figures showing the breakdown of STAR score in each project site by threat that can help focus conservation efforts by showing which threats contribute most to the extinction risk at each site, and orienting threat-reduction measures to the species that are affected by them; and (d) tables in the accompanying Annex providing a list of priority threatened species whose AOH overlaps with project sites. The information on priority threatened species can be used in communicating the importance of these project sites and conservation measures to policymakers, local communities, investors and the broader public, as well as to inform the design of effective conservation and related monitoring work.

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1 The assessed project sites are from three GEF-supported projects participating in the *GEF-6 Restoration Initiative program (TRI)*, and include the IUCN-led project "Supporting Landscape Restoration and Sustainable Use of Local Plant Species and Tree Products for Biodiversity Conservation, Sustainable Livelihoods and Emissions Reduction in Cameroon" (GEFID 9519), the FAO-led project *"Restoration of arid and semi-arid lands of Kenya through bio-enterprise development and other incentives under TRI"* (GEFID 9556), and the UNEP-led project *"Enhancing integrated natural resource management to arrest and reverse current trends in biodiversity loss and land degradation for increased ecosystem services in the Tana Delta, Kenya"* (GEFID 9526). More information on The Restoration Initiative online: https://www.iucn.org/restoration-initiative

2 Mair, L. et al. (2021). A metric for spatially explicit contributions to science-based species targets. *Nature Ecology & Evolution.*

3 Area of Habitat (AOH) is defined as "the area, characterized by its abiotic and biotic properties, that is habitable by a particular species" (Brooks, et al. (2019). Measuring Terrestrial Area of Habitat (AOH) and Its Utility for the IUCN Red List. *Trends in Ecology & Evolution*).

Acknowledgements

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In addition, the authors would like to thank and acknowledge the support of the three TRI project teams in Cameroon and Kenya for their contributions and feedback to improve the utility of this report and subsequent work. Lastly, the authors would like to thank Amit Poudyal for his work in designing this report.

Background

Conservation of threatened species is often limited by a lack of readily available and actionable information: information on where threatened species are found, the types of threats facing individual species and their significance, and the impacts that different actions and investments can make on conservation outcomes. Moreover, as funding is limited and biodiversity conservation often competes with other land use objectives, conservation actions and investments typically must be weighed against alternative options. To date, these decisions have been made in absence of a quantitative, comparable, scalable, and verifiable measure of the conservation gains from alternative actions and investments.

In response to this need, a new tool and approach are being developed by IUCN in partnership with The Biodiversity Consultancy, BirdLife International, Newcastle University, terraPulse, Inc., and a team of international experts. Called the Species Threat Abatement and Recovery (STAR) metric, the tool uses data from the IUCN Red List of Threatened Species™ to generate estimates of both potential and actual impacts of actions and investments to reducing species extinction risk at a range of scales and over a range of timelines.

STAR is presently being considered as a means for assessing contributions under the Kunming-Montreal Global Biodiversity Framework, similar to the way in which the global community has defined targets for limiting global warming under the UNFCCC. This assessment seeks to advance ways in which the STAR metric can be used to inform conservation and restoration action at project and landscape levels.

Calculating and interpreting STAR results

The STAR metric utilizes data on threatened species and threats from the IUCN Red List of Threatened Species™[4] (hereafter called the IUCN Red List), which employs a set of criteria to evaluate the extinction risk of thousands of species and subspecies throughout the world. Criteria include factors such as rate of population decline, population size, area of geographic distribution, and degree of population and distribution fragmentation. Species with sufficient data are classified into one of seven groups, ranging from "Least Concern," for those species unlikely to become extinct in the near future, to "Extinct[5]," for those species that are no longer extant.

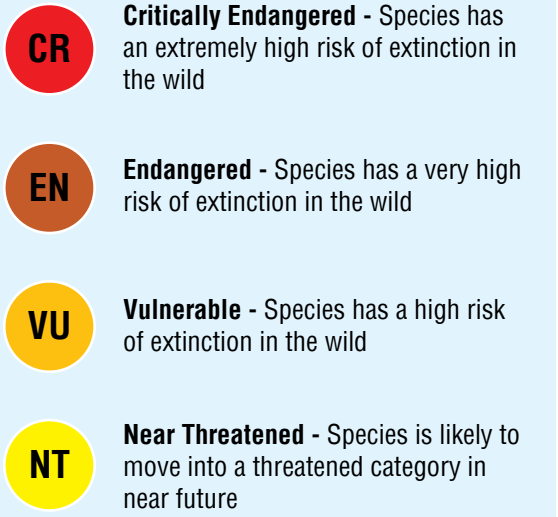
The STAR metric considers species classified in the IUCN Red List as threatened (classes CR, EN, VU) or "Near Threatened" (class NT) (see Box 1), and presently covers all assessed amphibians, birds and mammals. Future iterations of STAR will expand to additional species and groupings, including plants.

The central idea behind the STAR metric is that **for each threatened or Near Threatened species, the total global STAR score available represents the complete alleviation of threats sufficient to result in reclassifying that species as one of "Least Concern".** The total number of STAR units per species is dependent upon which Red List category a particular species is classified in, with higher amounts assumed to correspond to greater efforts needed to ensure species survival.

The total STAR units per species per Red List category are:

- 100 STAR units for a Near Threatened species
- 200 STAR units for a Vulnerable species
- 300 STAR units for an Endangered species
- 400 STAR units for a Critically Endangered species

Box 1. IUCN Red List species threat classification (abbreviated)



Underlying the STAR calculation are spatially explicit models estimating species Current Area of Habitat (Current AOH), defined as *"the area, characterized by its abiotic and biotic properties, that is presently habitable by a particular species"* as well as models estimating Lost AOH, defined as areas that were once habitable by a particular species but are now unoccupied by that species, presumably due to habitat modification and destruction[6]. To arrive at an estimate for species Lost AOH, information about the species historical range (i.e., Historical AOH) is combined with models incorporating landcover imagery from an earlier defined point in time. The difference between Current AOH and Historical AOH is then defined as Lost AOH.

For a detailed description of the methodology used to calculate the STAR metric see the Methodology section in Annex II of this report.

[4] https://www.iucnredlist.org

[5] A close category to "Extinct" is "Extinct in the wild," for those species that survive only in captivity, cultivation and/or outside native range.

[6] Brooks, et. al (2019). Measuring Terrestrial Area of Habitat (AOH) and Its Utility for the IUCN Red List. *Trends in Ecology & Evolution, 34*(11), 977-986. https://doi.org/10.1016/j.tree.2019.06.009

Application of STAR assessment data

Informing the prioritisation and design of conservation and restoration work

When results of the STAR metric calculation are presented in a map, areas of relatively higher STAR values (shown in red) may represent either overlapping AOH for several species, or the presence of highly threatened species, or a combination of both, and therefore offer significant opportunities for species conservation through actions that reduce risks to these threatened species. Project partners seeking to achieve conservation outcomes through project interventions may therefore wish to prioritize development of conservation measures including restoration within these areas.

Development of conservation measures should be done taking into consideration the particular threats that identified species within the project sites face[7]. A listing of priority threatened species for each site, along with their conservation status, and information on habitat, ecology and threats is found in Appendix I of this report. Moreover, the total STAR score for each site, shown at the bottom of each map, can be used in prioritizing conservation actions between different projects sites, including those assessed here, and subsequently to include other sites as STAR assessments become more widely available at a range of scales. The comparison between sites also enables managers to decide which site would generate the best contribution to species extinction reduction, and if combined with cost data (for instance land value, or cost of threat mitigation actions) could be used to allocate scarce financial resources cost-effectively.

Communications and awareness raising

Information on the priority threatened species for each site can be developed further into communication and awareness raising materials on the importance of project sites and conservation measures to conservation of threatened biodiversity.

Monitoring

These STAR assessments were performed using satellite imagery from 2019. This assessment data can potentially serve as baseline data to gauge the efficacy of subsequent conservation efforts, by repeating the same assessments using imagery from years following the start of conservation measures, and/or by subsequent assessments using on-the-ground surveying information on threatened species. Changes to the status of threats to species extinction that are not amenable to monitoring from satellite imagery, such as capture for food or trade, invasive species, or disease, will require other monitoring techniques. Detailed guidance on the monitoring of conservation outcomes using STAR is beyond the scope of this report but is key application of ongoing efforts to develop STAR[8].

[7] Note that the presence of threatened species at project sites has not been verified – only that threatened species AOH overlaps with project sites. Verification of presence of threatened species at project sites using on-the-ground sampling was beyond the scope of this assessment.

[8] For the latest information on STAR, please see: https://www.iucn.org/resources/conservation-tool/species-threat-abatement-and-recovery-star-metric

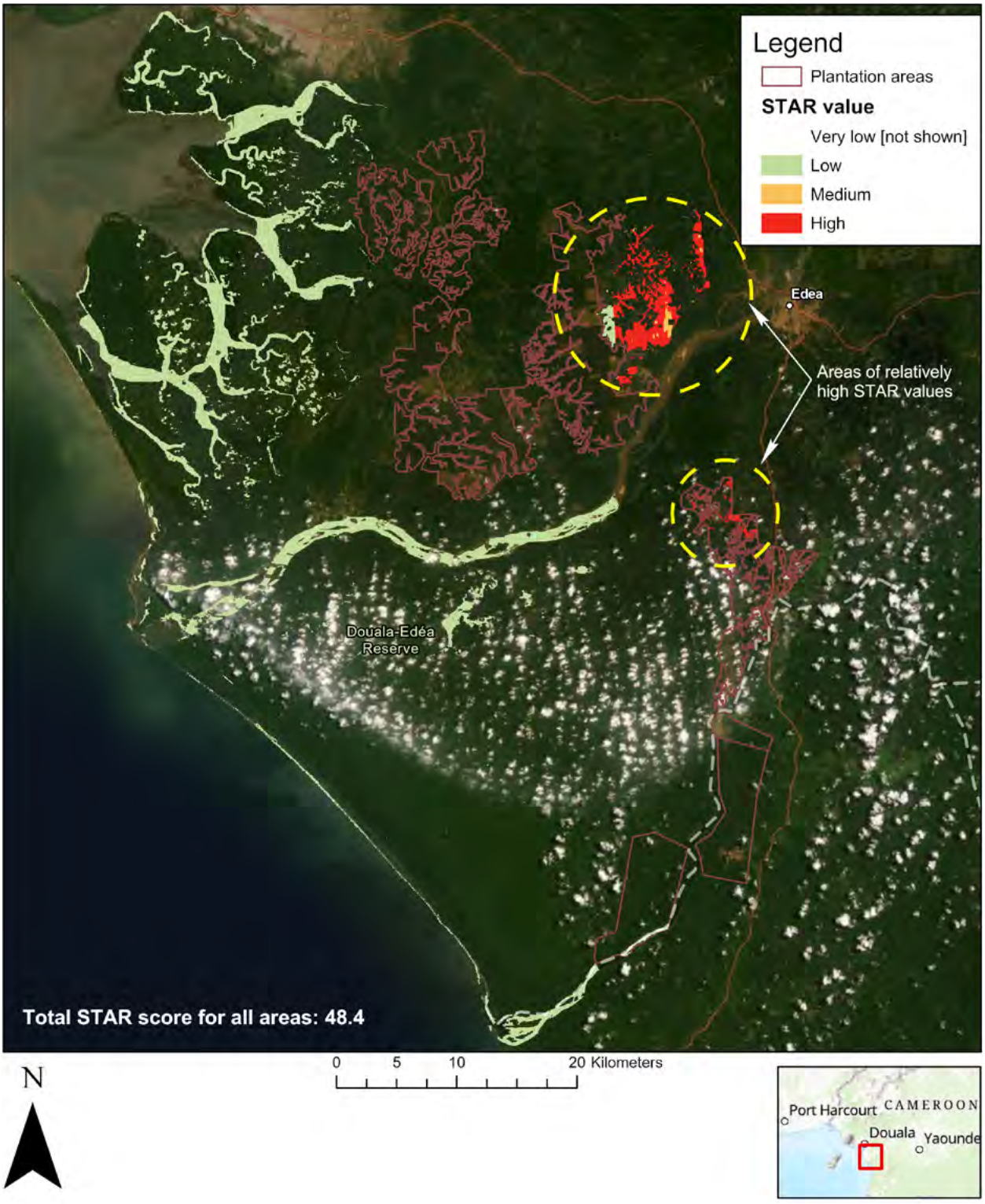
Findings

Findings in this section are grouped by project, with finding from the STAR assessment of the TRI Cameroon project site presented first, followed by finding from the TRI Kenya ASAL project sites and TRI Tana River Delta project sites.

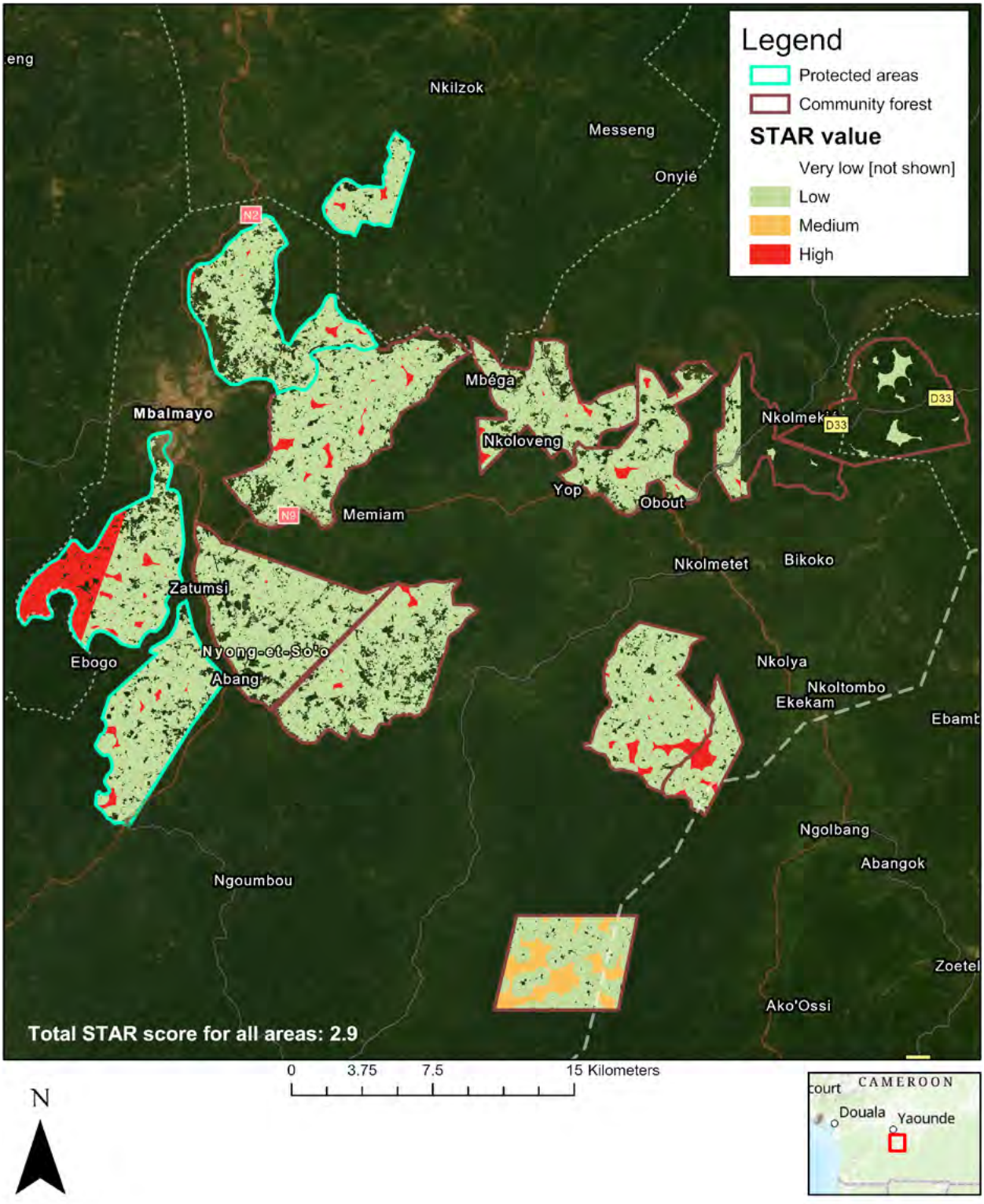
I. TRI Cameroon project sites

The high-resolution STAR assessment for the TRI Cameroon project sites focused on twenty threatened species that together comprise over 90% of the total low-resolution STAR assessment score at each of the three sites (see Table A1 on Annex 1 for a description of these threatened species). Two threatened species at the Douala-Edea project site on the coast – the Dizangue Reed Frog *(Hyperolius bopeleti;* IUCN Red List Classification: Vulnerable) and the Apouh Night Frog *(Astylosternus schioetzi;* IUCN Red List Classification: Endangered) – account for 86% of the total high-resolution STAR score for all the three project sites. As such, the Douala-Edea landscape is where the greatest opportunities for species conservation potentially lie among the three sites.

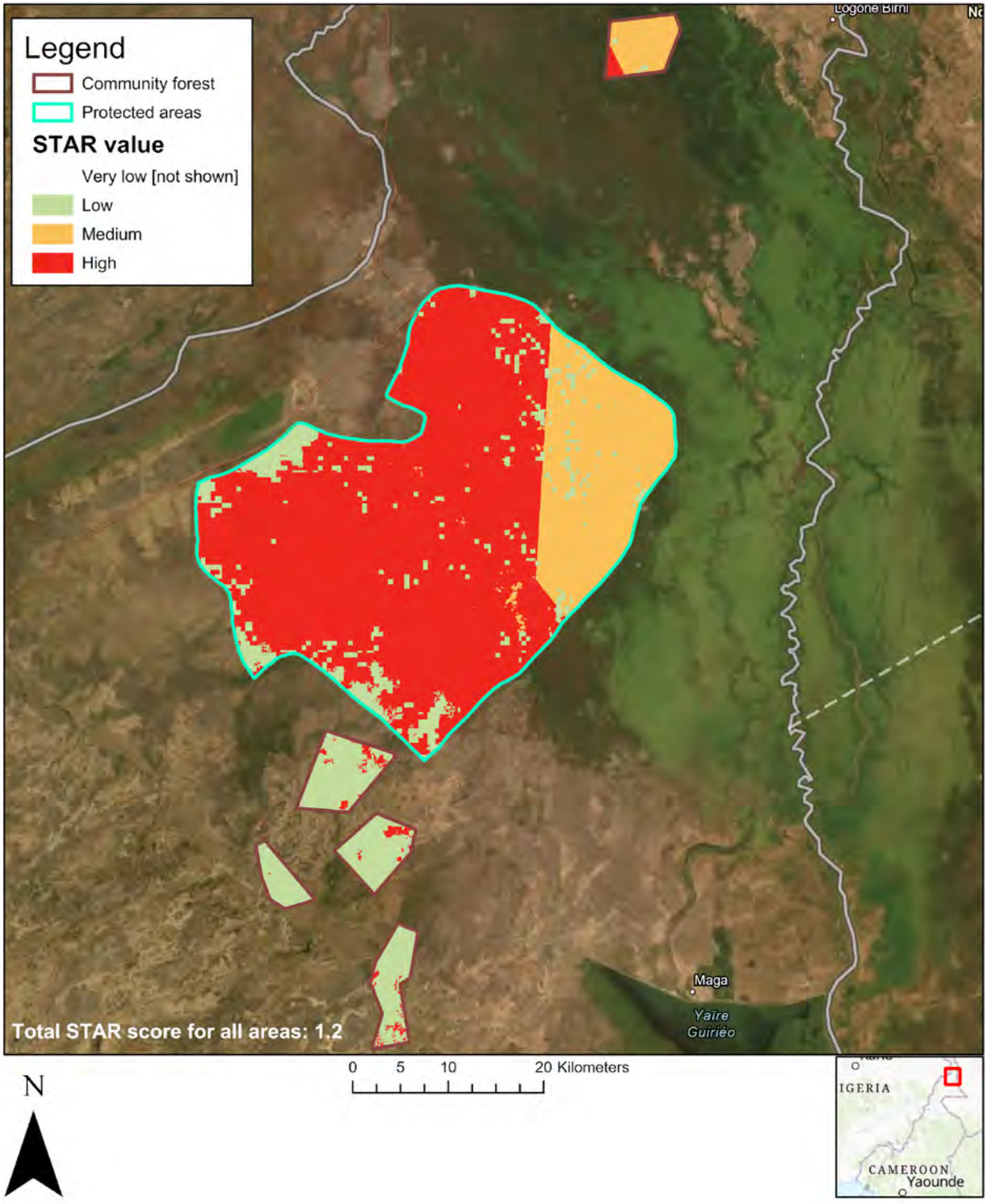
Maps 1, 2 and 3 on the following pages show the spatial distribution across the three project sites of total STAR threat abatement values for the 20 identified priority species, with areas of relatively high STAR values shown in red. **Areas of particular importance for threatened biodiversity are the northeast portions of the Douala-Edea Plantation sites shown in red on Map 1.** This finding is generally consistent with the prior low-resolution assessment although priority areas are here more clearly defined and easier to track with features on the ground.



Map 1. Distribution of total STAR threat abatement values from potential threat abatement actions for identified priority threatened species at the **TRI Cameroon Douala-Edea project site**. Classification of STAR values ("Very low" to "High") are relative to those at the project site. Areas shown in red in the northeastern areas are of particular importance to identified threatened species at this project site. (Source: Data compiled by the report authors)



Map 2. Distribution of total STAR threat abatement values from potential threat abatement actions for identified priority threatened species at the **TRI Cameroon Mbalmayo project site**. Classification of STAR values ("Very low" to "High") are relative to those at the project site. Areas shown in red are of particular importance to identified threatened species at this project site. (Source: Data compiled by the report authors)



Map 3. Distribution of total STAR threat abatement values from potential threat abatement actions for identified priority threatened species at the **TRI Cameroon Waza project site**. Classification of STAR values ("Very low" to "High") are relative to those at the project site. Areas shown in red are of particular importance to identified threatened species at this project site. (Source: Data compiled by the report authors)

Threats to identified threatened species at the three TRI Cameroon project sites[9]

STAR scores can be broken down according to their relative contribution to species decline at the project site, using specific information in the IUCN Red List of Threatened Species™ on the scope and severity of threats affecting listed species. As shown in Figure 1, 44% of the total STAR score for the Douala-Edea project site is associated with abatement of threats from agricultural (non-timber) crop expansion and intensification. Continuing downward in severity, the other threats believed to be affecting threatened species at the project site are residential and commercial development, logging and wood harvesting, and other lesser threats.

A similar set of relative threats is found at the Mbalmayo project site. As shown in Figure 2, 44% of the total STAR score for the Mbalmayo project site is associated with abatement of threats from agricultural (non-timber) crop expansion and intensification. Continuing downward in severity, the other threats believed to be affecting threatened species at the project site are invasive species, natural system modification, hunting, and other lesser threats.

At the Waza project site, as shown in Figure 3, the principle threat to identified threatened species is from hunting, which is associated with 24% of threats to identified threatened species at this project site. Continuing downward in severity, the other threats believed to be affecting threatened species at this project site are livestock farming and ranching, agricultural (non-timber) crop expansion and intensification, pollution, human disturbance, and other lesser threats.

A more detailed description of these threats is found in Table 1.

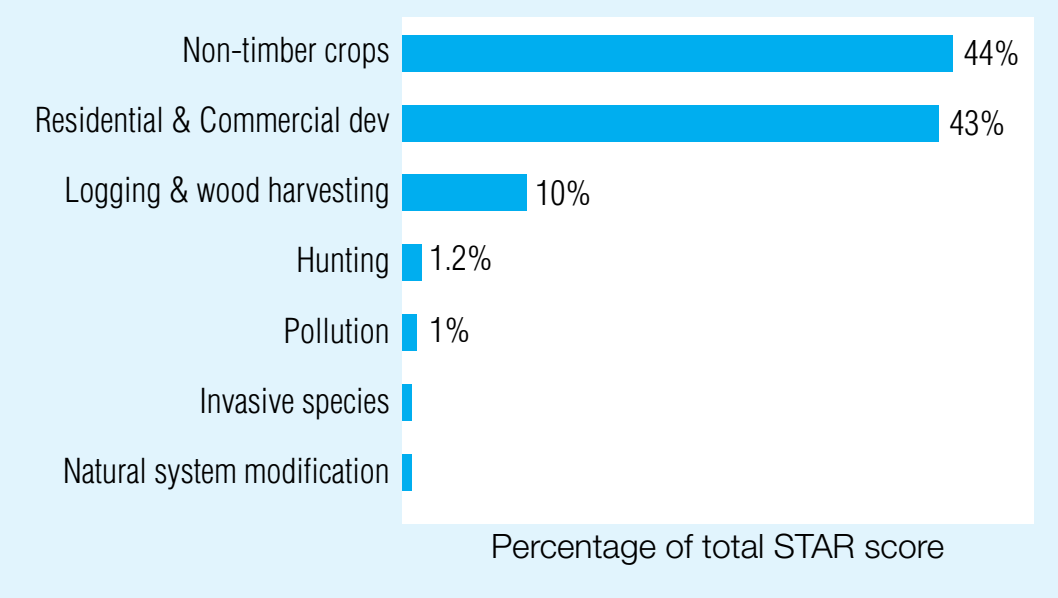


Figure 1. Relative contribution of threats to species risk of extinction at the **TRI Cameroon Douala-Edea project site**. Bars show the percentage of total STAR score (48.4) for the project site generated by actions addressing identified threats to assessed threatened species. (Source: Data compiled by the report authors)

[9] Note, findings should be interpreted with care, as they rely upon global data that may not reflect local conditions, either because they are outdated or incorrect

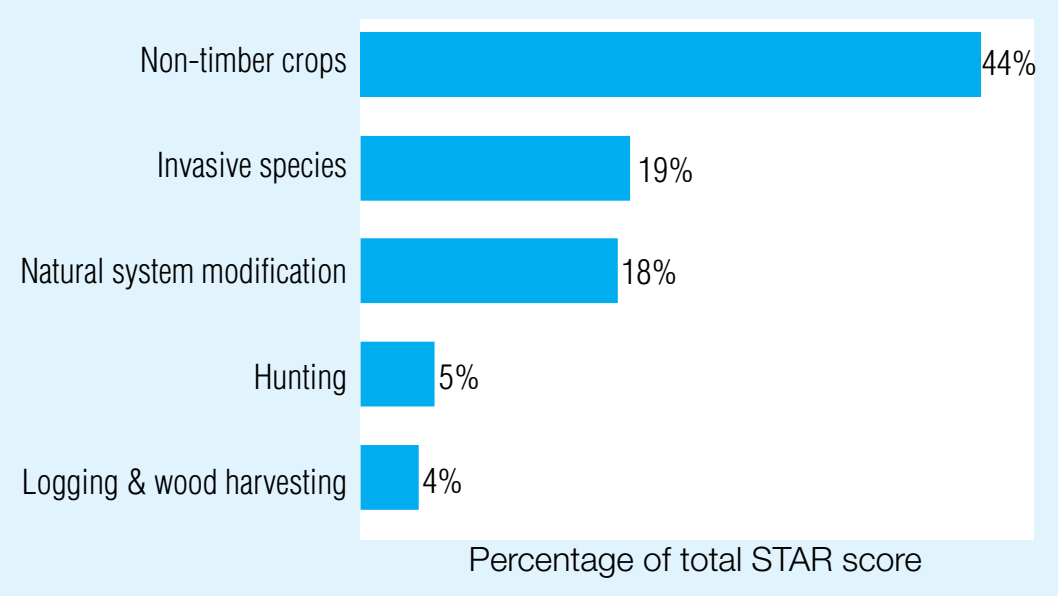


Figure 2. Relative contribution of threats to species risk of extinction at the **TRI Cameroon Mbalmayo project site**. Bars show the percentage of total STAR score (2.9) for the project site generated by actions addressing identified threats to assessed threatened species. (Source: Data compiled by the report authors)

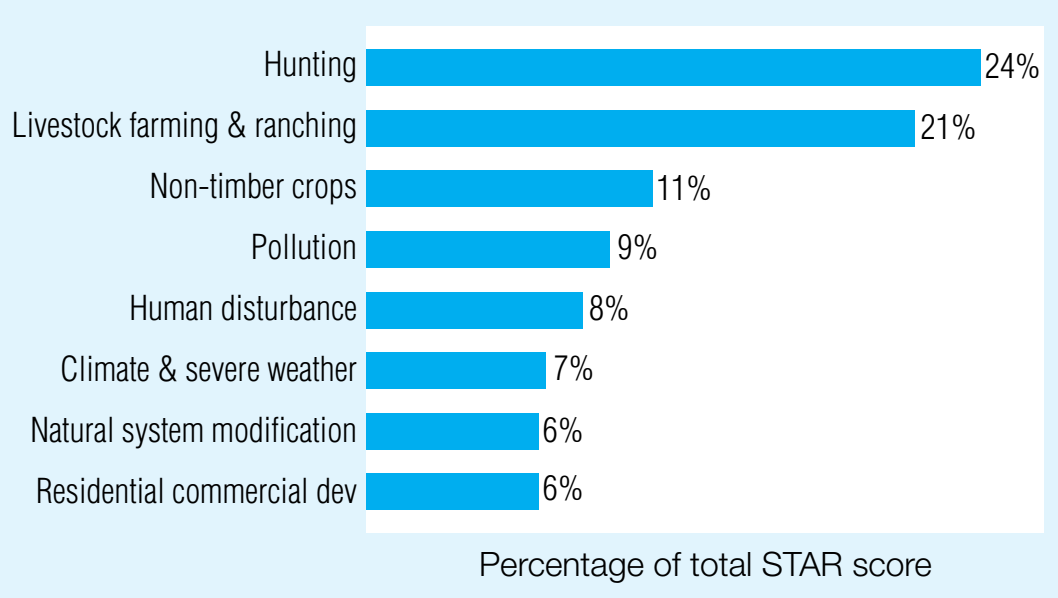


Figure 3. Relative contribution of threats to species risk of extinction at the **TRI Cameroon Waza project site**. Bars show the percentage of total STAR score (1.2) for the project site generated by actions addressing identified threats to assessed threatened species. (Source: Data compiled by the report authors)

Table 1. Summary information on the IUCN threats classification scheme[10]

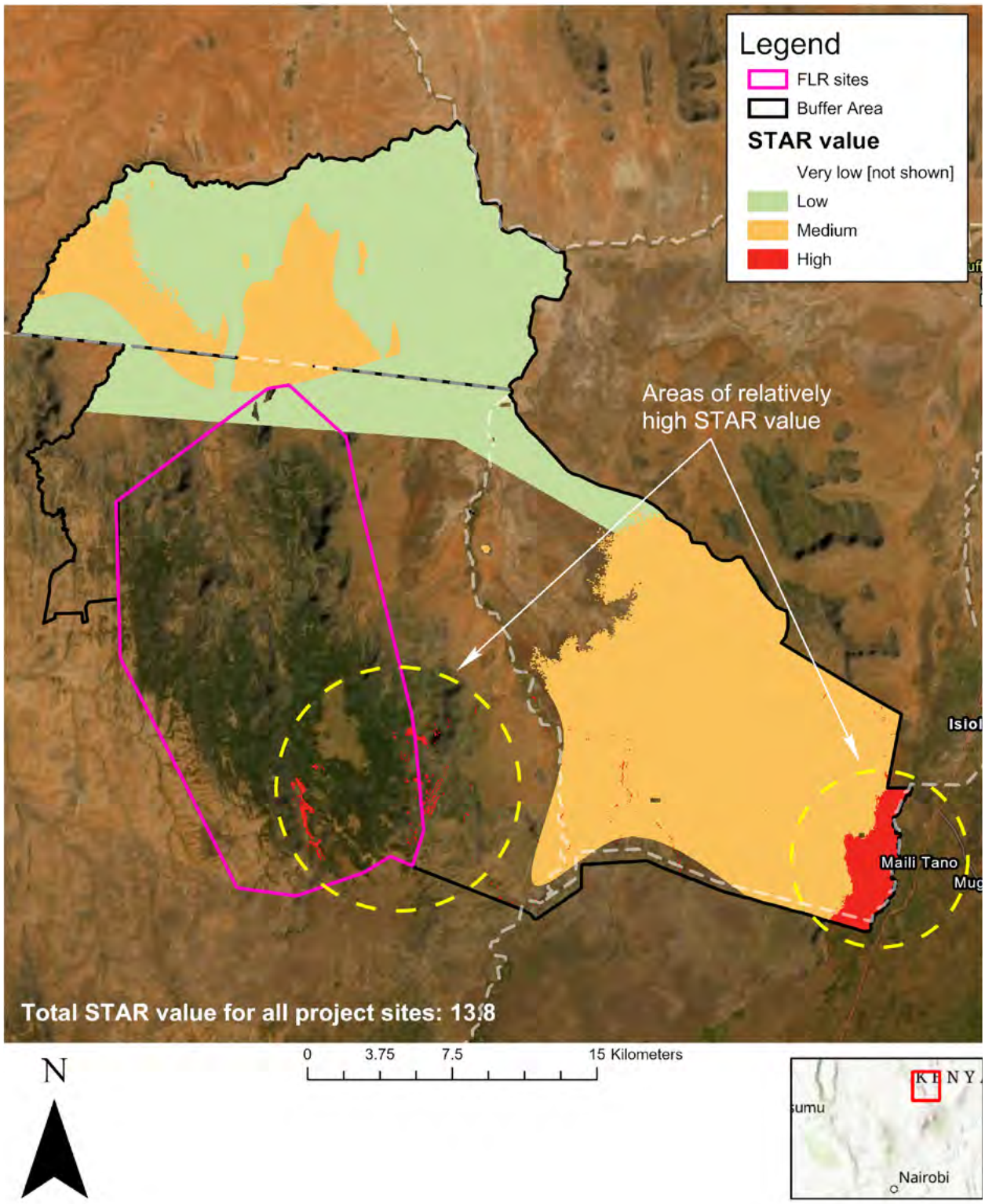
Threat	Description
Climate change & severe weather	Threats from long-term climatic changes which may be linked to global warming and other severe climatic/weather events that are outside of the natural range of variation, or potentially can wipe out a vulnerable species or habitat
Energy production & mining	Threats from production of non-biological resources. Examples include oil and gas drilling; mining and quarrying; and exploring, developing and producing renewable energy.
Human disturbance	Threats from human activities that alter, destroy and disturb habitats and species associated with non-consumptive uses of biological resources.
Hunting	Killing or trapping terrestrial wild animals or animal products for commercial, recreation, subsistence, research or cultural purposes, or for control/persecution reasons; includes accidental mortality/bycatch
Invasive species	Threats from non-native and native plants, animals, pathogens/microbes, or genetic materials that have or are predicted to have harmful effects on biodiversity following their introduction, spread and/or increase in abundance
Livestock farming & ranching	Threats from raising of domestic terrestrial animals in one-location (livestock farming), as well as threats from domestic or semi-domesticated animals allowed to roam in the wild and supported by natural habitats (livestock ranching)
Logging & wood harvesting	Harvesting trees and other woody vegetation for timber, fiber, or fuel
Natural system modification	Threats from actions that convert or degrade habitat in service of "managing" natural or semi-natural systems, often to improve human welfare. Examples include fire & fire suppression; dams and water management and use, and other ecosystem modifications like tree thinning, beach construction, etc.
Non-timber crops	Threats from farming of crops planted for food, fodder, fiber, fuel or other uses as a result of agricultural expansion and intensification
Pollution	Threats from introduction of exotic and/or excess materials or energy from point and nonpoint sources. Includes domestic & urban waste water, and industrial and agricultural runoff, and garbage and solid waste, as well as heat, sound or light that disturbs wildlife or ecosystems
Residential & commercial development	Threats from human settlements or other non-agricultural land uses with a substantial footprint. Examples include housing and urban areas; commercial and industrial areas; and tourism and recreation areas (e.g., golf courses; resorts; campgrounds)
Transportation corridors	Threats from long narrow transport corridors and the vehicles that use them including associated wildlife mortality
Wood & pulp plantations	Threats from establishment, expansion, and intensification of stands of trees planted for timber or fiber outside of natural forests, often with non-native species

II. TRI Kenya ASAL project sites

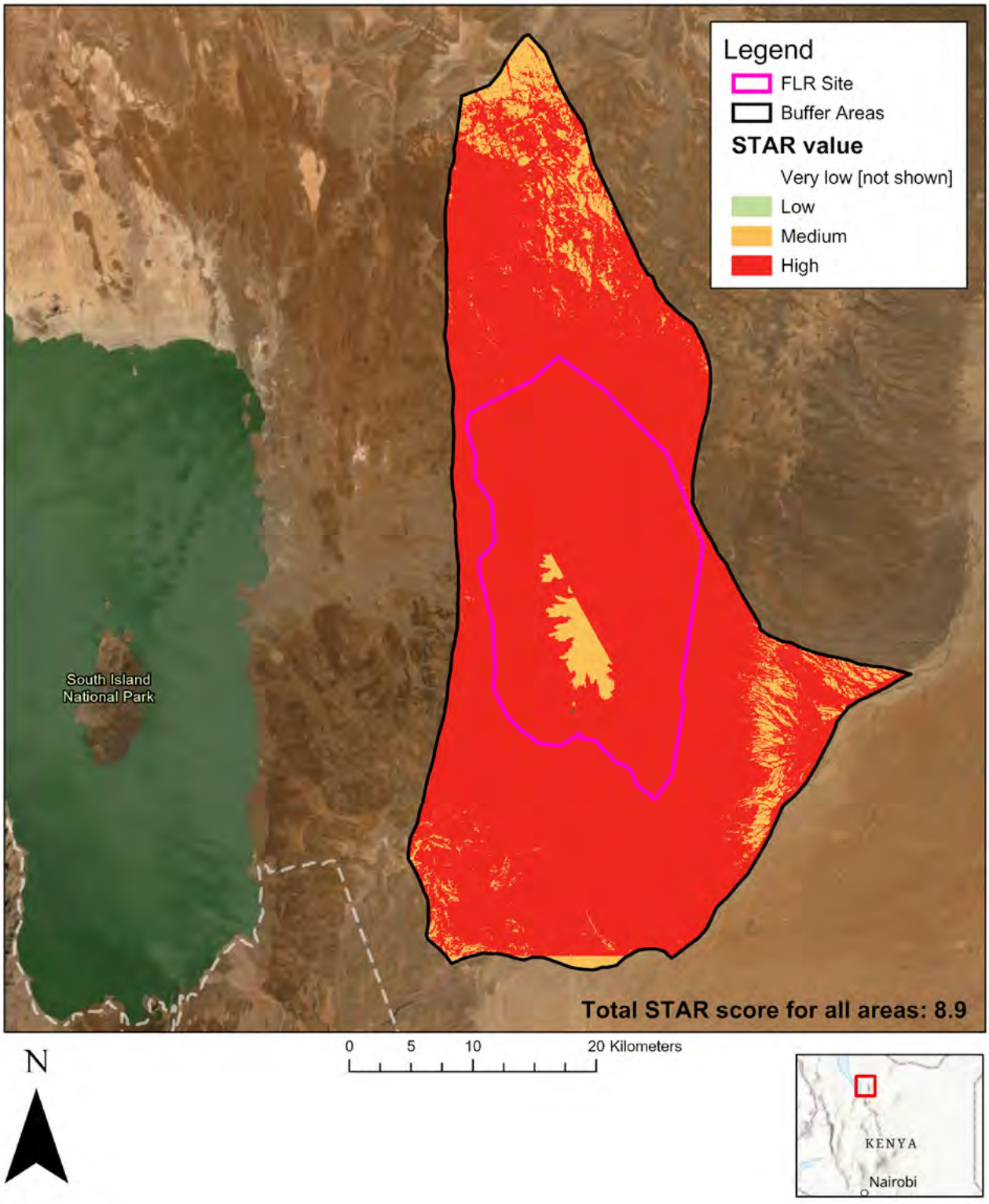
This high-resolution STAR assessment for the TRI Kenya ASAL project site focused on fifteen threatened species that together comprise over 90% of the total low-resolution STAR assessment score for the two sites (see Table A2 on Annex 1). The majority of these species are found in Savannah and Grassland (13 of 15) or Shrubland (12 of 15), and a few utilize Forest (6 of 15).

Maps 4 and 5 on the following pages show the spatial distribution across the two project sites of total STAR threat abatement values for the 15 identified priority species, with areas of relatively high STAR values shown in red. The high-resolution STAR assessment finds **the southeastern part of the buffer area of the Mukogodo forest landscape near Maili Tano as well as the Mt. Kulal site (both project and buffer areas) and some smaller forest remnants to be of particular importance to a number of threatened species.** This finding is generally consistent with the prior low-resolution assessment although priority areas are here more clearly defined and easier to track with features on the ground.

[10] IUCN Red List Threats Classification Scheme version 3.2, available: https://www.iucnredlist.org/resources/threat-classification-scheme



Map 4. Distribution of total STAR threat abatement values from potential threat abatement actions for identified priority threatened species at the **TRI Kenya ASAL Mukogodo Forest project site**. Classification of STAR values ("Very low" to "High") are relative to those at the project site. As indicated in red, the southeastern part of the buffer area of the Mukogodo forest landscape near Maili Tano and some smaller forest fragments are of particular importance to identified threatened species at this project site. (Source: Data compiled by the report authors)



Map 5. Distribution of total STAR threat abatement values from potential threat abatement actions for identified priority threatened species at the **TRI Kenya ASAL Mount Kulal project site**. Classification of STAR values ("Very low" to "High") are relative to those at the project site. Areas shown in red are of particular importance to identified threatened species at this project site. (Source: Data compiled by the report authors)

Threats to identified threatened species at the two project sites

As shown in Figure 4, 18% of the total STAR score for the Mukogodo forest project site is associated with abatement of threats from livestock farming and ranching. Continuing downward in severity, the other threats believed to be affecting threatened species at the project site are natural system modification, hunting, non-timber crops, human disturbance, and other lesser threats.

A similar set of relative threats is found at the Mount Kulal project site. As shown in Figure 5, 23% of the total STAR score for the Mount Kulal project site is associated with abatement of threats from livestock farming and ranching. Continuing downward in severity, the other threats believed to be affecting threatened species at the project site are hunting, natural system modification, human disturbance, and other lesser threats.

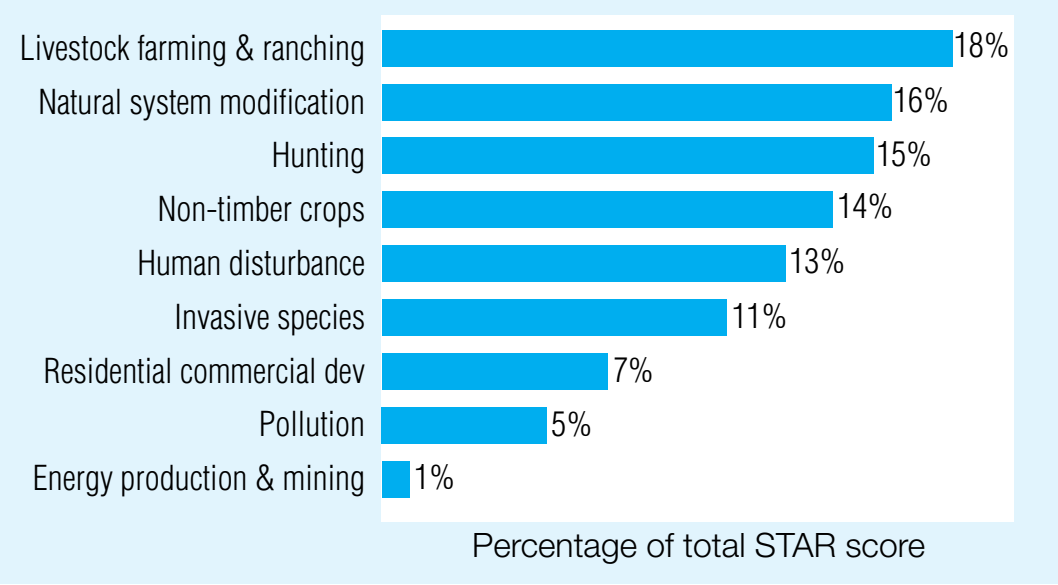


Figure 4. Relative contribution of threats to species risk of extinction at the **TRI Kenya ASAL Mukogodo Forest project site**. Bars show the percentage of total STAR score (13.8) for the project site generated by actions addressing identified threats to assessed threatened species. (Source: Data compiled by the report authors)

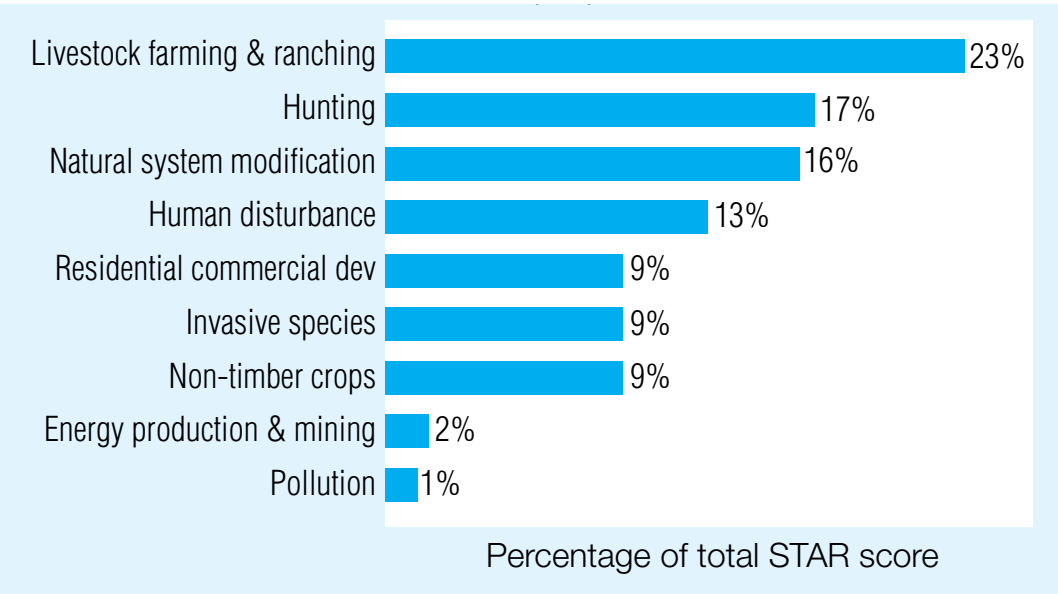
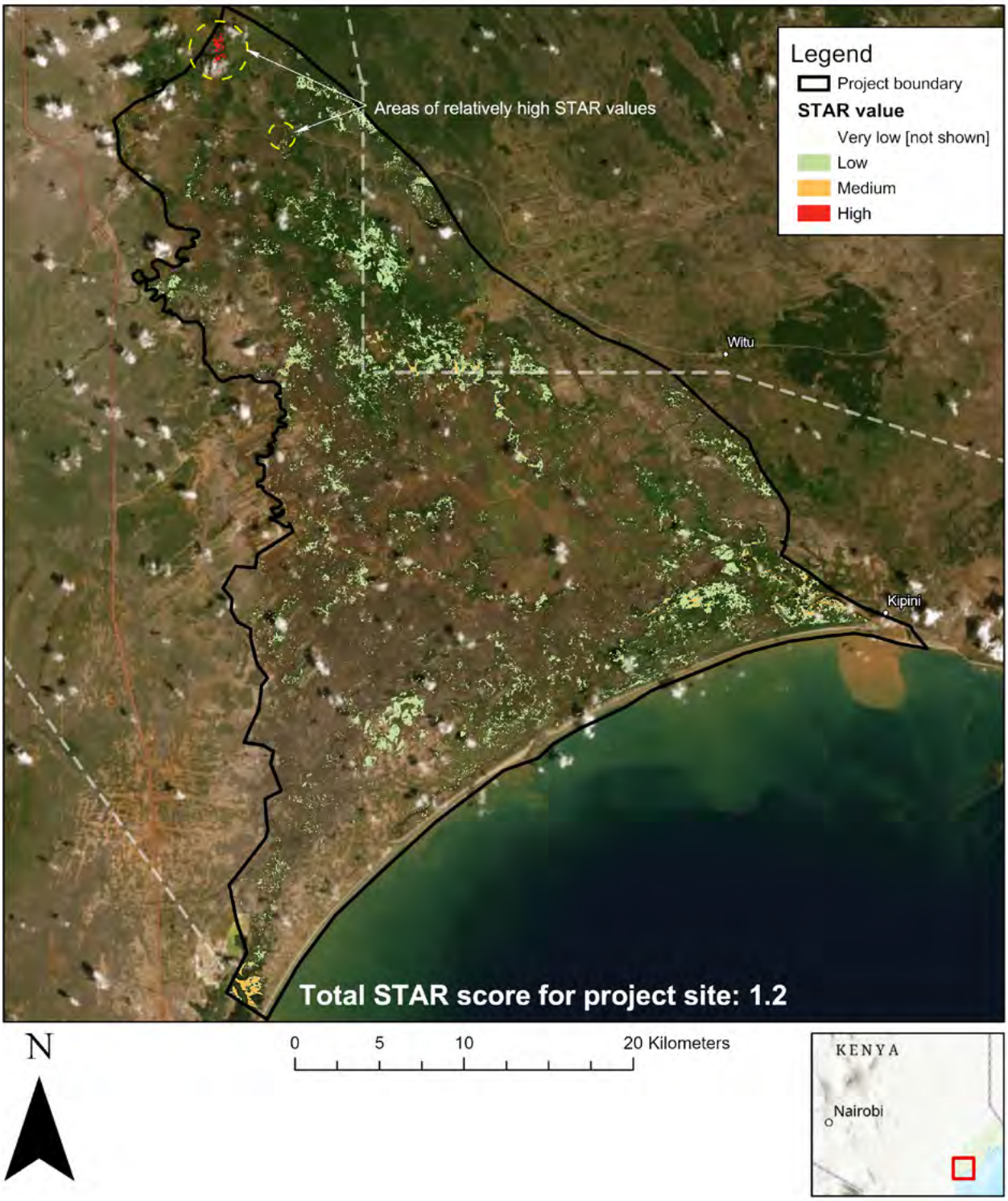


Figure 5. Relative contribution of threats to species risk of extinction at the **TRI Kenya ASAL Mount Kulal project site.** Bars show the percentage of total STAR score (8.9) for the project site generated by actions addressing identified threats to assessed threatened species. (Source: Data compiled by the report authors)

III. TRI Tana River Delta project site

This STAR assessment is limited in scope to three threatened species that together comprise over 90% of the total low-resolution STAR assessment score for the site: the Tana River Red colobus monkey (*Piliocolobus rufomitratus;* IUCN Red List status: Critically Endangered); the Sokoke dog mongoose (*Bdeogale omnivora;* IUCN Red List status: Vulnerable); and the Spotted ground thrush (*Geokichla guttata;* IUCN Red List status: Endangered). As described more fully in Table A3 on Annex 1, all three of these species are forest-dwelling species, with the Spotted ground thrush described as having a more restricted preference for disturbance-free (i.e., core) forest. In addition, localized shrubland is a suitable habitat for both the Tana River Red Colobus monkey and Spotted ground thrush, and the Tana River Red Colobus monkey also resides in certain localized wetlands.

Map 6 on the following page shows the spatial distribution across the project site of total STAR threat abatement values for the three identified priority species, with areas of relatively high STAR values shown in red. **The Northwest portion of the project site is where the highest concentrations of STAR values are found, indicating their relative importance within the site for conservation.** Other areas of relative concentration include the southwestern portion of the project side just off the coast as well as some scattered patches of forest in the center and northeast parts of the project site.



Map 6. Distribution of total STAR threat abatement values from potential threat abatement actions for identified priority threatened species at the **TRI Kenya Tana River project site**. Classification of STAR values ("Very low" to "High") are relative to those at the project site. Areas shown in red in the northwestern areas of particular importance to identified threatened species at this project site. (Source: Data compiled by the report authors)

Threats to identified threatened species at the project site

As shown in Figure 6, 22% of the total STAR score for the project site is associated with abatement of threats from logging and wood harvesting activities. Continuing downward in severity, the other threats believed to be affecting threatened species at the project site are natural system modification (including changes to the natural hydrology); non-timber crop production; invasive species; climate change and severe weather; and other lesser threats.

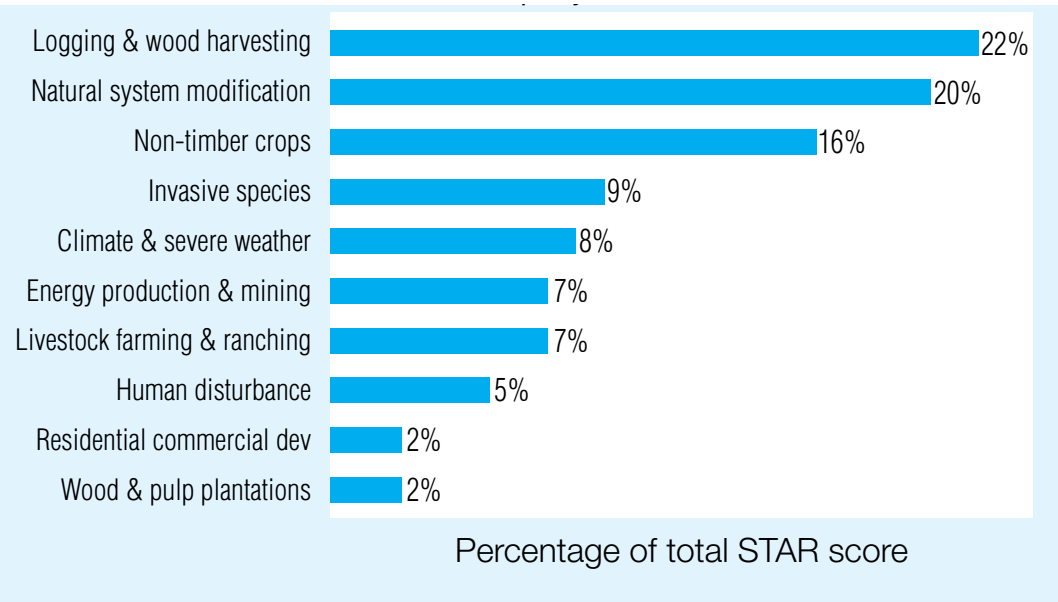


Figure 6. Relative contribution of threats to species risk of extinction at the **TRI Kenya Tana River project site**. Bars show the percentage of total STAR score (1.2) for the project site generated by actions addressing identified threats to assessed threatened species. (Source: Data compiled by the report authors)

Differences in STAR scores between low- and high-resolution assessments

A principal difference in findings between the low- and high-resolution assessments concerns the overall STAR score. **The high-resolution assessment indicates lower total STAR scores at the project sites compared to the low-resolution assessment:** 76.2 total STAR score (all sites) in the high-resolution assessment vs 245 total STAR score from the low-resolution assessment. The lower STAR score values in the high-resolution assessment are likely a result of three factors:

1. less inclusion in the high-resolution assessment of non-project site areas that overlap (wholly or partially) with the larger 5-km grid cells of the low-resolution assessment;

2. differences in the distribution of AOH for the priority species using the new land cover map developed for the high-resolution assessment; and

3. lack of re-calibrated global AOH values for priority species when calculating the estimated STAR values at the project site.

The above factors concern both the distribution and total amount of AOH for assessed species that is at the heart of the STAR calculation. Using the TRI Tana River Delta project site as an example and as shown in Table 1 below, **for each assessed species the low-resolution assessment identified much larger amounts of species AOH within the project site compared with the high-resolution assessment: 935 km² in total versus 74.7 km².** Some of this reduction may reflect "real" reductions in current AOH in 2019 – the date of remotely-sensed imagery used to generate Current AOH for the high-resolution assessment – compared with what existed in 2015 – the year of imagery used to generate Current AOH for the low-resolution assessment. However, given the historical pace of landcover change in the Tana Delta and the lack of any major changes in land cover management or large-scale disturbance at the project site between 2015 and 2019[11], the differences in total AOH within the project site are more likely the result of differences in the approach used to classify and code land cover. This underscores the importance of using consistent land cover mapping over space and time in developing STAR assessments.

Table 2. Comparison of values from the high-resolution (green highlighted columns) and low-resolution (blue highlighted columns) STAR analyses. AOH, % of total AOH, and STAR threat abatement values were much lower in the high-resolution analysis compared to the low-resolution analysis.

Common name	Area of Habitat (km²) in project site, high resolution analysis	Area of Habitat (km²) in project site, low resolution analysis	% of current AOH in project site, high resolution analysis	% of current AOH in project site, low resolution analysis	STAR score, high resolution analysis	STAR score, low resolution analysis
Tana River Red colobus	0.5	73.8	0.13%	18%	0.5	55.2
Sokoke dog mongoose	4.0	395.6	0.03%	4%	0.1	7.0
Spotted ground thrush	70.2	465.6	0.19%	1%	0.6	3.7
TOTAL	74.7	935	0.35%	23%	1.2	65.9

Land cover mapping approach and imagery and potential impacts on STAR scores

As described in more detail in the Methodology section in Annex 1, the low-resolution STAR analysis made use of freely-available land cover maps from the European Space Agency Climate Change Initiative (ESA CCI) at 300 meter resolution[12]. While the ESA CCI map covers the globe, along with its coarse resolution and lack of regular updates, the map was designed principally to aid in assessing large-scale climate change impacts but not identification and conservation of AOH for threatened species as assessed and characterized by the IUCN Red List of Threatened Species™. To address some of these concerns, a new land cover classification scheme was developed and used for this high-resolution analysis that is potentially better aligned with and customizable to match the species habitat classification scheme found in the IUCN Red List of Threatened Species™ data[13]. Whether the AOH mapping generated using the new land cover map is indeed more accurate than AOH mapping made using the ESA CCI map would need to be verified through on-the-ground surveying and other means. In any case, use of different maps to generate AOH is a likely factor in the difference in reported total AOH and likewise, total STAR within the project site between the high- and low-resolution assessments.

Another factor likely driving the difference in the STAR results is the reliance of both assessments upon global estimations of total STAR values based on the ESA CCI map and work done by Bernardo Strassburg and others[14]. That is, the new land cover map and updated species AOH was developed for the project site only, but the STAR calculation that relies upon an estimation of the percentage

[11] Confirmed through February 24, 2022 discussion with Paul Matiku, Nature Kenya

[12] Available online: https://www.esa-landcover-cci.org/?q=node/158

[13] See: https://www.iucnredlist.org/resources/habitat-classification-scheme

[14] Strassburg et. al (2019). *Global priority areas for ecosystem restoration, Nature 586,* 724-729 https://doi.org/10.1038/s41586-020-2784-9

of species total (i.e, throughout the world) current AOH found at the project site was made using the older, low-resolution values for total global AOH. As such, if the total global AOH for the assessed species using the site-level high-resolution assessment approach were substantially lower than that identified by Strassburg et al., STAR values presented here would be an underestimation of the site's potential value towards conservation of these threatened species.

Lastly, this high-resolution STAR assessment highlights the impact that differences in the year from which imagery is selected to estimate historical AOH can have in calculating Lost AOH, and subsequently, potential STAR scores from the restoration of Lost AOH. The low-resolution assessment uses imagery from 1992 and 2015 (a 23-year time span) to estimate historical and Lost AOH and calculates a value of 24.7 STAR score from restoration/threat abatement of Lost habitat at the project site. The high-resolution assessment uses imagery from 2010 and 2019 (a 9-year time span) to estimate historical and Lost AOH and calculates a negligible 0.001 STAR score from restoration/threat abatement of Lost habitat.[15]

Due to the extremely low STAR restoration values calculated in this high-resolution assessment, these values are not presented on the accompanying maps as they don't provide much useful information.

[15] As with the STAR threat abatement scores, calculation of the STAR restoration score in this high-resolution assessment relies upon the estimations of total global AOH from Strassburg et al.

Discussion and recommendations

This work to advance the development of STAR has demonstrated the importance and impact to STAR values that arise from changes in the way that underlying data on species ecology and habitat data are recorded, classified, and modeled. While some difference in the AOH and STAR values between the low- and high-resolution assessments was anticipated, the magnitude of the difference in values was significant. For STAR to develop into a comparable, scalable, and verifiable measure trusted and utilized by a wide range of stakeholders, an approach to calculating STAR values across any landscape of any size throughout the world needs to be developed that produces consistent, replicable, and verifiable results.

Results suggest a need for the following:

- Development of global, high-resolution land cover classification mapping datasets going back several decades (where possible), and regularly updated. These land cover classification datasets, which are the building blocks for AOH modeling and STAR calculation, should be tailored to the Habitat Classification and Threat Classification schemes employed by the IUCN Red List of Threatened Species™[16]. Factors to consider in developing these data sets would include:
  - The number and type of land cover classes needed to meet the needs of STAR stakeholders and users considering factors including feasibility (what can be reliably modeled using available remotely-sensed data and processing); cost; complexity; accuracy; and verifiability.
  - The thresholds/criteria for assigning the different landcover classes in developing land cover mapping using imagery and underlying data. For example, criteria for classifying landcover as “Forest” or “Savanna” or sub-classes such as “Pastureland”. The thresholds/criteria chosen are in effect the criteria that determine the overall size and distribution of any AOH developed using a particular land cover map, as an AOH model is essentially landcover that has met a number of criteria for a particular species including landcover type, elevation, and so on (see Methodology section). Moreover, one issue for developers of STAR and the IUCN Red List to consider is that the Red List Habitat Classification scheme was designed to describe viable habitat for species, and not necessarily non-viable habitat.[17]
  - Availability, coverage and cost in acquiring underlying imagery and frequency of updates
  - A systematic approach for verifying, updating, and refining land cover and AOH datasets.

- Development of additional guidance in calculating Lost AOH and STAR restoration values. Considering the strong political support and demand for restoration (e.g., UN Decade on Ecosystem Restoration; Bonn Challenge and regional commitments), and the potential role that STAR can play in identifying priority areas for restoration, guidance on the choice of an appropriate year(s) for baseline imagery and the way to interpret this data should be developed.

It is hoped that this High-Resolution STAR assessment can help inform the work of the TRI Cameroon and TRI Kenya projects, and other efforts to help conserve threatened species in Cameroon and Kenya, and support the development of STAR into a key tool for bringing site-specific and actionable knowledge on threatened species into the hands of conservation practitioners, policymakers, investors, local communities and other stakeholders.

[16] https://www.iucnredlist.org/resources/habitat-classification-scheme

[17] For example, Red List habitat and ecology information on the Spotted Ground Thrush – one of the three priority threatened species thought to be present at the TRI Tana River project site – notes that “the species avoids disturbance-prone areas.” However, the criteria for disturbance and corresponding sub-classes for landcover such as disturbed forest are not found within the present IUCN Red List Habitat Classification system. For this assessment, the land cover map developed included a class for “Edge Forest” derived using a buffer of 400 m to distinguish Core Forest from Edge Forest and based on work of Laurance (2008) which shows edge effects can persist at 400 m from the border of forest and non-forest land cover. However, the approach followed here is not universally adopted.

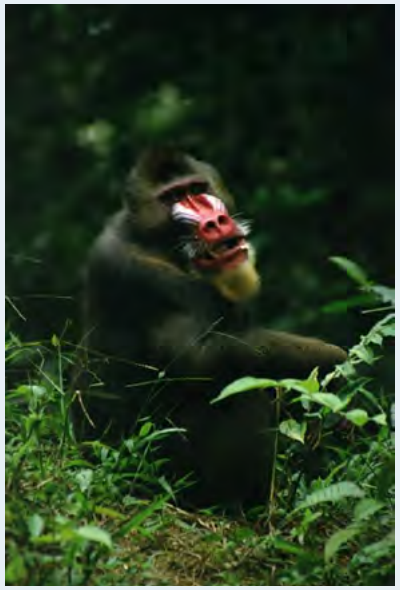
Annex 1. Priority threatened species with AOH overlapping project sites

The following tables provide information on habitat ecology and threats for all threatened species assessed in this high-resolution STAR assessment. These are species with Area of Habitat (AOH) that overlaps with project sites, and that together comprise over 90% of the total prior, 2020, low-resolution STAR assessment score at each project site. Actions to reduce threats at project sites to these identified threatened species would potentially be of greatest relative value to global biodiversity conservation efforts. Further field work to update the AOH for these species might reveal opportunities to further contribute to the conservation of the species.

Table A1. Information on habitat ecology and threats for the 20 identified priority threatened species at the three TRI Cameroon project sites, from the IUCN Red List of Threatened Species™. Habitat suitability coding using 8-class terraPulse classification scheme shown under Habitat and Ecology in detail (see Annex I, Coding species habitat suitability)

Common name; Scientific name; Conservation status; Project site	Photo image	Habitat and ecology in detail	Threats in detail
Dizangue Reed Frog ***Hyperolius bopeleti*** **Vulnerable** VU Doula-Edea project site	 *Photo credit: Jean-Louis Amiet*	This species lives in degraded former forest (farm bush) on sandy soil, however it is in an area with high levels of precipitation throughout the year which has high levels of humidity even during the dry season. It can live within a few meters of the sea. Breeding takes place in small pools, and the eggs are placed 4–5 m above still water into which the larvae fall and develop. **Suitable habitats** (IUCN Red List classification scheme): **Wetlands (inland); Artificial/Terrestrial** **Suitable habitats** (terraPulse classification scheme): **Wetlands, Water**	Although it is clearly adaptable, this species is probably at risk from expanding agriculture and human settlements within its small range.
Apouh Night Frog ***Astylosternus schioetzi*** **Endangered** EN Doula-Edea project site	 *Photo credit: Dave Blackburn*	This species lives in and near flowing water in lowland forest, and can survive in tall, secondary forest. It breeds in small streams and in marshy depressions with very small, superficial streams. **Suitable habitats** (IUCN Red List classification scheme): **Forest, Wetlands (inland)** **Suitable habitats** (terraPulse classification scheme): **Wetlands, Water; Core Forest; Edge Forest**	The major threat to the species is habitat loss and degradation due to clearance for agricultural land, human settlements and logging.

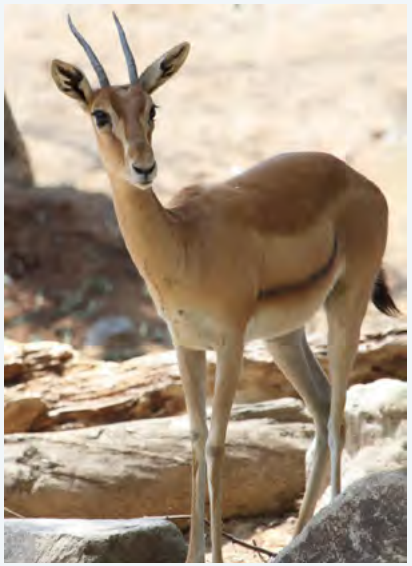
Common name; Scientific name; Conservation status; Project site	Photo image	Habitat and ecology in detail	Threats in detail
Bates's Weaver ***Ploceus batesi*** **Endangered** EN Mbalmayo & Douala-Edea project sites	 *Photo credit: Grant Durr on Unsplash https://unsplash.com/s/photos/ploceus-batesi*	This species occurs in lowland rainforest, although all recent records come from secondary forest and forest edge, particularly degraded forest around villages. It has been recorded on Mt Kupe up to 900 m. In 1979, a single bird was observed moving in a zig-zag manner up a creeper-covered tree-trunk, and it has been observed foraging under the canopy. It occurs singly and in pairs, and one record was in a mixed-species flock; it appears to use bark-gleaning to forage on insects. **Suitable habitats** (IUCN Red List classification scheme): **Forest** **Suitable habitats** (terraPulse classification scheme): **Core Forest; Edge Forest**	Since it is a bark-gleaning species it may be in competition with Preuss's Weaver P. preussi. In Cameroon, deforestation occurs due to agricultural expansion, and selective logging. A plan for a 70,000 ha palm oil plantation is underway and threatens to significantly fragment large areas of suitable habitat in southwestern Cameroon.
Goliath Frog ***Conraua goliath*** **Endangered** EN Mbalmayo & Douala-Edea project sites	 *Photo credit: Ignacio de la Riva*	This species lives in or near fast-flowing rivers and streams in rainforest, preferring warmer, slower rivers than Conraua robusta but faster rivers than C. crassipes. It can survive in secondary habitats close to rivers, as well as in forest, but not in very heavily degraded areas (farm bush). It requires large, clean rivers and, due to the heavy consumption of this species, it is now only found deep in undisturbed forest away from villages (M.-O. Rödel pers. comm. July 2016). Breeding occurs in streams and small rivers. The young rest by flowing water during the day. Around Nkongsamba in western Cameroon, C. goliath, C. crassipes and C. robusta occur sympatrically. A generation is assumed to be approximately five years. **Suitable habitats** (IUCN Red List classification scheme): **Forest; Wetlands (inland); Artificial/Terrestrial** **Suitable habitats** (terraPulse classification scheme): Core Forest; **Edge Forest; Wetlands/Water**	The major threat to this species is hunting for human consumption, both for local subsistence and to be sold at bush meat markets. New, sophisticated traps for catching this species are now being used in the Nkongsamba area of Cameroon. Large scale collection for the international pet trade is growing and also contributing to the decline of this species, with animals imported from Cameroon to the USA on a regular basis by animal dealers for zoos, the pet trade and, in the past, for competitive frog races (one estimate of this trade was 300 animals per year). There has been at least one instance of an import into Europe that did not satisfy legal requirements leading to customs seizure. It is also adversely affected by the loss of forest habitat for agriculture (including the creation of new cocoa plantations, banana plantations, and palm plantations), logging and human settlements. With the creation of a new roads network to extract and commercialise products from these plantations, the habitat of this species is now more accessible to people (N. Gonwouo pers. comm. January 2018). Other threats to its habitat include sedimentation of its breeding streams and the dumping of chemicals in river tributaries by locals often in streams around farms and villages where the species reproduces, which is likely to affect tadpole development.

Common name; Scientific name; Conservation status; Project site	Photo image	Habitat and ecology in detail	Threats in detail
Mandrill ***Mandrillus sphinx*** **Vulnerable** VU Mbalmayo & Douala-Edea project sites	 *Photo credit: Brent Huffman / UltimateUngulate*	Mandrills are found in evergreen rainforest, stretching between 100 and 300 km inland from the Atlantic coast, as well as in montane forest, and secondary forest. They avoid thick undergrowth areas and marshes. Mandrills are known to cross areas of savanna up to 180 m across to access forest fragments and have been known to enter plantations. They are semi-terrestrial and usually forage at less than 5 m above ground. Mandrills are omnivorous and their diverse diets include fruits, buds, leaves, roots, insects, fish, meat, crustaceans, fungus and seeds. Seeds form a more important part of the diet than the flesh of fruits, and large seeds are usually consumed (not dispersed). Data on the home range of a group which is not hunted come from only one site: Lopé National Park in Gabon, where a horde of ~720 individuals has remained stable over 20 years, using 182 km² of forest-savanna mosaic habitat, including 89 km² of suitable forest habitat. The group used gallery forests and isolated forest fragments with high botanical diversity far more intensively that the continuous forest block. Humans are the mandrill's major predator. **Suitable habitats** (IUCN Red List classification scheme): Forest; Artificial/Terrestrial **Suitable habitats** (terraPulse classification scheme): **Core Forest; Edge Forest**	Mandrills appear to be most seriously threatened in Cameroon and Equatorial Guinea. This species is affected by the destruction of its evergreen forest habitat since this reduces the capacity of environments to support mandrill populations. However, the most immediate threat is posed by poaching for their meat. Large males are preferentially targeted. Commercial bushmeat hunters pose a particular threat to populations that are located close to main roads and towns. Annual offtakes per hunted horde are likely to be lower for modern day hunters using guns and snares than in the past when hunters used dogs and nets, which could result in very high offtakes (>20% of the group in one hunt). However, impacts are more widely spread across the species' geographic range

Common name; Scientific name; Conservation status; Project site	Photo image	Habitat and ecology in detail	Threats in detail
Grey Parrot ***Psittacus erithacus*** **Endangered** EN Mbalmayo & Douala-Edea project sites	 *Photo credit: Rob. CC BY-NC 2.0*	Although typically inhabiting dense forest, grey parrots are commonly observed at forest edges, clearings, gallery forest, mangroves, wooded savannah, cultivated areas, and even gardens, but it is not clear whether these are self-sustaining populations. At least in West Africa, the species makes seasonal movements out of the driest parts of the range in the dry season. It is highly gregarious, forming large roosts at least historically containing up to 10,000 individuals. Feeding takes place in smaller groups of up to 30 birds and the diet consists of a variety of fruits and seeds, while the nest is in a tree cavity 10-30 m above ground. Nesting is usually solitary, but can take place in loose colonies, for example in Principe, while the breeding season varies across the range. In Cameroon, traditional smallholder agroforestry plots may maintain important breeding and feeding opportunities for this species, thus playing a role in habitat conservation strategies. **Suitable habitats** (IUCN Red List classification scheme): **Forest; Savanna, Artificial/Terrestrial** **Suitable habitats** (terraPulse classification scheme): **Core Forest; Edge Forest; Mixed Herbaceous; Cropland**	Grey parrot is one of the most popular avian pets in Europe, the United States, and the Middle East due to its longevity and unparalleled ability to mimic human speech and other sounds. Demand for wild birds is also increasing in China, and increased presence of Chinese businesses in central Africa (particularly for mining, oil and logging) may increase illegal exports of this species. From 1982 to 2001, over 1.3 million wild-caught individuals of both erithacus and timneh entered international trade, and considering the pre-trade mortality can be 30-66%. In the late 1990s and early 2000s, Cameroon exported an annual quota of 10,000 birds; estimates that 90% of trapped birds died before reaching Douala airport suggest that some 100,000 birds per year were being captured in Cameroon during that period. Up to 10,000 wild-caught birds from the Democratic Republic of the Congo are apparently imported into South Africa each year. There has been a reduction in the trade of this species, partly due to extra trade restrictions, but also due to population declines, which leads collectors to move onto populations previously not harvested. The majority of legal exports are now from central Africa, and difficulties regulating trade mean that quotas have been regularly exceeded. In addition, illegal international trafficking occurs but levels are difficult to quantify. Because the species concentrates in traditional nesting, roosting, drinking and mineral lick sites, it is especially vulnerable to trapping pressure. Habitat loss is undoubtedly having significant impacts, particularly throughout West and East Africa. In addition to capture for international trade, there is an active internal trade in live birds for pets and exhibition. The species is also hunted in parts of the range as bushmeat and to supply heads, legs and tail feathers for use as medicine or in black magic. Forest loss is also negatively impacting populations, and is considered to have contributed to declines in Ghana and may be a larger threat than the pet trade in Cameroon. The loss of large trees with nesting cavities may be particularly detrimental. Although some observers have noted populations are associated with primary forest, permanent populations in semi-urban areas, and its frequent use of farm-bush, plantations and secondary forest suggest this species may be robust to some habitat change.

Common name; Scientific name; Conservation status; Project site	Photo image	Habitat and ecology in detail	Threats in detail
Grey-necked rockfowl ***Picathartes oreas*** **Near Threatened** NT Mbalmayo & Douala-Edea project sites	 *Photo credit: Alexis Lamek*	This species inhabits closed-canopy, primary rainforest, but may have a greater tolerance for degraded habitat than previously believed. It feeds mainly on invertebrates, is a strong follower of ant columns, and also takes small vertebrates, primarily frogs and lizards. Additionally, it commonly feeds on a variety of invertebrates such as grasshoppers, beetles, weevils, earthworms, slugs and snails. It is recorded at 45-2,100 m in Cameroon but at 250-900 m on Bioko. It nests in caves and on rock-faces and cliffs (although there is a recent report of a nest in the buttress of a large Piptadeniastrum tree and appears to have very specific breeding habitat requirements, including overhanging rock to protect the nest from rain, and sheer rock and often a seasonal river below to protect it from predators. It has also been recorded nesting under concrete bridges in Lopé National Park, Gabon. It breeds colonially where nest-sites are limited, with home ranges of less than 0.5km2. The nest is a half-cup of dried mud impregnated with dry grass fibres and dead leaves, in which it lays one to three, but usually two, eggs. The incubation period is 21-24 days and the fledging period is about 24 days. In the Dja Reserve, southern Cameroon, nesting occurs between August and October, with activity peaking in September, however nesting occurs more widely from March to November in the country, with the peak in August-November. **Suitable habitats** (IUCN Red List classification scheme): **Forest; Wetlands (inland)** **Suitable habitats** (terraPulse classification scheme): **Core Forest; Edge Forest; Mixed Herbaceous; Cropland**	This species remains threatened by forest clearance and increasing human disturbance throughout much of its range, and at many sites in Cameroon survives only in poor quality habitat. Forest clearance takes place for agriculture, largely crop fields and cocoa plantations. In many non-protected areas where the species occurs, in Cameroon for example, disturbance is caused by activities such as logging and slash-and-burn agriculture. In protected areas, encroachment by farmers, hunters and loggers means that these populations are also under threat; and hunters' camps can also disturb the species and lead to abandoned breeding in addition to the removal of eggs and young. In Gabon and Bioko, there is only minimal habitat loss and the species is unlikely to be affected by human activity in the near future, as in these parts of its range it inhabits extremely rugged and inaccessible areas. Adults may be hunted to a limited extent for trade and, on Mt Kupe and the Ebo forest at least, it is often caught in spring-traps set for mammals. The lack of suitable breeding sites, particularly of suitable rocks, may also partly account for its scarcity. However, work in the Ebo forest, Cameroon has shown that nest site availability may not always be a limiting factor for P. oreas populations. Abandoned nests can remain unused for many years on suitable rock faces and population estimates may be unreliable where densities are are derived from nest counts. In addition, cannibalism and predation probably contribute to low breeding success. For example, low nests in Korup are known to be destroyed by chimpanzees (*Pan troglodytes*) and drills *(Papio)* leucophaeus. Disturbance resulting from human visits to breeding sites, especially by birdwatchers within the growing ecotourism sector, is becoming a major concern and it can lead to disproportionate effects on breeding success if safe viewing regimes are not put in place.
White-backed vulture ***Gyps africanus*** **Critically Endangered** CR Mbalmayo & Douala-Edea & Waza project sites	 *Photo credit: EcoView on AdobeStock*	White-backed vulture is primarily a lowland species of open wooded savanna, particularly areas of Acacia. It requires tall trees for nesting, but has also been recorded nesting on electricity pylons in South Africa. It is a gregarious species congregating at carcasses, in thermals and at roost sites. It nests in loose colonies. **Suitable habitats** (IUCN Red List classification scheme): **Forest; Savanna, Shrubland, Grassland, Desert, Artificial/Terrestrial** **Suitable habitats** (terraPulse classification scheme): **Edge Forest; Shrubland; Mixed Herbaceous; Desert**	The species faces similar threats to other African vultures, being susceptible to habitat conversion to agro-pastoral systems, loss of wild ungulates leading to a reduced availability of carrion, hunting for trade, persecution and poisoning. Cases across Africa suggest that the species may be subject to deliberate and accidental poisoning, respectively: in the former case for belief-based use and to prevent birds from drawing attention to poaching activities. Additionally, the wild ungulate populations on which this species relies have declined precipitously throughout West and East Africa, even in protected areas, and despite increased livestock numbers, improved animal husbandry and carcass disposal has reduced the number of livestock carcasses available. There is also a minor threat from road traffic, with individuals occasionally killed by vehicles. Reported threats in the Athi-Kaputiei area in Kenya (an important breeding site for the species) include wind energy development, illegal logging of large trees.

Common name; Scientific name; Conservation status; Project site	Photo image	Habitat and ecology in detail	Threats in detail
Black Crowned Crane ***Balearica pavonina*** **Vulnerable** VU Waza project site	 *Photo credit: BlueOrange Studio Adobe Stock*	**Behaviour:** The species is largely a resident, but undergoes local daily and seasonal movements of up to several dozen kilometres. It breeds during the wet season months of May-December in West Africa, and July-January in East Africa (subject to local seasonal variation), nesting in single pairs in territories 0.5-1 km^2. During the dry (non-breeding) season it is more congregatory, forming large flocks of up to several hundred individuals. In South Sudan it begins to flock along the Nile in November, reaching a peak in late February and March. In Chad it gathers in concentrations after breeding, and then moves south. In Nigeria it was subject to local movements with seasonal changes in water levels, though it no longer occurs in the country. It forages singly, in pairs or in small groups (Urban et al. 1986). **Habitat Breeding:** This species is found in wet and dry open habitats, but prefers freshwater marshes, wet grasslands, and the peripheries of water-bodies. In South Sudan it is especially found in areas with water up to 1 m in depth, and knee-high to hip-high vegetation dominated by Cyperus, Eleocharis, Scirpus, Setaria, Cynodon and various leguminous and rosaceous plants. It always remains near wetlands, but is rarely associated with deep, open water. It often prefers to forage on dry ground with short grass and, particularly in West Africa, it will sometimes forage and nest in upland areas, rice fields, wet crop fields and even abandoned fields. It prefers to roost in large trees, but will use small trees or shallow water when necessary. Non-breeding During the non-breeding season it congregates in larger permanent wetlands, and often forages near herds of domestic livestock or even in rubbish dumps. **Diet:** This species is a generalist omnivore. Its primary food source is small grain crops (45%), with small plants, small invertebrates and small vertebrates also featuring in the diet. It will take insects (grasshoppers, flies), molluscs, millipedes, crustaceans, fish, amphibians, reptiles, seed heads, grass tips and agricultural grain (corn, rice, millet). **Breeding site:** Nests are built on the ground in densely vegetated wetlands. The nest consists of a round, loosely constructed platform of reeds and grasses placed in short grass marsh in several centimetres of water, or occasionally on dry land. Its base is often over a metre in diameter. Clutch-size is c.2.5 eggs per nest. Incubation lasts 22-25 days, and chicks are able to fly when 35-40 days old. **Suitable habitats** (IUCN Red List classification scheme): **Savanna, Grassland, Wetlands (inland) Marine Coastal/Supratidal, Artificial/ Terrestrial, Aritificial/Aquatic & Marine** **Suitable habitats** (terraPulse classification scheme): **Edge Forest; Shrubland; Mixed Herbaceous; Desert**	Habitat loss and degradation are significant threats, occurring through drought, wetland drainage and conversion for agriculture, overgrazing, fire, agricultural and industrial pollution, industrial construction and dam construction (flooding wetlands upstream and dessicating those downstream). Droughts have both directly and indirectly impacted this species's habitat, since they force people to migrate to relatively moist, less populated regions, which are then subjected to the associated pressures mentioned above. Considerable hunting pressures also exist, including capture and sale of live birds, some destined for legal international markets (over 7,000 birds since 1985 when the species was listed on CITES Appendix II. Parts of dead Black Crowned-cranes, notably the head and wings, are used in traditional healing (Williams et al. 2003). In addition, indiscriminate pesticide application may be leading to harmful bio-accumulation of toxins, and direct poisoning to reduce crop depredation has been reported in East Africa. Warfare and political instability affects nations across the range of the species, and may have particularly impacted upon those in South Sudan where the implementation of conservation measures has not been able to proceed, and remains problematic. Oil exploration in and near the wetlands also poses a threat.

Common name; Scientific name; Conservation status; Project site	Photo image	Habitat and ecology in detail	Threats in detail
Red-fronted gazelle ***Eudorcas rufifrons*** **Vulnerable** VU Waza project site	 *Photo credit: Brent Huffman / UltimateUngulate*	Formerly this species was widespread in the Sahel zone in the sahelian grasslands, savannas and savanna woodlands, and shrubland. Red-fronted Gazelle is able to adapt to human occupation of its habitat to some extent; for example, it is known to reoccupy fallow land if sufficient cover is available. It occurs locally in small to moderate numbers in areas of largely unexploited rangeland. They are known to make seasonal movements in parts of the range, although these are increasingly restricted by human settlement. **Suitable habitats** (IUCN Red List classification scheme): **Grassland, Savanna, Forest, Shrubland, Artificial/Terrestrial** **Suitable habitats** (terraPulse classification scheme): **Edge Forest; Shrubland; Mixed Herbaceous**	Red-fronted Gazelle populations have been reduced to scattered remnants over most of its range by illegal hunting, competition with domestic livestock, and habitat degradation resulting from drought, overgrazing of livestock and clearance of land for agriculture.

Common name; Scientific name; Conservation status; Project site	Photo image	Habitat and ecology in detail	Threats in detail
Giraffe ***Giraffa camelopardalis*** **Vulnerable** VU Waza project site	 *Photo credit: Alicia Wirz*	About one million years ago, multiple ungulate species, including at least three Giraffe species, spread over the African continent along with the emerging savanna/woodland biome. But between 600,000 and 800,000 years ago, only a single species, Giraffa camelopardalis, is found in the fossil record. The adaptive radiation of Giraffes across Africa occurred during a period of environmental instability, climate change, and geological upheavals that produced distinctive lineages living in mostly disconnected areas of Africa. Continued natural, as well as human-induced, changes in habitat have yielded a suture zone in Eastern Africa, as well as possibly Northern and Southern Africa, that impedes our ability to mark specific boundaries between the various kinds of Giraffes. Hence, Giraffes evolved an ability to adapt to a variety of ecosystems and, as they did so, lineages emerged in different regions where they evolved distinctive characteristics, but whether these traits are significant enough to consider the differences as species or subspecies is unclear at the moment. Giraffes are most often found in savanna/woodland habitats, but range widely throughout Africa. They are browsers that subsist on a variable diet that includes leaves, stems, flowers, and fruits. They do not need to drink on a daily basis. Across the continent, detailed records of Giraffe feeding ecology have noted that each population has a very diverse diet of up to 93 different species, but that usually a half dozen plant species comprise at least 75% of the diet. Acacia is fed on in high proportions wherever Giraffes are found, but during the dry season, the preferred plant species varies by location. Faidherbia, Boscia, Grewia, and Kigelia have all been identified as the most common plant species in the diet of giraffes in the dry season in different locations. Some populations have seasonal shifts in home ranges. **Suitable habitats** (IUCN Red List classification scheme): **Forest, Savanna, Shrubland** **Suitable habitats** (terraPulse classification scheme): **Edge Forest; Shrubland; Mixed Herbaceous**	Four major threats to giraffes can be identified, although the severity and presence of these threats varies by region and population: (1) habitat loss (through deforestation, land use conversion, expansion of agricultural activities and human population growth) (2) civil unrest (ethnic violence, rebel militias, paramilitary and military operations), (3) illegal hunting (poaching), and (4) ecological changes (mining activity, habitat conversion to agriculture, climate-induced processes). In Southern Africa, the main perceived threats are habitat loss and conversion of land for human development, and illegal hunting. In West Africa, the main threats are habitat loss due to increasing human populations and human-wildlife conflict. In Eastern and Central Africa the main threats are habitat loss through rapid conversion of land for farming and increasing human populations, drought, illegal hunting for meat and hide, and armed conflict throughout unstable regions. Some of the highest human fertility rates in the world (>4%) occur in countries where Giraffes are present. Natural habitat changes from weather irregularities result in situations generating human movement, sometimes into protected, or semi-protected, areas. Drought conditions have become more common and increase the prospects of bush fires, loss of habitat, and human population movements. Substantial human population migration also characterizes regions and areas with military operations in giraffe habitats. In some countries (e.g., Namibia, South Africa) the hunting of Giraffes is legal, but Giraffe population sizes there are increasing; in other countries (e.g., Tanzania) the poaching of Giraffes is associated with declines in giraffe population size. Habitat fragmentation and degradation are probably the most widespread and greatest threats to African wildlife, including giraffes, often arising as a consequence of mineral extraction and/or habitat conversion to agricultural crops.

Common name; Scientific name; Conservation status; Project site	Photo image	Habitat and ecology in detail	Threats in detail
African bush elephant ***Loxodonta africana*** **Endangered** EN Waza project site	 *Photo credit: Jean-Christophe Vié*	African Savanna Elephants are found over a wide latitudinal range between the northern tropics in Mali (16° North) to the southern temperate zone (34° South) in South Africa. They occupy a variety of habitats ranging from montane forest, miombo and mopane woodland, thicket, savanna and grasslands to arid deserts and a wide altitudinal range from mountain slopes to oceanic beaches. African Savanna Elephants are capable of moving long distances and naturally do so in arid ecosystems and in response to climatic conditions (e.g., seasonality and drought). Depending on productivity, and water availability African Savanna Elephants demonstrate range residence, migratory, semi-migratory and near nomadic movement patterns in different regions of the continent. Home range sizes vary by several orders of magnitude primarily in relation to plant productivity and human activity in different ecosystems. Thirty African Savanna Elephant subpopulations (eight of which number more than 1,000 individuals) span international boundaries, including the more than 200,000 elephants in the five-country Kavango-Zambezi Transfrontier Conservation Area. **Suitable habitats** (IUCN Red List classification scheme): **Desert, Grassland, Shrubland, Savanna, Forest, Wetlands (inland)** **Suitable habitats** (terraPulse classification scheme): **Core Forest; Edge Forest; Shrubland; Mixed Herbaceous, Wetlands, Water; Desert; Cropland**	Poaching of African Savanna Elephants for ivory is a major cause of individual death and population decline (Wittemyer et al. 2014, Thouless et al. 2016). After a sustained period of intense poaching between the late 1970s and 1989, many African Savanna Elephant populations (e.g., in Kenya, Tanzania, Zambia, Uganda) experienced two to three decades of recovery. Some northern African Savanna Elephant populations, however, experienced persistent poaching pressure through the last three decades. Data collected as a part of the CITES Monitoring the Illegal Killing of Elephants programme (MIKE), indicate that poaching significantly intensified across the continent starting in 2008 and peaking in 2011 – an unsustainably high level of poaching has continued into current times in some areas of the continent (CITES 2018, 2019), and may be increasing in some of the historically less-affected southern African populations (CITES 2018, 2019). Rapid land use change by humans is driving the direct loss and fragmentation of habitat for African Savanna Elephants and is an increasing threat to populations across their range (Thouless et al. 2016, Mpakairi et al. 2019). Land conversion is a product of the ongoing expansion of the human population and associated agriculture and infrastructure development, which in turn are driven by economic and technological advances. A manifestation of this trend is the reported increase in human-elephant conflict. Human population growth projections suggest land conversion will accelerate rapidly in the coming decades across Africa (see https://population.un.org/wpp/Publications/) which will likely increase this threat.
Beaudouin's Snake-eagle ***Circaetus beaudouini*** **Vulnerable** VU Waza project site	 *Photo credit: dennisjacobsen, Adobe Stock*	Beaudouin's snake-eagle inhabits dry savannah but prefers more open areas of grassland and even cultivated areas. It is a seasonal migrant, moving between the Sudan zone (and northern Guinea zone) in the dry season and the Sahel (and northern Sudan) zone in the rainy season, but can be seen in some areas all year round, such as The Gambia, and while there has been no nest records there, juveniles have been seen. It is thinly distributed, territorial and generally solitary. **Suitable habitats** (IUCN Red List classification scheme): **Forest, Savanna, Shrubland, Grassland** **Suitable habitats** (terraPulse classification scheme): **Edge Forest; Shrubland; Mixed Herbaceous**	West African raptors have declined owing to a number of threats associated with increases in the human population within the region. Over the past 50 years, there has been a four-fold increase in the human population. Habitat destruction has resulted from agricultural intensification, overgrazing, woodcutting and major developments, such as urbanisation. Woodcutting for fuelwood, timber and charcoal has caused conversion of woodland into shrubland. Agricultural intensification has led to aerial and ground spraying of insecticides to control insect outbreaks. More specifically, the species is threatened by the spread of cotton fields and the associated use of organochlorine insecticides. Insect swarms were previously an important source of food for raptors directly, or their prey. Livestock are virtually ubiquitous, especially in the Sahel where overgrazing is a major cause of desertification. In addition, hunting has exacerbated the decline.

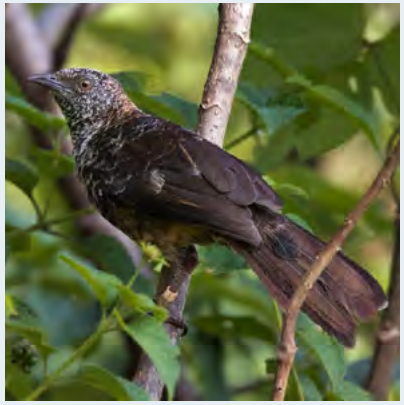
Common name; Scientific name; Conservation status; Project site	Photo image	Habitat and ecology in detail	Threats in detail
Hooded vulture ***Necrosyrtes monachus*** **Critically Endangered** CR Waza project site	 *Photo credit: Andre Botha*	The species is often associated with human settlements north of the Equator, but is also found in open grassland, forest edge, wooded savanna, desert and along coasts; and tends to occur at higher densities in areas where populations of larger Gyps vultures are low or nonexistent. It occurs up to 4,000 m, but is most numerous below 1,800 m. It feeds mainly on carrion, but also takes insects (and will congregate in large numbers during insect emergences. In West Africa and Kenya it breeds throughout the year, but especially from November to July. Breeding in north-east Africa occurs mainly in October-June, with birds in southern Africa tending to breed in May-December. It is an arboreal nester, favouring Ceiba pentandra in Senegal and lays a clutch of one egg. **Suitable habitats** (IUCN Red List classification scheme): **Forest, Savanna, Shrubland, Grassland, Desert, Artificial/Terrestrial** **Suitable habitats** (terraPulse classification scheme): **Edge Forest; Shrubland; Mixed Herbaceous, Desert**	Major threats to this species include non-target poisoning, capture for traditional medicine and bushmeat, and direct persecution. In Nigeria, a survey of medicinal traders found that Hooded Vulture was the most commonly traded species of vulture, with 90% of all vulture parts traded belonging to the species. And across West and Central Africa the species is one of the most heavily traded, with an estimated 5,850-8,772 individuals traded over a six-year period in West Africa. Hooded Vulture meat is reportedly sold as chicken in some places. Intentional poisoning of vultures may be carried out in some areas by poachers in order to hide the locations of their kills, but in Senegal at least vultures to receive a form of cultural protection from such killing because they are the totem for some families. Secondary poisoning with carbofuran pesticides at livestock baits being used to poison mammalian predators is also an issue in East Africa. Declines have also been attributed to land conversion through development and improvements to abattoir hygiene and rubbish disposal in some areas, and, in Senegal, a decline in the number of their favorite nesting tree species.
Denham's Bustard ***Neotis denhami*** **Near Threatened** NT Waza project site	 *Photo credit: alfotokunst on Adobe Stock*	Found up to 3,000 m. It inhabits grasslands, grassy Acacia-studded dunes, fairly dense shrubland, light woodland, farmland, crops, dried marsh and arid scrub plains, also grass-covered ironstone pans and burnt savanna woodland in Sierra Leone and high rainfall sour grassveld, planted pastures and cereal croplands in fynbos in South Africa. It feeds on insects, small vertebrates and plant material. The breeding season is variable and consequently unclear, perhaps indicating opportunism in reaction to rainfall. The clutch-size is one or two. **Suitable habitats** (IUCN Red List classification scheme): **Shrubland, Savanna, Grassland, Artificial/Terrestrial** **Suitable habitats** (terraPulse classification scheme): Edge Forest; Shrubland; Mixed Herbaceous, Cropland	Hunting is the primary cause of declines across the Sahel and throughout West Africa. In eastern and southern Africa, hunting is also a problem, but the main threat appears to be conversion of grassland and light woodland to agriculture. Collisions with power lines may be a significant threat in parts of the range, particularly South Africa. Accidental poisoning by agricultural pesticides may also be a threat to birds foraging on farmland. Climate change poses a potential threat through shifting habitats and severe droughts.
Peterson's free-tailed bat ***Mops petersoni*** **Near Threatened** NT Mbalmayo & Douala-Edea project sites	No picture available	The species is known only from rainforest, at one locality in Ghana and five in Cameroon (El-Rayah 1981, Smith et al. 1986). It is likely to occur where suitable rainforest habitat exists and likely to extend into the Northern Rainforest–Savanna Mosaic (Happold 2013). It has not been recorded from disturbed areas. **Suitable habitats** (IUCN Red List classification scheme): **Forest** **Suitable habitats** (terraPulse classification scheme): **Core Forest**	The species is considered to be threatened by loss and degradation of forest habitats within its known range, largely through the conversion of land to agricultural use and the extraction of firewood and timber.

Common name; Scientific name; Conservation status; Project site	Photo image	Habitat and ecology in detail	Threats in detail
Dark-brown serotine ***Neoromicia brunnea*** **Near Threatened** NT Mbalmayo & Douala-Edea project sites	 *Photo credit: Natalie Weber, some rights reserved (CC BY-NC), uploaded by Natalie Weber*	This is a highly specialised forest species. However, it also may occur in edge habitats, but not outside of rainforest (rather on the edge of the forest and some other habitat). This species is associated with moist tropical lowland rainforest and possibly from tropical dry forest. This species has been recorded almost exclusively in undisturbed to slightly disturbed lowland rainforests, mainly evergreen and semi-deciduous lowland rainforests, swamp forest and mangroves. This species is relatively abundant in appropriate habitat and can be found in disturbed forest. It appears relatively abundant in certain areas: for example, 13 specimens were captured at six localities on the Liberian side of Mount Nimba. Roosts are unknown, although Sanderson (1940) suggested that they roost in the roofs of disused houses and under the earthy banks of streams. **Suitable habitats** (IUCN Red List classification scheme): **Forest** **Suitable habitats** (terraPulse classification scheme): **Core Forest**	This species is threatened by deforestation and land degradation resulting from logging operations and land conversion for agricultural use.
Black colobus monkey ***Colobus satanas*** **Vulnerable** VU Mbalmayo project site	 *Photo credit: Eric Gevart on Adobe Stock*	This species inhabits coastal evergreen, lowland moist, montane and swamp forests. It is typically found high in the canopy of dense, primary rainforest, and is now only present in protected or undisturbed inaccessible areas. It appears unable to survive in secondary forest, and is rare or absent in forests where logging has reduced canopy height. Colobus satanas is a highly arboreal, diurnal species. Like other colobines, they eat seeds and leaves (seeds being around 50-60% of the diet). This species lives in groups averaging 13 individuals (range 5–30) and has an annual home range of between 70–570 ha. They are often found in polyspecific troops with guenons and mangabeys. **Suitable habitats** (IUCN Red List classification scheme): **Forest** **Suitable habitats** (terraPulse classification scheme): **Core Forest**	Colobus satanas is directly threatened by habitat loss and hunting throughout its range, and indirectly by increasing human populations and the creation of easy access routes into almost all previously remote forests. Human population growth in the range states of the taxon is roughly 2.7% annually and will not slow down for several decades (UN 2019, World Bank 2019). Road access into once-remote forests – even around protected areas – has increased hugely over the last 20–30 years, facilitating increased hunting and transport of bushmeat to both local markets and distant urban centres. Black Colobus meat is consumed locally and traded commercially in urban areas. This species is very easy for gun-hunters to kill, being rather slow-moving, and is sought after due to its high body weight. In the northwest of its range, in Cameroon and Equatorial Guinea, the species is subject to habitat modification, as intact forest is converted to farmland and "farm bush" which can be seen clearly in Tyukavina et al. (2016). Forest loss is relatively low in the Gabon parts of this taxon's range and the small area in Congo where it occurs (Hansen et al. 2013) due to historically low human population densities and use of selective logging techniques as opposed to clearcutting. However, there is an ongoing trend for gradually increasing annual forest loss since 2001 in all four range states, especially since 2013 (GFW 2019). Forest loss will increase greatly in the future as industrial-scale agriculture expands, removing forests suitable for various forest-obligate species.

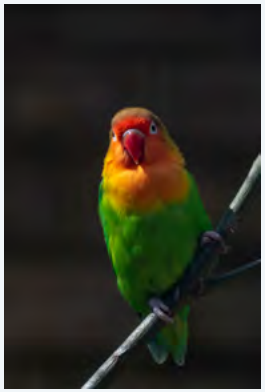
Common name; Scientific name; Conservation status; Project site	Photo image	Habitat and ecology in detail	Threats in detail
Secretarybird ***Sagittarius serpentarius*** **Endangered** EN Waza project site	 *Photo credit: William Konstant*	The species inhabits open landscapes, ranging from open plains and grasslands, to lightly wooded savanna, but is also found in agricultural areas and sub-desert, with up to 50% of recorded individuals in the Fynbos biome in winter being found in transformed environments. In Kruger National Park, South Africa, reports declined to zero in areas of >20% wood cover. It ranges from sea-level to 3,000 m. While it is nomadic, birds living in the moist grassland biome are less likely to be nomadic, but will travel on average 20-30 km per day while foraging. Breeding occurs throughout the year and the species typically nests in a flat-topped Acacia or other thorny tree, where it constructs a flattened stick structure. In Kenya, breeding attempts were observed to be disturbed by long droughts and unfavourable weather conditions. Juveniles can move a long way after leaving their nest site, but will return to their natal area. Juvenile males travel further than females, but returned closer to the nest site. Natal home ranges average 1.21 ± 0.34 km2 around the nest, and fledglings travel in an average 2.62 ± 0.37 km straight-line distance from the nest. A 2 year old male was also recorded to have successfully raised two chicks in South Africa. A variety of prey is consumed, with insects forming 86% of the diet. Rodents, other mammals, lizards, snakes, eggs, young birds and amphibians also form part of the diet **Suitable habitats** (IUCN Red List classification scheme): **Savanna, Shrubland, Grassland, Artificial/Terrestrial** **Suitable habitats** (terraPulse classification scheme): **Shrubland; Mixed Herbaceous; Cropland**	Although the species may benefit from deforestation, such positive effects may be outweighed by the negative impacts of spreading cultivation and urbanisation. The excessive burning of grasslands may suppress populations of prey species, whilst the intensive grazing of livestock is also probably degrading otherwise suitable habitat. The Grassland Biome in South Africa is threatened by the expansion of woody vegetation, which would translate to direct habitat loss and a possible reduction in foraging efficacy. In Kenya, suitable habitat is being converted to other land uses, particularly for commercial purposes. Disturbance by humans, probably most often herders, is likely to negatively affect breeding. The species is captured and traded in apparently small numbers; however, it is unknown how many die in captivity and transit. Direct hunting and nest-raiding for other uses and indiscriminate poisoning at waterholes are also potential threats. Exposure to secondary pesticide poisoning is a concern, and birds are also susceptible to negative impacts from collisions with fence lines and electric cables (Whitecross et al. 2019). 94 power-line fatalities have been recorded in 20 years by the Endangered Wildlife Trust. Large ranging behaviour outside of protected areas increases their risk of injury and fatality. These human-induced threats may compound the effects of severe droughts in some areas.

Common name; Scientific name; Conservation status; Project site	Photo image	Habitat and ecology in detail	Threats in detail
Lappet-faced vulture ***Torgos tracheliotos*** **Endangered** EN Waza project site	 *Photo credit: del Hoyo et al (1992 - 2000)*	The species inhabits dry savanna, arid plains, deserts and open mountain slopes up to 3,500 m. It ranges widely when foraging and is mainly a scavenger, feeding predominantly on any large carcasses or their remains. It is also known to hunt, probably taking a variety of small reptiles, fish, birds and mammals, and has been observed apparently group-hunting flamingo Phoenicopterus chicks. It builds solitary nests (containing just one egg), often in Acacia. It does not breed until at least six years old, then fledging c.0.4 young/pair/year. Ringing studies in Namibia have revealed a very low return rate. The species's minimum home range has been suggested to be 8 km2, and this can expand to 15 km2 in some habitats, but it may now be that 80-150km^2 may be more appropriate. In Mozambique, egg-laying occurs from late April until mid-August, with a peak in May and June. A nest found in Oman contained a small chick in early March, and thought to have fledged in mid-June. **Suitable habitats** (IUCN Red List classification scheme): **Grassland, Savanna, Forest, Shrubland, Desert** **Suitable habitats** (terraPulse classification scheme): **Edge Forest, Shrubland; Mixed Herbaceous; Desert, Cropland**	Widespread accidental poisoning, largely due to strychnine, used by many farmers for predator control, and more recently carbofuran, has contributed significantly to declines. Other major threats to the species include nest predation by humans, reduced food availability (including the replacement of the traditional "Dabokka" movement of camels with cargo tracks and electrocution. The population collapse in West Africa may be a result of higher nest disturbance, local extinctions of wild ungulates through habitat modification and over-hunting, intensified cattle farming in which sick or dying animals are rarely abandoned, and an increase in accidental poisoning. National vaccination campaigns in West Africa have reduced illness in domestic livestock, and sick animals can now be sold off, rather than abandoned, due to the proliferation of markets and abattoirs. The species may be hunted for medicine and cultural reasons in West Africa, and some ethnic groups in the sub-region hunt vultures for food, though the impact on this species is unknown. It is also thought to be used for traditional medicine in South Africa, with all vultures having the potential for traditional medicine use in southern Africa and has been recorded in trade in West and Central African markets.

Table A2. Information on habitat ecology and threats for the 15 identified priority threatened species at the TRI Kenya ASAL project sites, from the IUCN Red List of Threatened Species™. Habitat suitability coding using 8-class terraPulse classification scheme shown under Habitat and ecology in detail (see Annex I, Coding species habitat suitability)

Common name; Conservation status; project site	Photo image	Habitat and ecology in detail	Threats in detail
Hinde's babbler **Vulnerable** VU Mukogodo Forest project site	 *Photo credit: Lars Petersson on MacaulayLib Photo*	This species is a group-territorial, cooperative breeder. In June-July, following the end of the long rains, groups typically comprise 3-4 adults, often accompanied by 1-2 fledglings or immatures. It occurs in two contrasting habitats: thickets and woodland within semi-arid areas; and moist, fertile land largely cleared for agriculture, but with fragments of scrub, mainly of the exotic shrub Lantana camara. In both situations they are normally found in close proximity to dense vegetation associated with streams and rivers and are more abundant in higher rainfall (perhaps more invertebrate rich) areas that have retained some thicket cover. Similarly, changes in the species' distribution at these two sites during 2000–2011 were positively correlated with changes in scrub cover. Within 1-km transect sections the loss of a babbler group was associated with a reduction in scrub cover of 22 percentage points. At Mukurweini and Kianyaga, abundance was found to increase where thicket cover exceeded 3%, while breeding success improved where thicket cover exceeded 9%. Nest records peak in March to May and September to October, coinciding with the main periods of rainfall. Clutches of 2-3 eggs are laid in nests built at 1-3 m, usually in thickets. Productivity generally appears similar to its congeners, with fledglings and immatures together accounting for about 16% to 20% of birds aged during surveys between 2000 and 2011 respectively. **Suitable habitats** (IUCN Red List classification scheme): **Artificial/ Terrestrial, Shrubland; Wetlands (inland)** **Suitable habitats** (terraPulse classification scheme): **Shrubland, Wetlands/Water, Cropland**	A rapidly increasing human population and intensive farming within its range mean that remaining patches of thicket are being cleared rapidly, with little land left fallow or unweeded, and the thickets that remain are becoming increasingly fragmented. Thickets may also have been destroyed by rice irrigation and dams along the Tana River. Loss of thicket may have been partly mitigated by the spread of the exotic Lantana camara, which provides thicket cover in previously cleared areas. Its presence has probably slowed the species's decline, and may even have enabled it to colonise or re-colonise intensively farmed land. Disturbance during the breeding season may result in low breeding success. Inbreeding and competition from Northern Pied-babblers T. hypoleucus do not appear to be threats to this species, although formerly suspected as such. However, hunting for food is a serious threat in some areas (e.g. Kianyaga). Other potential threats are pesticide use, predation, brood parasitism (from Jacobin Cuckoo Clamator jacobinus) and low genetic diversity.

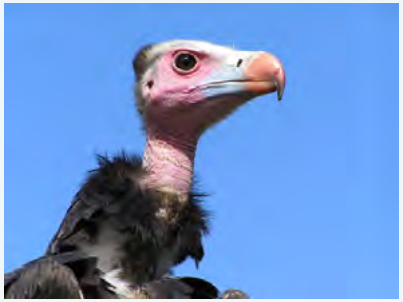
Common name; Conservation status; project site	Photo image	Habitat and ecology in detail	Threats in detail
Grevy's zebra **Endangered** EN Mukogodo Forest project site & Mt. Kulal project site	 *Photo credit: Christophe Vie*	Grevy's zebras live in arid and semi-arid grass/shrubland where they can gain access to permanent water. They are predominantly grazers, although browse can comprise up to 30% of their diet during times of drought or in those areas that have been highly transformed through overgrazing. Breeding males defend resource territories (water and food being the key resources) of 2–12 km²; the home range size of non-territorial individuals can be as large as 10,000 km². They are extremely mobile and individuals have been recorded to move distances of greater than 80 km, with movements determined by the availability of resources; lactating females, for example, can only tolerate one or two days away from water. Hence when pastoral livestock monopolize water, grevy's zebras suffer. They often mill around watering points in the late afternoon waiting to drink, thus reducing foraging time. By drinking predictably at night they are prone to predation by lions and in some areas when co-habiting with plains Zebras, they are preferentially attacked. During the dry season, when they are dependent on permanent water, grevy's zebra may stay nearer to water and tend to be more concentrated. However, in the Alledeghi Wildlife Reserve in Ethiopia, they are more concentrated during the wet season in order to avoid the pastoralists and livestock that move into the area during that season. Between 2010 and 2014 the population of grevy's zebras inhabiting the Mpala, Ol Jogi and Pyramid Conservancies in central Laikipia County, was monitored three times per year. During this period on average the population consisted of: 33% adult males of which 17% were territorial and 16% were bachelors; 40% adult females; 8% juveniles, half males and half females; and 19% infants of which 8% were males, 8% were females and 3% were of undetermined sex. Therefore 33% adult males + 40% adult females gives 73% of the population as mature. Given that population projection models show population stability is maintained when the percentage of recruits (juveniles and foals) reach 30%, the Laikipia Grev's Zebra population appears to be in relatively good demographic health. A decade of data on sightings of Grevy's Zebra numbers as well as age and sex class from scouts in the Meibae, Westgate, Sessia, Laisamas, Ngili West and Kalama Conservancies show that the percentage of recruits (foals and juveniles) has increased from 9% to 22% of the population, with the 2016 Great Grevy's Rally showing a Kenya-wide age structure of 28% recruits. This indicates that this population is approaching sustainability. **Suitable habitats** (IUCN Red List classification scheme): **Grassland, Shrubland** **Suitable habitats** (terraPulse classification scheme): **Shrubland, Mixed Herbaceous**	Kenya's grevy's zebra Technical Committee recently assessed and ranked the threats to Grevy's Zebras. In decreasing order they include: 1) Habitat degradation and loss induced by extremely heavy grazing by livestock; 2) Competition with livestock, especially over access to water and high quality rangeland; 3) Local hunting for meat as well as medicinal and cultural purpose; 4) Disease from contact with unvaccinated livestock, especially with respect to anthrax and babesiosis; 5) Hybridization with plains Zebras, although genes currently only flow from Grevy's to plains Zebras; 6) Predation; 7) Anticipated land conversion for resort development and other large-scale initiatives for economic expansion. In Kenya, hunting for skins in the late 1970s was the likely cause of the initial precipitous decline in numbers. Recent data suggest that numbers continued to decline because recruitment was limited by low levels of infant and juvenile survival. This was a result of competition for resources – both food and water – with pastoral people and their domestic livestock. However, a low level of hunting of Grevy's Zebra for food and, in some areas, medicinal uses continues. Furthermore, access to existing water sources continues to decline in some regions and the water supply in critical perennial rivers has been reduced, most notably in the Ewaso Ng'iro River where over-abstraction of water for irrigation schemes has reduced dry season river flow by 90% over the past three decades. In Ethiopia, the grevy's zebra population was in a declining trend during the last 30 years, due to habitat loss/fragmentation, drought, poaching and potential competition with livestock. Habitat loss, drought and poaching were considered to be the major threats. Illegal killing of Grevy's Zebra was the primary cause of the decline (Kebede 2013). The Alledeghi Wildlife Reserve population is small and genetically isolated. Initial population genetics research on the mtDNA control region revealed two new haplotypes that so far are not found in any other Grevy's Zebra populations. The nucleotide diversity levels for both the Alledeghi and the southern Ethiopian populations were extremely low (Kebede et al. 2014). Recently, Muoria et al. (2007) recorded an outbreak of anthrax in the Wamba area of southern Samburu, Kenya, during which more than 50 animals succumbed to the disease. Further research on disease prevalence is revealing that Grevy's Zebra are a reservoir for Theileria and Babesia (tick borne disease), and the first case of West Nile Virus has been found in one individual; the first detected in a wild equid. Disease represents a significant potential threat to fragmented and small populations of endangered species.

Common name; Conservation status; project site	Photo image	Habitat and ecology in detail	Threats in detail
Tigoni reed frog **Endangered** EN Mukogodo Forest project site	 *Photo credit: R.C. Drewes*	It is a species of open farmland (mainly tea plantations) and wet montane forests. It breeds in temporary, and sometimes permanent, pools. It is often found together with Hyperolius montanus. It is suspected that it is tolerant to a low level of disturbance. **Suitable habitats** (IUCN Red List classification scheme): **Wetlands (inland), Forest, Artificial/Terrestrial** **Suitable habitats** (terraPulse classification scheme): **Core Forest, Edge Forest, Wetlands/Water, Cropland**	The main threat to the forest habitat throughout its distribution is livestock grazing, and illegal logging, causing disturbance and destruction of the habitat and micro-habitat. The use of agro-chemicals on fields are also a potential threat, however this needs further investigation. Furthermore, reclamation of wetlands to create more farmland is a potential threat to its habitat.
Fisher's lovebird **Near Threatened** NT Mukogodo Forest project site	 *Photo credit: barmalini on Adobe Stock*	It inhabits semi-arid woodland with Acacia, Adansonia, and Commiphora at 1,100-2,200 m, deforested grassland, cultivation with remnant Adansonia and Borassus palm savanna. In the Serengeti, it is present in all types of woodland. Riverine forest dominated by Ficus, Ziziphus, Tamarindus, Aphania, Garcinia and Eckbergia is an important dry season habitat. The species is mostly granivorous, taking seeds from seedheads and off the ground. It also takes acacia seeds directly from trees. It attends waterholes and other types of surface water daily to drink. Breeding takes place from January to April and in June and July. Most nests are situated 2-15 m above the ground in holes and cracks in dead trees or dead branches on living trees, but possibly sometimes in cliffs as well. Its clutch-size in captivity is three to eight eggs, with an incubation period of c.23 days and fledging period of 38 days. **Suitable habitats** (IUCN Red List classification scheme): **Savanna, Forest, Artificial/Terrestrial** **Suitable habitats** (terraPulse classification scheme): **Core Forest, Edge Forest, Mixed Herbaceous, Cropland**	It was the most commonly traded wild bird in the world in 1987 and was the most popular wild-caught parrot imported into the then European Economic Community, accounting for c.80% of the Psittacine exports from Tanzania (RSPB 1991). Legal trapping for export has now been halted, but the population is still much lower than it was, and trade could re-start; although this bird is now being bred in captivity for the pet trade. The species has hybridised with Yellow-collared Lovebird A. personata in the wild, and although it was originally thought not to hybridise within its natural range (there is range overlap but A. fischeri appeared to be a non-breeding visitor to A. personata habitat, this is no longer considered the case. There is possible evidence of hybridisation within its range, presumed as a result of release/escape from captivity; with hybrids recorded in Serengeti NP - within the range of A. fischeri but well away from its contact zone with A. personatus. It remains unclear whether the destruction of woodland, that had previously separated the two species, has led to the two taxa encountering each other more often and leading to hybridization.
Taita falcon **Vulnerable** VU Mukogodo Forest project site	 *Photo credit: Bruno SCHMETZ*	It occurs at gorges and escarpments, up to 3,800 m, using associated cliffs for nesting and roosting, often overlooking river valleys. It is largely sedentary and does not wander far from favored sites. However, a review of sightings in Kenya confirms that it occurs in a variety of habitats. It is closely associated with cliffs but does not have an absolute fidelity to a 'home cliff' and is sometimes sighted away from cliff environments. A portion of the population is therefore prone to wander away from typical habitat. These findings from East Africa are at odds with studies from southern Africa where the species does not tend to wander into flat areas devoid of cliffs. It feeds mainly on small birds. **Suitable habitats** (IUCN Red List classification scheme): **Rocky areas, Forest, Savanna, Shrubland, Artificial/Terrestrial** **Suitable habitats** (terraPulse classification scheme): **Core Forest, Edge Forest, Shrubland, Mixed Herbaceous, Cropland**	The spraying of organochlorine pesticides in northern Zimbabwe may have reduced numbers there, and pesticide-spraying (e.g. through operations to control Quelea and locusts) may pose a significant threat in other areas, including a recorded case in Uganda. Helicopters and micro-light aircraft appear to have caused considerable disturbance to birds resident along the Victoria Falls gorges of the Zambezi, and the few birds that remain are threatened with flooding by a proposed dam. Reasons for its rarity in East Africa may include competition for food and nest sites with the larger and more dominant Peregrine Falcon F. peregrinus and predation of young by the Peregrine Falcon, Lanner Falcon F. biarmicus and owls, e.g. Spotted Eagle-owl Bubo africanus. For example, in South Africa, a territory that was occupied by this species from 2006 to 2009, has been lost to Lanner Falcons.

Common name; Conservation status; project site	Photo image	Habitat and ecology in detail	Threats in detail
East African oryx **Endangered** EN Mukogodo Forest project site & Mt. Kulal project site	 *Photo credit: Brent Huffman / UltimateUngulate*	Beisa and Fringe-eared Oryx prefer arid and semi-arid bushland and grasslands. The condition of grazing and state of the soil influence seasonal movements. They occur to altitudes of 1,700 m in Ethiopia. Both subspecies eat a wide range of grass species and growth stages, taking more browse during the dry season. Drinks regularly when water is available, but can get by on water-storing melons, roots, bulbs, and tubers, for which it digs assiduously. **Suitable habitats** (IUCN Red List classification scheme): **Shrubland, Savanna, Grassland, Desert** **Suitable habitats** (terraPulse classification scheme): **Shrubland, Mixed Herbaceous, Desert**	Hunting (for meat and hides) and encroachment by settlement and livestock remain the major threats to this species, especially since the majority of the population remains outside protected areas.
Somali ostrich **Vulnerable** VU Mukogodo Forest project site & Mt. Kulal project site	 *Photo credit: Steve Garvie (CC BY-NC-SA 2.0) https://creativecommons.org/licenses/by-nc-sa/2.0/*	The species is often encountered alone or in pairs in a variety of habitats including semi-arid and arid grassland, dense thornbush and woodland (Davies 2002, Ash and Atkins 2009). **Suitable habitats** (IUCN Red List classification scheme): **Grassland, Savanna, Forest, Shrubland, Artificial/Terrestrial** **Suitable habitats** (terraPulse classification scheme): **Core Forest, Edge Forest, Shrubland, Mixed Herbaceous**	Ash and Atkins (2009) document threats to and apparent declines in Ethiopia and Eritrea. The eggs are used as ornaments, water containers and symbols or protective devices on churches and graves, birds are shot for target practice, food, leather and feathers, and chased to exhaustion or death by drivers. Habitat loss and degradation undoubtedly represents a further threat.

Common name; Conservation status; project site	Photo image	Habitat and ecology in detail	Threats in detail
Rüppell's vulture **Critically Endangered** CR Mukogodo Forest project site & Mt. Kulal project site	 *Photo credit: Danita Delimont on Adobe Stock*	Rüppell's vulture frequents open areas of Acacia woodland, grassland and montane regions, and it is gregarious, congregating at carrion, soaring together in flocks and breeding mainly in colonies on cliff faces and escarpments at a broad range of elevations. In Kenya, the number of nests at a colony may be inversely related to rainfall in the previous year, and timing of nesting varies from year to year. It locates food entirely by sight. **Suitable habitats** (IUCN Red List classification scheme): **Rocky areas, Savanna, Shrubland, Grassland, Desert** **Suitable habitats** (terraPulse classification scheme): **Shrubland, Mixed Herbaceous, Desert**	The species faces similar threats to other African vultures, being susceptible to habitat conversion to agro-pastoral systems, loss of wild ungulates leading to a reduced availability of carrion, hunting for trade, In 2007, diclofenac, a non-steroidal anti-inflammatory drug often used for livestock, and which is fatal to Gyps spp. when ingested at livestock carcasses, was found to be on sale at a veterinary practice in Tanzania. In addition, it was reported that in Tanzania, a Brazilian manufacturer has been aggressively marketing the drug for veterinary purposes and exporting it to 15 African countries. The West African population has been heavily exploited for trade, with birds commonly sold in fetish markets. It is one of the most commonly traded vultures in West and Central African markets, with numbers traded (1,128-1,692 individuals over a six year period in West Africa) probably representing a significant proportion of the regional population, with vultures being used in traditional medicine. The Dogon of central Mali climb the Hombori cliffs to take eggs and chicks of this species. The decline and possible extirpation in Nigeria appears to be entirely attributable to the trade in vulture parts for traditional juju practices. It is apparently also captured for international trade. In 2005, 30 birds were reportedly confiscated by the Italian authorities. Disturbance, especially from climbers, is a particular problem for this species. In Mali, the Hombori and Dyounde massifs are dotted with at least 47 climbing routes, on which expeditions take place every year, mainly during the species's breeding season. However, the impact of these activities is not known. persecution and poisoning. In East Africa, the primary issue is poisoning (particularly from the highly toxic pesticide carbofuran), which occurs primarily outside protected areas; the large range sizes of this and G. africanus puts them both at significant risk as it means they inevitably spend considerable time outside protected areas. In addition, the ungulate wildlife populations on which this species relies have declined precipitously throughout East Africa, even in protected areas.

Common name; Conservation status; project site	Photo image	Habitat and ecology in detail	Threats in detail
Plains zebra **Near Threatened** NT Mukogodo Forest project site & Mt. Kulal project site	 *Photo credit: Jean-Christophe Vié*	Plains zebra live in all habitats in Africa from sea level to 4,300 m on Mount Kenya, with the exception of rain forests, deserts, dune forests, and Cape Sclerophyllous vegetation. A central feature of plains zebra ecology is their migration, tracking resource abundance across the seasons. One of the biggest ungulate migrations in the world occurs in the Serengeti. At a large scale zebras follow the long grass that grows after the rains, at a finer scale they move to maximize intake of food of sufficient quality, while minimizing time spent in habitats where they may encounter predators. Not all zebra herds migrate, with different herds reacting differently to changing conditions: in the Okavango Delta of Botswana only about 55% of zebras make the 588 km round trip. Migration allows zebras to optimize their nutrition by moving to prime grasslands during the wet season, selecting higher quality resources rather than absolute abundance of grass. The start and pace of migration is controlled by the environment: it is initiated by cumulative precipitation, with daily movement being a function of precipitation rate and NDVI. Zebras have the flexibility to alter their migration patterns to avoid adverse conditions or to find new resources. As fences constrain many populations, this allows them to re-establish migrations once barriers are removed. family groups of a stallion with mares and their juvenile offspring. While each of these groups have a home range, the groups join together and move as herds in some or all parts of the year. The home range of Plains Zebras varies across the continent, being determined by seasonal vegetation changes and habitat quality. In East Africa, home ranges in Ngorongoro were 80-250 km² in different parts of the crater, whereas they were larger in the Serengeti: 3-400 km² in the wet season and 4-600 km² in the dry season. Combined with a migration route of 100 to 150 km in each direction, Serengeti zebras cover at least 1000 km² in a year. This can be compared with annual home ranges of 49-566 km² in Kruger National Park. In some areas the herds form discrete subpopulations, separated by natural barriers or marginal habitats. These subpopulations cover areas from 28-136 km² in Zululand to 1530-1560 km² in Kruger National Park. In areas where resources are scarce or patchily distributed, zebras daily cover a lot of ground. In the dry season zebras moved up to 34.5 km to forage in Botswana, whereas in Ngorongoro they moved about 6 km; in Kruger National Park they tended to move less than 2 km in a day across the year. Studies of zebras have shown how their spatial awareness allows them to orient movements towards preferred forage patches or the nearest water source, and thus move efficiently across large distances. **Suitable habitats** (IUCN Red List classification scheme): **Grassland, Savanna, Shrubland** **Suitable habitats** (terraPulse classification scheme): **Shrubland, Mixed Herbaceous**	The quagga was driven to extinction in the late 19th century by overhunting and competition with livestock. While equid meat is often not a preferred choice, Plains Zebra are threatened by hunting through much of their range, especially when they move out of protected areas. Hunting for their skins occurs, particularly in East Africa as these subspecies do not have the shadow stripe present in southern African subspecies. Fencing areas can block migration corridors, although Plains Zebras have been shown to re-establish migration routes if barriers are removed, even if they are blocked for over 30 years.

Common name; Conservation status; project site	Photo image	Habitat and ecology in detail	Threats in detail
White-headed vulture **Critically Endangered** CR Mukogodo Forest project site & Mt. Kulal project site	 *Photo credit: Frank Wouters (CC BY 2.0) http://creativecommons.org/licenses/by/2.0/*	White-headed vulture prefers mixed, dry woodland at low altitudes, avoiding semi-arid thornbelt areas. It also occurs up to 4,000 m in Ethiopia, and perhaps 3,000 m in Kenya, and ranges across the thorny acacia-dominated landscape of Botswana. It generally avoids human habitation. The species is thought to be a long-lived resident that maintains a territory. It may generally fly lower than other vultures, and is often the first vulture species to arrive at carcasses . While it is often found on the periphery of vulture congregations at large carcasses, it is also often found at small carcasses and is probably an occasional predator. It nests and roosts in trees, most nests being in Acacia spp. or baobabs. Clutch size is one, the egg being laid a couple of months after rains have finished and the dry season is underway. Pairs that breed have a success rate of 65-75%, however, up to 61% of pairs do not attempt to breed each year, often due to the presence of a dependent chick from the previous breeding season. **Suitable habitats** (IUCN Red List classification scheme): **Forest, Savanna, Shrubland, Grassland, Artificial/Terrestrial** **Suitable habitats** (terraPulse classification scheme): **Shrubland, Mixed Herbaceous**	Reductions in populations of medium-sized mammals and wild ungulates, as well as habitat conversion throughout its range best explain the current decline. Additional threats include indirect poisoning at baits set to kill jackals in small-stock farming areas, and in East Africa at poisoned baits set for larger mammalian carnivores such as lions and hyenas, and, particularly in East Africa, secondary poisoning from carbofuran and other poisons. Deliberate poisoning to prevent vultures drawing attention to poaching activities has also been documented. Exploitation for the international trade in raptors also poses a threat. In 2005, 30 individuals of this species were confiscated by the Italian authorities.
Lion **Vulnerable** VU Mukogodo Forest project site & Mt. Kulal project site	 *Photo credit: Craig Hilton-Taylor*	The lion has a broad habitat tolerance, absent only from tropical rainforest and the interior of the Sahara desert (Nowell and Jackson 1996). There are records of lion to elevations of more than 4,000 m in the Bale Mountains and on Kilimanjaro. Although lions drink regularly when water is available, they are capable of obtaining their moisture requirements from prey and even plants (such as the tsama melon in the Kalahari desert), and thus can survive in very arid environments. Medium- to large-sized ungulates (including antelopes, zebra and wildebeest) are the bulk of their prey, but lions will take almost any animal, from rodents to a rhino. They also scavenge, displacing other predators (such as the Spotted Hyaena) from their kills. **Suitable habitats** (IUCN Red List classification scheme): **Grassland, Shrubland, Savanna, Forest, Desert** **Suitable habitats** (terraPulse classification scheme): **Core Forest, Edge Forest, Shrubland, Mixed Herbaceous**	The main threats to lions are indiscriminate killing (primarily as a result of retaliatory or pre-emptive killing to protect human life and livestock) and prey base depletion. Habitat loss and conversion has led to a number of subpopulations becoming small and isolated. Furthermore, trophy hunting has a net positive impact in a some areas, but may have at times contributed to population declines in Botswana, Namibia, Tanzania, Zimbabwe, Cameroon and Zambia.

Common name; Conservation status; project site	Photo image	Habitat and ecology in detail	Threats in detail
Cheetah **Vulnerable** VU Mukogodo Forest project site & Mt. Kulal project site	 *Photo credit: Alicia Wirz*	In Africa, Cheetahs are found in a wide range of habitats and ecoregions, ranging from dry forest and thick scrub through to grassland and hyperarid deserts, such as the Sahara. They are only absent from tropical and montane forest, although there are reports of Cheetah at altitudes of 4,000 m on Mt Kenya. In Iran, Cheetah habitat consists of desert, much of it with an annual precipitation of less than 100 mm. There, the terrain in which Cheetah are found ranges from plains and saltpans to eroded foothills, and rugged desert ranges that rise to an elevation of up to 2,000-3,000 m, a landscape not dissimilar to the mountains of the Algerian Sahara. Cheetah appear to show relatively low habitat selectivity compared with other carnivores, although there is variation between females of differing reproductive status. **Suitable habitats** (IUCN Red List classification scheme): **Desert, Grassland, Shrubland, Savanna** **Suitable habitats** (terraPulse classification scheme): **Shrubland, Mixed Herbaceous, Desert**	As a wide ranging carnivore that never attains densities of much more than two individuals per 100 km2, Cheetah are particularly vulnerable to habitat loss and fragmentation. Their low density means that Cheetah populations require much larger areas of land to survive than do those of other carnivore species, and hence they are particularly sensitive to these pressures which, together, represent the over-arching threat to Cheetah. Conserving viable subpopulations of Cheetah is likely to require areas of land far in excess of 10,000 km2. Fortunately, Cheetah can thrive in anthropogenically modified landscapes under the right circumstances; hence the landscapes that Cheetah require for their survival may be protected, unprotected, or a combination of the two. Cheetahs also have excellent dispersal abilities, making it likely to be comparatively easy to maintain gene flow between populations, and to encourage recolonization of suitable unoccupied habitat by conserving connecting habitat.
Harrison's large-eared giant mastiff bat **Vulnerable** VU Mukogodo Forest project site & Mt. Kulal project site	 *Photo credit: Ivan Kuzmin on Adobe Stock*	Individuals of O. harrisoni are associated with high altitudinal areas and have been recorded from a variety of tropical to semi-arid habitats in northeast Africa and the Arabian Peninsula. These include woodlands and shrublands of the Arabian Peninsula and Eritrea, montane grasslands, woodlands and forests of Ethiopia, xeric grassland and shrublands of Djibouti and the bushlands and thickets of Kenya. The species has a preference for roosting in mountain-associated cave systems and lava caves. Tightly-packed clusters of individuals congregate in the Mount Suswa and Ithundu lava caves system of the Rift Valley and Chyulu Hills in Kenya, the Sof Omar karst cave system of Ethiopia, the Hud Sawa caves at the Al-Rayadi Al-Gharbi Mountains in Yemen, the Day Forest National Park at the Goda Massif Mountains in Djibouti and within a disused railway line tunnel near Asmara in Eritrea. While it seems as though there is no direct evidence of migration in this species, marked seasonal absence from some areas and from major colony sites during the dry season has prompted the suggestion of migration. Animals are known to make long distance foraging flights during the dry season. **Suitable habitats** (IUCN Red List classification scheme): **Forest, Savanna, Artificial/Terrestrial** **Suitable habitats** (terraPulse classification scheme): **Core Forest, Edge Forest, Mixed Herbaceous**	The leading threat to this species appears to be roost disturbance. Major colonies in East Africa, such as the population at Mount Suswa (Kenya), seem to have disappeared through disturbance of their cave habitats. Threats to these caves include guano mining (with associated changes to the cave microclimate), blocking of entrances, recreational caving and general tourism activities. It is possible that the collection of 4,954 bats by Mutere (1973) as part of a reproductive study may have contributed to a decline of the Kenyan populations.

Common name; Conservation status; project site	Photo image	Habitat and ecology in detail	Threats in detail
Egyptian vulture **Endangered** EN Mukogodo Forest project site & Mt. Kulal project site	 *Photo credit: Srihari Kulkarni*	This species typically nests on ledges or in caves on cliffs, crags and rocky outcrops, but occasionally also in large trees, buildings (mainly in India), electricity pylons and exceptionally on the ground. It forages in lowland and montane regions over open, often arid, country, and also scavenges at human settlements. It has a broad diet including carrion, tortoises, organic waste, insects, young vertebrates, eggs and even faeces. Usually solitary, individuals congregate at feeding sites, such as rubbish tips, or vulture restaurants (i.e. supplementary feeding stations), and form roosts of non-breeding birds. It performs an energetic display flight with its mate. Several resident island populations show genetic isolation. Northern breeders conduct long-distance intercontinental migrations, flying over land and often utilising the narrowest part of the Strait of Gibraltar or the Bosphorus and Dardanelles on their way to Africa. The species exhibits high site fidelity, particularly in males. **Suitable habitats** (IUCN Red List classification scheme): **Rocky areas, Savanna, Shrubland, Grassland, Wetlands (inland), Desert, Artificial/ Terrestrial** **Suitable habitats** (terraPulse classification scheme): **Shrubland, Mixed Herbaceous, Wetlands/Water, Desert**	This species faces a number of threats across its range. Disturbance, lead poisoning (from ammunition used in hunting game), direct and secondary poisoning, electrocution (by powerlines), collisions with wind turbines, reduced food availability and habitat change are currently impacting upon European populations, with juveniles showing higher declines and mainland populations showing higher rates of juvenile mortality than island populations. Illegal poisoning against carnivores seems to be the main threat operating on the breeding grounds in Spain and the Balkans. Declines in parts of Africa are likely to have been driven by loss of wild ungulate populations and, in some areas, overgrazing by livestock and improvements in slaughterhouse sanitation. Poisoning is a threat to the species, often through the use of poison baits targeted at terrestrial predators, and through the consumption of poisoned animals. Recent analyses from many countries including Bulgaria have highlighted potential contamination of Egyptian Vultures that may lead to increased mortality. Antibiotic residues present in the carcasses of intensively-farmed livestock may increase the susceptibility of nestlings to disease (e.g. avian pox has been reported as a cause of mortality in Bulgaria.
Black rhinoceros **Critically Endangered** CR Mukogodo Forest project site & Mt. Kulal project site	 *Photo credit: Dave Hamman*	Black rhino occur in a wide variety of habitats from desert areas in Namibia to wetter wooded areas. The highest densities of rhinos are found in savannas on nutrient-rich soils and in succulent Valley Bushveld areas. Black Rhino are browsers and favor small acacias and other palatable woody species (Grewia's, Euphorbiaceae species, etc.) as well as palatable herbs and succulents. However, because of high levels of secondary plant chemicals, much woody plant browse (especially many evergreen species) in some areas is unpalatable. Failure to appreciate this, has in the past led to carrying capacities being over-estimated in some areas. Apart from plant species composition and size structure, black rhino carrying capacity is related to rainfall, soil nutrient status, fire histories, levels of grass interference, extent of frost and densities of other large browsers. To maintain rapid population growth rates and prevent potential habitat damage if the population overshoots carrying capacity, populations of Black Rhinos should be managed at densities below long term ecological carrying capacity (i.e., below zero growth densities). Surplus rhino that are removed from such established populations are routinely being profitably invested in new areas with suitable habitat and protection where populations can grow rapidly. **Suitable habitats** (IUCN Red List classification scheme): **Desert, Shrubland, Savanna** **Suitable habitats** (terraPulse classification scheme): **Shrubland, Mixed Herbaceous, Desert**	Black rhino face a variety of threats. The main threat to the species is illegal hunting (poaching) to supply the illegal international rhino horn trade. It is estimated that currently around 95% of rhino horn sourced in Africa for end user illegal markets in SE Asia are from this source (Emslie et al. 2019). Rhino horn has traditionally had two main uses: use in Chinese medicine, and ornamental use. Recently rhino horn has become a highly prized material for making carved expensive high-status items such bowls and bangles. In the past it was also used to produce ornately carved handles for ceremonial daggers (jambiyas) worn in Yemen and some Middle East countries. Historically rhino horn was also used in traditional Chinese medicine (as a fever reducer). However, most recently it appears to be shavings from carvings that are illegally sold to the medicinal market at lower prices than worked items. While black rhino numbers continue to increase at a continental-level poaching has slowed overall growth. Some populations have also declined. Black rhino poaching peaked in 2015 and has been declining since.

Table A3. Information on habitat ecology and threats for the 3 identified priority threatened species at the TRI Tana River project site, from the IUCN Red List of Threatened Species™. Habitat suitability coding using 8-class terraPulse classification scheme shown under Habitat and Ecology in detail (see Annex I, Coding species habitat suitability)

Common name; Conservation status	Photo image	Habitat and ecology in detail	Threats in detail
Tana River Red colobus monkey **Critically Endangered** CR	 *Photo credit: Yvonne de Jong & Tom Butynski*	This folivorous species has a home range of ca 4–19 ha. Mean group size is ca 13 individuals with generally one adult male. This species is arboreal but must come to the ground (rarely) to move between, and colonize, distant forest patches. This species occupies riverine and flood-plain forests. **Suitable habitats** (IUCN Red List classification scheme): **Forests, Shrubland, Wetlands (inland)** **Suitable habitats** (terraPulse classification scheme): **Core Forest; Edge Forest; Shrubland; Wetlands, Water**	This species has declined as a result of several causes, including: (a) drastic changes in vegetation due to dam construction, irrigation projects, and water diversion, which affect the water table and the frequency and severity of flooding which, in turn, affect the amount and quality of habitat; (b) forest clearance for agriculture; (c) fires that destroy forests; (d) habitat degradation due to livestock and the unsustainable collection of wood and other forest products; (e) selective felling of fig trees for canoes; and (f) corruption, inter-ethnic violence, and insecurity. Because all remaining forests inhabited by P. rufomitratus are small and seriously threatened, the long-term survival of the species is in question. There has been considerable alteration of river flow volume and the flood cycle by five hydroelectric power dams up-river. A sixth dam, the High Grand Falls Dam, is under construction. The High Grand Falls Dam, the second largest dam in Africa, will be accompanied by large-scale irrigation schemes and water transfer to the 'Lamu Port and Lamu Southern Sudan-Ethiopia Transport Corridor'. The establishment of this dam is expected to have additional negative impacts on the forests of the Lower Tana River and, therefore, on P. rufomitratus. One special concern is the rapidly growing human population in the region. Another is the possible annulment of the Tana River Primate National Reserve (TRPNR; 169 km²) which the High Court of Kenya ordered in January 2007. According to the Kenya Wildlife Act 2013, Section 37, change of boundaries or revocation of a National Reserve can only be published by the Cabinet Secretary and approved by Parliament. Change or revocation can only be recommended if they do not endanger any species or critical habitat. As such, it seems unlikely that annulment will occur, despite the court ruling in 2007. About 35% of P. rufomitratus occur in the TRPNR. Even with the continued existence of the TRPNR the long-term survival of P. rufomitratus is not certain, as the high level of insecurity and inadequate law enforcement in the region is expected to continue. According to Global Forest Watch data, Kenya's Tana River region has lost 16% of its forest cover since the turn of the century, tropical forest habitat being reduced from approximately 60,000 to 50,000 hectares. Although the annual rate of loss has remained fairly consistent throughout this period (530 ha/yr avg), it has spiked several times to more than double or triple that rate. Should the TRPNR be annulled and/or peak rates of deforestation be reached again, it is conceivable that this species could lose 80% or more of its habitat by mid-century.

Common name; Conservation status	Photo image	Habitat and ecology in detail	Threats in detail
Sokoke dog mongoose **Vulnerable** VU	 *Photo credit: Hans (pixabay.com)*	Restricted to the coastal forests of Kenya and Tanzania and possibly to mountainous areas near the coast. Has been observed foraging on roads at night after insects, when individuals may sometimes be injured or killed by vehicles. **Suitable habitats** (IUCN Red List classification scheme): **Forests** **Suitable habitats** (terraPulse classification scheme): **Core Forest; Edge Forest**	The population in the Arubuko–Sokoke Forest is under threat from habitat loss because of illegal logging and the Shimba Hills population is potentially under threat from afforestation with non-native pine species together with management for Sable Antelope Hippotragus niger.
Spotted ground thrush **Endangered** EN	 *Photo credit: AGAMI on Adobe Stock*	Occurs in deep shade in a variety of forest types with deep leaf-litter, from dry Cynometra thicket in Arabuko-Sokoke at sea-level (non-breeding birds) to moist evergreen forest at 1,200-1,700 m in Malawi. The species winters in tall coastal forests, with fischeri preferring coral rag forests, and guttata possibly using coastal dune forest, and this subspecies prefers larger forests for breeding. **The species avoids disturbance-prone areas**. It forages amongst the lower branches of leafy trees, on rotting logs and on the forest floor by scratching at leaf litter. It feeds on seeds, fruits, insects and their larvae, and land mollusks. It has a home range of at least 0.14 ha in the non-breeding season, but this is not known for breeding pairs. Clutch-size is 2-3. Its nest is described as a cup or bowl constructed from vegetation, small twigs and mud, lined with plant material and feathers; the exact composition of materials is dependent on the habitat and thus differs between subspecies. The species does not conceal its nests well, and they tend to be very exposed and easy to find, leading to a low breeding success rate, with about 85% of nests recorded as failing by one observer in South Africa. Nests may be re-used after a brood has fledged or even after the nest has been depredated, despite the clear indication that it is at risk. This may be a time- and energy-saving strategy. Snakes, raptors and domestic cats are the main nest predators, and contribute to nearly 50% of breeding failures. Laying has been noted in November in Malawi and in September-March in South Africa. **Suitable habitats** (IUCN Red List classification scheme): **Forests, Shrubland** **Suitable habitats** (terraPulse classification scheme): **Core Forest; Shrubland**	In Tanzania, coastal forest patches that are probably “stepping stones” during migration are under heavy pressure and becoming increasingly fragmented. Pugu Forest is being degraded as a result of charcoal production. Wintering habitat in Kenya is also under heavy pressure, particularly the smaller sites. In Malawi, forest is being cleared at all four known sites and there will soon be very little habitat remaining. At Mt Mulanje (Malawi) exotic species accompany the threats of encroachment, deforestation and possibly bush fires. In South Africa, mining has destroyed much wintering habitat and may affect more forest in the near future, while habitat disturbance is increasing in many protected areas. The species’s recovery is limited by its low breeding success, which is largely due to vulnerability of nests and resultant high rates of predation, perhaps exacerbated by domestic cats where they are present. This species occasionally suffers mortality from collisions with skyscrapers, probably due to the disorientating effect of city lights during nocturnal migration. The species may suffer additional habitat loss due to climate change.

Annex 2. Methodology for developing Area of Habitat (AOH) and STAR scores

I. Generation of an 8-class land cover map at 30-meter resolution

A key first step in developing any STAR assessment is developing (or making use of an already developed) spatially-explicit map that classifies land cover into categories related to those found in the Habitat Classification Scheme of the IUCN Red List of Threatened Species™ (version 3.1).[18] This land cover map is then used to assess whether the assessment area(s) contain any suitable habitat for threatened species represented as species Area of Habitat ((AOH); see step III below). Ideally this land cover classification mapping should be done globally to ensure a consistent approach in computing STAR values. For this high-resolution assessment, land cover maps were developed for the project site only and estimates for the distribution of total global AOH for priority species relied upon earlier work by Bernardo Strassburg and others.[19]

The Habitat Classification Scheme of the IUCN Red List of Threatened Species™ (version 3.1) has 18 categories of habitat that are further sub-divided into an additional 2 sub-levels of hierarchy, yielding 111 distinct habitat classes. Such fine scale delineation of habitats is useful for research and other potential applications. However, for STAR assessments, developing a 111 category land classification maps is neither feasible nor cost-effective with present technology and remotely-sensed imagery, nor needed, as most project sites and species of interest contain, or are found within, a narrow sub-set of habitat types. Moreover, further classification of land cover introduces both added complexity and potential errors in classification that must be balanced against potential benefits from having more distinct land cover mapping.

For this high-resolution STAR assessment, an 8-class land cover classification map was produced using remote sensing derived data layers at 30-meter resolution and geographic information system (GIS) processing, as described in Table 4. Data layers are as follows:

- **terraPulse Tree Canopy Cover** data represent the state of ecosystems as percentages of tree canopy cover (0-100) at 30-meter spatial and annual temporal resolution. Changes over time are detected using both the estimate and the uncertainty of the value in each pixel.

- **terraPulse Normalized Difference Vegetation Index (NDVI)** is a satellite-based index used to monitor vegetation. The annual mean NDVI (30-meter resolution) provides a gauge of non-forest vegetation and lack of vegetation.

- **terraPulse Surface Water Inundation** represent inundation of the ground surface of each pixel by water at 30-m resolution on an annual basis.

- **NASA Global Food Security-Support Analysis Data Cropland Extent** is available through NASA's Land Processes Distributed Active Archive Center (LP DAAC; https://lpdaac.usgs.gov/product_search/) and provides an estimate of cropland extent in 2015 at 30-meter resolution.

- **WorldPop Human Population Density** is an estimate of human population density modeled over 1 kilometer pixels on an annual basis available through WorldPop (https://www.worldpop.org/project/categories?id=18).

Table A4. Land cover classification categories of the 8-class terraPulse land cover classification scheme, along with input layers and processing used for their derivation

[18] See: https://www.iucnredlist.org/resources/habitat-classification-scheme

[19] Strassburg et. al (2019). *Global priority areas for ecosystem restoration, Nature 586,* 724-729 https://doi.org/10.1038/s41586-020-2784-9

Land cover classification	Input layers and processing used to identify landcover class
Core Forest	terraPulse Tree Canopy Cover >30%, more than 400 m[20] from forest edge
Edge Forest	terraPulse Tree Canopy Cover >30%, within 400 m from edge of forest
Mixed Herbaceous	terraPulse Tree Canopy Cover <10%, terraPulse NDVI > 0.1
Shrubland	terraPulse Tree Canopy Cover <30%, terraPulse NDVI > 0.1
Wetlands, Water	terraPulse Surface Inundation >25%
Desert	terraPulse NDVI <0.1, terraPulse Tree Canopy Cover <10%
Cropland	NASA Global Food Security-Support Analysis Data Cropland Extent
Urban Areas	WorldPop Human Population Density >386 per km^2 (US Census definition of urban areas)

II. Coding species habitat suitability based on IUCN Red List information

The IUCN Red List contains information on the habitat and ecology of assessed species and uses the Habitat Classification Scheme of the IUCN Red List of Threatened Species™ (version 3.1) to describe suitable habitat. Because the 8-class terraPulse land cover classification scheme used for these high-resolution STAR assessments differs from that of the Red List Habitat Classification Scheme, a process of assessing and coding habitat suitability[21] of the 8 land cover classes for each priority threatened species based on Red List information was utilized, as described below:

- **Core Forest** – Coded as suitable habitat for species that list IUCN Red List Class 1, Forest & Woodlands among their respective suitable habitats
- **Edge Forest** – Coded as suitable habitat for species that list IUCN Red List Class 1, Forest & Woodlands among their respective suitable habitats and the *Red List Habitat and Ecology* narrative section indicates that the species can tolerate disturbance-prone, fragmented forest.
- **Mixed Herbaceous** – Coded as suitable habitat for species that list IUCN Red List Class 2, Savanna and/or IUCN Red List Class 4, Native Grassland among their respective suitable habitats
- **Shrubland** – Coded as suitable habitat for species that list IUCN Red List Class 3, Shrubland among their respective suitable habitats
- **Wetlands, Water** – Coded as suitable habitat for species that list IUCN Red List Class 5, Wetlands and/or IUCN Red List Class 13, Marine - Coastal among their respective suitable habitats
- **Desert** – Coded as suitable habitat for species that list IUCN Red List Class 8, Desert among their respective suitable habitats
- **Cropland** – Coded as suitable habitat for species that list IUCN Red List Class 14.1, Arable Land among their respective suitable habitats
- **Urban Areas** – Coded as suitable habitat for species that list IUCN Red List Class 14.5, Urban Areas among their respective suitable habitats

[20] A buffer of 400 m is used to distinguish Core Forest from Edge Forest. This approach is derived from the work of Laurance (2008) which shows edge effects can persist at 400 m from the border of forest and non-forest land cover.

[21] Habitat classes are coded in a binary formulation as either "suitable" or "unsuitable" for assessed species.

A small number of assessed species (not among the 3 assessed Tana River project site priority species) list one or more of the following three IUCN Red List habitat subclasses as suitable habitat in their Red List assessment data. This information was not utilized in assessing and coding habitat suitability of the 8 land cover classes in the terraPulse scheme for priority species. These classes, and the likely impact of not including them in the coding process, are as follows:

- IUCN Red List subclass 14.2 Artificial – Terrestrial, Pastureland - Distinguishing pastureland from grasslands and savannas via remote sensing is challenging and beyond the scope of this STAR assessment. This type of landcover is likely coded as Mixed Herbaceous in the terraPulse map used for this assessment and all species that list Pastureland as suitable habitat also list Grassland or Savanah as suitable class.

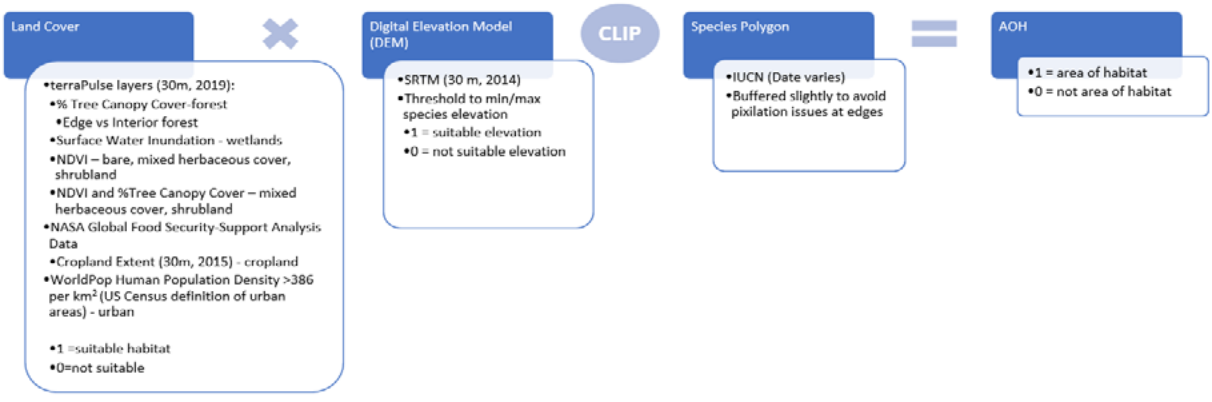
- IUCN Red List subclass 14.3 Artificial – Terrestrial, Plantations - Depending upon the age of plantations, plantation land cover would likely be coded as Core or Edge Forest in the terraPulse land cover map. All priority threatened species that list Plantations among suitable habitat types in their Red List information also show Forests as suitable class, so the impact from not discerning this habitat class within the terraPulse land cover map is likely to be negligible.

- IUCN Red List subclass 14.6 Subtropical/Tropical Heavily Degraded Former Forest – This was coded based on the current land cover rather than previous land cover. All species included in this study that listed this as suitable habitat also list other included habitats like Edge Forest or Mixed Herbaceous.

III. Generation of species Area of Habitat (AOH) polygons

Land cover classification and coding for species habitat suitability are inputs used to model species Current Area of Habitat (*Current AOH*) and species *Lost AOH*, which in turn allow for the calculation of STAR. *Current AOH* is defined as "the area, characterized by its abiotic and biotic properties, that is presently habitable by a particular species" and *Lost AOH* is defined as areas that were once habitable by a particular species but are now unhabitable, presumably due to habitat modification and destruction[22]. The land cover classification map(s) and coding for species habitat suitability are combined in a GIS with polygons and data indicating the species range and elevation thresholds[23] to generate the AOH represented as polygons. Figure A1 shows the process for generating AOH.

Figure A1. Inputs and process for generating species Area of Habitat polygons in a GIS.



For these high-resolution STAR assessments, *Current AOH* was calculated using land cover mapping based on remotely sensed imagery from 2019. *Lost AOH* was calculated using land cover mapping based on remotely sensed imagery from 2010 to generate species AOH, then subtracting *Current AOH* from the 2010 species AOH.

[22] Brooks, et. al (2019). Measuring Terrestrial Area of Habitat (AOH) and Its Utility for the IUCN Red List. *Trends in Ecology & Evolution.*

[23] Information on species elevation thresholds and range taken from the IUCN Red List of Threatened Species™

IV. Calculation of STAR values

Calculation of STAR values for these high-resolution STAR assessments follows the methodology developed by Mair et al, 2021[24], with some modifications given the incomplete coverage of the terraPulse land cover map. These are described below.

STAR values are calculated using data on species current AOH and Lost AOH, extinction risk (IUCN Red List category) and the relative contribution of each threat to the species' extinction risk. For this high-resolution STAR assessment, the STAR metric was calculated for the subset of threatened species that together comprise over 90% of the total low-resolution STAR assessment score for the project site[25]: the *Tana River Red colobus monkey*; the *Sokoke dog mongoose*; and the *Spotted ground thrush.*

The STAR threat-abatement score (*T*) for a location (*i*) and threat (*t*) is calculated among assessed species as:

$$T_{t,i} = \sum_{s}^{N_s} P_{s,i} W_s C_{s,t}$$

where $P_{s,i}$ is the current Area of Habitat (AOH) of each assessed species (s) within location (i), expressed as a percentage of the global species' current AOH; W_s is the IUCN Red List category weight of species s (Near Threatened = 1, Vulnerable = 2, Endangered = 3 and Critically Endangered = 4); C is the relative contribution of threat t to the extinction risk of species s; and N_s is the total number of species at location (i). The relative contribution of each threat to the species' extinction risk was calculated as the percentage population decline from that threat (derived from the product of severity and scope for that threat in each species' IUCN Red List assessment) divided by the sum of percentage population declines from all threats to that species. Scores were calculated using the most detailed threat classification available and then aggregated to higher levels in the threat classification scheme by summing scores.

The STAR restoration score (*R*) for the potential contribution of habitat restoration (and threat abatement therein) at location *i* for threat *t* is calculated as:

$$R_{t,i} = \sum_{s}^{N_S} H_{s,i} W_s C_{s,t} M_{s,i}$$

where $H_{s,i}$ is the extent of restorable AOH for species *s* at location *i*, expressed as a percentage of the global species' current AOH, and M_i is a multiplier appropriate to the habitat at location *i* to discount restoration scores. A global multiplier of 0.29 is used based on the median rate of recovery from a global meta-analysis assuming that restoration has been underway for ten years (the period of the post-2020 outcome goals).

These STAR values for all assessed species at a project site are summed, giving the total STAR scores presented in the maps shown here[26].

[24] Mair, L. et. al (2021). A metric for spatially explicit contributions to science-based species targets. *Nature Ecology & Evolution.*

[25] As noted earlier, this high-resolution assessment is a follow-on report to an earlier STAR assessment of the TRI Tana River project site using lower resolution imagery and a different land cover scheme. To reduce costs, this high-resolution STAR assessment focused on a subset of species assessed in the earlier low-resolution STAR assessment that together generated over 90% of the total low-resolution STAR assessment score for the project site

[26] Note that for this high-resolution assessment, STAR scores from restoration of lost habitat were calculated but are very low due in part to use of baseline imagery from 2009 rather than from a much earlier date (see Methodology section in Annex I). As such, these STAR restoration values have been left out in the maps presented in this assessment as they do not provide much useful information

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