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Outcomes of the Southern African Lepidoptera Conservation Assessment (SALCA)

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Abstract: The Southern African Lepidoptera Conservation Assessment (SALCA) was a collaborative venture between the Lepidopterists' Society of Africa (LepSoc Africa), the Brenton Blue Trust (BBT) and the South African National Biodiversity Institute (SANBI), and formed part of the National Biodiversity Assessment (NBA). SALCA was founded on the importance of Lepidoptera both ecologically and as biodiversity indicators and the proven expertise of the participants during the Southern African Butterfly Conservation Assessment (SABCA). The main outcomes of the SALCA project are presented and discussed here.

The SALCA tool, a custom-designed interactive distribution database, enabled high quality data to be derived so that accurate conservation assessments could be produced in accordance with IUCN methodology. The Red Lists of SALCA and SABCA facilitated the first opportunity to calculate the Red List Index (RLI) for South African butterflies during the period from 2012–2018. Other metrics required for the NBA included protection level and threats analyses. A further outcome was the critical habitat mapping for butterflies, which formed part of a screening tool implemented by SANBI, to ensure that land use changes did not cause any further loss of butterfly biodiversity.

A comprehensive distribution database was developed for South African moths, enabling data to be analysed so that moth species potentially threatened could be short-listed for further investigation.

Geographical hotspots and ecosystems (vegetation types) containing butterflies of conservation concern are highlighted. The societal, economic and human wellbeing benefits of conserving Lepidoptera are identified. Responses by LepSoc Africa to the increasing pressures on South African Lepidoptera biodiversity, are also reported on and discussed. The significant outcomes of SABCA and SALCA are benchmarked against a well-known European butterfly atlasing and conservation assessment project.

The 165 SALCA Red Lists and conservation assessments are presented at the end of this publication.

Key words: Red List, conservation, assessment, butterfly, moth, Lepidoptera, threats, red list index.

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INTRODUCTION

Lepidoptera belong to one of the most diverse orders of insects, contributing to important ecological processes, impacting plant growth and pollination, and are good indicators of ecosystem health. It is therefore highly desirable that Lepidoptera are monitored and conserved. The Lepidopterists' Society of Africa (LepSoc Africa) has contributed significantly to the conservation of southern African Lepidoptera through various projects that the society has initiated or contributed towards (Edge & Mecenero, 2015).

The Southern African Lepidoptera Conservation Assessment (SALCA) was launched in October 2015,

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following an invitation by the South African National Biodiversity Institute (SANBI) for butterflies to be included in the National Biodiversity Assessment (NBA) (Skowno et al., 2019). The NBA is key to SANBI's mandate to monitor and report regularly on the state of South Africa's biodiversity and feeds into policy for the conservation of threatened biodiversity, determination of areas of conservation value and general land use policy.

SALCA re-evaluated the conservation assessments of 154 taxa (species and subspecies) of conservation concern as identified during the previous Southern African Butterfly Conservation Assessment (SABCA) project (Mecenero *et al.*, 2013), as well as conducting seven new conservation assessments for Lepidoptera not included in the SABCA project (Mecenero *et al.*, 2015b). The project focussed on updating the distribution database for butterflies to a higher degree of accuracy as well as verifying the distribution data for the SALCA taxa. A conservation assessment database for the SALCA taxa was also produced. For the first time, a consolidated moth database has also been compiled, providing an important data resource for planned future moth conservation assessments.

The Red List assessments followed the International Union for Conservation of Nature (IUCN) guidelines (IUCN, 2017), a global standard for assessing the extinction risk of species. Over time, Red List assessments of a group of taxa can be used to measure the rate of loss of biodiversity, known as the Red List Index (RLI) (Butchart *et al.* 2004, 2005). The RLI identifies movement between Red List categories and is a good method for measuring change in taxon status (Butchart *et al.*, 2006). The two butterfly assessments, 2012 (SABCA) and 2018 (SALCA), allow for the trend in the RLI for southern Africa's butterflies to be measured for the first time. Now, all butterfly taxa in southern Africa have been assessed twice, allowing for the change in the national RLI of butterflies to be calculated.

The NBA also includes an analysis of how well the current protected area network in South Africa is protecting biodiversity. SALCA contributed towards this by calculating the butterfly protection levels. The analyses include looking at coverage (does a taxon occur in enough protected areas to ensure its long-term persistence?) and protection effectiveness (is the current protected area management adequately mitigating threats to the taxon?).

Additionally, SANBI has produced a land-use screening tool for the Department of Environment, Forestry and Fisheries to identify no-go areas for development where highly threatened biodiversity exists. SALCA participated in the critical habitat mapping process to identify no-go and sensitive areas for threatened butterflies.

The lead institutions of SALCA were the Brenton Blue Trust and LepSoc Africa, in collaboration with SANBI. The time scale of the project was October 2015 – December 2018. The project team is shown in Table 1 (page 20). The scope of the SALCA project was outlined at its initiation (Mecenero *et al.*, 2015b).

The main outcomes of the SALCA project are presented and discussed here, specifically focussing on the distribution database, conservation assessments, the RLI, protection levels and critical habitat mapping for butterflies, as well as the distribution database and basic summaries for moths. The threats to Lepidoptera biodiversity, hotspots for butterflies of conservation concern and endangered ecosystems for threatened Lepidoptera, benefits of conserving Lepidoptera and responses to pressures on Lepidoptera biodiversity, are also reported on and discussed.

In order to highlight the significant achievements of both the SALCA and SABCA projects under challenging conditions and limited resources, both projects are benchmarked against the Millennium Atlas, a well-known European butterfly atlasing and conservation assessment project (Asher *et al.*, 2001).

Individual assessments for each of the SALCA taxa are included at the end of this publication.

Abbreviations

AOO:	Area of occupancy
COREL:	Custodians of Rare and Endangered Lepidoptera
DNHM:	Ditsong Natural History Museum
EOO:	Extent of occurrence
IUCN:	International Union for Conservation of Nature
NBA:	National Biodiversity Assessment
QDGS:	Quarter degree grid square
RLI:	Red List Index
SABCA:	Southern African Butterfly Conservation Assessment
SALCA:	Southern African Lepidoptera Conservation Assessment
SANBI:	South African National Biodiversity Institute
TCC:	Taxa of conservation concern
UK:	United Kingdom

Terminology

The term 'butterfly' refers to Lepidoptera that belong to the superfamily Papilionoidea (as defined by Mitter *et al.*, 2017), which includes the Hesperiidae. The term 'moth' refers to all other Lepidoptera. This distinction is an artificial one because there is no natural or scientific reason for this divide. We use the terms here for practical purposes because of the huge disparity of available data and expertise between these groups, probably resulting from this artificial divide, making it difficult to consider all the Lepidoptera together for this project.

MATERIAL AND METHODS

Butterflies

SALCA's study region was southern Africa (South Africa, Lesotho and Eswatini). The project ran from October 2015 to September 2018. In total, 165 butterfly taxa were included in the SALCA conservation assessments: 154 SABCA taxa of conservation concern (TCC) that were Red Listed as Extinct, threatened (Critically Endangered – Possibly Extinct, Critically Endangered, Endangered and Vulnerable), Near Threatened, Data Deficient and those Least Concern taxa flagged as Extremely Rare or Rare; four Least Concern taxa from SABCA that had no recent observations during SABCA; and seven taxa that were new to the study region as recent colonisers (these were new assessments). The remaining 635 taxa from SABCA that were Red Listed as Least Concern were confirmed by LepSoc Africa experts to likely still be Least Concern (because they had been observed during the SABCA field surveys).

Distribution database

Distribution data were consolidated into LepSoc Africa's Lepidoptera database, Lepibase, which included all SABCA data, as well as post-SABCA data from the SALCA field surveys, the online virtual museum for Lepidoptera, LepiMap (Animal Demography Unit; http://vmus.adu.org.za) and many other observations made by LepSoc Africa members post-SABCA. The butterfly taxonomy conformed to the latest information in the *Afrotropical Butterflies Encyclopaedia* (Williams, 2019). Only data submitted to Lepibase by 31 March 2017 were included in the SALCA analyses, in order that the data verification and conservation assessment processes could be completed timeously.

The consolidated database conformed to Darwin Core database standards (Wieczorek *et al*., 2012) and included, as a minimum, the following fields: Family, Subfamily, Genus, Species, Subspecies, Collector (Observer), Date (day, month, year), Country, Province, Town, Locality description, Latitude (S) and Longitude (E) coordinates (degrees, minutes, seconds). Additionally, the level of accuracy of the coordinates was documented, where possible.

A number of additional fields exist in the database, or were added to the data during the course of SALCA. Not all of these were applicable to the project, but some that are of importance include:

- Record Source: This lists the source of the record. If records were added from a Microsoft Excel file, the Excel filename was added here.
- Record Source Detail: Additional information relating to the source of the record, such as when the records were submitted.
- Record Source Date: The date when the records were added to the master database.
- Updated coordinates (latitude and longitude): This field captured any updates or corrections made to the original coordinates to improve coordinate accuracy. The reason for keeping both original and updated sets of coordinates was that some specimens did not have accession numbers, and if the coordinates were updated the original information was still required to match the data with the specimen.
- Updated Province and Town: The locality information for some data records was also updated and captured in this separate field. As in the case with updated coordinates, a copy of the original locality information has been kept in its original field because it may be the only link between a database entry and a specimen.
- Cleanup: This integer field was used to indicate whether a record was verified by the original observer.
- A Status Comment field was added as a Binary Large OBject (blob): This field cannot be searched using conventional database queries, but it contains a trail of information about any changes made to the original status of the record.

Field surveys

LepSoc Africa members were appointed as provincial leaders to coordinate the field work in each province (Table 1: page 20). Provincial leaders were responsible for ensuring that all data collected post-SABCA were submitted to Lepibase and that the necessary new surveys were conducted (and permits obtained, where required). A field survey protocol was made available to those LepSoc Africa members that assisted with the SALCA field work. The protocol specified how to liaise with provincial leaders, what data to collect and how to submit data. Provincial and national parks permits were obtained for all participants, where necessary, including permissions from land owners and reserve managers.

Field work prioritised the SALCA taxa and focussed on obtaining new data for the TCC, especially for those that had less than three known localities during SABCA. In view of LepSoc Africa's success in finding new localities for Critically Endangered or Endangered taxa (e.g. Garvie *et al.*, 2014; Bazin & Edge, 2015; Coetzer, 2015; Lawrence, 2015; Morton, 2016), searches were also continued for the taxa assessed as Extinct during SABCA. Focused searches for butterfly taxa assessed as Data Deficient due to insufficient information during SABCA were carried out to try to obtain new information to be able to upgrade the status of the taxon to an appropriate Red List category. Field surveys also tried to target under-surveyed areas as decided by the surveyors.

Taxon assessors

Sixteen LepSoc Africa members agreed to be taxon assessors for the conservation assessments (Table 1: page 20). The criteria for selecting taxon assessors included one or more of these: having a close knowledge of the taxonomy, distribution and ecology of the taxon; being based in or close to the places where the taxon occurs; having been the taxon assessor during SABCA; having been the describer of the new taxon, or the first to record it in southern Africa; having studied and published on the ecology, distribution and conservation of the taxon recently as part of formal studies at a university or other appropriate research institution; having been appointed as the custodian of the taxon under the Custodians of Rare and Endangered Lepidoptera (COREL) programme (Edge, 2011); willingness and availability to participate. The 165 taxa were allocated amongst them.

Most of the assessors who were involved with the SABCA assessments and were thus already familiar with the assessment and Red Listing process were referred to the IUCN online Red List training course as a refresher (www.iucnredlist.org/technical-documents/red-list-training/online-training).

Extra guidance and training were provided to those few assessors who were new to the process. Instructions were sent out on how to verify distribution data for the taxa allocated to them and on how to complete the assessments. Additionally, two assessor workshops were held in 2017 (Magaliesburg and Johannesburg) to discuss any problems with the assessments and to provide further guidance with completing the assessments.

SALCA assessment tool

An important consideration with an assessment such as this is the veracity of the data and the assessment. It was therefore important to ensure that taxon assessors only used verified data and used the data objectively without personal bias. In order to promote this, a software tool was developed to facilitate examination and interrogation of the data, allowing assessors to review the data and make comments. The tool performed automatic data analyses with appropriate warnings to taxon assessors to guide them in decision making. A major goal was to make the SALCA assessment a scientific, data-based assessment with as little bias as possible.

LepSoc Africa's IT experts (Table 1: page 20) developed software known as the SALCA Tool, in order for taxon assessors to access and interact with the distribution and assessment databases for the verification and assessment steps. The SALCA Tool consisted of two sections: 1) to manage the distribution database containing specimen records for data verification, and 2) to manage the assessment database for the conservation assessments and Red Listing. Each taxon assessor was assigned a username and password to access the SALCA Tool. Data were only made available for the taxa which were assigned to each assessor.

The data verification section of the SALCA Tool

The first section of the SALCA Tool allowed taxon assessors to view and flag the distribution data associated with a specific taxon. The records were displayed on a map at a quarter degree grid square (QDGS) scale, as well as in table format where the coordinates could be viewed. Taxon assessors could flag the status of the records as Accepted, Rejected, Questionable, Locally Extinct or Unevaluated and were required to provide reasons or a rationale for rejecting records or flagging records as Questionable. Data could be exported to Excel, as a Keyhole Markup Language (.KML) file for viewing in Google Earth, and viewed in Google Maps. The data verification process was an important step in SALCA's aim of achieving a mapping accuracy of <250 m.

A number of rules were set to manage this distribution database. Firstly, no records were deleted. Secondly, assessors were not allowed to change any data. They could only flag the status of the records, where those flagged as Accepted were used in the conservation assessment analyses. In addition, all status changes made to the records were logged in the comments field. The logged in user, date and time, as well as the change in status were noted.

Records could be flagged as Rejected due to a number of reasons given as a predefined list, as follows:

- Out of range: The assessor did not agree that the record was correct because it was an outlier to the general distribution. However, using this criterion was not encouraged due to its subjectivity.
- Coordinates incorrect: This criterion was used where the coordinates did not match the specimen locality description.
- Coordinates inaccurate: This indicated that the locality description and general coordinates match, but the coordinates were not of sufficient accuracy to be included in the project. An example of this would be where a record may state Cape Point, but the coordinates associated with it lie in unsuitable habitat.
- Coordinates of nearest town: This is similar to the 'coordinates inaccurate' rationale, but was often used for old records where the coordinates represented centres of towns.
- Subspecies identification incorrect: Subspecies of a species are not sympatric. If an assessor Rejected a record because another subspecies occurs in the area, this was noted.
- Species identification incorrect: A record could be Rejected by an assessor if it was believed to have an incorrect identification. It was stressed that this reason should only be used after the actual specimen was evaluated, but this was not always possible.
- Requires updating: This was simply a flag that was used to mark records that required more information, confirmation, or that needed to be reviewed at a later stage.

Records were flagged as Questionable to indicate that closer inspection was required before a clear status could be assigned to it. Records were flagged as Locally Extinct for specific localities where a taxon was highly likely to no longer occur, i.e. localities from which populations have disappeared, (based on a lack of observations), or places where the habitat had been completely transformed.

An optional field was also added for additional comments relating to the flagged status of a record. This is a blob field, which is not searchable using standard database queries, but it allowed the user to note reasons for flagging a record if the reasons did not exist in the predefined list.

No records were automatically Accepted, even if they were Accepted during the SABCA project. This was because the resolution and accuracy required for records during SALCA was significantly finer than what was required during SABCA.

A number of records were automatically Rejected for the following reasons.

- They were collected prior to the year 2000.
- The coordinates associated with the record were coarse, meaning not enough decimal values were given. If no decimal degrees were given, or if both the latitude and longitude were multiples of a quarter degree, the record was automatically Rejected.

All automated rejections were flagged with the rationale of Auto Ignore or Auto Rejected. All automatically Rejected records could be changed to Accepted or another status such as Locally Extinct by the assessor if the accuracy was found to be at an acceptable level. The automated rejection was simply a method used to manage the effort required to complete the data verification process.

Changes made to records were then synchronised with a master database, and the updated master database was distributed to assessors at regular intervals. This synchronisation was done manually using software produced by SQLMaestro called Firebird Datasync. A filter query was set up so that only changes made to taxa for which an assessor was responsible were updated in the master database. This prevented assessors from changing data of taxa that were not assigned to them.

The conservation assessment section of the SALCA Tool

The second section of the SALCA Tool consisted of the conservation assessment fields using the data standards and requirements for Red Listing as guided by the IUCN (2017), as well as some SANBI requirements and other Lepidoptera-specific fields.

To promote objective assessments, the assessment portion of the SALCA Tool analysed the data automatically and offered results of the analysis to the assessor, to highlight differences between information based on actual data versus possible subjective assessments. Automatic summaries and calculations included: the number of the records per taxon; the status breakdown of the records per taxon; the extent of occurrence (EOO), the area of occupancy (AOO); and the number of subpopulations. For SALCA, the EOO is defined as the area encompassed by a minimum convex polygon around Accepted distribution records, whereas the AOO is defined as the sum of the areas of 2 x 2 km^2 grid cells that are occupied by a specific taxon (IUCN, 2017). Guidance was also given on the selection of Red Listing criteria and categories, based on related information entered elsewhere in the assessment database fields. The values used in the assessments were checked and refined by the assessors – the automatically-calculated parameters provided a comparison between automated assessments and manual assessments. The automated values were not used unless an assessor specifically marked them as correct. All assessments were subsequently reviewed to ensure a robust Red Listing (see "Conservation assessments and Red Listing" section).

The SALCA Tool allowed the latest and updated versions of both the distribution and conservation assessment databases to be uploaded onto assessors' computers, and download of assessors' distribution data verifications and conservation assessment inputs back into the main databases.

Data verification

Butterfly records for the 165 taxa were extracted from Lepibase and sent to 75 contactable data owners for verification of which 56 % responded. Data owners were asked to check the locality and georeferencing of each of their specimen records. Where errors were found, they were asked to give the correct coordinates. They were also requested to provide uncertainty measures for the coordinates, where possible, and the source used for determining the coordinates. In some cases, errors in specimen identifications were also found.

Overall, coordinates for about 25 % of all SALCA butterfly records were checked. Some of these records were updated where necessary. For the remaining 75 % of records where coordinates could not be checked, due to data owners not being contactable or not responding, these records were verified by the SALCA assessors during their data verification process, where possible.

SALCA assessors then accessed taxon-specific distribution records via the SALCA Tool, as described earlier, and flagged the status of the records for the taxa assigned to them. Where possible, further corrections were made to improve coordinate accuracy or correct misidentifications (in this case the data owner of the record was contacted, if possible, to confirm the specimen identification and sometimes this also included inspection of the specimen by a taxon expert). Particularly for the threatened taxa, accurate coordinates were essential because these taxa tend to be confined to very small areas, and these data would be used to identify critical habitat for the taxon.

Once the data verification process was completed, about 50 % of the distribution data for all the SALCA taxa were flagged as Accepted or Locally Extinct (8 970 Accepted and 300 Locally Extinct records).

Conservation assessments and Red Listing

The previous SABCA assessment data were imported into the new assessment database, and these data were updated by SALCA taxon assessors using the SALCA Tool. Conservation assessments followed the IUCN Red List Categories and Criteria (IUCN, 2017) for global assessments. The assessments were checked and reviewed by a few LepSoc Africa members (see Acknowledgements) prior to submission to SANBI's Threatened Species Programme for final review (towards the end of 2017). Following the feedback received from SANBI, the assessments were revised, finalised and submitted to SANBI for inclusion in the NBA (Skowno *et al.*, 2019). After the IUCN review of the assessments, some further refinements were made in 2020.

At a national level, rare and localised taxa that are currently not threatened are also of conservation importance. So, in addition to the IUCN Red Listing, two rarity categories were used to flag those rare taxa assessed as Least Concern (Mecenero *et al.*, 2013):

- Extremely Rare (taxon known from only one site).
- Rare. The Rare category had three sub-categories, following Rabinowitz (1981):
  - Rare – Restricted range (EOO less than 500 km^2).
  - Rare – Habitat specialist (restricted to a very narrow environmental niche).
  - Rare – Low density (small subpopulations or single individuals scattered over a wide area).

Red List Index

For the RLI, the 794 taxa assessed during SABCA were considered (but since then two taxa have been synonymised, so the number of taxa is 793) as well as the seven new taxa included in SALCA. Thus the RLI comprised 800 taxa. The two assessment periods used for the RLI are 2012 (SABCA) and 2018 (SALCA).

For the 2012 assessment period, the SABCA Red List categories for the 793 taxa were used, plus the seven new taxa included in SALCA had their Red List category backcasted for 2012. For the 2018 assessment period, the

SALCA Red List categories for its 165 taxa were used, and the remaining 635 taxa that were not part of SALCA were assumed to still be Least Concern as per their 2012 assessments.

To correctly calculate the RLI, taxa where a change in status occurred between the two assessment periods were identified. The reasons for the change in status were examined to assess whether the change in status was genuine or non-genuine for each taxon (see list of reasons below), as per the IUCN guidelines, because only genuine changes in status are taken into account for the RLI (Butchart *et al.*, 2004). Reasons for a change in status were assigned to one or more of the following, assessment-relevant genuine or non-genuine reasons (IUCN, 2017):

- Measured or inferred change in population size since previous assessment (genuine).
- Change in nature of threats since previous assessment (genuine).
- Change in intensity of threats since previous assessment (genuine).
- New or better information available (non-genuine).
- Incorrect Red List assessment application previously (non-genuine).
- Incorrect information used before (non-genuine).

In cases where both genuine and non-genuine reasons were given for a change in a taxon's status, consideration was given as to whether the genuine reason on its own would have resulted in the change in status. To ensure that the 2012 assessments did not affect the RLI due to taxonomic changes or new information, the 2012 assessments were re-evaluated using the backcasting method, to take into account new information not available at that time. Therefore, where a change in status was deemed non-genuine, backcasting was applied to retrospectively determine what the actual Red Listing should have been for the 2012 assessment (Butchart *et al.*, 2007; Teucher & Ramsay, 2013).

Thereafter, the RLI was calculated following Butchart *et al.* (2007), for each assessment period. The RLI was determined for all butterfly taxa together, as well as for each of the five butterfly families. The following weights were used per Red List category (following Butchart *et al.*, 2007; Juslén *et al.*, 2015): Extinct and Critically Endangered – Possibly Extinct = 5; Critically Endangered = 4; Endangered = 3; Vulnerable = 2; Near Threatened = 1, Least Concern = 0. Data Deficient taxa were excluded, unless backcasting of Data Deficient taxa in the 2012 assessment resulted in the taxon moving into another Red List category (of the nine Data Deficient taxa from the 2012 assessment, only one remained Data Deficient after the backcasting process). The three Extinct taxa from the first assessment were also excluded (Critically Endangered – Possibly Extinct taxa in the first assessment were not excluded). Therefore, four of the 800 taxa were excluded from the RLI calculations. Equations given in Butchart *et al.* (2007) were used to determine T (current threat score), M (maximum threat score) and RLI (Red List Index):

$$RLI_t = 1 - \frac{T}{M}$$

$$T_t = \sum_c W_c \,.\, N_{c(t)}$$

$$M = W_{EX} . N$$

where t is the year of assessment (we have two years of assessment, 2012 and 2018); W_c is the weight for each Red List category c; $N_{c(t)}$ is the number of taxa in each Red List category at time t; W_{EX} is the weight assigned to Extinct taxa (weight of 5); N is the total number of non-Data Deficient taxa assessed which must be the same between assessments (796 taxa). The RLI value ranges from 0 (all taxa are Extinct) to 1 (all taxa are Least Concern). Therefore, the smaller the RLI, the faster the group of taxa is deemed to be heading towards extinction.

Finally, the change in RLIs between assessment periods was determined by subtracting the 2012 RLI from the 2018 RLI (a negative value means that the group of taxa is becoming more threatened), as well as by determining the percentage of change. RLIs for the two assessment periods, and change in RLIs, were determined for all taxa, only the SALCA taxa, and per family.

Butterfly TCC hotspots and associated vegetation types

The new Red List and rarity statuses were used to identify butterfly TCC hotspots in the study region, at a QDGS scale. In this context, "butterfly TCC hotspot" is a region where several butterfly TCC occur. Butterfly TCC hotspots analyses included identifying those areas containing the highest number of threatened taxa and TCC (Mecenero *et al.*, 2013). Additionally, the vegetation types associated with these butterfly TCC hotspots were identified and prioritised according to how many threatened and TCC taxa they contain.

For these analyses, only Accepted data records were used. Quantiles in ArcMap 9.2 were used to display the QDGS maps, to identify hotspots for the threatened taxa and the TCC (except Extinct taxa). In this context, hotspots are those QDGSs containing one or more threatened taxa or TCC.

The vegetation map of SANBI (2018), which is an updated version of the Mucina and Rutherford (2006) vegetation map used during the SABCA project, was used to extract biomes and vegetation types of significant importance for our threatened taxa and TCC. Accepted data records for the SALCA taxa were overlaid onto the 2018 vegetation map in ArcMap and the biomes and vegetation types that each taxon occurred in were extracted per SALCA taxon.

Threats to butterflies

During the assessments, the threats to the SALCA taxa were revised and updated by the taxon assessors, according to the IUCN's threats classification scheme (version 3.2; https://www.iucnredlist.org/resources/threat-classification-scheme), which is also aligned with SANBI's threats classification. Threats for the threatened, Near Threatened and Data Deficient taxa (84 taxa) were analysed to determine which threats were the most prevalent amongst these taxa. Threats were differentiated between past, present and future threats. However, for the purposes of this analysis, the SABCA "present" threats from the 2012 assessment (Mecenero *et al.*, 2013) were considered to be past threats in SALCA, and these were compared to the SALCA present and future threats. The SABCA present threats were therefore aligned with the main threat categories of the IUCN threats classification scheme. The number of taxa within each main threat category was determined for each time period, noting that some taxa may have more than one main threat.

Two SABCA present threats had no analogous IUCN category ("Abandonment" and "Change of management regime") and these were relevant to 15 taxa which had one or both of these threats listed. Also, the SABCA main threat "Habitat Loss/Degradation (human induced)" could not be assigned to an IUCN threat category for two taxa, because lower-level sub-threat categories within this main threat category had not been further selected during SABCA, which would have allowed for assigning to an IUCN main threat. These unassigned SABCA threats therefore translated into the IUCN main threat of "Other" – this threat category was not considered for this analysis.

Protection levels

The consolidated butterfly distribution database was used, which included data flagged as Accepted for the 165 SALCA taxa and data for the non-SALCA taxa that were flagged as Accepted during SABCA. Overall, the database had records for 800 taxa. The three Extinct taxa were excluded from the protection level analyses, and thus only the 797 extant taxa were evaluated. Although SABCA verifications were not as rigorous as during the SALCA project, reliable records were marked as Accepted. In addition to this, distribution records from post-July 2010 for non-SALCA taxa were used, that were obtained from LepSoc Africa members and LepiMap (up until mid-2016). None of these records were verified and were flagged as Not Evaluated. Additionally, for non-SALCA taxa, records were also obtained from the literature of published checklists for relevant protected areas (various articles in *Metamorphosis* and Otto, 2014) as well as from LepSoc Africa members.

The following steps were used to determine the protection levels of butterflies, based on methods received from SANBI (Anon, 2017) and as agreed upon at a SALCA workshop:

1) The consolidated butterfly distribution database (described above) was overlaid with the South African protected area network (only gazetted protected areas – 1 273 protected areas consisting of national parks, provincial and private nature reserves and various other types of protected areas) as received from SANBI. Protected areas were extracted per taxon by determining which taxon-specific distribution records fell within a protected area (ArcMap 9.2).
2) For taxa found to occur in >10 protected areas, these were automatically flagged as "Well protected". Some SALCA taxon assessors were asked to scan this list to ensure they are common and occur at high densities in the relevant protected areas. Those that did not meet these conditions were flagged for further evaluation of their protection levels.
3) For taxa occurring in 10 or fewer protected areas, the protected areas for these taxa were sent to the relevant SALCA provincial leaders. The provincial leaders, with their knowledge of the province, indicated the protection effectiveness of each protected area (Good/Fair/Poor) (E_{PA}), where possible (for definitions of effectiveness categories, see Table 2: page 20). In cases where nothing was known about a specific reserve, an Unknown score was given. Where available, Management Effectiveness Tracking Tool (Cowan *et al.*, 2010) scores were used for unknowns (70–100 % = Good; 30–60 % = Fair, <30 % = Poor).
4) The protected area scores were then applied to each protected area per taxon.
5) For SALCA taxa occurring in 10 or fewer protected areas, the SALCA taxon assessors checked these effectiveness scores and adjusted them where necessary, to ensure that each score was relevant for the specific taxon occurring in the protected area (i.e. for each protected area a taxon occurs in, the score reflected the effectiveness of the protected area in mitigating threats to that taxon) (Anon, 2017). In cases where scores were Unknown, assessors were asked to examine the specific protected area in Google Earth to try and determine the land-use state of the protected area and to consider this when applying a score (assessors were supplied with Google earth kmz files for viewing the protected areas), or to ask other lepidopterists who may have been to the protected area in question, where possible. At the same time, SALCA assessors indicated their expert assessment of the viability of the population (P_{PA}) of the taxon in question per protected area it occurs in (viable vs. non-viable) (Anon 2017), where possible. Where scores were not possible an Unknown score was given.
6) For non-SALCA taxa occurring in 10 or fewer protected areas, as well as for the few taxa occurring in > 10 protected areas but flagged for further evaluation (see point 2 above), the taxa were circulated amongst the SALCA taxon assessors and a few other LepSoc Africa members, and protected area effectiveness scores were checked and viability scores entered, as in point 5 above. Once again, where scores were not possible an Unknown score was given.
7) Once all effectiveness and viability scores were determined for all taxa occurring in 10 or fewer protected areas, the protected area total population score (PS) was determined per taxon, per protected area:

$$PS_{PA,taxon} = P_{PA,taxon} \; x \; E_{PA,taxon}$$

where $P_{PA,taxon}$ is the population score for each protected area that a taxon was recorded in (if viable then the score was 1000, if non-viable then the score was 100 – *see note at the end of this point) and $E_{PA,taxon}$ is the effectiveness score for a taxon occurring in a protected area (if Good a score of 1 was used, if Fair a score of 0.5 was used, if Poor a score of 0.1 was used). For large reserves, LepSoc Africa members were asked to estimate the number of subpopulations in that specific reserve for a particular taxon, and if greater than one, then $P_{PA,taxon}$ was multiplied by this value. Where the number of subpopulations was unknown, it was assumed at least one subpopulation was present and the value of 1000 was used for $P_{PA,taxon}$, and where the number of subpopulations was given as greater than 10 then it was assumed that at least 10 subpopulations were present and the value of 10 000 was used for $P_{PA,taxon}$. *Note: For the protection level analyses of various taxon groups, including butterflies, a minimum viable population of at least 10 000 individuals was required. However, since invertebrate numbers fluctuate and population counts are meaningless, the decision was made that for butterflies at least 10 viable populations per species would be required for it to persist in the long term. Therefore, each viable population had a threshold of 1 000. The weighting of 100 for non-viable populations was an order of magnitude less to ensure that the overall number of 10 000 was not achieved if all 10 populations were not viable.

8) For taxa occurring in 10 or fewer protected areas, the percentage of the global population in South Africa was estimated (for endemics this was 100 %). Prevalence scores determined during the workshop for multi criteria decision analysis in 2013 were used here (unpublished data). Taxa with ≤ 10 % prevalence in South Africa were further evaluated to determine which ones had a prevalence of < 1 %. Taxa with a prevalence of < 1 % were considered marginal and thus were not further evaluated – they have a protection level of "Not evaluated".
9) For the remaining taxa occurring in 10 or fewer protected areas, the protection level (PL) per taxon was determined by summing all the total population scores per taxon:

$$PL_{taxon} = \frac{\sum_{PA} PS_{PA,taxon}}{Target_{taxon}}$$

where PL_{taxon} is the protection level for each taxon and $Target_{taxon}$ is the default value of 10 000 as recommended by SANBI (Anon, 2017). LepSoc Africa members were asked to estimate the total number of subpopulations for the entire population for taxa occurring in 10 or fewer reserves, and the $Target_{taxon}$ was adjusted accordingly by multiplying the number of total subpopulations by 1 000. Where the number of subpopulations was >10, then the default value of 10 000 was used. PL values were then categorised as "Not protected", "Poorly protected", "Moderately protected" and "Well protected" (for categorisations, see Table 2: page 20). For taxa containing any Unknown effectiveness and/or viability scores, their protection level was set as "Unknown".

Critical habitat mapping

The SALCA verified data and the Red Lists were used for SANBI's critical habitat mapping analyses. All threatened, extremely rare and rare butterfly taxa were evaluated for the critical habitat mapping analyses, to identify critical habitat areas where no development should be allowed. A "critical habitat" applies to one taxon only and defines exactly where it flies. Taxa were divided into three tiers of sensitivity, based on the criteria described below (taxa are represented in different tiers based on the accuracy of their records and may occur in all three tiers):

- Tier 1 (very high sensitivity) – These included single-site taxa with an EOO less than 10 km^2 (as determined during the conservation assessments). The occupied habitat was mapped by SANBI using habitat descriptions and distribution data points that had very high confidence and that were recent. Vegetation and elevation were also considered for the mapping. Expert input was provided by David A. Edge and maps corrected where necessary.
- Tier 2 (high sensitivity) – These included all taxa not included in tier 1, that had distribution data with a precision of < 500 m, the records were post-2000, and the records had been validated by the taxon assessors during the SALCA data verification process. The mapped habitats were based on recent occurrence records and thus the taxa are most likely to still occur in them. However, due to the mobility of butterflies, a buffer was added to the selected habitats, based on the intersection of their occurrence data with the land parcels. Land parcels are areas with similar vegetation structure and vegetation types, that were identified with remote sensing imagery using segment recognition. This layer was produced by SANBI for the entire landscape of South Africa.
- Tier 3 (medium sensitivity) – These included all taxa for which distributions could be modelled, using geo-spatial methods based on Mecenero *et al.* (2015a), to identify areas with suitable habitat where a taxon may occur but its presence has yet to be confirmed. The verified SALCA data were used to run these models, and the habitat within the modelled distributions was subsequently mapped.

Moths

Distribution database

Moth specimen distribution records were extracted from Lepibase, which consisted of records mainly from the H.S. Staude collection, Magaliesburg, and the J.G. Joannou collection, now housed in the Ditsong Natural History Museum (DNHM) in Pretoria. Other records in Lepibase included those from: the Iziko Museums, Cape Town; Natural History Museum, London; DNHM (prior to SALCA); D.M. Kroon collection, now housed in the DNHM; Curle collection, Piet Retief; and records extracted from the published literature. Records were also included from the Durban Natural Science Museum, LepiMap, iNaturalist, Barcode of Life Data System and the Caterpillar Rearing Group. Additional distribution data were obtained by digitising moth specimen labels at the DNHM during SALCA, which included the Duke collection, housed there. Most of these additional DNHM data records required georeferencing, primarily using the unpublished gazetteer compiled by Joannou and Staude.

The then-unpublished Lepidoptera checklist for southern Africa, based on Vári *et al.* (2002) and kept up to date by the late Martin Krüger (DNHM) and kindly provided by him (now published as Krüger, 2020), was integrated into the Lepibase checklist by Tony Rebelo (SANBI) to create a usable taxonomic list for the analyses.

Basic summaries

Once the moth distribution database was consolidated, the identifications of the records were updated to the latest taxonomic standing as much as possible using the taxonomic list. From these, only those records with identifications to species level, with latitude and longitude coordinates and occurring in the study region (South Africa, Lesotho and Eswatini) were extracted for further analyses. Basic summary analyses included species richness between time periods at a QDGS scale using five quantiles (each quantile contains 20 % of the total number of occupied QDGSs ranked by the number of species in each QDGS): all records including undated ones, records dated from 1980 onwards, and records dated from 2000 onwards.

Conservation assessments

No moths were assessed during SALCA using the IUCN Red Listing protocol. However, in future, a number of moths for which there are sufficient data will be assessed and Red Listed. A draft protocol is in place on the process to be followed for selecting the taxa:

- From the distribution database, the South African endemic and near endemic species will be extracted.
- From these, any species with ambiguous alpha-taxonomy will be removed.
- Taxa with a restricted distribution will be highlighted.
- Taxon specialists will be approached for their input on the final list, and whether any taxa have been missed. Further refining criteria may be added to filter out the taxa even more (e.g. the detectability of a taxon, the number of distribution records available for a taxon, the ease of identification of a taxon, availability of taxon specialists).
- The initial evaluation process used during SABCA (Mecenero *et al.*, 2013) may be applied to highlight the special taxa.

The above approach reduces bias as no group is excluded from the outset. Groups with insufficient data will automatically exclude themselves. The bias would be toward those groups that have been given attention historically, but this simply means that possibly threatened taxa in poorly studied groups would not be detected. The majority of distribution data were indiscriminately collected, hence reducing geographic and taxonomic bias. It would be preferable to select all taxa within a taxonomic group (e.g. within a subfamily tribe or genus) that mainly qualify with the above criteria. However, individual qualifying taxa may be selected from groups where exceptional information warrants this. The above approach would provide the following:

- Identification of widespread taxa not of immediate conservation concern (the majority).
- Identification of narrow endemics (important to help identify unique habitats).
- A list of taxa that could possibly be threatened, for further individual analysis.

Assessing the effectiveness of conservation interventions

A primary conservation intervention has been legislation initiated by government (e.g. DEA, 2015). Civil society has also played an important role in popularising Lepidoptera conservation through campaigns such as the one to save the Brenton Blue butterfly (*Orachrysops niobe*). LepSoc Africa's COREL programme (Edge, 2011) has focused on threatened Lepidoptera. The methods used by this programme included searching for new localities, monitoring known localities, conducting research on threatened taxa, and habitat conservation and management measures. The effectiveness of these measures will be assessed and reported on in the Discussion section below.

Benefits of conserving Lepidoptera biodiversity

Possible benefits accruing to human society from the conservation of Lepidoptera biodiversity were identified and the economic benefits, both current and in the future, described and, if possible, quantified.

RESULTS

Butterflies

Conservation assessments and Red Listing

For the 2018 assessment (SALCA), the dataset for the 165 taxa was 22 339 records. After verification by taxon assessors, 8 945 records (40.0 %) were flagged as Accepted, 351 (1.6 %) records were flagged as Locally Extinct, 269 (1.2 %) records were flagged as Questionable and 11 875 records (53.2 %) were Rejected. A further 899 records (4.0 %) were Unevaluated. Numbers of records used for the 2012 assessment can be found in Mecenero *et al.* (2013).

The 165 butterfly taxa that were assessed for SALCA are listed in Table 3 (page 21), together with their Red Listing, endemism status, and occurrence in South African provinces. Also shown are the rare categories for those Least Concern taxa considered of national conservation concern. 0.4 % of all taxa are extinct and 9.5 % are threatened (Table 4: page 24). 52 % of all taxa are endemic and 17 % of the endemics are threatened (Table 4: page 24). 7 % of all taxa are flagged as rare and overall 18 % of all taxa are of conservation concern (Table 4: page 24). Only one taxon is Data Deficient.

The family Lycaenidae easily contains the greatest number of threatened taxa, followed by the Nymphalidae and then the Hesperiidae (Table 5: page 24). There are no threatened taxa in the Papilionidae and Pieridae (Table 5: page 24). Overall, the Western Cape province has the most threatened taxa (32 taxa) followed by the Eastern Cape, KwaZulu-Natal, Limpopo and Mpumalanga provinces (11–13 taxa) (Table 6: page 25).

The SALCA assessments were included in the NBA (see Skowno *et al.*, 2019) and have also been uploaded onto SANBI's Species Status website (http://speciesstatus.sanbi.org). Those assessments that were accepted by the IUCN can be viewed on the IUCN's Red List website (www.iucnredlist.org; many of the SALCA assessments have been published on the website, the remaining taxa will be published later during 2020 once other queries have been finalised and species-level assessments have been completed for those taxa which were assessed at the subspecies level in SALCA, because a subspecies assessment cannot be published without a species assessment).

Red List index

A comparison of the Red Listings between the 2012 and 2018 assessments is given in Table 4 (page 24). The number of Extinct taxa remained the same between the two assessments but the number of Critically Endangered – Possibly Extinct taxa increased by two. The total number of threatened taxa has increased by 16 taxa from the 2012 to the 2018 assessments (Table 4: page 24). There were fewer Data Deficient taxa for the 2018 assessment. Overall the number of TCC decreased from 154 during the 2012 assessment to 143 for the 2018 assessment (Table 4: page 24).

Fifty-four taxa of the 794 assessed in 2012 have undergone a status change during the 2018 assessment. The number of taxa per reason for change in status (genuine and non-genuine) is given in Table 7 (page 25). Of these, only 13 were found to be genuine changes in status. Backcasting outcomes for non-genuine changes in status as well as for Data Deficient taxa during the 2012 assessment are shown in Table 7 (page 25).

For the RLI, one Data Deficient taxon and three Extinct taxa were excluded from the analyses. The RLI for all taxa decreased by 0.7 % from the 2012 to the 2018 assessments, but this decrease was six times greater when only the SALCA taxa were examined (4.3 %) (Table 8: page 26). When examining the five butterfly families separately, the highest increase in the extinction rate was for Lycaenidae (1.2 %) (Table 8: page 26), which is also the family with the highest number of threatened taxa (Table 5: page 24). This is followed by the Hesperiidae which has a slight increase in the rate of decline (0.8 %) (Table 8: page 26), due to a small increase in the number of threatened taxa since 2012 as well as some taxa being in higher threat categories than 2012. There was no change for three families (Table 8: page 26): Nymphalidae (mainly due to there being fewer Critically Endangered taxa than in 2012), as well as the Papilionidae and Pieridae (both these families contain no threatened taxa; Table 5: page 24).

Protection levels

Of the 797 taxa, 375 occurred in more than 10 protected areas and 422 occurred in 10 or fewer protected areas. Of the 375 taxa occurring in more than 10 protected areas, nine were identified as scarce/rare and were further evaluated, whereas all the other taxa (366 taxa) were identified as common and occurring in good numbers and were thus flagged as Well Protected.

In total, 431 taxa had their protection levels evaluated in detail (422 taxa occurring in 10 or fewer protected areas and nine scarce/rare taxa occurring in more than 10 protected areas). Although 53 % of all 797 taxa were determined to be well protected, when looking at the SALCA taxa alone (which include all the TCC) only 9 % of the SALCA taxa were found to be well protected and 78 % of the threatened taxa (Critically Endangered, Endangered and Vulnerable) were poorly protected or not protected at all (Fig. 1, Table 9: page 27).

Critical habitat mapping

Of the 131 threatened, extremely rare and rare taxa that were considered for the critical habitat mapping, only 44 taxa qualified for tier 1 (very high sensitivity). For tier 2 (high sensitivity), 119 taxa qualified based on the selection criteria, and for tier 3 (medium sensitivity) 83 taxa qualified (Table 10: page 27). The taxa listed in each tier may change as more accurate data become available, and the medium sensitivity tier will be updated with new modelling techniques and expert validation. Therefore, this list is dynamic and the results presented in this paper represent the status as of July 2020. Up-to-date sensitivity statuses of the taxa can be obtained on the National Screening Tool website:
https://screening.environment.gov.za/screeningtool/

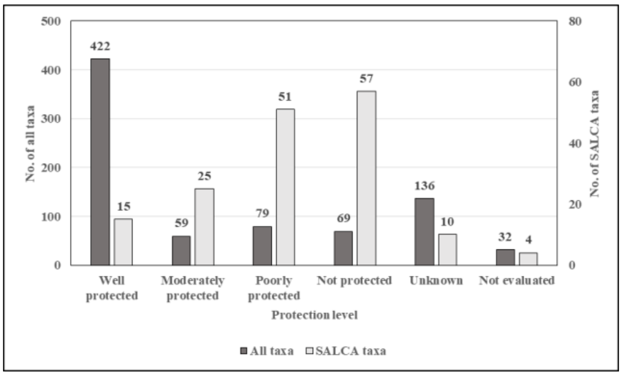

Figure 1 – The number of butterfly taxa in each protection level category, for all 797 taxa and for the 162 SALCA taxa (the three Extinct taxa were not included in this analysis). Also shown is the number of taxa for which protection levels are unknown and the number that were not evaluated.

Butterfly TCC hotspots and associated vegetation types

The butterfly TCC hotspots for the threatened taxa and the TCC are shown in Figures 2 and 3, respectively. The areas of greatest conservation concern are those QDGSs containing the most number of taxa (the dark red blocks). For threatened taxa there are seven high-priority QDGSs (i.e. three or more taxa) in the Western Cape, four in Mpumalanga, four in Limpopo, one in Gauteng and one in KwaZulu-Natal, and a similar pattern can be discerned for the TCC.

The number of threatened taxa and TCC (excluding Extinct taxa) in each biome are shown in Table 11 (page 28). The Grassland biome contains the highest number of threatened taxa, whereas the Fynbos biome contains the highest number of TCC. The third most significant biome is the Savanna biome, followed closely by the Forest biome. The vegetation types (2018 vegetation map) containing the highest number of threatened taxa and TCC (excluding Extinct taxa) are shown in Table 12 (page 28).

Threats to butterflies

The most significant main threats to the threatened, Near Threatened and Data Deficient taxa, for past, present and future, are: natural system modifications, agriculture, invasive species, climate change and property development (Fig. 4). Table 13 (page 29) lists the IUCN sub-threats for the main threats that are relevant to these taxa. Noteworthy changes between SABCA (2012 – past) and SALCA (2018 – present) are that:

- Natural system modifications are now the most prevalent present threats (increased from 35 to 51 taxa).
- Property development, even though it has declined,

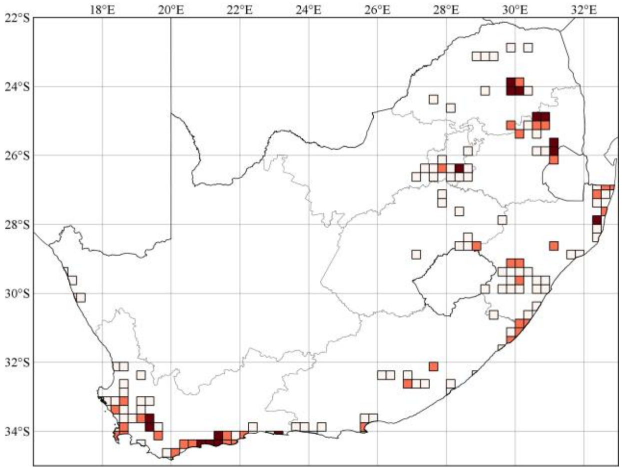

Figure 2 – The QDGSs in South Africa, Lesotho and Eswatini, that contain threatened taxa, divided into three quantiles: 1 taxon (□), 2 taxa (■) and 3–5 taxa (■).

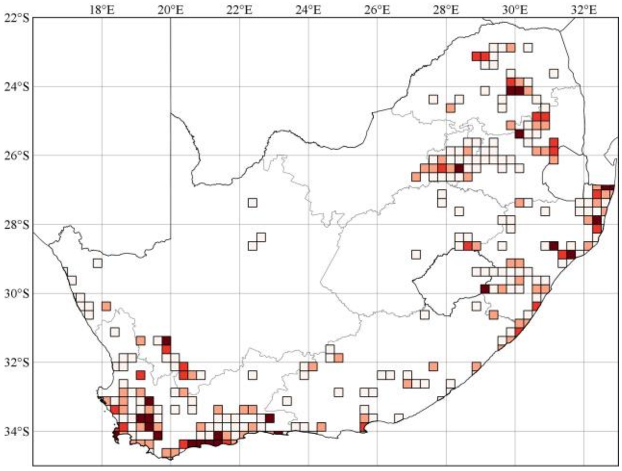

Figure 3 – The QDGSs in South Africa, Lesotho and Eswatini, that contain TCC, divided into four quantiles: 1 taxon (□), 2 taxa (■), 3 taxa (■) and 4–7 taxa (■).

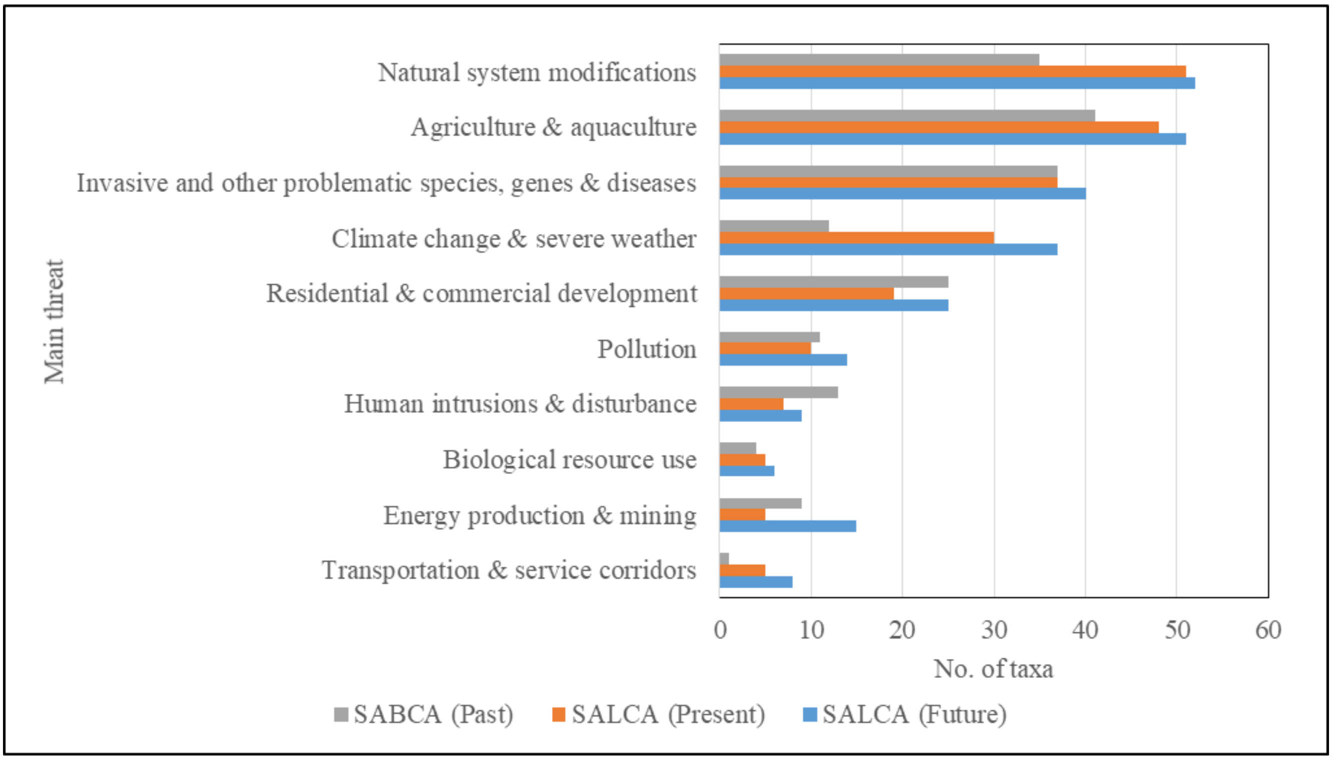

Figure 4 – The main SALCA threats (present and future) for the threatened, Near Threatened and Data Deficient taxa, ranked in order of frequency for the present. In comparison, the past threats are represented by the 'present' threats from SABCA (the 2012 assessment). The threats follow the IUCN threat classification scheme. For each time period, the number of taxa within each main threat category is given (note: some taxa have more than one main threat).

remains a serious threat with 19 taxa impacted.

- Climate change and severe weather threaten a much greater number of threatened taxa in 2018 than in 2012.

Moths

<u>Distribution database</u>

The final moth distribution database constituted 259 965 records, which included several duplicate records from various sources. Of these, 185 877 (72 %) had usable taxonomy to the species level as well as georeferencing, and of these 148 830 (80 %) occurred in the study region. Most of the georeferenced records extracted for the study region were sourced from Lepibase and the DNHM (Fig. 5).

<u>Basic summaries</u>

The georeferenced records for the study region included data for 23 superfamilies, 55 families, 143 subfamilies, 1 141 genera and 3 011 species. The top five superfamilies and top 10 families (both for number of records and number of species) are shown in Table 14 (page 30). The number of records and species per province, as well as for Eswatini and Lesotho, are shown in Fig. 6, with KwaZulu-Natal having both the highest number of records and species.

At the QDGS scale, 54 % (n = 1 083) of the QDGSs for the entire country (n = 2 026 whole and partial QDGSs) included moth distribution data (Fig. 7a). This coverage map included undated records which amounted to 20 586 (1 %) of the records. When looking at records collected from 1980 onwards, 45 % (n = 907) of the QDGSs were covered (Fig. 7b), and when looking at data from 2000 onwards, 40 % (n = 810) of the QDGSs were covered (Fig. 7c). Overall, the Northern Cape, North West and Free State provinces contain the least coverage, as well as Lesotho.

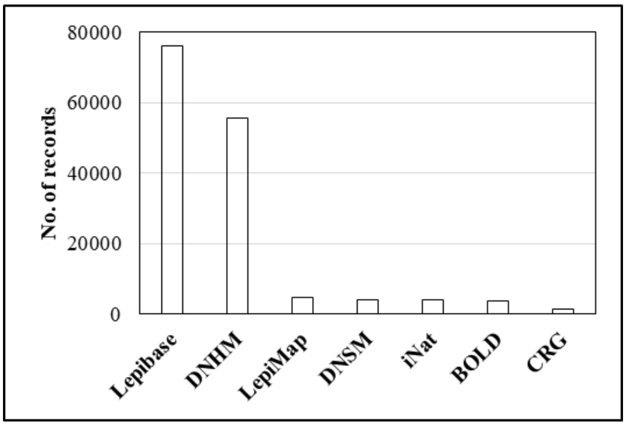

Figure 5 – The number of georeferenced moth records within the study region from each of the data sources (DNHM = DNHM records sourced during SALCA, DNSM = Durban Natural Science Museum, iNat = iNaturalist, BOLD = Barcode of Life Data System, CRG = Caterpillar Rearing Group).

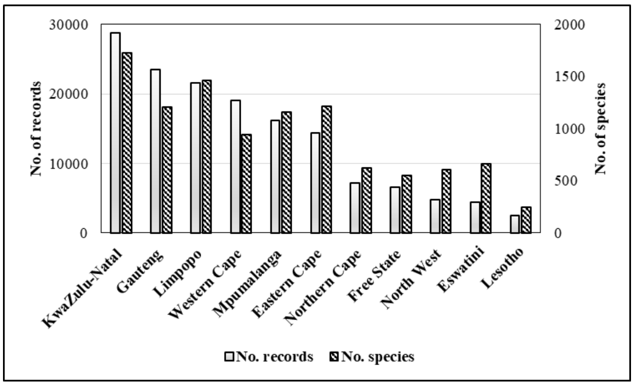

Figure 6 – The number of moth records and moth species per province, as well as for Eswatini and Lesotho, for the georeferenced records within the study region.

DISCUSSION

Butterflies

Differences between SALCA and SABCA

The primary aim of the SALCA project was to update the conservation assessments of the taxa assessed as TCC during SABCA. Most of these taxa have a very restricted range, and the accuracy of the records used to do the assessments is critical. The SABCA data included a high proportion of records transcribed from the label data of museum (public) and private collection specimens, many of which were very old (Mecenero *et al.*, 2013). Most specimens collected before 2010 do not have GPS coordinates, only place names. The persons digitising such specimens could only use the coordinates of the place name, which in many instances was as much as 30 km away. At the QDGS mapping scale of the SABCA project such accuracy was mostly sufficient, but such records clearly did not have sufficient accuracy to guide land-use decision making and to meet the aims of the SALCA project, which was seeking a mapping accuracy of <250 m. During SALCA the accuracy of field data provided by experts and citizen scientists (LepiMap) was much better, with the location of most records defined by GPS readings and verified using Google Earth. Greater accuracy leads to more objective red list and protection level assessments and precise identification of critical habitats to guide land-use decision making.

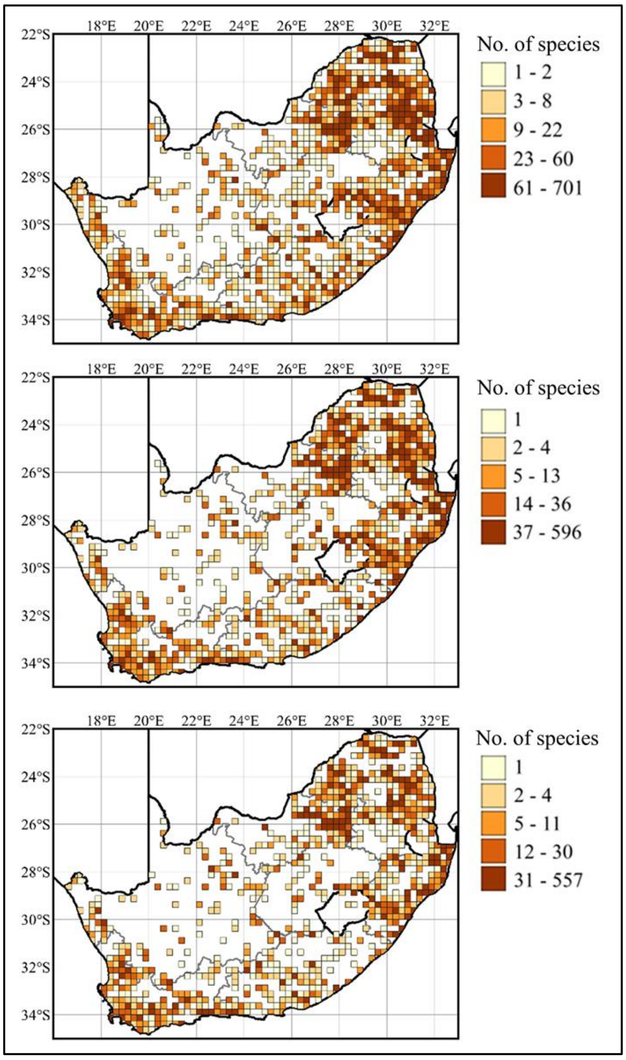

Figure 7 – Maps of the study region showing coverage and species richness for moths over three time periods: (a) all data (including undated records), (b) records from 1980 onwards, and (c) records from 2000 onwards. The number of species were divided into five quantiles as shown in the keys.

Furthermore, specimens in collections are grouped under the scientific names that applied at the time the specimen was collected. Subsequent taxonomic changes such as the splitting of species into two or more species or into several subspecies, was usually not known to the persons digitising the collection – who were mostly not butterfly experts. This created uncertainty about which taxon the specimen actually belonged to. These two sources of error could only be identified and rectified by butterfly experts during the SALCA project, as described in the Materials and Methods section.

SALCA Tool

The SALCA Tool proved to be very beneficial for the

SALCA project. It allowed assessments to be conducted using high accuracy data resulting in significantly improved assessments. The Lepibase dataset provides a verified dataset for future assessments. In addition, the required objective processes and analyses for data verification and the conservation assessments have mostly been achieved.

While development of the SALCA Tool has now stopped, the database it was built on is still being maintained. SALCA resulted in major changes to the database design, and future versions of the software will incorporate many of these lessons. A major improvement will be moving to a cloud-based database, and incorporating even more verification tools and steps into the database, specifically when records are entered.

Comparison with a similar European butterfly conservation assessment project

Despite the challenges and limited resources experienced during both SABCA and SALCA projects, the significant achievements of both of these projects, as well as the conservation challenges for South African butterflies, are highlighted when compared to the well-known butterfly conservation assessment project in the UK, known as the Millennium Atlas (Asher *et al.*, 2001). Table 15 (page 30) provides some relevant statistics.

The Millennium Atlas benefited from 28 years of data collection in the UK, led by Butterfly Conservation UK, which was founded in 1968. At the commencement of SABCA, over 20 years of butterfly distribution data had been accumulated by LepSoc Africa members and was stored in the Lepibase database using a software programme called Lepidops (Coetzer, 2008). The Millennium Atlas mainly benefitted from having more experts and observers per assessed taxon and observers per 1 000 km^2. This enabled the Millennium Atlas publication to have more accurate species distribution maps and a more detailed biological description of each species. Nonetheless, the achievements of the SABCA and SALCA projects are noteworthy, given the limited funding available to execute these projects and the scarcity of skilled and trained personnel.

The enormity of the challenges facing butterfly conservation in South Africa can most clearly be seen in the last statistic in Table 15 (page 30). In South Africa each expert now has to deal with 4.8 threatened taxa, against only 0.04 in the UK – in other words the responsibility (and workload) of the taxon experts in South Africa is 100 times greater. Adding to this responsibility is the fact that over 52 % of the South African taxa are endemic (so their loss would be a global extinction), whereas no UK butterflies are endemic.

Conservation assessments and Red Listing

The SALCA taxa were assessed by objectively evaluating the available data. South Africa is a large country and our butterfly experts are few and far between compared to more intensively studied countries (see Table 15: page 30), and there are still many gaps in our knowledge of distributions. Whilst the presence data are excellent, absence data are lacking although the IUCN system does allow for lack of absence data. There are still many unsampled places where it is possible that the taxon being assessed could occur, but given the paucity of observers in South Africa (see above) not everywhere can be surveyed. One could argue that all such taxa with small known distributions are "data deficient" but this would not be helpful for advancing butterfly conservation. When data are sparse, conservation biologists often apply the precautionary principle by assuming that the taxon does not occur elsewhere, to avoid type II errors which can happen when normal statistical methods are inappropriate to prove a risk of extinction hypothesis (McGarvey, 2007). Other type II errors can result when the taxonomy is uncertain – as a result of a "taxonomic impediment" (Cardoso *et al.*, 2011). Examples of taxonomic uncertainty are taxa such as *Pseudonympha swanepoeli*, *Aloeides pallida littoralis*, *Lepidochrysops penningtoni* and *Chrysoritis thysbe mithras* (see their conservation assessments). The IUCN advocates using the precautionary principle in uncertain cases (IUCN, 2017).

The outcomes of the SALCA conservation assessments and Red Listing have been included in the NBA (Skowno *et al.*, 2019), which is an important national and governmental document for setting policy and monitoring conservation of biodiversity. The inclusion of butterflies raises their conservation priorities on a national and provincial scale, as well as highlighting the importance of insects overall. The Red List assessments will also be published and will be accessible to the public on SANBI's website (http://speciesstatus.sanbi.org/taxa/lineage/1063/#).

Another beneficial process we have employed is to involve IUCN in the final checking and editing of the conservation assessments, so that they can ultimately include all the South African assessed butterfly taxa on the IUCN's Red List website (to date 230 SABCA/SALCA assessments have been published on the IUCN website; https://www.iucnredlist.org/).

Red List index

The RLI, and the change therein, has been measured for the first time for southern African butterflies, due to two assessment periods having been completed (2012 and 2018). When considering all butterfly taxa, the change in RLI showed a decline of 0.7% between the two assessment periods (i.e. increasing extinction risk), and was found to be the steepest decline amongst terrestrial taxon groups (mammals, birds, reptiles, amphibians) where RLIs were possible in South Africa (Skowno *et al.*, 2019). This is of concern because butterflies are good indicators of the status of many other terrestrial insect groups (Thomas, 2005), and our findings concur with the current and globally observed decline of insect populations towards extinction (Møller, 2019; Cardoso *et al.*, 2020). This will ultimately result in the loss of biodiversity and important ecosystem services necessary for human survival (Cardoso *et al.*, 2020). For a more inclusive animal group, the invertebrates, recent publications (e.g. Eisenbauer *et al.*, 2019) have also revealed a rapid decline. Since invertebrates are crucial to the functioning of many ecosystems, this trend has caused much consternation amongst the public as well as scientists and policymakers. In South Africa monitoring of invertebrates on a wider scale was highlighted in the NBA (Skowno *et al.*, 2019), and SANBI have initiated a project to commence monitoring (Raimondo, 2020).

When looking at only the butterfly TCC, the change in the RLI was six times larger than when looking at all butterfly taxa. This suggests strongly that our TCC are in rapid decline towards extinction, and conservation actions may be urgently required in many instances. The main present identifiable threats to our threatened, Near Threatened and Data Deficient taxa (Fig. 4) are natural system modifications (51 taxa); agriculture (48 taxa); invasive aliens (37 taxa); climate change (30 taxa); and property development (19 taxa). Preventing the resultant further habitat loss and degradation is therefore necessary to reverse the decline towards extinction. It is noteworthy that the most rapid decline in the RLI is for the family Lycaenidae, where most of the taxa are not only habitat specialists but also reliant upon symbiotic relationships with ants (Hymenoptera: Formicidae) and sometimes scale insects (Hemiptera: Coccidae) (e.g. Giliomee & Edge, 2015).

Our RLI results can be compared to those found in Finland, where a significant increase in the rate of biodiversity loss from 2000 to 2010 was found for 2 245 Lepidoptera species (butterflies and moths), with the loss of habitat specialists increasing faster than generalists, and coastal habitats suffering worst (Juslén *et al.*, 2015). However, they also found that 76 new Lepidoptera species had established populations in Finland between 2000 and 2010, with their northward expansion probably driven by climate warming. Such a trend is also apparent in South Africa, with southward range expansions of insect taxa (including butterflies) from further north (Perissinotto *et al.*, 2011).

Butterfly TCC hotspots

Mecenero *et al.* (2013: Section 3.2.4) listed the butterfly TCC hotspots as: Eastern Cape (Coega area, Amatolas and Camdeboo Mountains); Free State (Golden Gate highlands); Gauteng (West and East Rand); KwaZulu-Natal (Drakensberg foothills, South coast, Zululand and the Maputaland coast); Limpopo (Haenertsburg and Soutpansberg); Mpumalanga (Stoffberg, Dullstroom, Graskop and Barberton); and the Western Cape (Cape Town area, Swartland, the Upper Breede valley, Cape Fold Mountains, Witsand, Still Bay and Knysna). The SALCA data (Figs 2 & 3) shows a very similar pattern, but with a new butterfly TCC hotspot for threatened taxa becoming clear in Zululand and the Maputaland coast, where rapid population growth and demand for land is putting pressure on the remaining natural vegetation.

Vegetation types hosting threatened taxa and taxa of conservation concern

Vegetation types from the Fynbos and Grassland biomes seem to feature mostly in the priority list of vegetation types containing threatened butterfly taxa and taxa of conservation concern. This is supported by the fact that both these biomes contain the highest proportions of threatened ecosystem types (Skowno *et al.*, 2019).

Comparisons of the priority vegetation types between SABCA and SALCA were not possible for the following reasons. Firstly, the vegetation types used in SABCA were obtained from the Mucina & Rutherford (2006) vegetation map, whereas for SALCA the updated vegetation map was used (SANBI, 2018). This makes direct comparisons difficult, if not impossible. There are four new vegetation types from the SANBI (2018) vegetation map in Table 12 (page 28), which have replaced some vegetation types which featured in SABCA (see Table 3.9 of Mecenero *et al.*, 2013): AT40 Hartenbos Dune Thicket (replacing some areas of FFd9 Albertina Sand Fynbos and FFl3 Canca Limestone Fynbos); Gm30 Steenkampsberg Montane Grassland and Gm31 Long Tom Pass Montane Grassland (replacing some areas of Gm18 Lydenburg Montane Grassland); and Gs20 Moist Coast Hinterland Grassland (replacing some areas of Gd1 Amathole Montane Grassland and FOz3 Southern Mistbelt Forest). This also explains the absence of FFd9, Gm18, Gd1 and FOz3 from Table 12 (page 28), which were included in the top 16 vegetation types during SABCA (see Table 3.9 of Mecenero *et al.*, 2013).

Secondly, even when the SALCA records were overlaid onto the 2006 vegetation map, comparisons were not possible because SALCA used verified data whereas SABCA's data accuracy was much lower (many records used during SABCA have since been Rejected for SALCA, and many records had their coordinates updated to greater accuracy during SALCA, thus resulting in record data points moving out of or into 2006 vegetation types). FRs3 Roggeveld Shale Renosterveld appears to have been replaced by the adjacent vegetation type SKt3 Roggeveld Karoo, possibly because of the improved accuracy of the SALCA data.

New butterfly TCC vegetation hotspots appearing in Table 12 (page 28) are Gm23 Northern Escarpment Quartzite Sourveld, AT40 (discussed above), FOz7 Northern Coastal Forest, FFs10 Hawequas Sandstone Fynbos, FFs26 South Kammanassie Sandstone Fynbos, SKt3 (discussed above), FFb3 Central Shale Band Vegetation, FFs12 Overberg Sandstone Fynbos and FFs5 Winterhoek Sandstone Fynbos.

Threats

The perceived increase in the threat of climate change between the past and present is an artefact of greater willingness to consider climate change as a real threat during SALCA. During SABCA, using climate change as a threat was discouraged. Currently, the threat of climate change is more noticeable than during SABCA, mainly due to droughts and increased fire frequency and intensity. *Orachrysops niobe* on the south coast is an example, where strong drought conditions led to a large and uncontrolled fire in 2017. The fire devastated its last and small remaining habitat, with the consequence that this butterfly is quite possibly extinct because it was only seen in small numbers in November that year and not subsequently (D.A. Edge, pers. obs.).

Studies in the northern hemisphere have shown that as the climate warms, butterfly distributions shift northwards and to higher altitudes (Parmesan *et al.*, 1999; Parmesan & Yohe, 2003). Many of our threatened butterflies are already on top of mountain peaks or at their southernmost limit on the coast and will therefore not be able to easily adapt to the changing climate by migrating to a cooler climate higher up a mountain or further south.

Other important continuing threats result from changes in natural ecosystem functioning because of suppression of fires, replacement of indigenous wildlife with domestic livestock, or elimination of all large herbivores. New property developments frequently set aside areas of natural vegetation for conservation purposes, but then fail to manage them ecologically so they can function and sustain habitats for butterfly TCCs. The individual conservation assessments provide detail on what needs to be done for each taxon to reduce the threats that they are facing.

The threat status of butterflies relative to other South African taxon groups can be seen in Skowno *et al.* (2019: 77, Fig. 39), and can be summarised as follows:

- The threats to butterflies and plants are quite similar, and this is not surprising since most butterflies are dependent on plants for their sustenance in either the adult or larval stage.
- Fire and fire suppression affects 36 % of butterfly TCC, which is the second highest taxon group after amphibians (42%).
- Droughts affect butterflies (24 % of TCC) more than any other taxon group.
- Invasive alien plants affect butterflies similarly to birds, plants and reptiles.
- Agricultural activities affect butterflies, plants and amphibians less than birds, mammals and reptiles.

The IUCN threats classification system is fundamentally inadequate to cater for some of the threats identified during SABCA and SALCA for the following reasons:

- it only caters for extrinsic threats, and does not recognise intrinsic factors as threats (i.e. small closed populations, specialised habitats, loss of genetic diversity),
- the threat "land management of non-agricultural areas" and sub-threats "change of management regime" and "abandonment" defined in SABCA (which are common threats in Africa) have no equivalent threat in the IUCN system, and they could only be placed in the IUCN category "Other".

<u>Protection levels</u>

Although it seems that half of South Africa's total butterfly taxa are well protected within South Africa's protected areas network, closer examination of the threatened taxa has shown that two-thirds of these taxa are either poorly protected or not protected (see also Skowno *et al*., 2019). This is of serious concern, especially considering that the change in the RLI for the butterfly TCC is in steep decline, meaning that these taxa are steadily moving towards extinction. The expansion of South Africa's protected area network should ensure that more of these under-protected taxa are taken into account, thereby not only contributing to their protection, but also indirectly conserving other insect groups of which butterflies are an indicator (Thomas, 2005). Additionally, existing protected areas where these taxa occur should adjust their management practices to be in line with ecological research carried out on each taxon. Although some threats are already part of reserve management plans such as removal of invasive alien plants, the areas where butterfly TCC occur need to be prioritised. Fire management is a more complex issue, and whereas some TCC are impacted positively by a well-timed and controlled fire, there are others for which a fire of too high an intensity at the wrong time of year could be fatal. Interaction between LepSoc Africa experts and reserve managers is therefore essential to get the balance right. A new medium-term strategic framework target to all conservation agencies for the years 2021–2025 requires that there is a 5 % improvement in the protection level of species. Data generated through this analysis done as part of the SALCA project is being channelled to reserve managers and those responsible for establishing new protected areas and stewardship programmes, which target privately owned land that contains butterfly TCC.

The protection level analyses relied on adequate knowledge of management practices and butterfly occurrences and viability in > 1 000 protected areas. The taxon assessors applied their expertise to the best of the available knowledge, and in many cases assumptions had to be made. To improve future analyses and objectivity, protected area managers should be asked to provide more details on their management practices. A focused workshop for LepSoc Africa experts would improve standardisation of the determination of the input data such as ideal fire regimes suitable for various vegetation types and groups of TCC. LepSoc Africa should also do surveys in lesser-known protected areas to get a better understanding of butterfly populations occurring in these areas.

<u>Critical habitat mapping</u>

The term "critical habitat" was first given a legal meaning in the Endangered Species Act (USA, 1973), and referred to unique natural areas hosting threatened species. Butterfly species often have low dispersal capability and are "habitat specialists" confined to relatively small areas. Mapping of such areas for butterflies only became possible during SALCA because of the higher accuracy of the distribution data. SANBI have included these data in the national screening tool that they have developed, with all the areas where threatened biodiversity (not just butterflies but several other taxon groups) occurs accurately mapped. Environmental Assessment Practitioners have to enter the footprint of the proposed development into the screening tool and they then get a report letting them know which critical habitat for Red Listed plant or animal taxa occurs within the development footprint. There are three levels of sensitivity – Very High, High and Medium. The development site then needs to be studied in detail by relevant taxon experts and a report written to inform the development planning process. For butterflies, the taxon expert will be appointed by a registered Professional Natural Scientist who is a butterfly expert, who will either be a taxon assessor or a COREL custodian (Edge, 2011).

Moths

At the start of SALCA, the aim was to try and assess at least a few moth species for which enough distribution data and expert knowledge were available. Unfortunately this was not possible, mainly because the team ran out of time due to the more than expected time it took to develop the assessment tool, clean up the butterfly data and conduct the assessments. The advanced assessment tool, experiences learnt and skills developed to ensure the high level of data accuracy and taxon assessments achieved, however, will be invaluable when attempting future assessments taking all of the Lepidoptera fauna into account.

Butterflies constitute only about 6 % of the total Lepidoptera fauna in southern Africa (figure derived from Krüger, 2020). Therefore, getting both a reliable taxonomy and a verified database ready for the rest of the Lepidoptera took up most of the available time. Nevertheless, the SALCA project has resulted in a large step forward towards our goal of incorporating all Lepidoptera taxa into conservation research.

The moth distribution database has been consolidated and many records have been georeferenced, allowing for conservation assessments of key species in future as well as new opportunities for research into general patterns of Lepidoptera diversity or taxon-specific research, for all Lepidoptera. The recently updated taxonomic list, including butterflies, developed during SALCA, forms an important backbone to these and other future research and conservation efforts.

Moth species richness follows the same pattern as butterfly species richness (Mecenero *et al.* 2013). This is not surprising because they are all Lepidoptera. The butterfly–moth distinction is an artificial one, used historically and therefore used here for practical reasons because of the huge disparity of available data resulting largely from this historic divide. The aim is to get rid of this artificial distinction as soon as possible once the disparity of data has been improved.

The larger gaps in coverage for moth observations compared to butterfly observations is indicative of there being fewer active moth experts in the country, largely because of the historic artificial divide. There is an increasing interest in the rest of the Lepidoptera amongst LepSoc Africa members with less emphasis on this artificial distinction. Citizen science projects such as the Caterpillar Rearing Group (Staude *et al.* 2016) do not distinguish between butterflies and moths – and on iNaturalist (the most utilised citizen science platform in South Africa), where most of the Lepidoptera submissions are now moths, this distinction is also not made.

Measures to conserve butterfly diversity

LepSoc Africa's COREL programme was initiated by Edge (2011) and initially concentrated on 14 Critically Endangered butterfly taxa and one moth taxon (Table 16: page 31). The conservation status has since worsened for one taxon and improved for eight taxa; six taxa are unchanged. Eighteen subpopulations are now known to be extant for these taxa against only eight when COREL began. Successes achieved for individual taxa are summarised below:

Alaena margaritacea	New locality found; research into life history completed (Coetzer, 2015).
Chrysoritis dicksoni	New locality found; vegetation study to define habitat completed (Edge, 2016); alien eradication programme nearly complete; agreement reached to establish a contract nature reserve.
Dingana fraterna	New locality found; ecological research continuing; population stable (Lawrence, 2015).
Kedestes barberae bunta	Research into autecology completed (Adams, 2017); captive breeding programme initiated; *in situ* habitat management ongoing to improve condition of host plants and provision of more nectar plants for the adults.
Thestor b. brachycerus	New secure localities found; research completed into habitat requirements and adult behaviour (Bazin & Edge, 2015).
Thestor barbatus	Extent of type locality more clearly defined; alien removal programme is maintaining the habitat in suitable condition.

During 2014 three Extinct taxa and seven Data Deficient taxa were added to the COREL programme. Many searches for the Extinct taxa have not yet met with success, but much new data has been obtained about the Data Deficient taxa, which has clarified their status (see *Thestor barbatus* above). During the years from 2015 to 2018 another 16 taxa were added to the programme, and some progress has already been made in locating new subpopulations.

The COREL programme has had its limitations and disappointments and searches for new localities for some of the Critically Endangered – Possibly Extinct taxa have not been successful (*Stygionympha dicksoni*; *Trimenia m. malagrida*; *Trimenia m. paarlensis* and *Trimenia w. wallengrenii*). The population at the new locality for *Erikssonia edgei* in the Waterberg has declined and this is causing great concern, since the reason for the sudden collapse is not clear, despite a research programme. Another recent setback was the devastating fire that destroyed the only known habitat for *Orachrysops niobe* at Brenton, and the butterfly has not been seen since despite widespread searches.

Following SALCA, the COREL programme has again been expanded to now cover 26 Critically Endangered and 29 Endangered taxa, and there are currently 16 LepSoc Africa custodians appointed in every province of South Africa. They are guided by Edge *et al.* (2013), who described the future priorities for butterfly conservation and research, including the COREL programme, establishment of new reserves and protected areas, habitat management plans, population monitoring, establishing an ongoing distribution database, facilitating specimen collecting by lepidopterists to enable taxonomic studies, and ecological scientific research. The latter is a key activity to promote the success of COREL and inform butterfly conservation efforts. The South African universities are being persuaded to get more involved in butterfly conservation (a mainstream research topic in Europe) by encouraging some Honours and Masters students to make threatened butterflies the main focus of their research (e.g. Bazin & Edge, 2015; Adams, 2017).

Armstrong *et al.* (2013) outlined the necessary actions by conservation practitioners in terms of spatial biodiversity planning, environmental impact assessments (EIAs), protected area expansion, biodiversity management plans for species, and implementation of sustainable utilisation, biodiversity monitoring, environmental education, urban conservation and research. Whilst there has been insufficient progress in most provinces of South Africa, these actions are still valid and continue to define a good "road map" for authorities and conservation practitioners.

The National Environmental Management: Biodiversity Act (DEA, 2004; 2015) in principle facilitates biodiversity conservation, but implementation is not automatically enforced by government agencies. The implementation of the national screening tool mentioned above along with the Species Environmental Assessment Guideline that is currently under development and specifically refers to how butterfly TCC need to be catered for during EIAs, will greatly assist Lepidoptera conservation, but even property and other land use change developments that do not show up with the screening tool need to be surveyed as a matter of course. New localities for threatened butterflies (and even new species) have been found during EIAs.

Benefits of conserving Lepidoptera

The benefits of conserving Lepidoptera are shown in Table 17 (page 32). Mankind has always had a special relationship with Lepidoptera, not only for their beauty but also their fascinating life cycle (Smart, 1975). They are an essential element of the natural world, from which humans have derived much aesthetic and spiritual sustenance (Boyd *et al.* 2000). In today's frenetic world, experiences of wild and natural places are an antidote to the stresses of our lifestyle (Snyder, 2010). The popularity of Lepidoptera on online citizen science platforms such as LepiMap and iNaturalist (www.inaturalist.org) are testament to this.

The beauty, diversity and novelty of our South African Lepidoptera fascinates nature-loving tourists, and creates an added attraction to visit South Africa (e.g. https://www.naturetrek.co.uk/tours/butterflies-of-south-africa). Lepidoptera are indicators of the health of natural ecosystems (Thomas, 2005) upon which most of our national parks are based, and charismatic butterfly species can provide protection for other invertebrate species and ecosystems. Lepidoptera pollinate a wide variety of indigenous fynbos plants, and are overall the second most important pollinators after bees (Johnson & Bond, 1994). Butterflies pollinate some rare plants (e.g. *Aeropetes tulbaghia* is the only pollinator of *Disa uniflora*), and carry the pollen on their legs or wings which come into contact with the stamens (Peter, 2019). Some Lepidoptera also provide valuable resources to rural people e.g. mopane worms (larvae of *Gonimbrasia belina* – an Emperor moth) at certain times of year provide invaluable protein rich sustenance (Klok & Chown, 1999).

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Table 1 – The SALCA project team.

Project role	Name	
Director	David A. Edge	
Manager	Silvia Mecenero	
IT managers	Bennie H. Coetzer and Andre J. Coetzer	
Provincial leaders	Gauteng – Jeremy C.H. Dobson North West – Martin W. Lunderstedt Limpopo and Mpumalanga – André J. Coetzer Free State – Reinier F. Terblanche KwaZulu-Natal – Kevin N.A. Cockburn Western Cape – Andrew S. Morton Eastern Cape – Ernest L. Pringle Northern Cape – Etienne Terblanche Southern Cape – David A. Edge	
Taxon assessors	Adrian J. Armstrong André J. Coetzer Andrew S. Morton Bennie H. Coetzer Chris M. Dobson David A. Edge Ernest L. Pringle Fanie Rautenbach	Graham A. Henning Harald E.T. Selb Jeremy C.H. Dobson Jonathan B. Ball Justin D. Bode Kevin N.A. Cockburn Mark C. Williams Steve E. Woodhall
Moth manager/expert	Hermann S. Staude	
Review of conservation assessments	David A. Edge Silvia Mecenero Rolf G. Oberprieler	Domitilla C. Raimondo Mark C. Williams
Final editing of conservation assessments	David A. Edge Silvia Mecenero	Mark C. Williams

Table 2 – Definitions of protected area effectiveness used, as received from SANBI (Anon 2017). The protection level (PL) category thresholds are also given.

Effectiveness category	Definition
Poor	Protected area provides no mitigation of major threats to species – individuals inside the protected area are no better off than those outside.
Fair	Protected area provides some mitigation of major threats to species, but is not 100% effective.
Good	Protected area is fully effective in protecting the species against major threats and ensuring the long-term persistence of the population present within the protected area.

PL value	% of target	PL category
0 – 0.049	<5%	Not protected
0.05 – 0.49	5–49%	Poorly protected
0.5 – 0.99	50–99%	Moderately protected
1+	100+%	Well protected

Table 3 – The 165 butterfly taxa that were assessed for SALCA, including their Red List and endemism status (1 = yes), as well as their province of occurrence in South Africa (1 = present). Also indicated are those Least Concern rare taxa of national conservation importance. The seven taxa that were assessed for the first time are marked with an asterisk (*).

Full name	SALCA Red List[1]	Endemic	Occurrence per province[2]								
			WC	EC	KZN	LP	NC	MP	GP	FS	NW
HESPERIIDAE											
Abantis bicolor	Near Threatened	1		1	1						
Kedestes barberae bunta	Critically Endangered	1	1								
Kedestes lenis lenis	Critically Endangered	1	1								
Kedestes niveostriga schloszi	Vulnerable	1	1								
Kedestes sarahae	Critically Endangered	1	1								
Metisella meninx	Near Threatened	1			1	1		1	1		
Metisella syrinx	Vulnerable	1		1							
Platylesches dolomitica	Least Concern	1				1		1	1		1
**Teniorhinus harona*	Least Concern	0				1					
Tsitana dicksoni	Least Concern – Rare (LD)	1	1	1							
LYCAENIDAE											
Alaena margaritacea	Critically Endangered	1				1					
Aloeides barbarae	Endangered	0						1			
Aloeides caledoni	Least Concern – Rare (LD)	1	1	1							
Aloeides carolynnae aurata	Near Threatened	1	1								
Aloeides carolynnae carolynnae	Endangered	1	1								
Aloeides clarki	Endangered	1		1							
Aloeides dentatis dentatis	Endangered	1						1	1		
Aloeides egerides	Vulnerable	1	1								
Aloeides lutescens	Endangered	1	1								
Aloeides monticola	Least Concern – Rare (RR)	1	1								
Aloeides nubilus	Endangered	1						1			
Aloeides pallida jonathani	Least Concern – Rare (RR)	1	1								
Aloeides pallida juno	Endangered	1	1	1							
Aloeides pallida littoralis	Near Threatened	1	1								
Aloeides rossouwi	Critically Endangered	1				1		1			
Aloeides stevensoni	Critically Endangered	1				1					
Aloeides thyra orientis	Endangered	1	1								
Aloeides trimeni southeyae	Endangered	1	1								
Anthene crawshayi juanitae	Least Concern – Rare (RR)	1				1					
Anthene lindae	Near Threatened	0					1				
Anthene minima minima	Least Concern – Rare (LD)	0			1	1					
Aslauga australis	Endangered	1		1							
Capys penningtoni	Critically Endangered	1			1						
Chrysoritis adonis adonis	Critically Endangered	1	1								
Chrysoritis adonis aridimontis	Least Concern – Extremely Rare	1	1								
Chrysoritis aureus	Endangered	1						1	1		
Chrysoritis beaufortia charlesi	Least Concern – Rare (RR)	1					1				
Chrysoritis beaufortia stepheni	Least Concern – Rare (HS)	1					1				
Chrysoritis blencathrae	Least Concern – Rare (RR, HS)	1	1								
Chrysoritis brooksi tearei	Endangered	1	1								
Chrysoritis daphne	Least Concern – Rare (RR, HS)	1	1								
Chrysoritis dicksoni	Critically Endangered	1	1								
Chrysoritis endymion	Least Concern – Rare (HS)	1	1								
Chrysoritis irene	Least Concern – Rare (RR, HS)	1	1								
Chrysoritis lyncurium	Vulnerable	1		1	1						
**Chrysoritis lyndseyae*	Least Concern – Rare (RR)	1					1				
Chrysoritis nigricans rubrescens	Least Concern – Extremely Rare	1	1								
Chrysoritis oreas	Least Concern – Rare (RR, HS)	1			1						
Chrysoritis orientalis	Least Concern – Rare (RR)	1		1	1						
Chrysoritis penningtoni	Vulnerable	1		1							
Chrysoritis phosphor borealis	Endangered	1			1			1			
Chrysoritis phosphor phosphor	Least Concern	1		1							
Chrysoritis pyramus pyramus	Least Concern – Rare (RR, HS)	1	1								
Chrysoritis pyroeis hersaleki	Least Concern	1		1							
Chrysoritis rileyi	Endangered	1	1								

Chrysoritis swanepoeli hyperion	Least Concern – Rare (RR, HS)	1	1								
Chrysoritis swanepoeli swanepoeli	Least Concern	1	1								
Chrysoritis thysbe mithras	Critically Endangered – Possibly Extinct	1	1	1							
Chrysoritis thysbe schloszae	Critically Endangered	1	1								
Chrysoritis thysbe whitei	Endangered	1		1							
Chrysoritis trimeni	Vulnerable	1					1				
Chrysoritis turneri wykehami	Least Concern – Rare (HS, LD)	1					1				
Chrysoritis uranus schoemani	Least Concern – Rare (HS)	1	1								
Chrysoritis violescens	Least Concern	1					1				
Crudaria wykehami	Least Concern	1	1	1							
Deloneura immaculata	Extinct	1		1							
Deloneura millari millari	Least Concern – Rare (LD)	0		1	1						
Durbania amakosa albescens	Vulnerable	1		1	1						
Durbania amakosa flavida	Endangered	1			1						
Durbaniella clarki belladonna	Least Concern – Rare (RR, HS)	1		1							
Erikssonia edgei	Critically Endangered	1				1					
Hypolycaena lochmophila	Vulnerable	0			1						
Iolaus aemulus	Least Concern	1		1	1						
Iolaus diametra natalica	Least Concern – Rare (LD)	0			1						
Iolaus lulua	Vulnerable	0			1						
**Iolaus nasisii*	Least Concern	0				1					
Lepidochrysops bacchus	Least Concern – Rare (HS, LD)	1	1	1			1				
Lepidochrysops balli	Least Concern – Rare (HS)	1	1	1							
**Lepidochrysops frederikeae*	Least Concern – Rare (RR)	1					1				
Lepidochrysops gydoae	Least Concern – Extremely Rare	1	1								
Lepidochrysops hypopolia	Extinct	1			1						
Lepidochrysops irvingi	Vulnerable	0						1			
Lepidochrysops jamesi claassensi	Least Concern – Rare (RR, HS)	1					1				
Lepidochrysops jamesi jamesi	Least Concern – Rare (HS)	1					1				
Lepidochrysops jefferyi	Critically Endangered	1						1			
Lepidochrysops ketsi leucomacula	Endangered	1		1	1						
Lepidochrysops littoralis	Endangered	1	1								
Lepidochrysops loewensteini	Least Concern	0		1							
Lepidochrysops lotana	Endangered	1				1					
Lepidochrysops mcgregori	Least Concern – Rare (HS)	1	1				1				
Lepidochrysops methymna dicksoni	Extinct	1	1								
Lepidochrysops oreas oreas	Least Concern – Rare (RR)	1	1								
Lepidochrysops outeniqua	Least Concern	1	1	1							
Lepidochrysops penningtoni	Data Deficient – T	1					1				
Lepidochrysops pephredo	Vulnerable	1			1						
Lepidochrysops praeterita	Endangered	1							1		1
Lepidochrysops pringlei	Least Concern	1	1	1							
Lepidochrysops procera	Least Concern – Rare (HS)	1			1			1	1		1
Lepidochrysops quickelbergei	Least Concern – Extremely Rare	1	1								
Lepidochrysops swanepoeli	Critically Endangered	1						1			
Lepidochrysops victori	Vulnerable	1		1							
Orachrysops ariadne	Endangered	1			1						
Orachrysops brinkmani	Least Concern – Rare (RR, HS)	1	1								
Orachrysops mijburghi	Endangered	1							1	1	
Orachrysops montanus	Vulnerable	1								1	
Orachrysops niobe	Critically Endangered	1	1								
Orachrysops regalis	Endangered	1				1					
Orachrysops violescens	Endangered	1						1			
Orachrysops warreni	Least Concern – Extremely Rare	1						1			
Ornipholidotos peucetia penningtoni	Near Threatened	0			1						
Teriomima zuluana	Vulnerable	0			1						
Thestor barbatus	Critically Endangered	1	1								
Thestor brachycerus brachycerus	Critically Endangered	1	1								
Thestor calviniae	Least Concern – Rare (RR)	1					1				
Thestor camdeboo	Least Concern – Rare (RR)	1		1							
Thestor claassensi	Endangered	1	1								
Thestor compassbergae	Least Concern – Rare (RR)	1		1							
Thestor dicksoni malagas	Vulnerable	1	1								

Thestor dicksoni warreni	Critically Endangered	1	1								
Thestor kaplani	Critically Endangered	1	1								
Thestor petra tempe	Least Concern – Extremely Rare	1	1								
Thestor pictus	Least Concern – Rare (RR, HS)	1	1								
Thestor protumnus terblanchei	Vulnerable	1								1	
Thestor rooibergensis	Least Concern – Rare (RR)	1	1								
Thestor strutti	Critically Endangered	1	1								
Thestor yildizae	Least Concern – Rare (RR)	1	1								
Trimenia argyroplaga cardouwae	Least Concern	1	1								
Trimenia malagrida malagrida	Critically Endangered – Possibly Extinct	1	1								
Trimenia malagrida maryae	Endangered	1	1								
Trimenia malagrida paarlensis	Critically Endangered – Possibly Extinct	1	1								
Trimenia wallengrenii gonnemoi	Endangered	1	1								
Trimenia wallengrenii wallengrenii	Critically Endangered – Possibly Extinct	1	1								
Trimenia wykehami	Least Concern	1	1				1				
Tuxentius melaena griqua	Least Concern	1					1			1	
NYMPHALIDAE											
Cassionympha camdeboo	Least Concern – Rare (RR)	1		1							
**Cassionympha perissinottoi*	Least Concern – Rare (RR, HS)	1	1								
Charaxes druceanus solitarius	Least Concern – Rare (RR)	1				1					
Charaxes marieps	Least Concern – Rare (RR)	1						1			
Charaxes xiphares occidentalis	Least Concern – Extremely Rare	1	1								
Charaxes xiphares staudei	Least Concern – Rare (RR)	1				1					
Coenyropsis natalii poetulodes	Least Concern	1				1					
Cymothoe alcimeda clarki	Least Concern	1		1							
Dingana alaedeus	Near Threatened	1			1			1			
Dingana clara	Endangered	1				1					
Dingana dingana	Endangered	1			1						
Dingana fraterna	Critically Endangered	1				1		1			
Dingana jerinae	Vulnerable	1				1					
Dira swanepoeli isolata	Vulnerable	1				1					
Neita lotenia	Least Concern – Rare (LD)	0			1						
**Neptis serena serena*	Least Concern	0				1					
Pseudonympha paragaika	Least Concern – Extremely Rare	1								1	
Pseudonympha southeyi kamiesbergensis	Least Concern – Rare (RR, HS)	1					1				
Pseudonympha southeyi southeyi	Least Concern – Extremely Rare	1		1							
Pseudonympha swanepoeli	Endangered	1				1		1			
Serradinga clarki amissivallis	Vulnerable	1						1			
Serradinga kammanassiensis	Least Concern – Rare (RR, HS)	1	1								
Stygionympha dicksoni	Critically Endangered – Possibly Extinct	1	1								
Telchinia induna salmontana	Endangered	1				1					
Torynesis mintha piquetbergensis	Vulnerable	1	1								
Torynesis orangica	Least Concern – Rare (RR, HS)	1								1	
PAPILIONIDAE											
Papilio ophidicephalus entabeni	Least Concern	1				1					
Papilio ophidicephalus transvaalensis	Least Concern	1				1					
Papilio ophidicephalus zuluensis	Least Concern – Rare (RR, HS)	1			1						
PIERIDAE											
Colotis celimene amina	Least Concern	0			1	1		1	1		
**Dixeia leucophanes*	Least Concern	0				1					

[1] LD = Low Density, HS = Habitat Specialist, RR = Restricted Range, Data Deficient – T = taxonomic uncertainty.

[2] Provinces: WC = Western Cape, EC = Eastern Cape, KZN = KwaZulu-Natal, LP = Limpopo, NC = Northern Cape, MP = Mpumalanga, GP = Gauteng, FS = Free State, NW = North West.

Table 4 – The number of butterfly taxa in each Red List and Rare category from the 2012 and 2018 (current) conservation assessments. The categories for the seven new taxa assessed for SALCA are shown in the second-last column, but they are also included in the totals for 2018. Also indicated are the rare categories used to flag Least Concern taxa that are of conservation concern nationally. The last column gives the numbers of endemic taxa (% in parentheses).

Red List categories	No. of taxa			No. of endemics (%) for 2018
	2012	2018	Non-SABCA taxa	
Extinct	3	3	0	3 (100)
Critically Endangered – Possibly Extinct	3	5	0	5 (100)
Critically Endangered	11	20	0	20 (100)
Endangered	27	31	0	30 (97)
Vulnerable	19	20	0	16 (80)
Near Threatened	5	7	0	5 (71)
Data Deficient	9	1	0	1 (100)
Least Concern – Extremely Rare & Rare	77	56	3	52 (93)
Least Concern	639[1]	657	4	282 (43)
Total	**793[1]**	**800**	**7**	**414 (52)**
Total Threatened[2]	**60**	**76**	**0**	**71 (93)**
Least Concern – Extremely Rare	6	9	0	9 (100)
Least Concern – Rare (Restricted Range)	27	17	2	17 (100)
Least Concern – Rare (Habitat specialist)	22	7	0	7 (100)
Least Concern – Rare (Low Density)	15	6	0	2 (33)
Least Concern – Rare (Restricted Range, Habitat Specialist)	6	15	1	15 (100)
Least Concern – Rare (Habitat Specialist, Low Density)	1	2	0	2 (100)
Data Deficient – T[3]	5	1	0	1 (100)
Data Deficient – D[3]	4	0	0	0
Total taxa of conservation concern[4]	**154**	**143**	**3**	**92**

[1] Since SABCA, *Charaxes karkloof karkloof* and *Charaxes karkloof capensis* have been synonymised to *Charaxes karkloof karkloof*. Both were assessed as Least Concern and both are endemics. Therefore, the 2012 Least Concern and Total values have been adjusted accordingly by reducing the numbers by a value of one.
[2] Threatened taxa include all those assessed as Critically Endangered (including Possibly Extinct), Endangered and Vulnerable.
[3] Data Deficient – T = taxonomic uncertainty, Data Deficient – D = distribution uncertainty.
[4] Taxa of conservation concern include all the taxa except those that are Least Concern and not rare.

Table 5 – The number of butterfly taxa in each Red List and Rare category per butterfly family, for the 165 SALCA taxa.

Red List categories	No. of taxa per family				
	Hesperiidae	Lycaenidae	Nymphalidae	Papilionidae	Pieridae
Extinct	0	3	0	0	0
Critically Endangered – Possibly Extinct	0	4	1	0	0
Critically Endangered	3	16	1	0	0
Endangered	0	27	4	0	0
Vulnerable	2	14	4	0	0
Near Threatened	2	4	1	0	0
Data Deficient	0	1	0	0	0
Least Concern – Extremely Rare & Rare	1	42	12	1	0
Least Concern	2	13	3	2	2
Total	**10**	**124**	**26**	**3**	**2**
Total Threatened[1]	**5**	**61**	**10**	**0**	**0**
Total taxa of conservation concern[2]	**8**	**111**	**23**	**1**	**0**

[1] Threatened taxa include all those assessed as Critically Endangered (including Possibly Extinct), Endangered and Vulnerable.
[2] Taxa of conservation concern include all the taxa except those that are Least Concern and not rare.

Table 6 – The number of Red Listed and Rare butterfly taxa per province in South Africa, for the 165 SALCA taxa.

Red List categories	No. of taxa per province[1]								
	WC	EC	KZN	LP	NC	MP	GP	FS	NW
Extinct	1	1	1	0	0	0	0	0	0
Critically Endangered – Possibly Extinct	5	1	0	0	0	0	0	0	0
Critically Endangered	12	0	1	5	0	4	0	0	0
Endangered	11	5	5	5	0	7	4	1	1
Vulnerable	4	5	6	2	1	2	0	2	0
Near Threatened	2	1	4	1	1	2	1	0	0
Data Deficient	0	0	0	0	1	0	0	0	0
Least Concern – Extremely Rare & Rare	27	11	8	4	11	3	1	2	1
Least Concern	6	8	2	9	3	2	2	1	1
Total	68	32	27	26	17	20	8	6	3
Total Threatened[2]	32	11	12	12	1	13	4	3	1
Total taxa of conservation concern[3]	62	24	25	17	14	18	6	5	2
Total endemics	68	30	18	20	16	17	7	6	3

[1] Provinces: WC = Western Cape, EC = Eastern Cape, KZN = KwaZulu-Natal, LP = Limpopo, NC = Northern Cape, MP = Mpumalanga, GP = Gauteng, FS = Free State, NW = North West.
[2] Threatened taxa include all those assessed as Critically Endangered (including Possibly Extinct), Endangered and Vulnerable.
[3] Taxa of conservation concern include all the taxa except those that are Least Concern and not rare.

Table 7 – The 54 butterfly taxa for which the Red List status changed from the 2012 to the 2018 assessment periods. The original 2012 Red List assessment is given as well as that for 2018. An indication of whether or not the change in status from 2012 to 2018 is genuine or not is given, and in cases where the change in status is not genuine back-casted Red Listings are provided for the 2012 period. The reasons for change in status are shown: A – Measured or inferred change in population size since previous assessment (genuine); B – Change in nature of threats since previous assessment (genuine); C – Change in intensity of threats since previous assessment (genuine); D – New or better information available (non-genuine); E – Incorrect Red List assessment application previously (non-genuine); F – Incorrect information used before (non-genuine).

Taxon	2012 Red List[1]	2018 Red List[1]	Genuine change (Yes/No)	Back-casted 2012 Red List[1]	Change in status reason					
					A	B	C	D	E	F
Abantis bicolor	LC	NT	N	NT	1	0	1	0	1	0
Aloeides pallida juno	LC	EN	Y	LC	0	1	0	1	0	0
Aloeides pallida littoralis	DD	NT	N	NT	1	0	1	1	0	0
Aloeides rossouwi	EN	CR	N	CR	1	1	0	1	0	0
Aloeides stevensoni	EN	CR	Y	EN	1	1	0	1	0	0
Anthene crawshayi juanitae	CR	LC	N	LC	1	0	1	1	0	0
Anthene lindae	VU	NT	N	NT	0	0	0	1	0	0
Aslauga australis	NT	EN	N	EN	0	0	0	1	0	0
Capys penningtoni	EN	CR	Y	EN	1	1	1	1	0	0
Chrysoritis adonis adonis	LC	CR	N	CR	0	0	0	1	0	1
Chrysoritis brooksi tearei	VU	EN	N	EN	0	0	0	1	0	0
Chrysoritis oreas	NT	LC	N	LC	0	0	0	0	1	0
Chrysoritis phosphor borealis	LC	EN	N	EN	1	1	0	1	0	0
Chrysoritis pyroeis hersaleki	VU	LC	N	LC	0	0	0	1	1	1
Chrysoritis rileyi	CR	EN	N	EN	0	0	0	1	0	0
Chrysoritis thysbe mithras	DD	CR–PE	N	CR–PE	1	0	0	1	0	0
Coenyropsis natalii poetulodes	DD	LC	N	LC	0	0	0	1	0	0
Crudaria wykehami	DD	LC	N	LC	1	0	0	1	0	1
Cymothoe alcimeda clarki	VU	LC	N	LC	0	0	0	0	1	1
Dingana dingana	VU	EN	N	EN	0	0	0	1	1	0
Dingana fraterna	CR–PE	CR	N	CR	1	0	0	0	0	0

Dingana jerinae	LC	VU	N	VU	0	0	0	1	1	0
Dira swanepoeli isolata	LC	VU	N	VU	0	0	0	1	1	0
Durbaniella clarki belladonna	VU	LC	N	LC	0	0	0	0	1	0
Hypolycaena lochmophila	LC	VU	N	VU	0	1	1	1	0	0
Iolaus lulua	LC	VU	N	VU	0	1	1	1	0	0
Kedestes lenis lenis	EN	CR	Y	EN	0	1	1	0	0	0
Kedestes niveostriga schloszi	EN	VU	N	VU	0	0	0	1	0	0
Kedestes sarahae	LC	CR	Y	VU	0	0	0	1	0	1
Lepidochrysops irvingi	EN	VU	N	VU	1	0	1	1	0	0
Lepidochrysops jefferyi	EN	CR	N	CR	0	0	1	0	0	1
Lepidochrysops littoralis	NT	EN	N	EN	1	0	1	1	0	0
Lepidochrysops swanepoeli	EN	CR	N	CR	0	0	1	0	0	1
Metisella meninx	LC	NT	Y	LC	1	0	1	0	0	0
Metisella syrinx	LC	VU	N	VU	0	0	0	1	0	0
Orachrysops montanus	LC	VU	N	VU	0	0	0	0	1	0
Orachrysops regalis	LC	EN	Y	LC	0	1	1	1	1	0
Orachrysops violescens	VU	EN	N	EN	0	0	0	0	1	0
Ornipholidotos peucetia penningtoni	LC	NT	N	NT	0	0	0	1	1	0
Pseudonympha paragaika	VU	LC	N	LC	0	0	0	0	1	0
Pseudonympha swanepoeli	DD	EN	N	EN	0	1	1	1	0	0
Serradinga clarki amissivallis	LC	VU	N	VU	0	1	0	1	0	0
Teriomima zuluana	LC	VU	N	VU	1	0	1	1	0	0
Thestor barbatus	DD	CR	Y	LC	0	0	1	1	0	0
Thestor claassensi	VU	EN	Y	VU	1	0	0	1	0	0
Thestor dicksoni warreni	DD	CR	N	CR	0	0	0	1	0	0
Thestor kaplani	EN	CR	N	CR	0	0	0	1	0	1
Thestor strutti	LC	CR	Y	LC	0	0	0	1	0	0
Torynesis mintha piquetbergensis	LC	VU	N	VU	0	0	1	0	1	0
Trimenia malagrida maryae	LC	EN	Y	LC	0	0	0	1	0	0
Trimenia malagrida paarlensis	CR	CR–PE	Y	CR	1	0	0	0	0	0
Trimenia wallengrenii gonnemoi	VU	EN	N	EN	0	0	0	1	0	1
Trimenia wallengrenii wallengrenii	CR	CR–PE	Y	CR	1	0	0	1	0	0
Tuxentius melaena griqua	DD	LC	N	LC	0	1	0	1	0	0
Total					**17**	**12**	**17**	**40**	**14**	**9**

Table 8 – The Red List Index (RLI) for butterflies assessed in 2012 (first assessment) and 2018 (second assessment). Data Deficient taxa were excluded (n = 1), as were taxa assessed as Extinct in the first assessment (n = 3). The RLI is given for all butterfly taxa, only the SALCA taxa and per family.

Family	**Number of taxa**	**RLI 2012**	**RLI 2018**	**Change (%)**
All	796	0.945	0.939	-0.006 (0.7%)
Only SALCA taxa	161	0.728	0.697	-0.031 (4.3%)
Lycaenidae	393	0.911	0.900	-0.011 (1.2%)
Hesperiidae	108	0.974	0.968	-0.006 (0.6%)
Nymphalidae	227	0.974	0.974	0 (0%)
Pieridae	50	1	1	0 (0%)
Papilionidae	18	1	1	0 (0%)

Table 9 – The number of taxa in each protection level category, for the 162 SALCA taxa (three Extinct taxa excluded), per Red List or rarity category. Also shown is the number of taxa for which protection levels are unknown and the number that were not evaluated.

Red List or rarity category	No. of taxa per protection level					
	Well protected	Moderately protected	Poorly protected	Not protected	Unknown	Not evaluated
Critically Endangered – Possibly Extinct	1			4		
Critically Endangered	2	3	1	12	2	
Endangered		1	19	11		
Vulnerable	2	5	4	8	1	
Near Threatened		2	4		1	
Data Deficient				1		
Least Concern – Extremely Rare	4	1		2	3	
Least Concern – Rare (Restricted Range)	2	3	7	4		
Least Concern – Rare (Habitat specialist)	1	1	2	3		
Least Concern – Rare (Low Density)		2	3		1	
Least Concern – Rare (Restricted Range, Habitat Specialist)	3	5	3	3	1	
Least Concern – Rare (Habitat Specific, Low Density)			1	1		
Least Concern		2	7	8	1	4
Total	**15**	**25**	**51**	**57**	**10**	**4**
Total threatened[1]	**5**	**9**	**24**	**35**	**3**	**0**
Total taxa of conservation concern[2]	**15**	**23**	**44**	**49**	**9**	**0**

[1] Threatened taxa include all those assessed as Critically Endangered (including Possibly Extinct), Endangered and Vulnerable.

[2] Taxa of conservation concern include all the taxa except those that are Least Concern and not rare (but the three Extinct taxa are excluded in this analysis).

Table 10 – The sensitivity levels that the threatened, extremely rare and rare taxa qualified for during the critical habitat mapping analysis.

Red List or rarity category	Sensitivity		
	Very high	High	Medium
Critically Endangered – Possibly Extinct	2	3	4
Critically Endangered	18	20	17
Endangered	0	28	28
Vulnerable	5	17	19
Least Concern – Extremely Rare	6	7	1
Least Concern – Rare (Restricted Range)	6	16	0
Least Concern – Rare (Habitat specialist)	0	6	7
Least Concern – Rare (Low Density)	0	6	6
Least Concern – Rare (Restricted Range, Habitat Specialist)	7	14	1
Least Concern – Rare (Habitat Specialist, Low Density)	0	2	0
Total	**44**	**119**	**83**

Table 11 – The number of threatened taxa and TCC in each biome, ranked by the biome containing the most number of threatened taxa.

Biome	No. of taxa							No. threatened taxa	No. TCC[1]	% of total threatened (*n* = 76)	% of total TCC[1] (*n* = 140)
	CR–PE	CR	EN	VU	NT	DD	LC (Extremely Rare and Rare)				
Grassland	0	7	17	12	3	0	17	36	56	47.4	40.0
Fynbos	5	12	11	4	2	0	35	32	69	42.1	49.3
Savanna	0	1	10	6	4	0	7	17	28	22.4	20.0
Forests	1	0	8	6	2	0	7	15	24	19.7	17.1
Albany Thicket	1	1	7	0	1	0	3	9	13	11.8	9.3
Indian Ocean Coastal Belt	0	0	2	3	2	0	2	5	9	6.6	6.4
Succulent Karoo	0	0	1	1	0	1	10	2	13	2.6	9.3
Azonal Vegetation	0	0	0	0	0	0	2	0	2	0.0	1.4
Nama-Karoo	0	0	0	0	0	0	3	0	3	0.0	2.1

[1] Extinct taxa have been excluded.
[2] CR–PE = Critically Endangered – Possibly Extinct; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; DD = Data Deficient; LC = Least Concern.

Table 12 – The vegetation types (SANBI, 2018) containing the highest number of threatened taxa and TCC, ranked first by the vegetation types containing five or more threatened taxa, then ranked by the vegetation types containing three or more TCC.

Vegetation type	CR–PE	CR	EN	VU	NT	DD	Extremely Rare and Rare	No. threatened taxa	No. TCC[1]
Gm23 Northern Escarpment Quartzite Sourveld		1	6	1			1	8	9
FOz4 Northern Mistbelt Forest			4	2			3	6	9
AT40 Hartenbos Dune Thicket	1		5		1			6	7
Gs9 Midlands Mistbelt Grassland		1	3	1			1	5	6
Gm26 Wolkberg Dolomite Grassland		2	3					5	5
FOz5 Scarp Forest			2	1	1		3	3	7
FOz7 Northern Coastal Forest				3	2		2	3	7
SVcb11 Andesite Mountain Bushveld			4		1		1	4	6
FFs10 Hawequas Sandstone Fynbos		1	1	1			3	3	6
FFs26 South Kammanassie Sandstone Fynbos							6	0	6
SKt3 Roggeveld Karoo							6	0	6
FFd10 Knysna Sand Fynbos	1	2	1		1			4	5
FFl3 Canca Limestone Fynbos		1	3		1			4	5
Gm11 Rand Highveld Grassland		2	2		1			4	5
Gm17 Barberton Montane Grassland		2	1	1	1			4	5
Gm30 Steenkampsberg Montane Grassland			2	1	1		1	3	5
Gm8 Soweto Highveld Grassland			3		1		1	3	5
SVl18 Tembe Sandy Bushveld				3	1		1	3	5
CB1 Maputaland Coastal Belt				2	1		2	2	5
FFs12 Overberg Sandstone Fynbos			1	1	1		2	2	5
Gd4 Southern Drakensberg Highland Grassland		1		1			3	2	5
Gs20 Moist Coast Hinterland Grassland			1	1	1		2	2	5
SVl23 Zululand Lowveld				2	1		2	2	5
FFs5 Winterhoek Sandstone Fynbos		1					4	1	5
FFb3 Central Inland Shale Band Vegetation							5	0	5
Gm31 Long Tom Pass Montane Grassland			3	1				4	4
Gs8 Mooi River Highland Grassland		1	2	1				4	4
CB3 KwaZulu-Natal Coastal Belt Grassland			2	1	1			3	4
FFl2 De Hoop Limestone Fynbos			2	1	1			3	4
FRs9 Swartland Shale Renosterveld	1	1		1			1	3	4

Gs10 Drakensberg Foothill Moist Grassland		1	1	1			1	3	4
FFa2 Breede Alluvium Fynbos			2	1				3	3
FFd8 Breede Sand Fynbos			2	1				3	3

[1] The Extinct taxa have been excluded.
[2] CR–PE = Critically Endangered – Possibly Extinct; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; DD = Data Deficient; LC = Least Concern.

Table 13 – The relevant sub threats to the main threats shown in Figure 4, for the threatened, Near Threatened and Data Deficient taxa, in the same order as in Figure 4. This follows the IUCN threat classification scheme.

Main threat	**Sub threat**
Natural system modifications	Dams & water management/use
	Fire & fire suppression
	Other ecosystem modifications (bush encroachment)
	Other ecosystem modifications (bush clearing)
	Other ecosystem modifications (road verge clearing/mowing)
Agriculture & aquaculture	Livestock farming & ranching
	Wood & pulp plantations
	Annual & perennial non-timber crops
Invasive and other problematic species, genes & diseases	Invasive non-native/alien species/diseases
	Problematic native species/diseases
Climate change & severe weather	Habitat shifting & alteration
	Droughts
	Temperature extremes
	Storms & flooding
Residential & commercial development	Housing & urban areas
	Commercial & industrial areas
	Tourism & recreation areas
Pollution	Agricultural & forestry effluents
	Air-borne pollutants
	Garbage & solid waste
	Domestic & urban waste water
	Industrial & military effluents
Human intrusions & disturbance	Recreational activities
	Work & other activities
Transportation & service corridors	Roads & railroads
	Utility & service lines
Energy production & mining	Mining & quarrying
	Oil & gas drilling
Biological resource use	Logging & wood harvesting
	Hunting & trapping terrestrial animals
	Gathering terrestrial plants

Table 14 – The top five moth superfamilies, as well as the top 10 families, from the georeferenced data within the study region, both for number of records and number of species. The values in parentheses were not in the top five or 10, respectively.

Superfamily	**No. of records**	**No. of species**	**Family**	**Count records**	**Count species**
Noctuoidea	72 540	1 163	Noctuidae	37 710	445
			Erebidae	29 769	589
			Notodontidae	4 400	69
Geometroidea	47 696	907	Geometridae	47 406	894
Bombycoidea	14 636	207	Sphingidae	6 993	63
			Saturniidae	3 580	(26)
			Lasiocampidae	2 879	80
Zygaenoidea	(2196)	(64)	Limacodidae	2 111	55
Gelechioidea	7 393	234	Gelechiidae	6 607	209
Pyraloidea	2 240	231	Crambidae	1 914	154
			Pyralidae	(326)	77

Table 15 – Comparison between the UK Millennium Atlas (2001)[1], SABCA project (2012)[2] and SALCA project (2018).

	Britain & Ireland [1]	**South Africa, Lesotho & Eswatini** [2]	
		SABCA [2]	**SALCA**
Period of data collection	1995–1999	2007–2011	2013–2017
Size of study area (1 000 km^2)	312 [3]	1 262 [3]	1 262 [3]
No. of described taxa	59	794	800
No. of assessed taxa	59	794	165
Taxa assessed per 1 000 km^2	0.19	0.63	0.13
No. of taxon experts	>100 [4]	13	16
No. of observers	c. 10 000	<100	<50
Experts per assessed taxon	> 1.70	c. 0.03	c. 0.12
Observers per assessed taxon	c. 170	< 0.13	<0.30
Observers per 1 000 km^2	c. 32	< 0.08	< 0.04
Endemic taxa	0	420	414
% endemic taxa[5]	0	52.9	52.0
Threatened taxa[6]	4 [7]	60 [8]	76 [8]
% threatened	6.8	7.6	9.5
Threatened taxa per expert	0.04	4.6	4.8

[1] Asher *et al.*, 2001; [2] Mecenero *et al.*, 2013; Edge & Mecenero, 2015b; [3] Readers Digest, 2007; [4] Mostly with tertiary qualifications; [5] % of described taxa; [6] includes Critically Endangered, Endangered, Vulnerable categories; [7] local assessments only; [8] global assessments.

Table 16 –The initial and current status of COREL butterflies and moths.

Taxon	Province	Status when added[1]	No. of initial localities	Current status[1]	No. of current localities
Original taxa (2011)					
Alaena margaritacea	Limpopo	CR	1	CR	2
Anthene crawshayi juanitae	Limpopo	CR–PE	0	LC – Rare (RR)	2
Callioratis millari	KwaZulu-Natal	CR	1	CR	1
Chrysoritis dicksoni	Western Cape	CR	1	CR	2
Chrysoritis rileyi	Western Cape	CR	1	EN	3
Chrysoritis thysbe schloszae	Western Cape	CR	1	CR	0
Dingana fraterna	Mpumalanga	CR–PE	0	CR	2
Erikssonia edgei	Limpopo	CR–PE	0	CR	1
Kedestes barberae bunta	Western Cape	CR	1	CR	2
Orachrysops niobe	Western Cape	CR	1	CR	1
Stygionympha dicksoni	Western Cape	CR–PE	0	CR–PE	0
Thestor brachycerus brachycerus	Western Cape	CR	1	CR	2
Trimenia malagrida malagrida	Western Cape	CR–PE	0	CR–PE	0
Trimenia malagrida paarlensis	Western Cape	CR–PE	0	CR–PE	0
Trimenia wallengrenii wallengrenii	Western Cape	CR–PE	0	CR–PE	0
Taxa added in 2014					
Deloneura immaculata	Eastern Cape	EX	0	EX	0
Lepidochrysops hypopolia	KwaZulu-Natal	EX	0	EX	0
Lepidochrysops methymna dicksoni	Western Cape	EX	0	EX	0
Aloeides pallida littoralis	Western Cape	DDT	?	NT	13
Chrysoritis thysbe mithras	Western Cape	DDT	?	CR–PE	0
Crudaria wykehami	Eastern Cape	DDT	?	LC	?
Lepidochrysops penningtoni	Western Cape	DDT	1	DDT	?
Pseudonympha swanepoeli	Limpopo	DDT	5	EN	5
Thestor barbatus	Western Cape	DDD	1	CR	1
Thestor dicksoni warreni	Western Cape	DDD	1	CR	1
Taxon added in 2015					
Aloeides thyra orientis	Western Cape	EN	2	EN	4
Taxa added in 2016					
Aloeides trimeni southeyae	Western Cape	EN	2	EN	3
Kedestes niveostriga schloszi	Western Cape	EN	1	VU	3
Lepidochrysops littoralis	Western Cape	NT	8	EN	10
Lepidochrysops outeniqua	Western Cape	LC – Rare (RR)	2	LC	<10
Taxa added in 2018					
Aloeides rossouwi	Mpumalanga	CR	1	CR	1
Aloeides stevensoni	Limpopo	CR	1	CR	2
Capys penningtoni	KwaZulu-Natal	CR	8	CR	8
Chrysoritis adonis adonis	Western Cape	CR	1	CR	1
Kedestes lenis lenis	Western Cape	CR	4	CR	4
Kedestes sarahae	Western Cape	CR	1	CR	1
Lepidochrysops jefferyi	Mpumalanga	CR	1	CR	1
Lepidochrysops praeterita	Gauteng, North West	EN	<10	EN	<10
Lepidochrysops swanepoeli	Mpumalanga	CR	1	CR	1
Thestor kaplani	Western Cape	CR	1	CR	1
Thestor strutti	Western Cape	CR	1	CR	1

[1] EX = Extinct; CR–PE = Critically Endangered – Possibly Extinct; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; DDT = Data Deficient Taxonomy; DDD = Data Deficient Distribution; LC = Least Concern; RR = Restricted Range.

Table 17 – Benefits of conserving Lepidoptera diversity.

Benefit	**Description**
Economic benefits	Economic benefits. Direct use value – silk moths; Mopani worms. Indirect use value – butterfly farms, attraction to tourists. Option value – potential future benefits of physiological chemicals. Existence value – they are irreplaceable.
The wild experience	Beauty – aesthetics, artistic inspiration. Metamorphosis – fascination.
Ecological importance	Part of the food web; predators, prey, parasites or hosts; symbiosis with ants. Control of agricultural pests. Pollination of plants. Impact on succession processes of plants. Contribution to ecosystem services.
Indicators of community or habitat health/ human disturbance	Most butterfly species easily recognisable and we have considerable knowledge of their ecology.
As flagship species for conservation	Public interest and sympathy.
As subjects of scientific study	To better understand invertebrate evolution and ecology. Population dynamics. DNA studies.