DISCUSSIONS
ДИСКУССИИ

THE BOTTOM-UP ASSESSMENT OF THREATENED SPECIES

Bruno Kestemont[1,2]

[1]*Université Libre de Bruxelles, Belgium*
[2]*Federal Public Service Economy, Belgium*
e-mail: bruno.kestemont@economie.fgov.be

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Identifying the percentage of endangered species is crucial for the protection of biodiversity from local to global levels. However, the high costs of species evaluation jeopardise the feasibility of evaluating all world species. We propose a model to consolidate imperfect local assessments to a first (conservative) estimation of national to global assessment. We used it for the evaluation of 8132 Belgian species starting with incomplete red lists at lower geographic levels (Belgian regions). The model is based on the logical assumption that if a species is safe («Least Concern») at local level (> 10 000 km^2), then it is safe at global level. It can be used at various geographic levels to help aggregate imperfect local red lists into a first estimate of global ones. Testing the model shows that it gives very conservative results because less species are evaluated endangered at global level than when using other methods. Our model can deal with non-standard local red lists, with an error range that is reducing when local red lists become compliant with the IUCN standards. It cannot and does not aim to replace full IUCN-compliant assessments. We show the value of publishing the lists of currently safe species – not only those that are threatened. Actually, in the light of the sixth mass extinction, identifying safe species becomes as important as those that are endangered. We encourage trained biologists to evaluate less-known groups like invertebrates, algae, or microfungi. Our model facilitates a low cost first rough conservative estimate at global level. This can help historical reviews as well as identifying research and policy priorities. Our tests question the IUCN guidelines for species that are stable but only present in areas smaller than a few km^2.

Key words: Belgium, biodiversity, geographic levels, global level, indicator, local level, model, red list, species mass appraisal, threat

Introduction

The percentage of threatened species is a widely used indicator of biodiversity (e.g. Demolder et al., 2017; IUCN, 2018; OECD.Stat, 2018). Identifying specific endangered species within «red lists» is crucial to protect biodiversity. The combination of biodiversity data from all over the world contributed to reveal the human-induced sixth mass extinction (Ceballos et al., 2015) and to identify it as one of the major planetary problems humanity faces today (Rockström et al., 2009). The assessment of the status of individual species is often a matter of expert consensus based on the literature and, basically, on regional or national surveys (more and more citizen science data is used to determine the Extent of Occurrence and/or Area of Occupancy; also to calculate trends) (van Swaay et al., 2011; Maes et al., 2015). A rather implicit or explicit set of models is then used by the expert groups to consolidate the regional assessments into a global assessment. However, the high costs of species evaluation jeopardises the feasibility of evaluating all world species. This problem becomes particularly crucial in a globally changing world where more large-scale regular assessments over a period of time could be needed. Since the improvement of information flow between national and global red list assessments is critically important (Rodríguez et al., 2000; Gardenfors, 2001), we propose a model which promotes local or national red lists for mass assessment on a larger scale. The model not only diminishes the huge amount of work needed for a global assessment but also helps determine research priorities.

The following section explains our proposed method followed by the case data used. The result section presents an illustrative case for amphibians in Belgium and the resulting aggregated indicators and figures for several species groups. We finish by discussing the pros and cons of the model compared to alternative calculations. We then move to conclude.

Material and Methods

Various methods can be used at local level to assess the threat status of a species or of a specific type of ecosystem. «Local» here means relatively large areas: ideally at minimum 10 000 km^2 (depending on the species group and the nature of the ecosystem considered), for example, national or subnational regions or states. The IUCN regional (non-global) criteria (2003) can be used at almost all levels of more than 10 000 km^2. Our method assumes that if a short-range moving species or an ecosystem is not threatened at the local level, then it is not threatened at the global level. The method is reliable for short-range moving species. For large-range moving species (e.g. migrating birds), it concentrates on the breeding locations – as is generally accepted.

The goal here is to know whether a species is threatened or not in a certain area. For example, if there were plenty of a breeding species in a given area, it would probably be assessed as «Not Threatened» (IUCN status «Least Concern»). The biologically correct method to assess the threat status of a species would be to not evaluate the extinction risk of anything but entire, totally isolated populations (Gardenfors, 2001). Nevertheless, many conservation policies are bound within geopolitical borders, and most of the red lists are only available at this level. From a local (regional) point of view, an expert would consider that there is no local (regional) problem for this species, if one of the following conditions is met:

(1) The number of mature individuals for this species is sufficient, within the considered area, to survive in the long term. And the habitat potential is sustained (which means that there is a sufficient breeding potential together with no dramatic decrease of the population or habitat conditions); or

(2) There are sufficient exchanges of individuals from other areas, which can, apparently, sustain the local population in the long term.

Condition (1) above is a summary of the most detailed IUCN criteria list (see IUCN, 2003). Condition (2) above could be added to cover the sub-global levels, for which exchanges with a sustained «rest of the world» is possible. This would rely on a hypothetical knowledge of the «rest of the world».

In practice, the local status of a species is often studied with grids (e.g. 1 km × 1 km) of the occurrence of a breeding species at regular time intervals (usually around 10 years but also depending on the generation length of a species). The status is calculated by a combination of rarity, trend, and nativity classes (Van Landuyt et al., 2006). Nativity involves excluding exotic invasive species from a local list. Rarity is commonly expressed as a small Area of Occupancy (AOO) and Extent of Occurrence (EOO) (see criterion B in IUCN, 2017). Trend is the number of grids where the species was found, when information on the population is not available. Note that these criteria highly depend on the size of the grid resolution (Van Landuyt et al., 2006). An arbitrary standard of 2 km × 2 km is recommended. We have assumed that local red lists used as basic data for our model are scientifically valid and at least in line with the philosophy of the IUCN (2003) rules. In practice, historical assessments are needed for red list construction and historical data are seldom IUCN (2003) compliant. However, our method is designed to deal with incomplete, not fully standardised, but yet scientifically sound local assessments.

Assuming that all assessments cover the same species and are conducted following scientific standards, the expectation would be that more species are threatened at the regional level than at the global level (Brito et al., 2010). This point will be dealt with in the Discussion section.

Let us assume that if a short-range moving species or ecosystem is not threatened at the local level, then it is not threatened at the global level. We assume that local assessments do not consider wider geographic context. This is possibly not always the case for mobile species like migratory birds, butterflies or large mammals – but it could be considered as realistic when considering the assessment of resident species. The method described here is valid if, and only if, local assessments are conservative enough not to consider the wider context. Local red lists are made by local specialists – not relying on the rest of the world to protect the species at the lowest level.

Barring the precautions above, it should be recommended that if the local expert knows that this area is the last where the species exists in the world, they should be more severe and careful in their assessment. If they can prove that the local population is absolutely safe, then, logically, the global assessment could be revised as «safe» (no threat). Otherwise, the local expert has good reasons to classify the species in one of the endangered categories at the local level. Our method is sufficient for a first assessment of most of the species at the lowest levels of the trophic pyramid. For practical and normative reasons, it should not replace a full IUCN assessment when resources are available to proceed.

Let us give decreasing numeric codes (arbitrary from 10 to 1) to threatened categories as typically used in local red list studies, and additional 11–13 for exotic or non-breeding species (Table 1). These codes have no meaning other than to allow our proposed aggregation method. Most of these categories correspond to IUCN (2003) categories, but local experts usually add «rare» and other subcategories. Local status, like «introduced», «exotic invasive», or «not known», as well as the IUCN status «Not Evaluated»

(NE), can, alternatively, be given the «missing» code. This means that they would not be taken into account in the calculation of the global assessment.

Special attention is needed before giving a code to non-invasive species within the limits of their natural geographic dispersion. In these cases, many old local red lists have noted the species as «rare», «data deficient», or even «not evaluated», but with a comment mentioning the historical observations of the species in the region. For IUCN, «rare» is basically similar to «Near Threatened». The problem with using existing local red lists is verifying the interpretation of «rare». In this frequent «rarity» case, we propose a numeric code just better than «extinct», here «9» or «8» for data deficient species and a default «7» for species classified as «rare» without further documentation on their rarity status. If comments clearly indicate that a species reaches the limit of its natural distribution area in this particular region, or that it is considered «occasional visitor», the status «Non Evaluated» might be given instead. The numeric codes have no purpose other than to help the model select the most probable global status. In the case of «rare» evaluations, a manual check of literature and documentation is recommended in order to interpret the status either as «near threatened» (code «2») or «rare» and not viable without contacts with the rest of the world (default code «7»). In Belgium, for most cases of vertebrates, the species were documented «rare» in one region and critically endangered or extinct in others. A species documented as «rare» in a region and critically endangered in surrounding regions runs the risk to be wrongly evaluated as «near threatened» («2») as a whole. If information is missing on the interpretation of «rare», a default notation of «7» reduces this risk.

We initially calibrated the model for amphibians on older red lists (Table 2, 2004) and the default «7» for «rare» gave the most reliable status for Belgium as a whole. Table 3 shows the resulting percentage of remaining «rare» species on those evaluated for Belgium in 2012. It is important to mention here that «rare» evaluations should be avoided in the future and that strict IUCN criteria should be used instead. Both reintroduced and increasing species also need careful interpretation since, most of the time, it is preferable to interpret them using the values «missing» or «Data Deficient».

By using these decreasing numeric codes, and comparing individual species status for all available regional assessments of a country, we can apply equation 1 to project the main assumption:

$$(1) \quad X = \min(x_i),$$

where X is the numeric code of the status of a given species at the considered global level, ranking from low («Not Threatened» or «Least Concern») to high («Extinct»); x_i is the numeric code of the status of the same species in a spatial sublevel i (Table 1).

Table 1. Numeric codes for threatened categories

Code	Description	IUCN	IUCN code
13	Introduced	Non Evaluated	NE
12	Alien Invasive	Non Evaluated	NE
11	Visiting, Non-Breeding	**Non Evaluated**	**NE**
10	Regionally Extinct	**Regionally Extinct**	**RE**
9	Data Deficient	**Data Deficient**	**DD**
8	Reintroduced	Data Deficient	DD
7	Rare (default)	Data Deficient	DD
6	Recolonising	Data Deficient	DD
5	Critically Endangered	**Critically Endangered**	**CR**
4	Endangered	**Endangered**	**EN**
3	Vulnerable	**Vulnerable**	**VU**
2	Near Threatened	**Near Threatened**	**NT**
1	Least Concern	**Least Concern**	**LC**
	Unknown (Missing)	Non Evaluated	NE

Note: The key of this coding is codes 1–5. All other codes can be given «missing» or the code above. Codes 6, 8, 11–13 can be replaced by 0 or negative number in order to facilitate table sorting only (providing that they are treated as «missing» in the aggregation formula, or 7 as default for 6–8, all depending on taxonomic groups and available literature. The corresponding IUCN code is given in bold for exact match. Other IUCN-equivalents are most probable proxies if no other information is available. Codes 6–8 are often interpreted as 3–5 in local assessments, depending on experts and taxonomic groups.

Table 2. Status of Belgian amphibians based on regional assessments using the «rare» status (2004)

Species name	Belgium	Wallonia	Flanders	Brussels	English Name
Rana arvalis Nilsson, 1842	7		7		Moor Frog
Hyla arborea (Linnaeus, 1758)	5	10	5	10	European Tree Frog
Pelobates fuscus (Laurenti, 1768)	5	10	5		Common Spadefoot Toad
Bombina variegata (Linnaeus, 1758)	5	5	10		Yellow-Bellied Toad
Rana dalmatina Fitzinger, 1838	4	4	10		Agile Frog
Triturus cristatus (Laurenti, 1768)	4	4	7	10	Crested Newt
Epidalea calamita (Laurenti, 1768)	4	4	7		Natterjack Toad
Pelophylax lessonae (Camerano, 1882)	1	1	7		Pool Frog
Lissotriton helveticus (Razoumowsky, 1789)	1	1	7	3	Palmate Newt
Alytes obstetricans (Laurenti, 1768)	1	1	4	5	Midwife Toad
Salamandra salamandra (Linnaeus, 1758)	1	1	3	5	Fire Salamander
Pelophylax esculentus (Linnaeus, 1758)	1	1	1	10	Edible Frog
Lissotriton vulgaris (Linnaeus, 1758)	1	1	1	3	Smooth Newt
Rana temporaria Linnaeus, 1758	1	1	1	2	Common Frog
Bufo bufo (Linnaeus, 1758)	1	1	1	1	Common Toad
Mesotriton alpestris (Laurenti, 1768)	1	1	1	1	Alpine Newt
Status date	2004	2003	1996	2004	
% threatened species*	**40%**	**31%**	**44%**	**57%**	

Note: The Flanders 1996 Red List is not validated as IUCN (2003) compliant. The case shows that it is still possible to get a proxy of the global % of endangered species with imperfect regional data (undefined «rare» status for several species in old assessments). An area-weighted average (treating values > 5 as missing) would have given *Alytes obstetricans* as Nationally Vulnerable and *Salamandra salamandra* as Near Threatened at this time. Exotic species are not displayed in this table (full lists are available in the Electronic Supplement 1).
Source: authors based on Jacobs (2007), Bauwens & Claus (1996), Weiserbs & Jacobs (2005).
* Best IUCN estimate = % threatened extant species if DD and «rare» species are equally threatened as data sufficient species, i.e. (CR + EN + VU) / (total assessed – EX – DD – Rare).

Table 3. Status of Belgian amphibians based on IUCN-compliant regional assessments (2012)

Species name	Belgium (area-weighted)	Belgium (paper model)	Wallonia	Flanders	Brussels
Hyla arborea (Linnaeus, 1758)	5	5	10	5	10
Pelobates fuscus (Laurenti, 1768)	5	5	10	5	
Bombina variegata (Linnaeus, 1758)	5	5	5	10	
Rana dalmatina Fitzinger, 1838	4	4	4		
Triturus cristatus (Laurenti, 1768)	4	3	4	3	10
Epidalea calamita (Laurenti, 1768)	4	3	4	3	
Rana arvalis Nilsson, 1842	3	3		3	
Pelophylax lessonae (Camerano, 1882)	1	1	1	2	
Alytes obstetricans (Laurenti, 1768)	2	1	1	4	5
Salamandra salamandra (Linnaeus, 1758)	2	1	1	3	5
Pelophylax esculentus (Linnaeus, 1758)	1	1	1	1	10
Lissotriton helveticus (Razoumowsky, 1789)	1	1	1	1	3
Lissotriton vulgaris (Linnaeus, 1758)	1	1	1	1	3
Rana temporaria Linnaeus, 1758	1	1	1	1	2
Bufo bufo (Linnaeus, 1758)	1	1	1	1	1
Mesotriton alpestris (Laurenti, 1768)	1	1	1	1	1
Status date	2012	2012	2003	2012	2004
% threatened species*	**44%**	**44%**	**31%**	**50%**	**57%**

Note: The area-weighted average treats values > 5 as missing.
Source: authors based on Jacobs (2007), Jooris et al. (2012), Weiserb & Jacobs (2005).
* Best IUCN estimate referring to the evaluated «known extant species» excluding extinct species.

We tested this explicit model on various species groups in Belgium, using data from NSI (1989), Desender et al. (1995, 2008), Bauwens & Claus (1996), Maelfait et al. (1998), Vandelannoote & Coeck (1998), Maes & Van Dijck (1999), Walleyn & Verbeken (1999), Decleer et al. (2000), Gommers & Vermoesen (2000), Pollet (2000), Biesbrouck et al. (2001), Bonte et al. (2001), Grootaert et al. (2001, 2010), Dekoninck et al. (2003), Bauwens (2004, personal communication), Jacobs (2003, 2007), De Knijf (2006), Goffart et al. (2006), Lamotte (2006), Saintenoy-Simon (2006), Van Landuyt et al. (2006), Philippart (2007), Weiserbs & Jacobs (2007), Fichefet et al. (2008), Triest et al. (2008), Jacobs et al. (2010), Kestemont (2010), Maes et al. (2011, 2012, 2014, 2015), Jooris et al. (2012), Verreycken et al. (2012, 2014), Lafontaine et al. (2013), Lock et al. (2013), Adriaens et al. (2014), Thomaes et al. (2015), Devos et al. (2016), Van Landuyt & De Beer (2017), INBO (2018), and IUCN (2018).

In Belgium, a federal country, nature conservation is the responsibility of the regional authorities. This means that resources are made available in order to assess the biodiversity at the regional level, – not at the national level. The advantage of this case study is that, even if the regional assessments are completely independent, many contacts between experts contribute to the quality improvement of the data (see Maes et al., 2012). We assume that the methods are more or less comparable between the regions; a «nice to have» condition for the use of our method. Another advantage is that the Belgian regions are morphologically very different even though they may share many species. In Belgium, red lists are produced for three regions and the North Sea: the Brussels-Capital Region (162 km^2), the Flemish Region (13 522 km^2), the Walloon Region (16 844 km^2), and the Belgian part of the North Sea (3462 km^2). At the level of Brussels most of the species are threatened – it is not surprising for a city (see Gardenfors, 2001). In the densely populated and coastal Flanders, the situation is mitigated whilst, in the open fields and woods of Wallonia, many species can be considered as «safe». Flanders shares fish species with the North Sea. The Brussels case allows testing the model with a tiny area (much less than the minimum recommended of 10 000 km^2). Small areas should not be excluded from the evaluations, but they do require special attention, as in the case of rarity, explained above and in Table 2. Small natural reserves can, for example, significantly contribute to higher level evaluations. Strictly following IUCN criteria gives the possibility to consider as «Least Concern» a species with an area of occupancy smaller than 10 km^2 on a unique site if its population is stable or increasing on the long term (see IUCN, 2017; Appendix 2).

Results

We constructed a Belgian red list using the model (1) for various species groups. A total of 8132 species, including 7724 native species, have been evaluated so far, out of an estimated number of > 54 000 known or expected breeding species in Belgium (53 907 native + 408 introduced species) (Appendix 1). We present here an example of the detailed data for amphibians (2004) in order to illustrate the effect of the model in the case of basic (not always IUCN-compliant) regional red lists (Table 2). This includes species still considered «rare» without IUCN compliant status.

Table 3 shows an updated result for amphibians (2012) using IUCN-Compliant regional red lists alongside an area-weighted average of the regional scores between «1» and «5». The area-weighted average is only possible with full compliant IUCN-data. We will discuss this alternative method later in this paper.

At the European level, all Belgian species presented here were assessed as «Least Concern» (Temple & Cox, 2009). If there were a species with a European status worse than our result for Belgium then we would suspect a number of possible causes: the local assessment was not IUCN-compliant; the global experts were not aware of the good situation in a Belgian region; an exceptional situation presented above – when a global status could be worse than a local status due to a rapid decrease of the global population.

From the local to the national point of view, the status code numbers of each species either increase or remain the same. In Table 3, the harmonised status codes from the regions are consolidated in column 2 using Equation (1) in order to get a national code number and the related status. Column 1 gives a score using an area-weighted average of the scores between «1» and «5». The resulting indicator of percentage of threatened species is the same for both models in this particular case.

However, as can be seen in Table 3, our model gives a more conservative assessment for each individual species, whilst an area-weighted average would give a more alarmist national/global result. We will discuss this point in the Discussion section.

We have selected the amphibians as an example. The same basic rule was used for the longer lists of plant and invertebrate species, remembering that available historical data often do not fully comply with IUCN (2003) guidelines and that additional information for certain species might lead to manual editing, which is documented in the corresponding records.

Table 4. Regional and resulting national share of threatened species* in Belgium (2019)

Groups	Belgium	Flanders	Wallonia	Brussels	North sea	Year
Vertebrates	**30%**	43%	33%	40%	21%	2016
Mammals	***33%***	*47%*	*29%*	*64%*	*67%*	2016
Reptiles	***57%***	*100%*	*57%*	*100%*		2012
Amphibians	***44%***	*50%*	*31%*	*57%*		2012
Breeding Birds	***32%***	*40%*	*29%*	*30%*		2016
Fish	***22%***	*47%*	*48%*	*11%*	*19%*	2014
Invertebrates						
Ants	**55%**	55%				2003
Ladybugs	**28%**	29%	29%			2014
Dragonflies	**41%**	35%	49%			2013
Butterflies	**40%**	35%	41%			2010
Beetles	**48%**	48%				2008
Aquatic Insects	**25%**	25%				2013
Grasshoppers and Locusts	**33%**	33%	32%			2000
Diptera: Dolichopodes	**35%**	35%				2001
Diptera: Hybotides	**33%**	33%				2001
Spiders	**39%**	39%				1998
Snails and Slugs	**33%**	33%				2009
Molluscs	**13%**					1989
Crustaceans	**2%**					1989
Higher Plants	**32%**	25%	38%			2006
Mosses	**51%**					2017
Macrofungi	**51%**	51%				1999

Note: *Best IUCN estimate (Critically Endangered + Endangered + Vulnerable divided by known extant species excluding «Data Deficient» and all «Rare» and other non-compliant local status).
Source: Author based on all Belgian references in the reference list (see full lists in Electronic Supplement 1).

The resulting indicator «share of threatened species» is shown in Table 4 for several groups of species. It shows that the national aggregated indicator varies widely around the indicators of the regions and the Belgian part of the North Sea, which is a federal administrative responsibility. The case of ladybugs shows that the national indicator can be outside the range between the lower and the higher regional indicators, depending on the particular distribution of the species and their status in different regions. This can be easily explained by an extreme example. Imagine two regions with the same species. One has the first half of the list of species as endangered, and the second half as least concern. In the second region, it is the contrary: the first half of the list is of least concern and the rest is endangered. Applying our method, all species of the country are least concern. This gives 0% threatened for the country while 50% are threatened in both regions.

When there are data for one region only, the default national indicator is the same as the indicator for this region. Table 4 (comparing the score of one region to the national one) shows that a default national percentage in the threatened species indicator resulting from poor data availability (if only one region published a red list) can result in too alarmist or too conservative a national indicator (ranging between the extreme respective local values). However, it gives a quite satisfying first approximation – better than no approximation at all. For example, if we had only Walloon data for amphibians (31% threatened), the use of this indicator as a first estimate for the country would hardly underestimate the national threat. Actually, what our method gives is a national threat that ranges between more or less 31% (Walloon) and more or less 50% (Flanders), with a most probable 44%.

The method used above has been adopted by default and progressively adjusted over the years by Statistics Belgium (2019) to update aggregated biodiversity statistics in formats like Table 4, Fig. 1, Appendix 1, and an additional table showing the evolution of the indicator over time for available groups. It helps to supply statistics or national reports to international organisations like OECD, Eurostat, or the United Nations (see Kingdom of Belgium, 2014; OECD.Stat, 2018). The resulting national and regional «red lists» for almost 5249 species (Kestemont, 2010) were used to document the http://www.species.be inventory (Grootaert et al., 2010). The full updated database is available at Electronic Supplement 1.

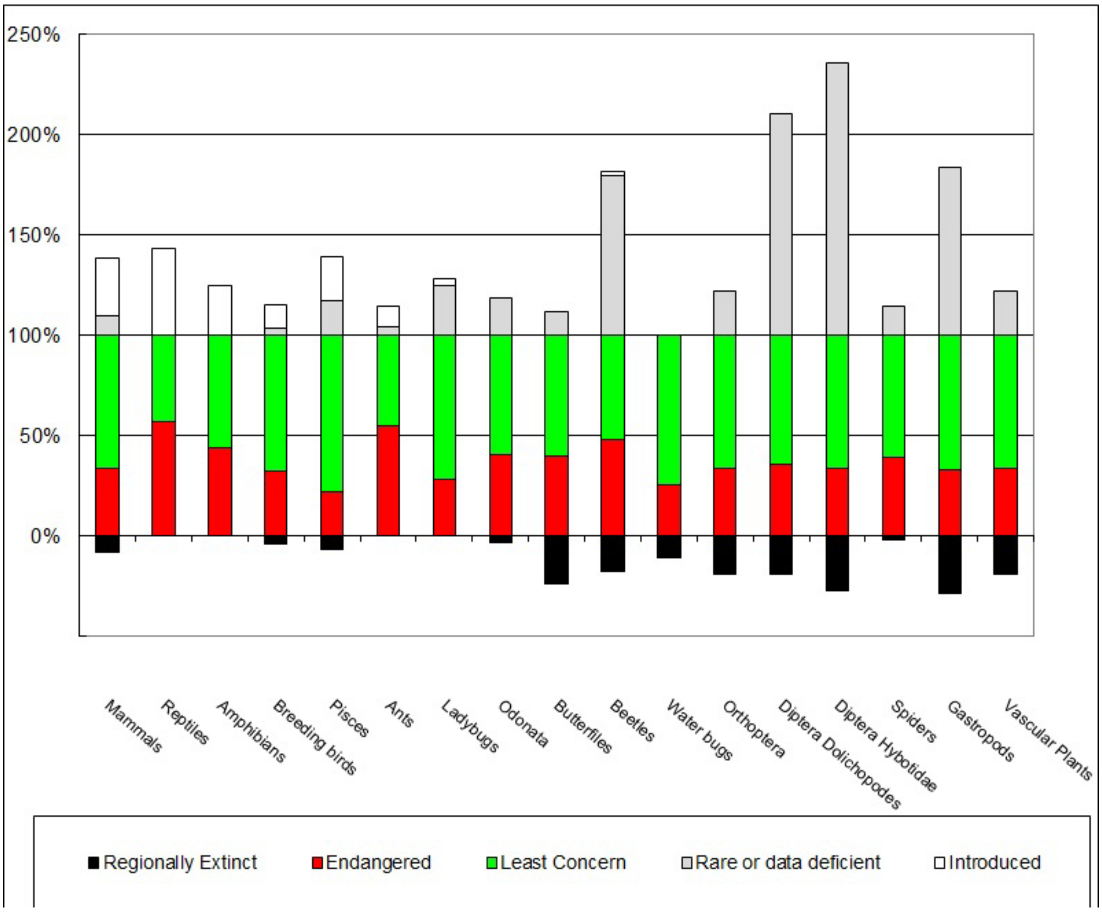

Fig. 1. Example chart: Share of endangered species in Belgium (evaluated species) based on Electronic Supplement 1.

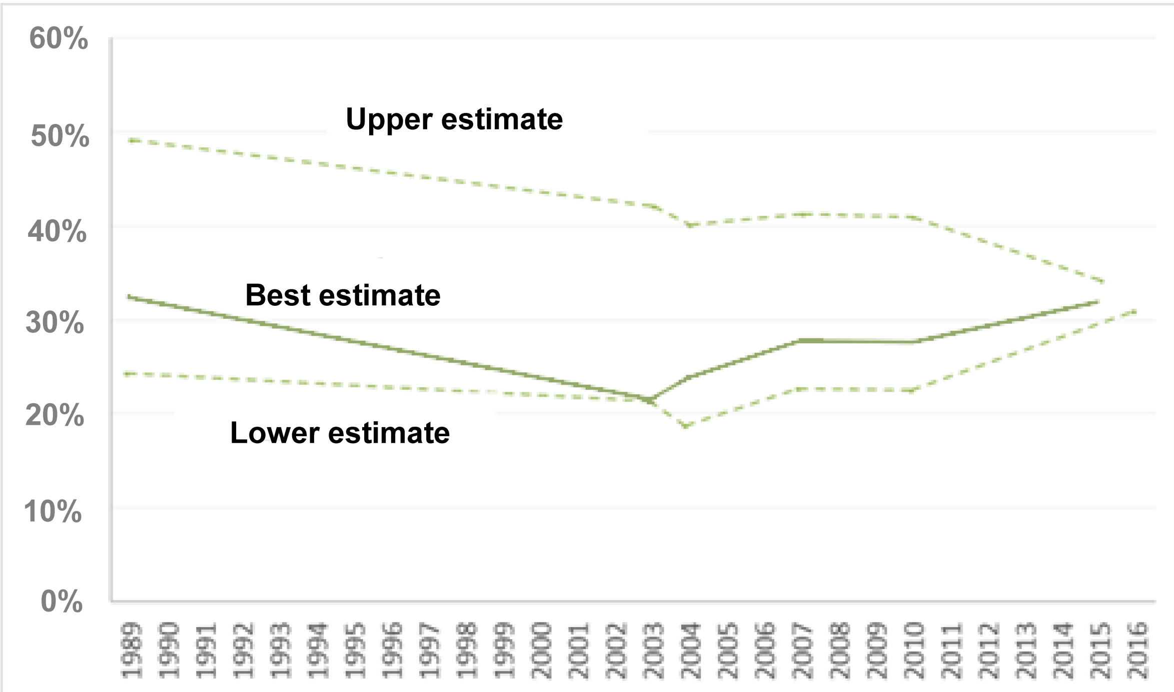

Fig. 2. Example of chart: Evolution of the share of threatened birds in Belgium based on Electronic Supplement 1. The main line represents the Best IUCN estimate (Critically Endangered + Endangered + Vulnerable, divided by known extant species excluding «Data Deficient» and all «Rare» and other non-compliant local status, excluding extinct). The upper line gives the upper IUCN estimate (Critically Endangered + Endangered + Vulnerable + «Data Deficient» and all «Rare» and other non-compliant local status, divided by the total extant evaluated species excluding extinct). The lower line gives the lower IUCN estimate (Critically Endangered + Endangered + Vulnerable, divided by known extant species including «Data Deficient» and all «Rare» and other non-compliant local status, excluding extinct). Note that the multiple timeliness character of the basic data (compare «Status Date» of Table 2 and Table 3) makes the successive evaluations a kind of «moving average» over about 10 years.

Fig. 2 shows that it is possible to derive a Belgian indicator with any old non-compliant and incomplete regional red lists but with a large range of uncertainty. When regional data becomes more IUCN-compliant with time, the indicator becomes more accurate.

Discussion

Our method is based on the assumption that if a short-range moving species or ecosystem is not threatened at local level, then it is not threatened at global level. It is already implicitly used to assess threatened species at various levels. We only made it explicit, which allows the quick «default» scoring of many not threatened species when fully comparable basic data used for regional red lists are not available (which is the common case, certainly for historical data). «Local» is recommended larger than 10 000 km^2 but can be as small as 10 km^2 under strict IUCN conditions.

IUCN (2003) follows this logical assumption most of the time, though exceptions may occur when strictly applying the criteria: «taxa classified as Vulnerable on the basis of their global declines in numbers or range might be Least Concern within a particular region where their populations are stable». We consider this situation as an inevitable bias of any standard, – not a scientific or logical bias of our method. On the contrary, we argue that our assumption gives a sound result in the vast majority cases. Being a standard, IUCN (2003) makes arbitrary choices. For example: the choice of a measurement grid of 2 km × 2 km, which is not necessarily appropriate for all species groups (see discussion in IUCN, 2017; Maes et al., 2012). A standard may be arbitrary per definition and we do not wish to criticise this particular bias here. IUCN (2012) gives a further example of the Australian Dugong (*Dugong dugon* (Müller, 1776)) being vulnerable at the world level even if it is not listed as a threatened species in Australia: «There are many management plans and protection measures in place for the Australian Dugong population, and these are helping to maintain a good population there». This situation stresses that local red lists should be published with full underlying data if one wants standard results. Our point is that local assessments following the philosophy of IUCN standard as much as possible are better than no evaluation at all. And that these results – even a simple red list without underlying data – might be very useful to deduce some first historical macro assessments. By comparing global and four big tropical countries' red lists, Brito et al. (2010) found 14% listed as globally threatened, but not nationally listed, thereby encouraging the compilation of local red lists. The ideal condition for «local to global» assessment generalisation is that the assessments at various levels comply with the IUCN regional standards. This is not the case for many historical assessments. As an example of the effective use of the IUCN guidelines, experts validated (as IUCN-compliant) the Flanders status of 107 species out of 2799 evaluated between 1994 and 2003, 2956 species status out of 3121 evaluated after 2003, and all the evaluations published after 2006 (own calculation after INBO, 2018).

When including the «Least Concern» species in the red lists, the exercise turns from a collection of bad news (only lists of threatened species) to an estimate of the (remaining) biodiversity part of the natural stock (publishing the Least Concern species list as well). Common species are used for other than red lists assessments and indicators, where the population trend plays a central role (see for example Grooten & Almond, 2018; Lister & Garcia, 2018). As they are well-known by the common public, they have a better potential to be well followed by Crowding Citizen Scientist. The quality of global assessment is always sensitive to the availability of local data. Common species are likely to attract the supply of better data.

If data are only available for regions where the threat level of all species is underestimated, the national default estimate obtained with our method could be too conservative. In general, our method is conservative in the sense that a species evaluated as safe on the local level is assumed to be safe at the global level even if it is extinct or declining all over the rest of the world. On the contrary, missing local data can lead to a more alarming global assessment of the percentage of threatened species in a given group, – if the only available data were in a very threatened region. The same biases apply for the choice of species groups to be assessed. Ideally, all groups should be assessed, not only the higher indicated species in the trophic chain like vertebrates, because low trophic level species can play a significant role to the entire system as well (Lister & Garcia, 2018). The huge amount of data needed for accurate global assessment makes the feasibility of such an approach quite hypothetical. This fact alone pleads for the use of a «second best» method, as outlined in this paper, in order to give first estimates. And, thereby, it will help prioritise and concentrate assessment efforts going forward.

By «eliminating» the safe species from the global assessment, this method helps to focus the local study efforts on species potentially at greater risk. It is important that the first regions making an assessment publish the list of non-threatened species in addition to endangered ones. This can help other regions to focus their own studies. They can, for example, quickly publish that a given default «endangered» species is actually «safe» in their region. Table 4 shows the national advantage of most studied regions (in this case Flanders) covering new groups of species. If national or global inventories are too expensive, local inventories still allow a first national or global rough estimate, which is better than nothing, and pioneering for less known taxonomic groups.

The main risk when using our method is the possible error migration from a locally erroneous «Least Concern» assessment to a global «Least Concern» conclusion. A locally threatened status has less impact on the global conclusion. Appendix 2 shows a test of different alternative methods on an old (non-compliant) red list of Orthoptera where supplementary detailed information was available for the regions and the country. It showed that, all other things being equal, our method and the surface-weighted average method found respectively 65% and 57% correct national species assessments as compared to a reference IUCN-Compliant calculation. These results underline the limits of any «meta» method like ours for individual species assessments. It is clear that full local to global assessments with full distribution and historical data are much better when affordable at reasonable cost. Our method cannot qualitatively replace more specific global studies involving all cartographic data and best experts (see van Swaay et al., 2011; Maes et al., 2015).

In today's practical situation, certainly for invertebrates, it is pragmatic to rely on imperfect methods, like the one we propose, in order to have an idea of the global threat to an individual species. Why not use the area-weighted average? Appendix 2 tends to suggest that the «right» method is the weighted average, because in this case, it appears to give the same percentage of threatened species as the reference. Nevertheless, the area-weighted average suffers a series of limitations. First, the logic of the areas is misleading: a single natural reserve can be more relevant for nature conservation than a huge disturbed area. Second, an area-weighted average cannot manage the «rare» and «data deficient» cases, which are very common in published red lists because these are the «difficult» cases to consider with IUCN guidelines (a «rare» species is locally stable most of the time, neither common nor considered threatened). Third, the result can be supposed to be alarmist by policy makers and subject to methodological criticisms. We believe our method is definitively conservative and is logically sound. Moreover, it gives a «minimum» percentage of threatened species in a given group using current knowledge. We believe that this kind of uncertain result has more policy potential and that any sound alternative model would give more alarmist results. In the case of an alarmist global status resulting from a unique local red list «extrapolated» by default to the world, the only way to reduce the «policy bias» is to add information by proving the species is less threatened in another area. In the event of a local scientist describing a species as endangered locally, this calls for assessments in other places in order to verify the resulting global assumption. This is challenging and a real incentive for more and more local red list publications.

The Equation (1) is transitive: the assessments can be derived step by step from a small nature reserve to local, regional, national, and finally global levels. With the number of remaining species to evaluate, we think the method can help reduce the burden and focus on groups for which few (even local) assessments are available.

Conclusions

We proposed a simple and efficient model to facilitate the consolidation of imperfect local assessments to a first (conservative) estimation of national/global assessment. Its main use is to provide a percentage of threatened species indicator with underlying data. Based on published regional red lists, this model can help reduce the work needed to construct indicators at different spatial levels and identify priorities for further work. We tested our model for the evaluation of 8132 Belgian species. Local assessments are of global interest if they cover lesser-known groups of species like invertebrates, microfungi, and algae. Listing the safe species in one region can help other regions and global experts reduce the overall cost of evaluation and focus on threatened species identified elsewhere. Moreover, the method can help construct historical national or global red lists. However, the results of this model are very sensitive to the quality of the local assessments used. It cannot and does not aim to replace full IUCN-compliant assessments. Rare but not declining species draw specific attention. Specific IUCN regional guidelines should be developed in particular for species that are stable but only present in areas smaller than a few km^2.

Supporting Information

The full dataset with 8132 Belgian species (Electronic Supplement 1: Red list of Belgian species, Electronic Supplement 2: Robustness check) may be found in the Supporting Information **here**.

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Appendix 1. Status of Belgian Fauna and Flora (2019)

	Nationally Extinct (a)	Threatened (b)	Rare and Data Deficient (c)	No Threat (d)	Assessed Native Species (e)	% Threatened (f)	Introduced Species (g)	Expected Species (h)	Year (i)
Total								**> 54287**	
Fauna								**> 36368**	
Vertebrates	**18**	**110**	**30**	**253**	**411**	**30%**	**+68**	**> 893**	2016
Mammals	*5*	*21*	*6*	*42*	*74*	**33%**	*+18*	*> 113*	2016
Reptiles	*0*	*4*	*0*	*3*	*7*	**57%**	*+3*	*> 16*	2012
Amphibians	*0*	*7*	*0*	*9*	*16*	**44%**	*+4*	*> 21*	2012
Breeding Birds	*6*	*55*	*6*	*117*	*184*	**32%**	*+20*	*> 492*	2016
Fish	*7*	*23*	*18*	*82*	*130*	**22%**	*+23*	*> 236*	2014
Invertebrates	**144**	**566**	**907**	**1855**	**3472**	**23%**	***+11***	***> 35475***	2016
Ants	*0*	*27*	*2*	*22*	*51*	**55%**	*+5*	*> 56*	2003
Ladybugs	*0*	*9*	*8*	*23*	*40*	**28%**	*+1*	*> 41*	2014
Dragonflies	*2*	*24*	*11*	*35*	*72*	**41%**		*> 72*	2013
Butterflies	*21*	*35*	*10*	*53*	*119*	**40%**		*> 119*	2010
Beetles	*36*	*97*	*161*	*106*	*400*	**48%**	*+5*	*> 405*	2008
Aquatic Insects	*6*	*14*	*0*	*41*	*61*	**25%**		*> 61*	2013
Grasshoppers and Locusts	*7*	*12*	*8*	*24*	*51*	**33%**		*> 51*	2000
Diptera: Dolichopodes	*22*	*40*	*125*	*73*	*260*	**35%**		*> 260*	2001
Diptera: Hybotides	*27*	*33*	*134*	*66*	*260*	**33%**		*> 260*	2001
Spiders	*9*	*204*	*76*	*315*	*604*	**39%**		*> 604*	1998
Snails & Slugs	*14*	*16*	*41*	*33*	*104*	**33%**		*> 104*	2009
Molluscs		*39*	*61*	*250*	*350*	**13%**		*> 350*	1989
Crustaceans		*16*	*270*	*814*	*1100*	**2%**		*> 1100*	1989
Flora								**> 15519**	
Higher Plants	92	423	126	889	1530	**32%**	+380	> 1910	2006
Mosses	22	189	4	179	394	**51%**	+5	> 571	2017
Lichens		495	343	0	838	**100%**		> 838	2003
Macrofungi	43	230	60	219	552	**51%**		> 5740	1999
Microfungi								> 2898	2016
Algae								> 4400	2003
Microorganisms								**> 2400**	2017

Source: Author based on all Belgian literature cited in the reference list.
(a) Nationally extinct after 1950.
(b) Critically Endangered + Endangered + Vulnerable.
(c) Species at the limit of their range, and species difficult to assess (Data Deficient).
(d) Least Concern + Near Threatened.
(e) Assessed native species, including extinct, rare and data deficient species, excluding species introduced since 1950.
(f) The percentage relates to the total number of known evaluated extant native species excluding extinct, rare and data deficient: column b / (e–a–c).
(g) Artificially or naturally introduced after 1950. Reproducing in the wild without human intervention.
(h) Maximum Expected Species Number given by the consulted literature (invasive and non-breeding migratory species included).
(i) The base year is the last year for which the assessment of at least one group of species was completed for at least one region.

Appendix 2. Robustness check with a (non-IUCN-compliant) full set of data for orthoptera in Belgium and its regions

Starting from detailed distribution and historical data from Decleer et al. (2000), we derived a «statistical red list v.3» for all three regions using the following criteria:

Decline 10 years		Presence (number of grids)	Area of occupancy (AOO)				
			0	< 10 km²	< 500 km²	< 2000 km²	≥ 2000 km²
from	to						
-80%			**RE**	**CR**	**CR**	**CR**	**CR**
-50%	-80%	**1**	**RE**	**CR**	**EN**	**EN**	**EN**
		> 1	**RE**	**EN**	**EN**	**EN**	**EN**
-30%	-50%	**1**	**RE**	**CR**	**EN**	**VU**	**VU**
		≤ 5	**RE**	**EN**	**EN**	**VU**	**VU**
		> 5	**RE**	**VU**	**VU**	**VU**	**VU**
-1%	-30%	**1**	**RE**	**CR**	**EN**	**VU**	NT
		≤ 5	**RE**	**EN**	**EN**	**VU**	NT
		≤ 10	**RE**	**VU**	**VU**	**VU**	NT
		> 10	**RE**	NT	NT	NT	LC
1000%	-1%		**RE**	LC	LC	LC	LC
If absent the former 10 years:							
		1	**RE**	**CR**	**EN**	**VU**	NT
		≤ 5	**RE**	**EN**	**VU**	NT	LC
		≤ 10	**RE**	**VU**	NT	LC	LC
		> 10	**RE**	NT	LC	LC	LC

Note: RE – Regionally Extinct, CR – Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened, LC – Least Concern, RA = Rare (which was used in the old red lists, not conforming with IUCN (2003)).

The basic data compared the periods 1981–1990 to 1991–1999 with presence-absence of the studied taxa in squares of 5 × 5 km². In the case of 0 squares in 1981–1990, no evolution can be calculated. The authors of the paper derived the status of the related species (sometimes a «?» equivalent with IUCN Data Deficient) but in an inconsistent way, considering the criteria described in this paper as a base, but adding their expertise and auxiliary data. For the purpose of this test, we strictly applied the rules above in order to calculate a «statistical red list v.3» for the three regions, thus without any expert or auxiliary data adjustment. The statistical status was compliant with the official result of the paper for respectively 79%, 67%, and 86% for Wallonia, Flanders, and Brussels. The differences were mainly observed for «rare» taxa (< 15% occupancy), which is not surprising.

The use of a statistical regional red list v.3 is only for the purpose of comparing «all other things equal» results for Belgium. We then calculated the «Statistical red list v.3» for Belgium using the same strict criteria. This would be the «correct» assessment for Belgium as a reference to test the quality of different simple aggregation methods. Starting from the «statistical» regional red lists only (without further detailed information on rarity and evolution), we calculated two Belgian red lists, one using our «best status» method and an alternative «area-weighted» score one for each species of the list. The results of the test are shown below.

IUCN Best Estimate (on 44 extant evaluated species)

Area (km²)	30 529.12			16 845.49	13 522.25	161.38
Region	**Belgium**	**Belgium**	**Belgium**	**Wallonia**	**Flanders**	**Brussels**
Method	Statistical red list v.3	This paper's method	Area-weighted average	Statistical red list v.3	Statistical red list v.3	Statistical red list v.3
Regionally Extinct	16%	16%	16%	14%	15%	75%
Critically Endangered	**0%**	**0%**	**0%**	**2%**	**0%**	**0%**
Endangered	**7%**	**2%**	**2%**	**7%**	**3%**	**50%**
Vulnerable	7%	2%	11%	12%	0%	0%
Near Threatened	34%	7%	18%	10%	6%	0%
Least Concern	52%	89%	68%	69%	91%	50%
Total Endangered	**14%**	**5%**	**14%**	**21%**	**3%**	**50%**

It shows that, when full IUCN 2003 compliant regional red lists are available, both this paper's method and the area-weighted average give relatively conservative indicators of threat, our method being the most conservative in this particular case for all indicators with 5% total endangered. In this test, the first colon is supposed to give the reference «correct» indicators («14% Total Endangered»). By chance, the weighted average method gives the right conclusion («14% Total Endangered»).

The table below compares the «correct» «statistical» and the modelled status of each individual species. Number of correct (OK) and incorrect (NOK) statuses given to 51 orthopteran species (44 + 7 extinct):

	This paper's method	Area-weighted average
OK	33	29
NOK	18	22
Total	51	51
%OK	65%	57%
%NOK	35%	43%

All other things being equal, our method and the surface-weighted average method found respectively 65% and 57% correct national species assessments as compared to a reference IUCN-Compliant calculation. Detailed alternative calculations and lists are available in Electronic Supplement 2.

ОЦЕНКА «СНИЗУ ВВЕРХ» УГРОЖАЕМЫХ ВИДОВ

Б. Кестемонт[1,2]

[1]*Брюссельский свободный университет, Бельгия*
[2]*Федеральная государственная служба экономики, Бельгия*
e-mail: bruno.kestemont@economie.fgov.be

Определение доли исчезающих видов имеет решающее значение для охраны биоразнообразия от локального до глобального уровня. Однако высокие затраты на оценку видов ставит под угрозу возможность оценки всех видов в глобальном масштабе. Мы предлагаем модель для сведения несовершенных локальных оценок к первой (консервативной) оценке от национальной до глобальной оценок. Мы использовали эту модель для оценки 8132 видов Бельгии, начиная с неполных красных списков на более низких географических уровнях (регионы Бельгии). Модель основана на логическом предположении, что если вид не стоит на грани исчезновения (статус «Least Concern») на местном уровне (> 10 000 км^2), то для него отсутствует угроза исчезновения на глобальном уровне. Модель можно использовать на различных географических уровнях, чтобы объединить несовершенные красные списки местного уровня в первую глобальную оценку. Тестирование модели показывает, что она дает очень консервативные результаты, поскольку на глобальном уровне оценивается меньше видов, находящихся под угрозой исчезновения, чем при использовании других методов. Наша модель может работать с нестандартными красными списками местного уровня с диапазоном ошибок, который уменьшается, когда локальные красные списки становятся совместимыми со стандартами Красного списка МСОП (IUCN Red List). Эта модель не может и не имеет целью заменить полные оценки видов в соответствии с стандартами МСОП. Мы показываем ценность публикации списков видов, для которых отсутствует угроза исчезновения в настоящее время, а не только угрожаемых таксонов. На самом деле, в свете шестой волны массового вымирания видов, определение таксонов, которым не грозит исчезновение, становится столь же важным, как и угрожаемых таксонов. Мы призываем биологов-специалистов оценивать менее изученные группы таксонов, такие как беспозвоночные, водоросли или микроскопические грибы. Наша модель облегчает малозатратную предварительную оценку таксонов на глобальном уровне. Это может помочь историческим обзорам, а также определить приоритеты исследований и политику природоохранной деятельности. Наши тесты ставят под сомнение руководящие принципы МСОП для видов, которые являются стабильными, но присутствуют только в районах, меньших чем несколько квадратных километров.

Ключевые слова: Бельгия, биоразнообразие, географические уровни, глобальный уровень, показатель, локальный уровень, модель, красный список, массовая оценка видов, угроза