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Short communication

Conservation importance of non-threatened species through their direct linkages with nature's contributions to people

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ABSTRACT

Over the last half-century, nature conservation has shifted through several steps from ‘nature for itself’ to ‘nature and people’, corresponding to a new perspective that all species count to ensure ecosystem functioning, and with them that nature's contributions to people (NCPs) are effective and maintained. Yet, despite these conceptual shifts in the academic literature, conservation practices have remained largely focused on threatened species and protected areas. The last Global Biodiversity Framework (GBF) of the Convention on Biological Diversity insisted on the need to use biodiversity sustainably and ensure nature's contributions to people, including ecosystem functions and services for the benefit of present and future generations by 2050. Here, using recently developed tables relating a large number of species observed in the Western Swiss Alps (vascular plants and vertebrates; n = 2066) to 17 key NCPs, we show that focusing on protecting threatened species only does not ensure the maintenance of key NCPs. Our results suggest that all species (threatened or not) need to be considered, in addition to strict conservation of threatened species, to support NCP provision. Similarly, considering all species better supports existing conservation programs. Developing such direct species-NCP relationships more broadly will be needed to support spatial prioritizations and help reach the 2050 GBF goals.

1. Introduction

There is a need today more than ever to protect nature (Mace et al., 2018; Pollock et al., 2020), with mounting pressure on human societies to prevent further biodiversity loss, particularly because human influence is a leading cause of these losses (Caro et al., 2022). Conserved and protected areas are fundamental to biodiversity conservation to reduce extinction threats and preserve existing biodiversity (Kremen and Merenlender, 2018). Over the last six decades, the human vision of nature protection has changed progressively through several phases: nature ‘for itself’, ‘despite people’, and ‘for people’ (Costanza et al., 1997; Mace, 2014). More recently, with various attempts in the latter stage to convince stakeholders of the usefulness and importance of nature by illustrating the key services and other contributions that nature provides to human societies (e.g. Díaz et al., 2006; Millenium Ecosystem Assessment, 2005), nature protection entered a new phase of ‘nature and people’ (Mace, 2014). A central milestone in this endeavour has been the identification of planetary boundaries (Rockström et al., 2009; Steffen et al., 2015), including biosphere integrity that can only be ensured by protecting biodiversity, followed by the establishment of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (Díaz et al., 2015).

Therefore, recent tendencies of biodiversity conservation stress that nature's contributions to people (NCPs) cannot be ensured without plainly conserving nature and its biodiversity, not only within protected areas but everywhere humans live and exploit the landscape (Buscher and Fletcher, 2020) i.e., by integrating biodiversity and its conservation fully in the governance of human societies (Cumming et al., 2023; Díaz et al., 2019, 2015). The importance of NCPs is being recognized in global policy. Recently, in December 2022, the Kunming-Montreal Conference of the Parties of the Convention on Biological Diversity (CBD) pointed to the same conclusions about the importance of protecting biodiversity with links to NCPs. The proposed Global Biodiversity Framework (GBF) aims to achieve four main goals for 2050 and 23 specific targets by 2030 (SM, Text D1), but only two goals (A: to halt species extinction and conserve genetic diversity; and B: to manage sustainably biodiversity, NCPs, ecosystem functions and services) can be achieved by the support of scientific conservation. This integration follows many strategies of biodiversity conservation, first by trying to protect nature for itself and despite people, and then by valuing its services to humans (often the

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most monetizable), sometimes even 'despite' its constitutive biodiversity (Ramel et al., 2020; Rey et al., 2023). The management of NCPs will have an impact on the future of human beings, as up to 5 billion people may be at risk from diminishing NCPs (Chaplin-Kramer et al., 2019). Consequently, effectively managing ecosystems to meet the GBF goals and targets will require information about both biodiversity and NCPs, providing critical feedbacks that inform conservation decision-making (Brauman et al., 2020), and developing tools to assess the status of species to aid in prioritizing the allocation of limited conservation resources (Kass et al., 2024; Molina-Venegas et al., 2021a; Richards and Lavorel, 2023).

The International Union for the Conservation of Nature (IUCN) Red List of Threatened Species has long been used to inform business decisions (Bennun et al., 2018) and particularly for conservation decisions in national (e.g. OFEV, 2016), continental (e.g. Fischer et al., 2018), and global assessments (e.g. Díaz et al., 2019), by providing comprehensive information on global species threat status and extinction risk (Hoffmann et al., 2008; Rodrigues et al., 2006). To complement the Red List, and in light of the proposed GBF targets, the IUCN created new tools and programs to guide conservation decisions and sustainable management. For example, i) the Key Biodiversity Areas, to identify sites that contribute significantly to the persistence of the world's biodiversity (Eken et al., 2004; IUCN, 2016); ii) the Green List of Protected and Conserved Areas to improve the governance and the management of protected and conserved areas (Wells et al., 2016); and iii) the Green Status of Species to provide an optimistic view of species conservation by measuring species recovery (Akçakaya et al., 2018, 2020; IUCN, 2021a).

Yet, although the development of these programs is useful and promising, they remain mostly dedicated to threats on species and biodiversity (as reflected in e.g., Goal A of the GBF; SM, Text D1), and all of them are *in fine* based on Red List information. Species in the greatest need of conservation interventions (i.e., with an conservation status of Critically Endangered, Endangered, or Vulnerable) are typically rare and assumed to contribute mostly through their intrinsic value and little for their contributions to people, often due to their small populations or limited ranges (Ingram et al., 2012; Ridder, 2008), even though rare threatened species can still be critical for some NCPs in some areas (e.g., Schirpke et al., 2018). Although how threatened species relate to NCPs has previously mainly been assessed indirectly by overlapping maps of conservation priorities and ecosystem services (Naidoo et al., 2008; Nelson et al., 2009; Polasky et al., 2012) and by examining the trade-offs between conservation planning and economic development (Lavorel et al., 2020; Leroux et al., 2009; Ramel et al., 2020), it is necessary to note that contributions of rare or threatened species to NCPs remain poorly understood. As mentioned by Dee et al. (2019), they can have direct and indirect contributions to NCPs through species interactions. An expectation highlighted by recent work shows the importance of food webs and ecological networks when assessing the relationship between species and NCPs (Antunes et al., 2024; Bianco et al., 2024; Keyes et al., 2021). Currently, the identification of direct relationships between NCPs and species, and not only the threatened ones, has been mainly investigated for plants (Diazgranados et al., 2020; Mabberley, 2017; Molina-Venegas et al., 2021a, 2021b; Oka et al., 2019). Few studies have considered other taxa (e.g., Noriega et al. (2018) for insects; Rey et al. (2023) for vertebrates and plants), despite these groups being potentially important to ensure a sustainable future and support Goal B of the GBF more efficiently (SM, Text D1; Kass et al., 2024; Rey et al., 2022; Richards and Lavorel, 2023). Concurrently, the consideration of the conservation status of species may also allow capturing biodiversity more effectively in conservation programs (currently many areas classified as "protected" by the IUCN do not consider species/biodiversity (Dudley, 2008)), and developing strategies to integrate existing NCPs directly linked with species/biodiversity into decision-making for future frameworks for spatial prioritization.

As recent studies in Europe have highlighted that the consideration of all species is necessary to improve conservation actions with or without linkages with NCPs (O'Connor et al., 2021; Virtanen and Moilanen, 2023), more investigation is still needed to support these conclusions and confirm the added value of considering all species - not only threatened ones - through their links to NCPs to inform conservation planning aimed at not only ensuring species conservation but also sustainable ecosystem functioning, the contributions they deliver to people, and therefore to human well-being (Costanza et al., 2017; Cumming et al., 2023; Mace et al., 2012).

Here, we explore whether and how species' conservation statuses are related to their roles in NCP delivery, by i) comparing the number and type of NCPs supported by species of different conservation statuses (e.g., non-threatened species, including IUCN statuses of Least Concern and Near Threatened (n = 1687); and threatened species, including IUCN statuses of Vulnerable, Endangered, and Critically Endangered (n = 360)), ii) determining if these patterns are similar between taxonomic groups (i.e., vascular plants and vertebrates), and iii) mapping the distribution of threatened and non-threatened species within areas of different degrees of protection (based on IUCN categories) to summarize potential protection of NCPs. We use two recently-developed tables that relate 2066 vascular plant and vertebrate species occurring in the Western Swiss Alps with 17 key NCPs in Switzerland (Rey et al., 2023), which, to our knowledge, currently constitutes one of the largest and most recent and detailed species-NCPs tables. Work with this relationship table will allow making national progress in Switzerland to define the value of NCPs for biodiversity, based on the methodology used here for relating vascular plants and vertebrates to NCPs, especially in the context of current GBF goals and targets.

2. Materials & methods

2.1. Species and study area

The species included in the two tables were selected as being present in the Alpine regions of the Vaud state (list of species in SM, Table B1), a thoroughly investigated study area in Switzerland (hereafter referred to as 'Western Swiss Alps'; Von Däniken et al., 2014, https://rechalp.unil.ch; SM, Fig. A1C), over the last 20 years. They represent 44 % (250/568) of all terrestrial vertebrates and 45,8 % (1816/3961) of all tracheophytes found in Switzerland and span a large diversity of habitats (i.e. 46,5 % (119/256) found in Switzerland according to the EUropean Nature Information System (EUNIS); Moss, 2008). Among the 119 characteristic EUNIS habitats, we observed between 2 (i.e. C3.28 – Riparian *Cladium mariscus* beds) and 642 (i.e. I - Regularly or recently cultivated agricultural, horticultural and domestic habitats) species per habitat (SM, Table A1; Delarze et al., 2015). The species' documented IUCN status included 1 species 'not evaluated' (NE), 18 'data deficient' (DD), 1380 'least concern' (LC), 307 'near threatened' (NT), 221 'vulnerable' (VU), 107 'endangered' (EN), 32 'critically endangered' (CR), and 1 'regionally extinct in the wild' (RE) (SM, Text B1). Sources come from conservation status at the national level (i.e., Switzerland level, vascular plants: Bornand et al. (2016); bats: Bohnenstengel et al. (2014); birds: Knaus et al. (2021); mammals: Capt (2022); amphibians: Schmidt et al. (2023); reptiles: Ursenbacher and Meyer (2023)).

Species occurrences were provided by the Swiss Species Information Center InfoSpecies (www.infospecies.ch) on June 03, 2022 (Andriollo et al., 2022), and were then aggregated to a 100-m (hectare) resolution for the period 1980–2022. These data represent Swiss occurrences of native species present in the study area (Western Swiss Alps) based on validated occurrences. Occurrences of non-native species introduced regionally or present in cultivation were removed (as long as declared). Only data with a spatial uncertainty ≤250 m were considered. In this study, we only worked with the presence of the species mentioned in SM (Table B1) at the hectare level (total of n = 2047 species across 43,806 cells covered for 343,460 total occurrences). For the spatial coverage analyses, we only reported if the cell was occupied by non-threatened or threatened species to calculate different percentages of spatial coverages (more details in Section 2.3).

Over the 946 km^2 covered by the study area, protected areas cover 687 km^2 (i.e., 72.6 %; SM, Fig. A1 and Table A2). 15 types of protected areas are present in the study area and are distributed into five IUCN protected areas defined by Dudley (2008): i) Ia – strict nature reserve (e.g., High marsh and marshy site); ii) Ib – wilderness area (e.g., Emerald, Francs districs, Ramsar sites); iii) III – natural monument or feature (e.g., Pro Natura reserves); iv) IV – habitat or species management areas (e.g., biotopes of federal importance, such as alluvial zones, amphibians reproduction sites, low and high marshes, dry meadows and pastures, or water birds' reserves); v) V - protected landscapes or seascapes (e.g., federal inventory of landscapes, regional nature park) and one UNESCO cultural site (SM, Table A2; Fig. A1). Although some protected areas of our study region contain threatened species (Fig. 3A, D), only Pro Natura, Emerald (equivalent of Natura2000 in Europe), and Ramsar water birds' reserves have strict management rules that apply to all species (i.e., to both non-threatened and threatened species). A large proportion of non-threatened and threatened species are observed in two other types of protected areas, the 'Federal landscape inventories' and 'Regional nature parks', but no species management plans are required in these areas.

2.2. Species-by-NCP table

Two tables were previously built to highlight the direct relationships between 2066 species and 17 nature's contributions to people (NCPs; Definitions of NCPs in SM, Text C1; Rey et al., 2023), informing on positive, negative, and neutral relationships between each species and each NCP for most tracheophyte (vascular plants) and vertebrate species of the Western Swiss Alps, thus including a large diversity of species across a wide altitudinal and associated environmental gradient (372–3206 m). The tracheophyte table relates 1866 species to 16 NCPs: seven from material category (Burned wood; solid wood; Forage-pasture; Mellifera production (for domestic bees); Wild food; Wild use medicinal, dye, fur; Potential crop (genetic resources)), six from regulating/maintenance category (Riverbank erosion; Reduce runoff from agroecosystems; Reduce landslide; Hedge for crop yield; Decontamination; Keystone species), and three from non-material category (Linked with an endangered habitat; Scientific interest; Iconic species). The vertebrate table relates 250 species to 9 NCPs: two from material category (Wild food; Wild use medicinal, dye, fur), four from regulating/maintenance category (Riverbank erosion; Reduce landslide; Reduction of species damage and disease vector species; Keystone species), and three from non-material category (Linked with an endangered habitat; Scientific interest; Iconic species). The two tables are based on NCPs defined from the 'Common International Classification of Ecosystem Services' (CICES V.5.1, Haines-Young and Potschin-Young, 2018), which represents the most relevant NCP classification and aligns with the NCP assessment of the IPBES (Díaz et al., 2018), and were built in a way that allow them to be easily updated in the future and adapted to other regions. Definitions of each NCP and detailed methodology to establish relationships between NCPs and species are available in SM, Text C1.

2.3. Red List analyses

To streamline the comparison between species with distinct conservation statuses, we first reclassified species into two groups: non-threatened species (including Least Concern (LC), Near Threatened (NT) species; n total = 1687) and threatened species (including Vulnerable (VU), Endangered (EN) and Critically endangered (CR) species; n total = 360). Data deficient (DD), Not Evaluated (NE) and Regionally Extinct in the wild (RE) species were excluded from the analyses on the two groups (i.e., Figs. 1, 3). For tracheophytes, 1516 species were considered non-threatened and 284 threatened, and for vertebrates, 171 non-threatened for 76 threatened species. Based on this reclassification, we (i) determined if the average of NCP values per category were significantly different between non-threatened and threatened species, and ran this separately for both tracheophytes and vertebrates species (the two groups used in Rey et al., 2023); (ii) mapped the occurrences of non-threatened and threatened species across the study area between 1980 and 2021 (total of n = 2047 species across 43,806 cells at hectare resolution); and (iii) calculated the percentage of IUCN protected areas (for each class) overlaid by non-threatened and threatened species, the percentage of the spatial coverage of non-threatened and threatened species included in each class of IUCN protected areas and, finally, the percentage of the number of species observed by IUCN protected areas (incl. the % of all species, the % of all non-threatened, and % of all threatened species) (Fig. 3; SM, Table A2).

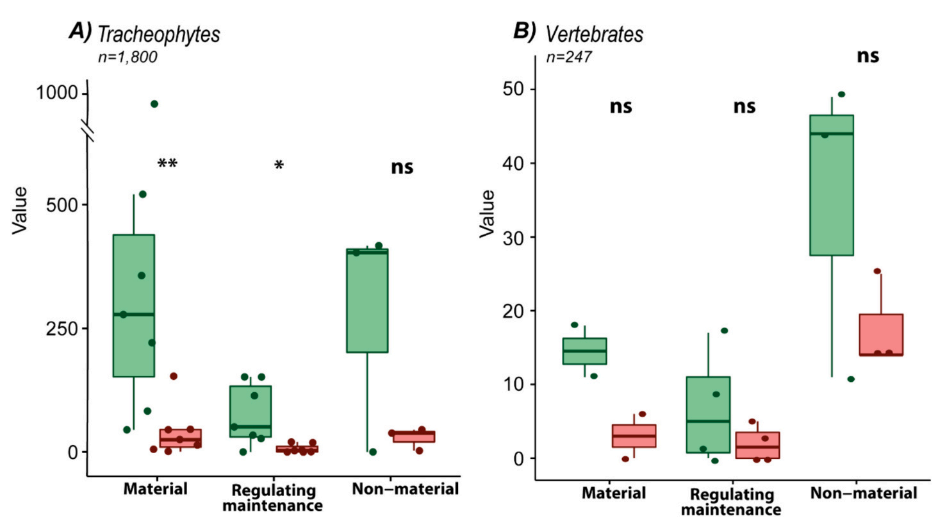

Fig. 1. Comparison of non-threatened (green boxes) versus threatened (red boxes) species (for tracheophytes and vertebrates species observed in the study area). A) Boxplot expressing value of tracheophyte's species (n = 1800) by Nature's Contributions to People (NCP) within each NCP category. B) Boxplot expressing value of vertebrate's species (n = 247) by NCP within each NCP category. For each boxplot, the central box represents the 1st quartile, the median, and the 3rd quartile. The two whiskers extend to the furthest non-outlier points (i.e., that are within 3/2 times the interquartile range of the 1st and 3rd quartiles). Wilcoxon tests were used to assess statistical significance in differences between methods with **: $p < .01$; ns: non-significant. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Next, to get an overview of trends across species and NCPs, we summed species number by conservation status, expressing a positive or negative value (i.e., $\sum$ p, where p = 1 or − 1) in each NCP sorted by three categories (i.e., material, regulating/maintenance, and non-material). All species (including DD species) were considered in the analyses except one species with NE status (golden jackal – *Canis aureus*; not established in the country) and one species with RE status (Meadow violet – *Viola pumila*; local population extinct), which were removed from all analyses. We then represented these counts per NCP and conservation status graphically with barplots (Fig. 2). To complete analyses we established the percentage of species in each IUCN Red List category that support the NCP category (Fig. 2B).

Finally, in supplementary analyses, we tested if our results could be biased by the sample size (i.e., we analysed many more tracheophyte species than vertebrate species) or by the inclusion of DD species (n = 19) if we consider them as threatened species (as suggested in Borgelt et al., 2022). We repeated the following analysis with and without DD species included in the threatened species group: we i) randomly selected 100 species per group (i.e., non-threatened and threatened) and summed the number of relationships (i.e., positive or negative, same process as the IUCN counts previously) established by NCP and NCP category, ii) repeated the operation 100 times, and iii) conducted Wilcoxon tests to observe if there were significant differences between the two groups (SM, Figs. A2–A3).

R v.4.2.3, Rstudio v.2022.07.2 + 576 "Spotted Wakerobin" was used for all statistical analyses. Adobe Illustrator (v.27.0) was used to produce all final figures.

3. Results

For tracheophytes, significantly more non-threatened species supported Material and Regulating/maintenance NCP categories than threatened species (Fig. 1A). For the material category, the p-value was 0.004367 with mean ± confidence interval (CI) value for the non-threatened of 354.43 ± 235.66 and 41.43 ± 38.72 for threatened species. For the regulating/maintenance category, the p-value was 0.01037 between non-threatened (75.71 ± 46.42) and threatened species (6.71 ± 6.57). However, the non-material category had no significant differences between both (p-value: 0.35). For vertebrates (Fig. 1B), no significant differences were observed between non-threatened and threatened species across the three NCP categories.

Regardless of IUCN or taxonomic group, the count of species with a value (either positive or negative; data available in Rey et al., 2023) by NCP was dominated by species of LC and NT status (Fig. 2A). Furthermore, the percent of values (i.e., the percent counts of only positive and negative values; non-attributed and zero values were not considered in the frequency estimation by IUCN status) expressed by Red List status for each NCP category confirmed the dominance of LC species for all NCP categories (Fig. 2B). However, the percent of CR species was greater than the percent of NT species for regulating/maintenance and non-material categories of NCPs, revealing a greater relative importance of CR species than if only comparing total counts (see Fig. 2). Though only comprised of 18 species, DD species accounted for the second-highest percentage of NCP value expressed for regulating/maintenance and material categories overall. Species with VU and EN statuses had the lowest overall percent of NCP value (as simple barplots, it is not possible to verify if there are significant differences between IUCN statuses). These overall results were maintained when comparing equal numbers

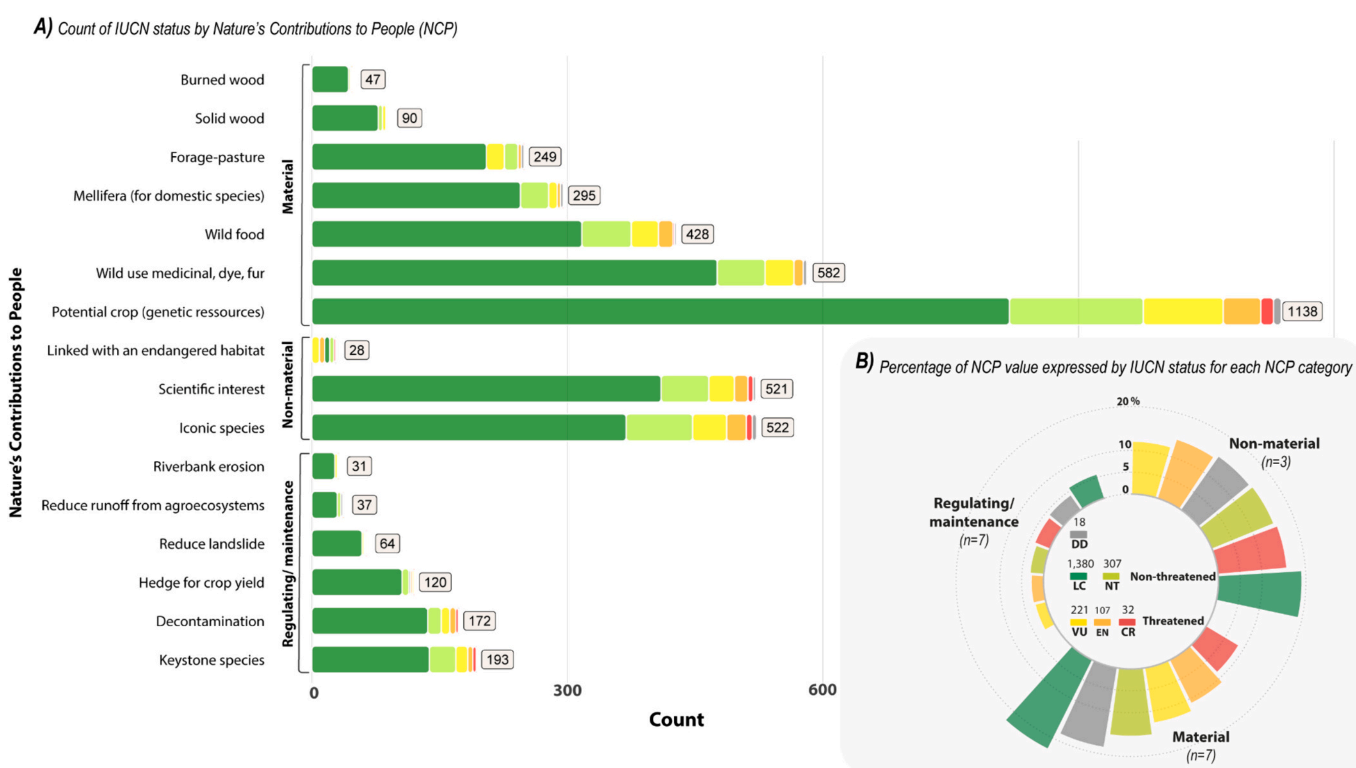

Fig. 2. Expression of the conservation status of species across Nature's Contributions to people (NCP). A) Count of IUCN status by NCP derived from Rey et al. (2023). Each segment represents count of expressed value for IUCN status. The total count of each NCP is expressed at the end of the line. B) Percentage of NCP value expressed by IUCN status for each NCP category. Dotted lines show respectively marks of 5, 10 and 20 %. The numbers in the middle of the figure remind the number of species by IUCN status. 2065 species are included in these analyses. 1 species not evaluated and 1 regionally extinct in the wild have been removed from the analyse. DD = 'data deficient'; LC = 'least concern'; NT = 'near threatened'; VU = 'vulnerable'; EN = 'endangered'; CR = 'critically endangered'. For both analyses, non-attributed and null values were not considered. Colours used come from Red List IUCN chart colour (IUCN, 2018). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

of threatened and non-threatened species (i.e., 100 random species from each group): non-threatened species contributed significantly more to NCPs than threatened species. There was no significant difference between the two groups for the "Reduce landslide" NCP, and threatened species contributed significantly more than non-threatened species towards the "Linked with an endangered habitat" NCP (SM, Fig. A2). Similarly, these same overall patterns were observed when considering DD species as threatened species (SM, Fig. A3).

The distribution of occurrences of non-threatened and threatened species over the study area for the period 1980–2021 (total of n = 2047 species across 43,806 cells) showed that 15.1 % of cells share occurrences between threatened and non-threatened species, and 3 % contained only threatened species (Fig. 3D; SM, Table A2). The majority of species occurring in the main protected areas and IUCN protected areas related to them (incl. the stricter reserves category Ia and Ib; Dudley, 2008) are non-threatened species (Fig. 3B), which is further supported by the percentage of non-threatened species being greater than threatened ones in each class of IUCN protected areas (Fig. 3E). The percentage of threatened species observed by IUCN protected areas highlight that approximately half of threatened species are observed outside of IUCN protected areas (Fig. 3E; SM, Table A2). However, threatened species have a greater percentage of occurrences in each IUCN protected areas than that of non-threatened ones (Fig. 3C; SM, Table A2). We highlight that IUCN cat. V is the protected area with the greatest percentage of species occurrences (e.g., 68.3 % for non-threatened and 71.5 % for threatened species), followed by IUCN cat. Ib (e.g., 16.2 % for non-threatened and 17.5 % for threatened species), and in the last position we found the IUCN cat. Ia (e.g., 3.1 % for non-threatened and 6.4 % for threatened species). With 43.5 % of protected areas overlapped by non-threatened and 8.5 % by threatened species, >70 % of occurrences of each (respectively 70.3 % and 74.3 %) occur within protected areas (SM, Table A2).

4. Discussion

As underlined by previous studies (O'Connor et al., 2021; Virtanen and Moilanen, 2023), we confirm the added value of considering all species - not only threatened ones - through their links to NCPs, to set protection targets for biodiversity and achieve the GBF goals. When we compared NCPs supported by non-threatened species (including LC and NT; n = 1687) and those supported by threatened species (including VU, EN and CR; n = 360), we found that focusing solely on threatened species provides only partial support to NCPs, stressing the necessity to include all types of species, even species of least conservation concern since these significantly support human well-being through NCPs. These results were reinforced by our analysis to avoid size effect between the two groups in pointing than non-threatened species provide more NCP than threatened ones (Fig. A2).

There were significant differences between the extent to which different species' conservation status (i.e., non-threatened and threatened) and taxa (i.e., tracheopytes and vertebrates) contributed to NCPs (Fig. 1; SM, Fig. A2). Non-threatened species dominated the count and percentage of non-neutral relationship values (i.e., positive and negative relationships) of species to NCPs, within each NCP category (Fig. 2). Considering this dominance, it is interesting to observe that despite the fewer number of NCP values expressed by threatened species (Fig. 2A), their percentages to express the value of NCP categories remain quite similar to those of non-threatened species (Fig. 2B; e.g., critically endangered (CR) species were the second and third most expressed relationship values respectively for non-material and regulating/maintenance NCP categories). The importance of species with a CR status for non-material NCPs may be explained by the link between threatened species, scientific interest, and endangered habitats (i.e., the latter two defined 2/3 of NCPs in the non-material category). Because data deficient (DD) species accounted for the second-highest percentage of NCP value expressed for both material and regulating/maintenance categories, this further emphasizes the importance to account for all species and therefore to fill data gaps for species for which we lack information (Borgelt et al., 2022) even though, in our case, considering DD species as threatened does not impact our results (SM, Fig. A3).

We highlighted with these results that it could be necessary to consider not only threatened species but also non-threatened and DD species when the goal is to include species and NCPs in spatial planning, as suggested by Bianco et al. (2024) with their quantitative framework for identifying the role of individual species in NCPs. In the same way, and combined with the "cascade network" of Bianco et al. (2024), the species-NCP relationship table (Rey et al., 2023) could be helpful to apply potential weights directly in the implementation of the spatial prioritization (e.g., as simple species weights with Zonation software; Lehtomäki and Moilanen, 2013), identifying key species or communities when considering species with a high overall NCP value (e.g., Breckheimer et al., 2014; Carroll et al., 2001; Di Minin and Moilanen, 2014; Roberge and Angelstam, 2004).

When also considering taxonomic differences, the value of material and regulating/maintenance NCPs was explained better by non-threatened tracheophytes than threatened tracheophytes, while no difference was observed for non-material NCP. This could be explained in part by there being only three non-material NCPs, the smallest number within a service category (Fig. 1A). There were no significant differences between non-threatened and threatened vertebrate species, which may also be due to the lower number of NCPs by category for this group (i.e., 9 material, 4 regulating/maintenance, and 3 non-material) (Fig. 1B). To verify if results are biased by the sample size of NCPs, it could be interesting to apply the quantitative framework proposed by Bianco et al. (2024), to better identify the role of individual species in NCPs and into the cascade network.

Due to the limited overlap between threatened and non-threatened species occurrences, focusing protection on threatened species only clearly does not protect biodiversity as a whole (i.e., all species), nor the functioning and contributions of ecosystems (O'Connor et al., 2021; Virtanen and Moilanen, 2023). Conservation actions need to integrate all types of species to ensure efficient maintenance of biodiversity and ecosystem functioning (Akçakaya et al., 2020; Cadotte et al., 2011; Richards and Lavorel, 2023). Although current protected areas in our study area seem to encompass the main occurrences of all species (SM, Table A2), we illustrate the need to refine the goals of different protected areas (see Vincent et al. (2019) for the Western Swiss Alps) to better integrate all species in conservation planning. In our case study, the distribution of species occurrences (i.e., non-threatened and threatened) highlights a high overlap with IUCN category V protected areas (i.e., a flexible classification of protected areas that implements a natural conservation plan that also maintains a range of for-profit activities) as with the regional nature park that has no legal constraint to set conservation plans. At the global scale, Pironon et al. (2024) highlighted the distribution of plants used by humans, and confirmed the necessity to improve the correlation between utilized species richness and protected areas because they are currently negatively correlated. This shows the need to involve species in a broader concept of protected areas that promote biodiversity as a whole (Móstiga et al., 2023; Ramel et al., 2020), including their benefits for NCPs, in order to help achieve the GBF 30 × 30 target to protect by 2030 at least 30 % of terrestrial, inland water, and marine areas, especially areas of particular importance for biodiversity and ecosystem functions and services (Goal B Target 3; SM, Text D1; CBD, 2022). However, it is important to remember that this conclusion depends on the local context and the final goal of the protected sites. Indeed, we cannot integrate all types of species-NCP relationships in all types of protected areas. As illustrated by Eastwood et al. (2016), protected sites, like IUCN Ia and Ib (i.e., strict reserves) designed to protect threatened species, are more oriented to deliver non-material NCPs and are a priori not compatible with material NCPs (e.g., *potential crops*; *forage-pasture*; *wild use and wild foods*; *burned wood* and *solid wood*).

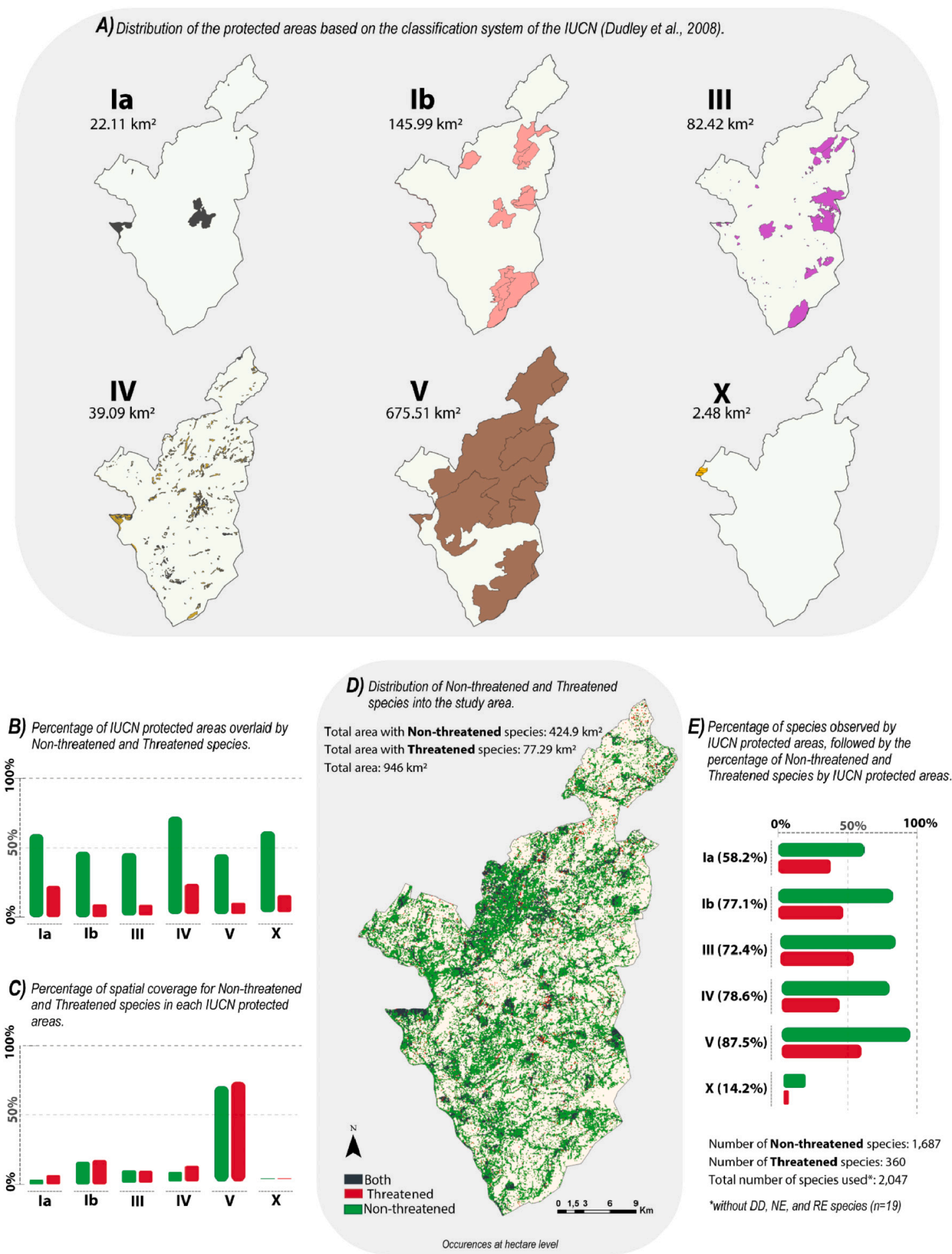

Fig. 3. Diagrams summary of the non-threatened and threatened species across the IUCN protected areas (as defined in Dudley, 2008) in the study area. A) Spatial coverage of the six protected areas identified by the IUCN classification (Dudley, 2008). Protected areas based on the classification system of the IUCN were defined by authors for each Switzerland protected areas (details of the aggregation are available in Table A2 and each Switzerland protected area is shown in Fig. A1). B) the percentage of IUCN protected areas overlaid by non-threatened and threatened species represented with barplots. C) The percentage of the spatial coverage for Non-threatened and Threatened species in each IUCN protected area represented with barplots. D) The distribution of non-threatened and threatened species in the study area (each cell represents one or more occurrences but only the number of cells is used for percentages of B) and C). The cell is at the hectare level). E) The percentage of species observed by IUCN protected area. The % of all species is on the right of the IUCN protected areas and the % of non-threatened and threatened species are illustrated with barplots.

Currently, international programs and tools (such as the IUCN Red List, GSS, KBAs, and GL; as defined previously) do not integrate NCPs, and have limited capacity to achieve all global biodiversity goals. For instance, the Red List does not consider NCPs in its criteria for evaluating species' conservation statuses or extinction risk, and the GSS only considers ecological functions (Akçakaya et al., 2020). KBA is the most representative program to identify and create protected areas in the world, but this only relates to three GBF targets under Goal A (KBA Partnership, 2023). Our results show the possibility to encompass the relationship between species and NCPs to help decision-makers evaluate criteria for the successful conservation outcomes directly linked to nature's contributions and be eligible to obtain a Green List status. For example, in the Western Swiss Alps, the natural regional park "Gruyère Pays-d'en-haut" could build a case to gain a GL status by explaining the added value of the site for species and human well-being (based on the NCP-species relationship table; Wells et al., 2016). However, GL status per se cannot contribute to create new protected areas to completely achieve the 30 × 30 goal of the GBF.

Although the IUCN Red List reveals that trends in species extinction risk would have been at least 20 % worse in the absence of conservation actions (IUCN, 2021b), different strategies may thus be required to ensure biodiversity conservation. In particular, the integration of direct links between species and NCPs – as we used here – can be used to map NCP distribution based on species predictions (e.g., using species distributions models) under present conditions (Pironon et al., 2024) and future scenarios (Rey et al., in prep.). This may strengthen the development of Nature-based Solutions (Chausson et al., 2020; Girardin et al., 2021; Pauleit et al., 2017) and ultimately allow achieving a greater number of GBF targets (see green targets in SM, Text D1; Kass et al., 2024; Rey et al., 2023; Richards and Lavorel, 2023).

Furthermore, to highlight benefits of species for people, the IUCN Red List has recently created an additional species filter for the "Use and Trade" of species, which contains information about how species are known to be used for different purposes by humans (e.g., use for food, medicine, fuel, clothing, etc.; a total of 17 categories) ("*The IUCN Red List of Threatened Species: General Use and Trade Classification Scheme (Version 1.0)*", n.d.) for 36,533 extant species globally. The information about use and trade of species from this additional filter could be used at multiple scales (i.e., local, national, global), together with species distributions, to help promote the sustainable use and management of NCPs (i.e., achieve Goal B of the GBF). It could be interesting to see current databases of direct relationship between species and NCP (e.g., Diazgranados et al., 2020; Mabberley, 2017; Rey et al., 2023) merged in this platform.

In the case of the European continent, green infrastructure proposals were mainly designed to deliver networks with natural and semi-natural habitats including a wide range of NCPs to enhance human well-being (Chatzimentor et al., 2020). Although recent studies proposed green infrastructure based on connections between NCPs and biodiversity (Hermoso et al., 2020; Liquete et al., 2015; O'Connor et al., 2021), our results show that it may be useful to directly link all species to all NCPs (as in Rey et al., 2023) to reflect the dependencies of the latter on all types of biodiversity, not just threatened species, to maintain NCPs and support human well-being (Díaz et al., 2019). As recently demonstrated in a global study, utilized and total plant diversity have the potential for simultaneously conserving species diversity and its contributions to people (Pironon et al., 2024), a conclusion strengthened by Molina-Venegas et al. (2021b) showing the importance to conserve a maximum level of phylogenetic diversity to capture efficiently species services for humankind. This is well in line with the proposition to build sustainable development for Europe using the Nature-based solutions process (Maes and Jacobs, 2017) and with the "IUCN Europe work plan", grounded in the "IUCN Nature 2030, one nature, one future" programme (IUCN, 2021b, 2021c), especially to help support the development of its 5Rs concept (Recognise, Retain, Restore, Resource, Reconnect).

5. Conclusions

Currently, many reports have proposed solutions to bend the curve of biodiversity decline (e.g., IUCN programs, Allan et al., 2022; Brennan et al., 2022), but only a few have proposed to encompass species of all threat categories (including non-threatened) together with NCPs (e.g., Bianco et al., 2024; Kass et al., 2024). Explicitly considering the connections between broader biodiversity and NCPs would protect biodiversity in a diverse set of areas, allowing for the simultaneous protection of nature for itself and for human well-being. Based on our species-NCP relationship table, focused here for illustrative purpose on plants and vertebrates, we showed the importance to consider also non-threatened species and NCPs in conservation to ensure a more sustainable future. Such species-NCP table represents a promising tool to better support global biodiversity goals and promote synergistic species-NCP relationships rather than trade-offs.

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CRediT authorship contribution statement

Pierre-Louis Rey: Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Caroline Martin:** Writing – review & editing, Investigation. **Antoine Guisan:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Supplementary data

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