Species Threat Abatement and Restoration Metric

Assessment of potential reduction in likelihood of species extinctions for El Salvador Coffee Farms

FINAL REPORT

20 February 2019

Frank Hawkins, Craig R. Beatty

IUCN-US
Washington DC
Species Threat Abatement and Restoration Metric

Assessment of potential reduction in likelihood of species extinctions for
El Salvador Coffee Farms

Aim: to use the existing approach and methodology for STAR to calculate an initial ex-ante value for the project area of the coffee farms in El Salvador, and to make management recommendations based on the result of that analysis.

Tasks and results:

Task list from contract

1) Identify the threatened species whose ranges overlap with the polygon
2) The proportion of the total range of each species covered by the polygon
3) The proportion of the total Extent of Suitable Habitat (ESH) for each species covered by the polygon
4) The rate of loss of ESH for each species in the polygon
5) From the IUCN Red List of Species, the threats that apply to each species
6) For the species that are affected by habitat loss, the proportion of their total range that has been affected by ESH loss in the polygon

This analysis utilizes the methods of the Species Threat Abatement and Restoration Metric (STAR) (see Appendix 1) to deliver quantified estimates of the contribution that investment could make to the reductions in extinction pressures for taxa listed as ‘Threatened’ (Critically Endangered, Endangered, Vulnerable or Near-Threatened) in the IUCN Red List of Threatened Species (see https://www.iucnredlist.org/). In brief, the STAR methodology assesses the extent to which an investment can reduce the risk of species extinction through reduction of the scope and severity of threats that apply to species present at a site. The Red List assessment is a thorough, scientifically-based and expert-led process using established standards and principles.

This analysis was conducted across the spatial extent of a set of coffee farms in El Salvador. The set of coffee farms included in this analysis include 182 distinct polygons, however, many of these are adjacent to each other and are either owned or operated by the same entity. The total area of all coffee farms in this analysis is nearly 3000 hectares (2787ha) with an average estimated size of 15ha and a median size of 3.78ha. The largest farm is 629ha (ASOC. COOP. DE PRODUC. AGROPECUARIA LAS LAJAS DE R.L. ACOPE LAS LAJAS DE R.L.) and 79 of these farms are less than 1ha in area. Generally the farms analyzed here are clustered in Western El Salvador around the union of the departments of Santa Ana (Southern),

1 The IUCN Red List is a critical indicator of the health of the world’s biodiversity. Far more than a list of species and their status, it is a powerful tool to inform and catalyze action for biodiversity conservation and policy change, critical to protecting the natural resources we need to survive. It provides information about range, population size, habitat and ecology, use and/or trade, threats, and conservation actions that will help inform necessary conservation decisions.

The IUCN Red List is used by government agencies, wildlife departments, conservation-related non-governmental organizations (NGOs), natural resource planners, educational organizations, students, and the business community. The Red List process has become a massive enterprise involving the IUCN Global Species Program staff, partner organizations and experts in the IUCN Species Survival Commission and partner networks who compile the species information to make The IUCN Red List the Indispensable product it is today.
Ahuachapán, and Sonsonate. Additional farms occur in La Liberdad, San Salvador, San Miguel, Usulután, and Morazán. The 182 farms included in this analysis occur between altitudes of 498m and 1854m.

1. Identification of the threatened species whose ranges overlap with the polygon

The following 13 species ranges’ overlap with the wider landscape of the farms. They are listed in alphabetical order of scientific name, and are classified as ‘Near-threatened (NT)’, ‘Vulnerable (VU)’, ‘Endangered (EN)’, and ‘Critically Endangered (CR)’ on the IUCN Red List of Species. They were therefore identified as potential conservation targets in the initial phase of the analysis.

Table 1. Threatened species present in the general vicinity of the coffee farms

<table>
<thead>
<tr>
<th>Vernacular name</th>
<th>Scientific name</th>
<th>Threat category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow-naped Amazon</td>
<td>Amazona auropalliata</td>
<td>EN</td>
</tr>
<tr>
<td>Geoffroy’s Spider Monkey</td>
<td>Ateles geoffroyi</td>
<td>EN</td>
</tr>
<tr>
<td>Salvin’s Mushroom-tongue Salamander</td>
<td>Bolitoglossa salvinii</td>
<td>EN</td>
</tr>
<tr>
<td>Spanish Cedar</td>
<td>Cedrela odorata</td>
<td>VU</td>
</tr>
<tr>
<td>Great Curassow</td>
<td>Crax rubra</td>
<td>VU</td>
</tr>
<tr>
<td>American Crocodile</td>
<td>Crocodylus acutus</td>
<td>VU</td>
</tr>
<tr>
<td>Mexican Caecilian</td>
<td>Dermophis mexicanus</td>
<td>VU</td>
</tr>
<tr>
<td>(Crab)</td>
<td>Elsalvatoria zurstrasseni</td>
<td>VU</td>
</tr>
</tbody>
</table>
2. Calculate the proportion of the total range of each species covered by the project area polygon
3. Calculate the proportion of the total Extent of Suitable Habitat (ESH) for each species covered by the project area polygon
4. Calculate the rate of loss of ESH for each species in the polygon

In addition to being the first step in the ex-ante STAR calculation, these steps permit the elimination of species that are not currently known from the coffee farms, or for which the proportion of their range represented by the project polygon and the coffee farms themselves is very small. These species will not contribute significantly to the ex-ante STAR calculation. However they are species which might have a wider distribution than currently known, so they are retained as species for which further fieldwork would be prioritised under the recommendations.

The Extent of Suitable Habitat (ESH) is a measure of the area within the species range that the species is likely to occupy. It may include areas where the species has not yet been recorded, but for which the ecological conditions (habitat type and elevational range) are appropriate. ESH was calculated using data in the Red List of Species on the habitat requirements, including (for instance) dependence on forest, wetland or grassland, and altitudinal range of each threatened species. Data on forest cover were acquired through Hansen/UMD/Google/USGS/NASA\(^2\) and represent forest cover in the year 2000. Data were also acquired on canopy cover loss but were not used in this analysis due to time constraints\(^3\).

---


\(^3\) Identifying the areas where canopy cover has been lost since 2000 would be a simple overlay of the existing results. We could also determine the extent to which these losses occurred within the coffee farms and when these losses occurred. To incorporate canopy cover loss into the STAR calculations would take more time since the ESH for each species would need to be updated and the STAR calculations re-run.
Forest cover in 2000 presents an optimistic scenario of the available habitat for the forest-dependent species in this analysis. For these species all areas greater than 1% canopy cover are included as forest⁴. We included all potential forest as the life history information of many of the species included here indicates that they can persist in heavily modified forests and landscapes. As such only areas that were definitely not forest were excluded. It should be noted here that the analytical process here retains the spectrum of forest percent per pixel, which can allow for a more specific definition of forest cover percentage in the future. Data from the 2000 forest cover was used because it is the baseline against which much of the global forest/canopy loss has been calculated. Using forest cover data from 2000 provides a best case estimate during STAR calculations. Furthermore, it then allows for the analysis of recent forest loss or land cover change – changes that may be easier to address than areas that have been degraded for a longer time.

For water-feature dependent species, waterway features were sourced from Open Street Maps for Guatemala, El Salvador, and Honduras. Species relying on water features (rivers, streams) had ranges that only extended across these countries. Buffers were calculated extending 500m around all sides of these features – consistent with life history information.

Where elevation ranges were included in the Red List accounts of species, this information was used to further refine the extent of suitable habitat for each species, removing areas within the species range that were outside of its elevation envelope.

Using the steps above, this wider list was narrowed to 11 species. Salvin’s Mushroom-tongue Salamander Bolitoglossus salvinii and the crab Esalvadoria zurstrasseni); based on a calculation of the Extent of Suitable Habitat (ESH) within each species range polygon, these two species’ ESH did not overlap with the coffee farms. A further three species were excluded from the analysis at this point, though their ranges and habitat did overlap with the coffee farms. These are Spanish Cedar Cedrela odorata, American Crocodile Crocodylus acutus, and Giant Anteater Myrmecophaga tridactyla. While these species are of global conservation concern, their very large range size compared with the size of the coffee farms means that changes in the management of the coffee farms would have an insignificant impact on the risk of species extinction and therefore the ex-ante STAR value. Additionally, Baird’s Tapir Tapirus bairdi is listed as extinct in El Salvador, though its historical range overlapped with the areas of interest.

The remaining species are listed in Table 2 below.

⁴ Similarly to the reason we used 2000 forest cover data, using 1% forest tries to capture all possible forest types. Since different species have different requirements of forest, and in an analysis that includes many different species, we wanted to capture as much potential suitable habitat as possible. The FAO definition of forest is often related to how governments agree on what “counts” as a forest for all sorts of reporting and monitoring under UN conventions and national law. Since the STAR process is species-oriented we wanted to take as broad an approach as possible to not exclude any potentially marginal forest habitat that may be important for forest-dependent species. Changing the extent of forest from presence/absence as it currently is to 0.5ha, 5m, and 10% may end up excluding habitat that would be important for species.
Table 2. Ecological information on selected threatened species found in the general vicinity of the coffee farms, from the IUCN Red List of Species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Lower elevation</th>
<th>Upper elevation</th>
<th>Habitat</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Amazona auropalliata</em></td>
<td>0</td>
<td>600</td>
<td>Forest, Artificial/Terrestrial</td>
<td>Yellow-naped Amazon (EN)</td>
</tr>
<tr>
<td><em>Ateles geoffroyi</em></td>
<td>-</td>
<td>-</td>
<td>Forest</td>
<td>Geoffroy’s Spider Monkey (EN)</td>
</tr>
<tr>
<td><em>Crax rubra</em></td>
<td>0</td>
<td>1900</td>
<td>Forest, Artificial/Terrestrial</td>
<td>Great Curassow (VU) undisturbed humid evergreen forest (also seasonally dry forest in some areas) and mangroves although there are reports that it tolerates limited disturbance</td>
</tr>
<tr>
<td><em>Dermophis mexicanus</em></td>
<td>0</td>
<td>900</td>
<td>Artificial/Terrestrial, Forest</td>
<td>Mexican Caecilian (VU) This species lives in humid to dry soils beneath leaf-litter, logs, banana or coffee leaves and hulls or similar ground cover. In El Salvador it is present in dry forest and savanna between sea level and 900m asl (Köhler et al., 2006). It is adaptable to secondary habitats.</td>
</tr>
<tr>
<td><em>Hyopachus barberi</em></td>
<td>1470</td>
<td>2200</td>
<td>Wetlands (inland), Forest, Artificial/Terrestrial</td>
<td>Barber’s Sheep Frog (VU) This species occurs in humid pine-oak forests. It is able to tolerate some limited habitat destruction, but probably requires humid microclimates, and occurs in short-grasses and in coffee groves. It breeds in temporary to semi-permanent pools.</td>
</tr>
<tr>
<td><em>Ptychohyla salvadorensis</em></td>
<td>-</td>
<td>-</td>
<td>Wetlands (inland), Artificial/Terrestrial, Forest</td>
<td>(Stream Frog: no common name) (EN) This stream-breeding species lives on low vegetation along streams in premontane to lower montane moist forest. It is tolerant of some habitat disturbance; however, it requires some woody vegetation, such as trees along streams in pastureland.</td>
</tr>
</tbody>
</table>
Once all the ESH ranges for each of the remaining threatened species had been calculated, it was then possible to overlay these ranges to evaluate the spatial distribution across the project area and the coffee farm boundaries. Figure 1 below shows the locations of the coffee farms, and the shading shows the density of overlap of the ESH of threatened species in the region.
5. From the IUCN Red List of Species, identify the threats that apply to each species

Threats that are listed in the IUCN Red List of Species (see Appendix 2 for a full list of Red List Threats) that most commonly affect the species listed above are shown in the graphic below. The size of each block indicates the importance of the threats in influencing the risk of species extinction among the threatened species that occur in the project area.
List of threats: 2.1 Annual & perennial non-timber crops, 0.00417, 1.1 Housing & urban areas, 0.00136, 5.3 Logging & wood harvesting, 0.00092, 1.2 Commercial & industrial areas, 0.00128, 2.3 Livestock farming & ranching, 0.00031, 8.1 Invasive non-native/alien species/disease, 0.00017, 5.1 Hunting & trapping terrestrial animals, 0.00016, 9.3 Agricultural & forestry, pollution, <0.0001, 10.3 Avalanches & landslides, <0.0001, 2.4 Marine & Freshwater aquaculture, <0.0001, 9.1 Domestic & urban waste water, <0.0001, 9.5 Air-borne pollutants, <0.0001, 7.1 Fire & Fire Suppression, <0.0001, 11.2 Droughts, <0.0001, 11.4 Storms & flooding, <0.0001.

According to the data held in the IUCN Red List of Species, the most important threats to species occurring in the project area are those posed by annual and perennial non-timber crops (clearly in this case the cultivation of coffee), the expansion of urban areas, logging and wood harvesting and expansion...
of commercial, agricultural and industrial areas. These threats will have their impacts through habitat change. It is unclear which of these threats is the most important cause of habitat loss in the specific context of the coffee farms; analysis to investigate this issue is proposed in the recommendations and would be part of the ex-post STAR analysis.

6. For the species that are affected by habitat loss, assess the proportion of their total range that has been affected by ESH loss in the polygon

In terms of the scale and scope of impact, it is likely that expansion of urban and commercial areas would result in the permanent loss of habitat, whereas cultivation of coffee and other non-timber crops, and logging and wood harvesting would result in the partial or substantial degradation of a habitat, which might be possible to restore. Other forms of agriculture such as conversion of forest to cattle ranching might prove possible but more difficult to restore.

However, overall, by measuring the rate of loss of primary habitat, a good measure of the likely combined impact on these species can be gained, and the ex-ante STAR value for the individual farms calculated.

**Calculation of ex-ante STAR values for threatened species present in the project area**

Figure 3 below shows the relative contribution to STAR scores that could be generated by reducing each of the threats to each threatened species to zero. Note that the usual protocol for calculating ex-ante STAR scores is that only comprehensively-assessed taxa are included (Appendix 1). In this case we have included the crab *Raddaus mertensi* even though the crabs are not a comprehensively assessed taxon.

**Figure 3 Schematic diagram of the contribution of each threatened species to the total risk of species extinction in the project area**
From Figure 3 it is clear that the species that generate the greatest potential ex-ante STAR scores are: *Ptychohyla salvadorensis*, *Hypopachus barberi*, and *Raddaus mertensi*. These are freshwater/streamside forest species (two frogs and a crab) that have small global ranges, a significant proportion of which are covered by the coffee farms in the project area. If it were confirmed that these species do occur in these coffee farms, then this suggests that the conditions under which the coffee is being cultivated are compatible with the survival of these species. Steps that can be taken to confirm this hypothesis are outlined in the Recommendations below.

The total estimated potential ex-ante STAR yield for the ensemble of the coffee farms is 0.0067 STAR units, where one STAR unit is approximately equivalent to the reduction in extinction risk of one species by one threat category (Critically Endangered to Endangered, Endangered to Vulnerable, Vulnerable to Near-threatened). Given the small surface area of the coffee farms, this is a significant contribution to the total risk of species extinction in the region.

The other four threatened species present in the coffee farms offer more limited opportunities to contribute to reduction of species extinction risk. This is because the proportion of the total population of these species present in the coffee farms (measured as a proportion of ESH) is very small. Clearly there are significant populations of all seven species in the larger landscape around the coffee farms, so there is still opportunity to contribute to the conservation of these and other species by improving the management practices used outside the coffee farms in the wider landscape.
Focusing on the three species that provide the greatest STAR score provides the future opportunity to move to the ex-post STAR measurement, through calculation of the specific contributions to a reduction in extinction pressure that each land parcel could contribute through actions to support these species and reduce their primary threats. A total of 39 parcels covering a total area of 689 ha have the potential to contribute to reducing these pressures for more than one species of the three highest value STAR species (\textit{Raddaus mertensi, Hypopachus barberi, and Ptychohyla salvadorensis}). These parcels are listed below and are indicated in RED on the STAR Map (Figure 1). Given that each parcel is so small, calculation of STAR values for each would give very small values, and our recommendation is to proceed by verifying the presence of the key species in each farm to permit the measurement of a STAR ex-post value for each (see Recommendations, below).

**Table 3** Farms contributing STAR reduction in species extinction risk for more than one of the highest value species. Total surface area of all blocks is 689 ha. Landuse blocks within farms are colored similarly.

<table>
<thead>
<tr>
<th>OBJECTID</th>
<th>Nombre_del</th>
<th>Categoría</th>
<th>Rubro</th>
<th>Área_Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>710</td>
<td>CASAL, S.A. DE C.V.</td>
<td>Cafetal</td>
<td>Café</td>
<td>21.65369</td>
</tr>
<tr>
<td>711</td>
<td>CASAL, S.A. DE C.V.</td>
<td>Zona boscosa</td>
<td>Café</td>
<td>8.601581</td>
</tr>
<tr>
<td>712</td>
<td>CASAL, S.A. DE C.V.</td>
<td>Caso de la finca</td>
<td>Café</td>
<td>0.433344</td>
</tr>
<tr>
<td>1525</td>
<td>OBRAJUELO, S.A. DE C.V.</td>
<td>Café</td>
<td>Café</td>
<td>193.1571</td>
</tr>
<tr>
<td>1705</td>
<td>Luis Palomo</td>
<td>Siembra 2016</td>
<td>Café</td>
<td>20.53463</td>
</tr>
<tr>
<td>1707</td>
<td>Luis Palomo</td>
<td>Bosque</td>
<td>Café</td>
<td>27.92988</td>
</tr>
<tr>
<td>1708</td>
<td>Luis Palomo</td>
<td>Siembra 2017</td>
<td>Café</td>
<td>16.38252</td>
</tr>
<tr>
<td>1709</td>
<td>Luis Palomo</td>
<td>Siembra 2012</td>
<td>Café</td>
<td>2.592239</td>
</tr>
<tr>
<td>1710</td>
<td>Luis Palomo</td>
<td>Siembra 2012</td>
<td>Café</td>
<td>40.70928</td>
</tr>
<tr>
<td>1711</td>
<td>Luis Palomo</td>
<td>Vivero</td>
<td>Café</td>
<td>0.672133</td>
</tr>
<tr>
<td>1712</td>
<td>Luis Palomo</td>
<td>Casco</td>
<td>Café</td>
<td>0.182952</td>
</tr>
<tr>
<td>1741</td>
<td>ILAMATEPEC, SOCIEDAD ANONIMA DE CAPITAL VARIABLE</td>
<td>Café</td>
<td>Café</td>
<td>29.65077</td>
</tr>
<tr>
<td>1742</td>
<td>ILAMATEPEC, SOCIEDAD ANONIMA DE CAPITAL VARIABLE</td>
<td>Bosque</td>
<td>Café</td>
<td>27.74043</td>
</tr>
<tr>
<td>1744</td>
<td>ILAMATEPEC, SOCIEDAD ANONIMA DE CAPITAL VARIABLE</td>
<td>Camino</td>
<td>Café</td>
<td>0.771676</td>
</tr>
<tr>
<td>1822</td>
<td>LIMA MENA, ERNESTO</td>
<td>Café</td>
<td></td>
<td>6.735887</td>
</tr>
<tr>
<td>1824</td>
<td>LIMA MENA, ERNESTO</td>
<td>Café</td>
<td></td>
<td>0.719128</td>
</tr>
<tr>
<td>1825</td>
<td>LIMA MENA, ERNESTO</td>
<td>Café</td>
<td></td>
<td>6.206597</td>
</tr>
<tr>
<td>1826</td>
<td>LIMA MENA, ERNESTO</td>
<td>Café</td>
<td></td>
<td>0.239224</td>
</tr>
<tr>
<td>1827</td>
<td>LIMA MENA, ERNESTO</td>
<td>Café</td>
<td></td>
<td>0.090772</td>
</tr>
<tr>
<td>1828</td>
<td>LIMA MENA, ERNESTO</td>
<td>Café</td>
<td></td>
<td>0.052223</td>
</tr>
<tr>
<td>1829</td>
<td>LIMA MENA, ERNESTO</td>
<td>Café</td>
<td></td>
<td>0.046012</td>
</tr>
<tr>
<td>OBJECTID</td>
<td>Nombre_del</td>
<td>Categoría</td>
<td>Rubro</td>
<td>Área_Ha</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------------------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>1320</td>
<td>LLACH VDA. DE SAGARRA, DEBORAH ANNE</td>
<td>Café</td>
<td>Café</td>
<td>23.50808</td>
</tr>
<tr>
<td>1524</td>
<td>MENENDEZ MARTINEZ, JUAN EDGARDO ESTEBAN</td>
<td>Café</td>
<td>Café</td>
<td>22.25001</td>
</tr>
<tr>
<td>1973</td>
<td>J. F. AGUILAR Y COMPAÑIA, S.A DE C.V.</td>
<td>Café</td>
<td>Café</td>
<td>51.60797</td>
</tr>
<tr>
<td>1981</td>
<td>IBARRA DE URRUTIA, BLANCA MARIA</td>
<td>Café</td>
<td>Café</td>
<td>21.02196</td>
</tr>
</tbody>
</table>

Table 4. Farms only contributing to *Raddus mertensi* reduction of extinction risk
Table 5. Farms only contributing to *Ptychohyla salvadorensis* reduction of extinction risk

| 1324 | LA BUENA ESPERANZA, S.A. DE C.V. | Café | Café | 28.27753 |

These farms are shown on Figure 1 (repeated here) in the red polygons.

The three species that contribute most to the potential ex-ante STAR yield are all freshwater species that occur along streamsides in areas used for coffee forest. The most likely threats to them will be linked to habitat change that could occur if the management of coffee farms were changed to some other purpose (e.g. urbanisation), or changed to one that did not retain these habitat features in the area (for instance conversion to non-shade coffee). In the circumstances of the current coffee production, it seems unlikely that the threat of conversion of these farms to other uses is very high, but a change in the coffee production practices that enable the habitats to hold the threatened species is clearly a possibility.

**Conclusion**

The potential for delivering significant species conservation benefit in the coffee farms in this report is significant. There are clear and relatively simple steps available to the coffee farm managers to deliver this benefit. Further studies could reveal other threatened species present in the coffee farms that could increase the potential conservation yield of the farms.

**Management recommendations to generate STAR impacts**

**A. Assess ex-post STAR baseline**

1. Given the current level of knowledge and analysis, conduct surveys for the three highest-yielding STAR species and the extent of actual or potential suitable habitat based on life history and ecology (*Raddaus mertensi*, *Hypopachus barberi*, and *Ptychohyla salvadorensis*) in each coffee farm to establish presence and estimate population size in each.
2. Estimate the scope and scale of the identified threats applying to each of these species in each coffee farm, and estimate the population trend for each species in each farm and the threat causing any negative trend.

3. Calculate ex-post STAR baseline based on actual assessment of the potential of reducing the risk of extinction of each in each coffee farm, through management of identified threats.

4. Propose management of key threats identified, to deliver targeted reductions in species extinction risk at specified intervals.

5. Develop management protocols for each farm based on conclusions of steps 1-4, and identify yearly ex-post STAR targets.

6. Identify counterfactual sites where management protocols will not be established, and monitor threats to species at these sites.

7. Conduct surveys for each of the other threatened species identified in Table 1 (Yellow-naped Amazon, Geofroy’s Spider Monkey, Salvin’s Mushroom-tongue Salamander, Great Curassow, Mexican Caecilian, Dermophis mexicanus and Crab Elsalvadoria zurstrasseni) in each coffee farm to establish whether STAR yields for each farm could be improved by management for these species.

B. Assess potential for further conservation impacts at regional scale

8. The map (Figure 1) shows that the coffee farms that can contribute to elevated ex-ante STAR are clustered in areas indicated by red circles. Given the small size of each farm, the populations of threatened species in each may be too small to be viable. The impact on reduction of species extinction risk limited to these small areas would be increased if the areas between the farms were to be managed for conservation using similar principles established under steps 1-5 above.
Appendix 1: STAR methodology

A pressure-based metric for Species Threat Abatement and Restoration

The pressure-based metric has three forms:

1. **Comparative ex-ante STAR.** Large-scale assessment of geographic variation in the *ex-ante* return on investment, i.e. the *potential* for intervention to achieve reduction in overall pressure intensity and hence in extinction risk. For a particular site or grid square, this potential depends on the number of threatened species present, the category of extinction risk for each one, and the proportion of each species’ global population present in the site or grid square. The potential can be partitioned out using information on the relative significance (from scope and severity scoring) of each pressure for the species concerned. This produces a probabilistic map of ex-ante STAR, as it is not known whether or not a particular threat impacts a particular species at a particular site or grid square— but this is more likely for threats that apply to a large percentage of the population. This analysis can be automated for birds but cannot be carried out for other taxonomic groups yet without improvement in the information base (i.e. more complete scoring of threat scope and severity).

2. **Site-focused ex-ante STAR.** Focused site-scale assessment of the *ex-ante* return on investment, i.e. the *potential* for intervention to achieve reduction in overall threat intensity and hence in extinction risk. This potential depends on the number of threatened species present, the category of extinction risk for each one, and the proportion of each species’ global population present at the site. For specific pressures, the potential depends on the severity of the threat to each species and whether the site is within its scope. This analysis requires some site-specific information on the pressures present, so cannot at the moment be fully automated\(^5\). For taxa other than birds, it would also require scoring of threat severity for the pressures present.

3. **Site-focused ex-post- STAR.** Focused site-scale assessment of the *ex-post* return on investment, i.e. the reduction in overall threat intensity *achieved* over time by addressing one or more specific pressures at the site. The reduction depends on the number of threatened species present, the category of extinction risk for each one, the proportion of each species’ population present, the severity of the pressures addressed for each species and the effectiveness of addressing those pressures. This analysis requires development of a counterfactual scenario (what would happen without intervention) and assessment of the before and after levels of targeted pressures against this counterfactual.

The metric:

---

\(^5\) This might become possible in future, with improved comprehensiveness and documentation of site-level threats for Key Biodiversity Areas
- Applies to geographic areas, either across a large scale (providing a map of ex-ante STAR) or to particular sites
- Allows comparison of return on investment across sites or grid squares, and across different pressures
- Allows prediction of return on investment for interventions targeted at particular threats, at particular sites
- Allows assessment of achieved return on investment for interventions targeted at particular threats, at particular sites
- Depends on apportioning the relative contribution of pressures to a species’ extinction risk, across the species’ range
- Employs the same approach for site-focused ex-ante and ex-post measures. However, an extra step is needed to calculate ex-post measures, which involves the actual reduction in threat magnitude against predicted levels. This requires geographically-focused measures of threat magnitude, usually including a time series.

At present, the detailed threat scores needed to calculate the ex-ante metric consistently and rapidly are only documented for one major fully assessed group – birds. Birds are generally a good indicator group for overall biodiversity importance (BirdLife International 2013 – SOWB) but are far from perfect, and have overall lower levels of threat than, for example, mammals or amphibians (IUCN 2016). Birds are also usually better indicators for the terrestrial than for the marine realm. The supporting data for Red List assessments is continuously being improved, however, and it is expected that scores for scope and severity will be completed for other fully assessed groups in the near future (e.g. for mammals by 2018).

It is possible to apply the approach to other taxa even without fully documented threat scores, but this requires input of expert knowledge, and is likely to be practical only case-by-case.
Comparative ex-ante STAR

**Step 1.** Determine the site(s) or landscape of interest – i.e. the potential geographical targets for investment

*Figure 1a and 1b.* Schematic of application of the comparative ex-ante approach to a region with site of biodiversity interest (A-I, e.g. Key Biodiversity Areas), or a set of grid squares (A1-D6).
**Step 2a.** Determine which threatened species occur in the landscape or region

Confirmed presence of species is documented for Key Biodiversity Areas in the World Database of KBAs ([www.keybiodiversityareas.org](http://www.keybiodiversityareas.org)). Potential presence of threatened species can be determined by a GIS analysis using Red List range maps, available for commercial use via IBAT for Business ([https://www.ibatforbusiness.org/](https://www.ibatforbusiness.org/)). Red List categories Near-threatened, Vulnerable, Endangered and Critically Endangered should be included. For consistency, only species in fully assessed groups should be included. As of 2017, these are birds, mammals, amphibians, certain groups of reptiles and fishes, reef-forming corals, cycads and conifers. This is to avoid biases caused by geographical variation in the comprehensiveness of Red List assessment.

*Figure 2.* The hypothetical region of interest holds five threatened species, 1-5, in Red List categories ranging from Vulnerable to Critically Endangered.

---

6 See [http://www.iucnredlist.org/about/summary-statistics#Tables_3_4](http://www.iucnredlist.org/about/summary-statistics#Tables_3_4)
**Step 2b.** Determine the proportion of each threatened species’ global population \((P, \text{as a percentage)}\) that is present at each site, or in each grid square.

This may be done in different ways.

A method that can be automated is to use range as a proxy, and calculate the proportion of the mapped range intersected by each site or grid square.

This is a crude method, and more reliable results will be achieved using ‘extent of suitable habitat’ maps, i.e. maps that show where in the overall range the species may actually be present. Such maps have been developed for birds, mammals and amphibians but are not yet available in IBAT. Once ESH maps are available, this approach can also be automated.

For site-scale analyses, more detailed information is necessary. Suitable information may be available in the World Database of KBAs (www.keybiodiversityareas.org) or IUCN Red List species assessments (www.iucnredlist.org), including population estimates for particular species at particular KBAs. For species largely or entirely confined to KBAs and for which KBAs have been identified throughout their distribution, the area of each KBA as a proportion of the combined area of all KBAs identified for the species can be used as a proxy measure.

*Figure 3.* Site A (in the hypothetical landscape in Figure 1) holds five threatened species, with different extinction risk categories and different proportions of their global population at the site.
Step 3. For each threatened species, assess the relative contribution of individual pressures to ongoing/anticipated declines.

The IUCN Red List and the World Database of KBAs use a standard, hierarchical classification of 'direct threats' or pressures (see Annex D). For birds, and many other assessed species, each pressure has been scored for timing (past, current, future), scope (the proportion of the population it affects) and severity (how rapid a decline the threat causes for the proportion of the population that is affected).

For the STAR, only current or future pressures are relevant. These scores provide a straightforward way to calculate the relative contribution of individual direct pressures to ongoing or anticipated declines (see Annex D). Table 1 summarises the relative weighting of different combinations of scope and severity scores, from the mean expected value of the population decline expected over ten years or three generations.

<table>
<thead>
<tr>
<th>Scope</th>
<th>Severity</th>
<th>Very Rapid Declines</th>
<th>Rapid Declines</th>
<th>Slow, Significant Declines</th>
<th>Negligible Declines</th>
<th>No decline</th>
<th>*Causing/ could cause fluctuations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole</td>
<td></td>
<td>63</td>
<td>24</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Majority</td>
<td></td>
<td>52</td>
<td>18</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Minority</td>
<td></td>
<td>24</td>
<td>7</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 1. Mean % population decline expected in 10 years or three generations for different combinations of scope and severity scores (for current and future pressures only). Pressures that cause or could cause significant fluctuations can be treated as for slow, significant declines; so can pressures of unknown scope and severity where there is credible evidence for a non-negligible effect. *For the purposes of the STAR, decline rates for fluctuating populations are arbitrarily treated the same as those for "slow, significant declines".

Some issues:

Threatened species not subject to pressures

Species listed only under Red List criterion D (CR and EN) or D1 (VU) are listed as threatened because of their small population size without any requirement for the existence of a current or future threat. A threat-based approach to assessing STAR is not appropriate for these species, and they should be excluded from the analysis. There are only 124 bird species (8.5% of all threatened birds) classified as threatened under just criterion D.

Species classed only under D2 are listed because of small range size, but only if there is a plausible future threat that could quickly reduce their status to CR or EX in a short time frame. Such species are thus amenable to this approach, if the future threat is identified and scored.

Probabilistic assessment based on overall significance of pressures

The analysis is carried out for each species as a whole. For this overview analysis, the result for each site or grid square is a probabilistic assessment based on the overall scope scores for each threat (i.e. there's...
a higher chance of the threat being an issue in any particular square if it affects a larger proportion of the population). Specific pressures may not always be relevant to the species at a particular site or grid square. For example, a species threatened by invasive alien species (IAS) may occur at some sites where the IAS in question are not yet present. This is addressed for specific sites by the method outlined for Element 2 (see below).

**Differences between species in comprehensiveness of threat scoring**

Some species are better known than others. Even among birds, the comprehensiveness of threat assessment and conservation planning is patchy. Some species have only a few pressures listed, others many – sometimes including numerous pressures of low scope or severity. One approach to this would be to ignore, or cap the contribution of, lower-impact pressures. However, an analysis of threat scores for birds has shown only a handful of cases (16 species out of 2,489 threatened and Near Threatened species: 0.6%) where the cumulative threat scores are inappropriate for the threat category (BirdLife International, unpublished data); these will be corrected in the coming months. This suggests that it is reasonable to use the full suite of identified pressures when assessing the relative contribution each threat makes to ongoing and future declines.

**Interacting pressures**

Some pressures may be inter-dependent or synergistic. For example, climate change or road building may be direct pressures, and also promote another direct threat through the spread of invasive alien species. This is not problematic for the STAR except in cases where addressing one threat will not provide the positive results expected, because another threat must also be addressed alongside. Such cases are likely to be unusual.

**Hierarchical level of pressure classification**

Which pressures to use to calculate the STAR? The IUCN/Conservation Measures Partnership (CMP) Unified Classification of Direct Threats is hierarchical. Threats are always coded at the lowest level in the hierarchy (see Annex D). For example, the first-level pressure Agriculture & Aquaculture includes four second-level pressures, covering non-timber crops, forestry, livestock and aquaculture. ‘2.1 Annual and perennial non-timber crops’ in turn covers four third-level pressures, categorised as 2.1.1. Shifting agriculture; 2.1.2. Smallholder farming; 2.1.3. Agroindustry farming; 2.1.4. Scale Unknown/Unrecorded.

For calculating the comparative ex-ante STAR, it is recommended that threats are included at the most detailed level where scoring is available. However, these may later be ‘rolled up’ into higher-level categories for purposes of presentation or decision-making (making the assumption that the STAR from addressing different pressures is additive). This ‘rolling up’ may be especially useful when considering interventions and calculating the ex-post STAR (see below), as one kind of intervention, e.g. land acquisition or community conservation management, could address several kinds of pressure together.

Using these means, scope x severity scores can be filled in for each species and each pressure as in Table 2 below.
Table 2. Hypothetical example of assessing the mean population implications of scope x severity scores for particular pressures (see Table 1 above; species as in Figure X).

The importance of these scores is in assessing the relative contributions of pressures to each species’ extinction risk. The absolute values are of less relevance because species may be placed in a Red List category for a number of different reasons. Rates of population decline are one factor in a set of complex criteria, with varying thresholds depending on other factors.

Using the scores in Table 2, the proportional contribution of different pressures to each species’ extinction risk can now be calculated (Table 3 below).

<table>
<thead>
<tr>
<th>Species</th>
<th>Invasive species</th>
<th>Energy &amp; mining</th>
<th>Biol Res Use</th>
<th>Agriculture</th>
<th>Cl change</th>
<th>Pollution</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 VU</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>15.0</td>
</tr>
<tr>
<td>2 VU</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>16.0</td>
</tr>
<tr>
<td>3 EN</td>
<td>0</td>
<td>1</td>
<td>24</td>
<td>10</td>
<td>1</td>
<td>9</td>
<td>45.0</td>
</tr>
<tr>
<td>4 EN</td>
<td>10</td>
<td>0</td>
<td>18</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>52.0</td>
</tr>
<tr>
<td>5 CR</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>52</td>
<td>0</td>
<td>0</td>
<td>64.0</td>
</tr>
</tbody>
</table>

Table 3. Hypothetical example of the proportional contribution of species pressures to species’ extinction risk, calculated from the scores in Table 3 (species as in Figure X). The pressure portions add up to 1 for each species.

Pressure - portion of contribution to extinction risk, r

<table>
<thead>
<tr>
<th>Species</th>
<th>Invasive species</th>
<th>Energy &amp; mining</th>
<th>Biol Res Use</th>
<th>Agriculture</th>
<th>Cl change</th>
<th>Pollution</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 VU</td>
<td>0.00</td>
<td>0.00</td>
<td>0.60</td>
<td>0.33</td>
<td>0.07</td>
<td>0.00</td>
<td>1</td>
</tr>
<tr>
<td>2 VU</td>
<td>0.63</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.31</td>
<td>0.06</td>
<td>1</td>
</tr>
<tr>
<td>3 EN</td>
<td>0.00</td>
<td>0.02</td>
<td>0.53</td>
<td>0.22</td>
<td>0.02</td>
<td>0.20</td>
<td>1</td>
</tr>
<tr>
<td>4 EN</td>
<td>0.19</td>
<td>0.00</td>
<td>0.35</td>
<td>0.46</td>
<td>0.00</td>
<td>0.00</td>
<td>1</td>
</tr>
<tr>
<td>5 CR</td>
<td>0.02</td>
<td>0.02</td>
<td>0.16</td>
<td>0.81</td>
<td>0.00</td>
<td>0.00</td>
<td>1</td>
</tr>
</tbody>
</table>

7 In ten years or three generations (whichever is longer)
Step 4. Combine weighted species and threat scores to calculate the ex-ante Return on Investment for each pressure, and for each site or grid square overall.

Figure 4. Schematic showing calculation of STAR component for Species 4 in Site A, for one relevant pressure (Biological Resource Use) which contributes 46% of pressures overall based on scope and severity scores.

Threat category weightings

The assumption behind the STAR is that if all identified pressures were effectively addressed, and reduced to negligible scope and severity, that would permit the species to be downlisted from its current threat category to Least Concern.

The reduction in extinction risk achieved by eliminating pressures on a Critically Endangered species is much greater than for a Vulnerable species. Without weighting species, however, these would have the same potential contribution to the STAR. Therefore it is desirable to weight species by their Red List category.

The two most obvious options for weighting are:

(a) by relative extinction risk – estimated as 0.5 for Critically Endangered species, 0.05 for Endangered, 0.005 for Vulnerable and 0.0005 for Near Threatened (Butchart et al. 2004 PLoS Biol. 2: e383);

(b) using an equal steps approach – 4 for Critically Endangered species, 3 for Endangered, 2 for Vulnerable and 1 for Near Threatened, as applied in the Red List Index (Butchart et al. 2004).

Using approach (a) would mean the STAR would be overwhelmingly influenced by a small set of highly threatened species. This is not a desirable attribute for the STAR, so the equal steps weighting approach is preferred. (A similar logic has been applied in the case of the Red List Index.)
Pressure - portion of contribution to extinction risk, \( r \)

<table>
<thead>
<tr>
<th>Species</th>
<th>Red List category weight, ( w )</th>
<th>Population ( P )</th>
<th>Invasive species</th>
<th>Energy &amp; mining</th>
<th>Biol Res Use</th>
<th>Agri-culture</th>
<th>Cl change</th>
<th>Pollution</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VU</td>
<td>2</td>
<td>3.2</td>
<td>0.00</td>
<td>0.00</td>
<td>0.60</td>
<td>0.33</td>
<td>0.07</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>VU</td>
<td>2</td>
<td>8.2</td>
<td>0.63</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.31</td>
<td>0.06</td>
</tr>
<tr>
<td>3</td>
<td>EN</td>
<td>3</td>
<td>0.7</td>
<td>0.00</td>
<td>0.02</td>
<td>0.53</td>
<td>0.22</td>
<td>0.02</td>
<td>0.20</td>
</tr>
<tr>
<td>4</td>
<td>EN</td>
<td>3</td>
<td>23.1</td>
<td>0.19</td>
<td>0.00</td>
<td>0.35</td>
<td>0.46</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>5</td>
<td>CR</td>
<td>4</td>
<td>12.5</td>
<td>0.02</td>
<td>0.02</td>
<td>0.16</td>
<td>0.81</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 4. Hypothetical example of the proportional contribution of species pressures to species’ extinction risk, calculated from the scores in Table 2 (species as in Figure X), with Red List category weight and population portion (% at the site) for each species.

Pressure - STAR contribution = \( w.P.r \)

<table>
<thead>
<tr>
<th>Species</th>
<th>Red List category weight, ( w )</th>
<th>Population ( P )</th>
<th>Invasive species</th>
<th>Energy &amp; mining</th>
<th>Biol Res Use</th>
<th>Agri-culture</th>
<th>Cl change</th>
<th>Pollution</th>
<th>Total ex-ante STAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VU</td>
<td>2</td>
<td>3.2</td>
<td>0.00</td>
<td>0.00</td>
<td>3.8</td>
<td>2.1</td>
<td>0.4</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>VU</td>
<td>2</td>
<td>8.2</td>
<td>10.3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>5.1</td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td>EN</td>
<td>3</td>
<td>0.7</td>
<td>0.0</td>
<td>0.0</td>
<td>1.1</td>
<td>0.5</td>
<td>0.0</td>
<td>0.4</td>
</tr>
<tr>
<td>4</td>
<td>EN</td>
<td>3</td>
<td>23.1</td>
<td>13.3</td>
<td>0.0</td>
<td>24.0</td>
<td>32.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>5</td>
<td>CR</td>
<td>4</td>
<td>12.5</td>
<td>0.8</td>
<td>0.8</td>
<td>7.8</td>
<td>40.6</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Total ex-ante STAR</td>
<td>24.4</td>
<td>0.8</td>
<td>36.8</td>
<td>75.2</td>
<td>5.6</td>
<td>144.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Hypothetical example showing calculated components of potential contribution to STAR at this site or grid square, by pressure and by species, from the data in Table 4. The maximum STAR across the whole range of a species ranges from 100 (NT) to 400 (CR); for these five species, addressing all pressures across the whole range would give an STAR of 1400. At this site, the maximum potential returns equate to the sum of the proportional ranges of species, weighted by threat, which is 144.2. Assessing the ex-ante STAR for each pressure allows the potential returns to be assessed alongside the costs and feasibility of interventions, and measurability of changes in pressure intensities (see ‘Selecting and implementing interventions’, below).

The ex-ante STAR for a particular pressure at a site or grid square with \( n \) threatened species

\[
= \sum_{i=1}^{n} w_i P_i r_i
\]

The total ex-ante STAR is the sum of the ex-ante STAR across all pressures.
If all pressures were addressed effectively for a single species, the STAR score for that species would range from 100 (if NT) to 400 (if CR).

In Table 5, the total ex-ante site STAR is 144.2 – equivalent in conservation terms to reducing the full suite of pressures on one CR species by 36%. However, not all pressures can usually be addressed at once. The pressures with the highest ex-ante STAR here are agriculture (75.2) and biological resource use (36.8). These are therefore likely targets for interventions for this set of species in this landscape.
Appendix 2 Threat Categories from the IUCN Red List of Species

From IUCN's threat classification scheme: https://www.iucnredlist.org/resources/threat-classification-scheme

Residential & commercial development

- 1.1 Housing & urban areas
- 1.2 Commercial & industrial areas
- 1.3 Tourism & recreation areas

2 Agriculture & aquaculture

- 2.1 Annual & perennial non-timber crops
- 2.2 Wood & pulp plantations
- 2.3 Livestock farming & ranching
- 2.4 Marine & freshwater aquaculture

3 Energy production & mining

- 3.1 Oil & gas drilling
- 3.2 Mining & quarrying
- 3.3 Renewable energy

4 Transportation & service corridors

- 4.1 Roads & railroads
- 4.2 Utility & service lines
- 4.3 Shipping lanes
- 4.4 Flight paths

5 Biological resource use

- 5.1 Hunting & collecting terrestrial animals
- 5.2 Gathering terrestrial plants
- 5.3 Logging & wood harvesting
- 5.4 Fishing & harvesting aquatic resources

6 Human intrusions & disturbance

- 6.1 Recreational activities
- 6.2 War, civil unrest & military exercises
- 6.3 Work & other activities

7 Natural system modifications
o 7.1 Fire & fire suppression
o 7.2 Dams & water management/use
o 7.3 Other ecosystem modifications

8 Invasive & other problematic species, genes & diseases

   o 8.1 Invasive non-native/alien species/diseases
   o 8.2 Problematic native species/diseases
   o 8.3 Introduced genetic material
   o 8.4 Problematic species/diseases of unknown origin
   o 8.5 Viral/prion-induced diseases
   o 8.6 Diseases of unknown cause

9 Pollution

   ▪ 9.1 Domestic & urban waste water
   ▪ 9.2 Industrial & military effluents
   ▪ 9.3 Agricultural & forestry pollution

10 Geological events

   ▪ 10.1 Volcanoes
   ▪ 10.2 Earthquakes/tsunamis
   ▪ 10.3 Avalanches/landslides

11 Climate change & severe weather

   ▪ 11.1 Habitat shifting & alteration
   ▪ 11.2 Droughts
   ▪ 11.3 Temperature extremes
   ▪ 11.4 Storms & flooding
   ▪ 11.5 Other impacts

12 Other options

   ▪ 12.1 Other threat