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Serendipity versus proactive search of elusive species - the Encounter Predictability Scorecard (EPS), a new customizable tool for field researchers

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Abstract
Since field research requires a lot of effort, time, economic and resource investment, it necessitates fact-based tools for a sound preliminary evaluation of the actual possibility to achieve its objective. Such a tool, the Encounter Predictability Scorecard (EPS), is here described for the first time. The rediscovery of the endemic Orthopteran *Uromenus annae* proved that field research is performed under strong biases including blind faith in previous scientific literature, and expectations about the biology and ecology of the target species. *U. annae* escaped field researches in the documented localities, and was rediscovered serendipitously in two new unrelated locations. This casts doubt on the capacity of field researchers to assess, even in general terms, the possibility of success of field expeditions. We conceived a method inspired by the performance management tools from the world of corporate strategy: scorecards. The most famous among closed-choice, qualitative-quantitative checklists, is the Balanced Scorecard, based on original work from the late 1980's. We adapted those methods to the constraints of field research, and field-tested in a retrospective way for the search of *U. annae*. The EPS is freely available as a digital spreadsheet, and can be tested and customised at any time. Although in its infancy, the EPS looks like a promising operational tool to help saving time and money, and to identify which objectives and organizational setups are more promising. Besides providing a clearer, more rational basis for operational decisions, the straightforward compilation of an EPS may also mitigate the impact of cognitive biases.

Key words: cognitive bias, cost-effectiveness, expedition, field research, assessment, elusive species.

Introduction

Fortuitous findings may be particularly rewarding, and have always played a role in science: yet, no serious researcher would rely on serendipity alone.

Naturalistic research is a time-consuming activity, requiring relevant economic support and often an important involvement of human resources (Fontaine et al. 2007, 2012; Schvartzman & Schvartzman 2008; Britz et al. 2020). Although many of the factors affecting cost-effectiveness are well-known, scientific methodology is seemingly lacking general-purpose, quick and easy methods for the preliminary assessment of the possible success of field searches for living specimens.

To improve the quality of predictions about future events, we should understand the psychological mechanism by which expectations are built. Among those who delved into the subject, the work by Kahneman (2000) provides many useful insights, including the following: «*When an evaluative summary of a temporally extended outcome is required, a representative moment that stands for the entire outcome is selected or constructed; the temporally extended outcome is then assigned the value of its representative moment*».

With oversimplification as a built-in feature of our brain, inaccurate predictions are unsurprising. We need methods capable of ensuring a systematic, consistent and complete planning phase: by collecting, storing and pondering as much information as possible about the factors influencing our target-event, we'll improve the reliability of our predictions.

The quest for an elusive Sardinian endemic orthopteran, *Uromenus annae* (Targioni-Tozzetti, 1881), whose last captures dated back to the 1960's, confirmed that a combination of blind faith in scientific literature and undetected cognitive biases - including those of the first discoverer - may generate misleading expectations. In the last 20 years, several academic and amateur naturalists, including author Cesare Brizio, were involved in the search for living specimens of *U. annae*. Analogously to what recently reported by Liu et al. (2019) in the emblematic case of the rediscovery of the pollen-beetle *Brassicogethes sal-*

van (Coleoptera: Nitidulidae), all the surveys over the last decades concentrated exclusively on the *locus typicus* and all the other known localities (extrapolated from museum specimens and literature: Targioni-Tozzetti 1881; Fontana & Buzzetti 2001). At that time, it seemed sensible to assume that Targioni-Tozzetti's description of the habitat ("in or the surrounding of *Taxus baccata* bushes"), supported by the specimens collected (and subsequently lost: see Fontana & Buzzetti 2001), was accurate. *T. baccata,* once nearly ubiquitous in Sardinia, in the last two centuries experienced an extreme rarefaction (Paule et al. 1993; Brunu 2011; Multiple Authors 2018), mostly caused by anthropogenic factors, and is now restricted to a few well-known areas, most of which at elevations of more than 600 meters above sea level. As a consequence, the decline of *T. baccata* distribution seemed also to provide a plausible explanation for the apparent rarefaction and possible extinction of *U. annae,* a species biologically, even if unclearly, related with the disappearing tree.

Then, in the summer of 2018, *U. annae* serendipitous reappeared in two totally unrelated localities (including the island of San Pietro), none of which hosted *T. baccata* trees. Those findings forced a general reconsideration of the work by Targioni-Tozzetti (1881) who, most probably, failed to understand that the nearly-ubiquity (in his time) of that kind of tree voided any significance of the postulated relation.

This is an obvious example of strategic failure, as well as an alarm signal that improved decisional support is needed. In their four-step mathematical model of strategic renewal, Huff et al. (1992) define strategic renewal as "*the outcome of interacting stress and iner*tia". Any renewal path must go through four states (incremental adaptation within the framework of current strategy; deciding whether or not to consider a significant change in strategy; envisioning renewal alternatives; honeymoon and trial), a roadmap that provides a befitting description of the process from which this paper and our method emerged (it currently may be placed at the end of stage three of the four-step model). Citing Kuhn (1970), we hope that the alternative we propose will appear to be able to reduce the stress that the old strategic frame was not capable of addressing: then, the inertia supporting the old way of acting can quickly erode.

Methodologically, whenever a problem requires a numerical solution, random number generators and algorithm-based methods mark the limits of a range of increasing exactness, spanning from unsupported guesses to pure calculations. When complexity and complication impede - or make too expensive – the design of an accurate mathematical model, it's common practice to resort to the combination of experience-based induction and common sense going under the name of "educated guess".

We propose a form of number-assisted "guess education system" that provides a non-exact, yet reliable and meaningful approach to a preliminary, relative quantification of the possibilities that a field expedition reaches its objectives. Any objection pointing at the incapacity of the method to provide exact and absolute values is inadmissible - in fact, it declaredly hasn't neither of those purposes. As explained more under, the method is based on a set of indicators to be evaluated by selecting among a given number of indicator-specific, closed-choice descriptions, with each description automatically translated to a pre-set numerical value. Those values, on which simple calculations are based, may be considered as "quasi-numbers": they can be the subject of the arithmetical treatment described herein, but are exclusively meant for that treatment only, and may be compared, averaged or summarized just in the frame of a Consistent Set of scorecards as defined more under. Any other mathematical treatment of the values in the scorecard, or of its total score, is out of context. The reliability of the educated guess emerging from our method depends on an adequate and exhaustive choice of the parameters that will be assigned numerical scores: this paper illustrates the reasons for our initial proposal of indicators, whose number and ponderation - as long as the method is applied consistently throughout the whole scorecard - may be freely extended and modified according to specific needs and sensibilities of any research team. To encourage adoption, we needed a method that is flexible, easy to implement and to use, capable of being repurposed to any relevant need, and of delivering results immediately: we shaped our general purpose tool in the form of a multi-factor scorecard. Our methodology applies both in the case that at least one collection-based record is available, and in general when the ecological constraints, the habitus and the behaviours of the target species are at least partially known.

Born in sports such as baseball and basketball, the term "scorecard" is used in the world of corporate strategy to describe a family of performance management tools, the most famous of which is the Balanced Scorecard, based on original work from the late 1980's (Schneiderman 2006). In this usage, scorecards are closed-choice, qualitative-quantitative checklists, used to assess the degree of optimality of a strategy or the degree of compliance with corporate policies. By analogy, our **Encounter Predictability Scorecard** (**EPS**), considering all the factors that impact the possibility to obtain a (new) encounter with a target species, can help researchers to assess the possibility of success of their field activities.

The EPS is obviously sensible to data quality, and cannot be used to detect factual errors such as those by Targioni-Tozzetti. Yet, once the research objectives are clearly defined, it provides a decision support tool capable of testing the relative optimality of different logistic and organizational setups of a field expedition, and may help in eradicating wrong assumptions. Besides being very quickly compiled even by an untrained operator, an EPS can be adapted to specific needs. Despite its plasticity, it remains a valid first approximation frame to substantiate preliminary evaluations in an easily shared way, thus providing a more objective approach than "impressions" and "hopes" about the possibility of success granted by a specific organizational and logistic setup.

The multiple, complex and often complicate factors that dictate the success of a field expedition are virtually impossible to describe exactly in mathematical terms and, even if it were possible, the methodological cost of a correct mathematical representation of all the factors and of their interaction would be unaffordable. For that reason, we moved away from objective statistical quantities such as probability, a potentially misleading word that we avoided in the context of this paper.

Materials and Methods

An Excel spreadsheet, configured as required by the current version of the EPS and implemented with the necessary dropdown lists and calculations, can be downloaded from the following URL, is released under CC-SA license and can be freely modified, provided that the authors are credited: https://bit.ly/3edYYeG.

Indicator families

By "family" (Table 1) we refer to a loose grouping of indicators addressing a specific dimension of the predictability problem. Currently, we identified: Reliability; Space; Time; Accessibility.

Indicators' score

The scorecard is compiled by selecting one of the closed-choice descriptions available for each indicator. Each choice corresponds to a pre-set numeric value (score): for simplicity sake and consistency (see also "*Ponderation factors for the indicators"*, more under), the minimum and maximum score (respectively, 0 and 100) are equal for every indicator.

Table 1 – Search for *U. annae* in the four scenarios described in the text. Multipliers not applied.

Family	Indicator	Scenarios			
		A) Visit to Arcu Correboi, 2016	B) Hypothetical repetition of a visit to Arcu Correboi	C) July 2019 visit to Carloforte	D) July 2019 visit to Tepilora/Crastazza area
Reliability	Nature of the evidence	100=specimen collected and reliably determined	100=specimen collected and reliably determined	33=indirect	100=specimen collected and reliably determined
	State of the evidence	100=optimal quality	100=optimal quality	33=poor quality	100=optimal quality
	Form of the report	100=scientific publication.	100=scientific publication.	33=social media	100=scientific publication.
Spatial	Precision of location	33=general area	33=general area	33=general area	100=latitude and longitude
	Mobility of obs. species	66=semi-nomad	66=semi-nomad	66=semi-nomad	66=semi-nomad
	Mobility of the reporter	33=nomad	33=nomad	33=nomad	66=semi-nomad
	Habitat / ecol. constraints	100=ascertained	0=undefined	0=undefined	50=probable
	Specimen size	33=centimetric	33=centimetric	33=centimetric	33=centimetric
Time	Repeatability in time	66=often	33=sometimes	33=sometimes	33=sometimes
	Seasonality	50=probable	50=probable	50=probable	100=ascertained
	Number of observations	66=2 or 3	66=2 or 3	33=one,	66=2 or 3
Accessibility	Accessibility by public	66=allowed	66=allowed	0=absent/unknown (private areas),	66=allowed
	Nature of ground	33=mountain, steep climbs	33=mountain, steep climbs	66=hills, easy ascents	100=plain or semiplain;
	Vegetation cover	100=low and sparse vegetation, low grass patches.	100=low and sparse vegetation, low grass patches.	0=thick bush or high grass	100=low and sparse vegetation, low grass patches.
	Anthropic features	100=uninhabited area.	100=uninhabited area.	0=small patches of fenced land	66=agricultural or pasture with few boundaries between properties
Serendipity	Expedition duration	33=one day	33=one day	33=one day	33=one day
	Expedition timing	50=near the expected seasonality	50=near the expected seasonality	50=near the expected seasonality	100= coincident with reported seasonality
	Expedition basecamp	0=still undetermined	0=still undetermined	0=still undetermined	0=still undetermined
	Team size	33=one operator	33=one operator	33=one operator	33=one operator
	Kind of survey	33=one technique (visual)	33=one technique (visual)	33=one technique (visual)	33=one technique (visual)
	Total score	**1195**	**1062**	**595**	**1345**

Even if conceived as an objective system, the scorecard will be compiled by operators that will express their personal judgement on each indicator. It would be nonsense to require them to assign directly a precise score in a continuous 0-100 range. What would 45 or 56 mean? Consequently, just a few discrete scores are available, corresponding to the three (0-50-100) or four (0-33-66-100) different closed-choice descriptions available.

The assignment of numerical values to the chosen parameters, central to our proposal, may raise questions and - to err on the side of caution - in the following paragraphs we'll state the obvious - perhaps unnecessarily. As clarified, we are talking about arbitrary discrete numerical values, chosen within an arbitrary range. The scorecard does not provide an absolute value, but a relative numeric Final Score (FS) (Fig. 1; Table 1) to be compared with:

- a Maximum Reference Score (MRS);
- other compilations of the very same scorecard;
- a confidence range.

The concepts of FS, MRS and confidence range will be elucidated more under. For now, it suffices to say that for a valid and meaningful application of the method, we should ascertain that the four entities in play (the scorecard and the three terms for comparison in the list above) comply with the same set of conventions.

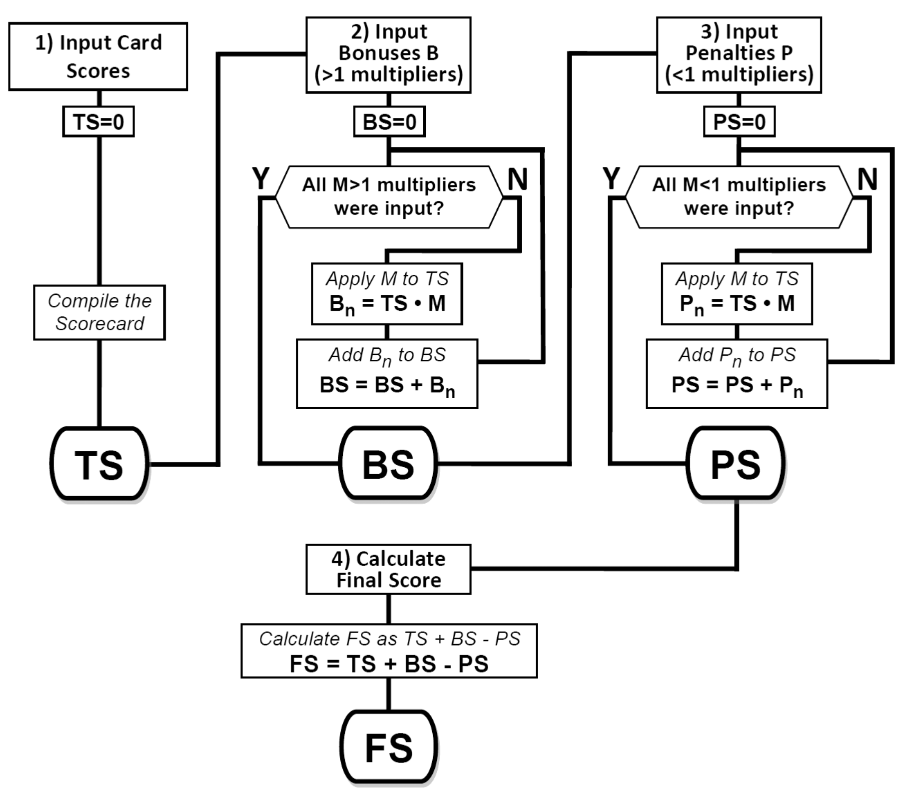
In other words, I cannot compare the TS of a scorecard where a given parameters may be assigned discrete values of, e.g., 25, 50, 75 and 100, with the TS of another scorecard where the very same (homonymous and homosemantic) parameter may be assigned values of 1, 2, 3 and 4. I cannot compare the TS of the latter scorecard with the MRS of the former.

Summarizing, comparability among any number of scorecards is meaningful only insofar as they include the same indicators and insofar as each indicator may be assigned the same discrete scores in every scorecard. Only under these obvious and intuitive conditions all those scorecards have the same MRS. As long as our proposed confidence threshold space is based on MRS and TS, the confidence index of each of those scorecards can be matched with the same confidence brackets. We may define such a set of scorecards as a Consistent Set.

When an indicator cannot be evaluated, it should be eliminated from the scorecard. Yet, if a general-use scorecard is prepared, specific indicators may not always apply, and altering the structure of the scorecard may be impractical. Whenever one decides to keep an inapplicable indicator on the scorecard, it should be assigned a zero score, to avoid any influence on the final score. When describing indicators, the following format will be used:

- Indicator name (number of different options): List of nominal values in ascending order, separated by a pipe character |

Fig. 2 – Confidence Threshold Space. Acronyms: TS, Total Score (sum of the indicator scores); MRS, Maximum Reference Score (total score when every indicator gets the maximum score); FS, Final Score (after the application of multipliers).



Alternative EPS's
For each scenario, it's plausible to compile more than one copy of the same EPS. This can occur in one, or both, the two following cases:
– **the same setup is submitted to more than one compiler:** for example, each member of the expedition assigns the scores according to his/her sensibility and his/her opinions, generating his/her own EPS. To summarize more than one EPS, some form of averaging is needed. With indicators assigned predefined discrete values, it may have no sense to average the scores attributed by different compilers to a specific indicator – in fact, the averaged values would be meaningful only as long as they can be traced back to one of the discrete values in the relevant list, which cannot be granted. It's much easier and meaningful to average the Final Scores (designated by the acronym FS) of all EPS's.

When doing so, it may be wise to find a way to account for the higher experience of some compilers, by assigning to each member an integer "experience factor" E that increases with field experience (e.g. each member is assigned an E from 1 to 3). That way, the scores assigned by the most expert members are counted more than once and have a higher influence on the averaged EPS score.

E is used as a multiplier for the final score by each compiler. That way, an expert team member with a competence factor of three would have his score multiplied by three, a less expert member would have his score multiplied by two, and members with no relevant experience would have no multiplier (multiplier = 1). For the following explanation, we'll refer to the result of those multiplications as "competence scores".

The final weighted score ws would be calculated by dividing the sum of the competence scores by the sum of the competence factors (in the example of three members with E as above, the sum would give six). The formula to calculate ws for n compilers assigned an E factor can be represented as follows:

$$ws = \frac{\sum_{c=1}^{n} FS_c E_c}{\sum_{c=1}^{n} E_c}$$

As an alternative, the scorecard may be compiled by the most expert team member(s) only - yet, it's advisable that the indicators are discussed by all the stakeholders.

One may ask whether it is reasonable to apply to our "quasi-numbers" operations such as averaging and weighted averaging, as in the case of the calculation of ws. In the light of the explanations provided in the "Indicators' score" section, the answer is obviously yes, insofar as we are averaging FS's from a Consistent Set of scorecards. Again, neither the simple average, nor the weighted average are meant as exact values, but as relative values that will be compared with a MRS and a confidence range.

The collective weighted FS of a Consistent Set of scorecards shifts towards a value nearer to the individual FS of the scorecards compiled by the most reliable and expert members (those assigned an E factor greater than 1).

– **alternative setups are submitted to any compiler:** for example, teams with a different number of differently skilled and differently equipped researchers are considered; different approach routes to the target sites are evaluated; alternative objectives (such as photos or audio recordings vs. living specimen capture) are considered. That way, the EPS works as a tool to evaluate the most cost-effective option.

Ponderation factors for the indicators
By assigning an equal maximum weight of 100 to all the indicators, we recognize our current incapability to generalize assumptions about which single factor, or which family, should influence more the expected outcome. In different contexts, specific families or specific indicators may outweigh others, in which case a suitable multiplier may be applied to the relevant entities.

Reliability indicators
The family includes all the indicators related with the reliability of the previous report(s) of the elusive species. They currently include:

- Nature of the evidence (4): anecdotal | indirect (photographic and/or acoustic) | specimen collected | specimen collected, stored and reliably determined;
- State of the evidence (4): unusable/lost | poor quality | suboptimal quality | optimal quality;
- Form of the report (4): anecdotal | digital post on social media | digital post on specialized forum | scientific publication.

After considering to evaluate the cultural background of the reporter, we decided that such an indicator would be misleading. As an example, the capture of a living specimen by an untrained observer is as good as the capture of the same specimen by a scholar; on the other hand, anecdotal evidence reported by a renowned scientist remains anecdotal.

Spatial indicators
The family includes all the indicators related with the precision of the previous report(s) in providing precise geographic coordinates of the collection station, as well as a dimension indicator, also affect the researcher's ability to locate the specimen. They currently include:

- Precision of location (4): absent | general area | locality name | latitude and longitude (at least two decimals);
- Mobility of the observed species (4): unknown | nomad | semi-nomad | resident or sessile;
- Mobility of the reporter (4): unknown | nomad | semi-nomad | fixed station;
- Habitat or ecological constraints (3): undefined | probable | ascertained;

- Specimen size (4): sub-centrimetic or requiring lenses | centimetric (1-10 cm) | decimetric (10 - 100 cm) | above 1 m.

From the point of view of the field researcher, the two following situations are at the extremes (respectively, positive and negative) of predictability: "This spider is now spinning a web in my garden" and "While I was on track in Sardinia, that spider crossed my path and disappeared". In the first case, both parties (reporter and observed species) stay stably fixed in a given location. In the second case, the encounter was just the intersection of two trajectories, at least one of which unpredictable. The second case is providing close to null information of the actual whereabouts of the elusive species and cannot provide any certainty about new encounters.

Time indicators
The family includes all the indicators related with the repeatability in time of the encounter with the elusive species. Currently defined time indicators are quite close to the spatial ones, and include:

- Observed Repeatability in time (4): not repeated | sometimes | often | always;
- Seasonality (3): undefined | probable | ascertained
- Number of observations (4): unknown | one | 2 or 3 | more than three.

It's much easier to replicate an encounter with a species that always shows up in summer in great numbers. It's just a matter of luck to collect one more specimen of something that was observed just once with no demonstrated seasonality.

Accessibility indicators
The family includes all the indicators related with the actual accessibility of the location previously reported. All other indicators being equal, the effort to reach a remote place, or to traverse a terrain full of obstacles including private properties, may outweigh the other factors. To err on the side of caution, when no information is available about its difficulty, progression will be considered extremely difficulty (score=0). Currently defined accessibility indicators include:

- Accessibility of the area by general public (4): absent (private areas) | on request | allowed | encouraged (e.g. by previous agreements with the owners/managers);
- Difficulty of progression (4): undefined | high (e.g. mountain, steep climbs...) | medium (e.g. hills, easy ascents, sandy ground) | low (e.g. plain or semi-plain, open and wide trails);
- Vegetation cover (4): thick bush or high grass | forest with thick undergrowth | forest with modest or no undergrowth | low and sparse vegetation or low grass patches.
- Anthropic features (4): small patches of fenced land, delimited by nets or walls | agricultural land with cultivated fields and ditches or fences | agricultural or pasture with few boundaries between properties | uninhabited area.

If we imagine a field trip as a transect, it's obvious that the more features the transect intersects, the more difficult is the research.

Reverse or "serendipity" indicators
History has shown, e.g. in the case of *Uromenus annae*, that it may be easier for an elusive species to unwillingly "find" us (or better to cross our spatial-temporal coordinates), than for us to find it proactively. Swapping perspective can be useful: how "findable" are we? The answer depends from the amount of time spent in the habitat of our target-species and in the precise spots where specimens can be encountered. Indicators currently defined include:

- Expedition duration (4): still undetermined | one day | 2 – 7 days | more than one week;
- Expedition timing (3): unknown or not coincident with expected species seasonality | near the expected seasonality | coincident with reported seasonality;
- Expedition basecamp (2): still undetermined | fixed base camp in the expected area of observation;
- Team size (4): still undetermined | one operator | 2 operators | more than 2 operators;
- Kind of survey (4): still undetermined | one technique (e.g. visual) | 2 techniques (e.g. visual + traps) | more than 2 techniques (e.g. visual + acoustic + traps).

We enclosed the "kind of survey" indicator because engaging more than one sense (e.g. sight and hearing) to intercept a species could also be described as making us "easier to find" by that species. The same concept can be applied to expedition timing.

It's obvious that setting a camp (or renting a house) in the area from where previous reports exist, would allow 24 hours per day for the target species to find us. Not by chance, *U. annae* entered respectively a building at Tepilora/Crastazza and a private garden at Carloforte, San Pietro Island. Local premises, gardens, tent camps should be considered as a peculiar kind of traps, especially for small species.

Multipliers
Regardless of the score derived by the indicators, the encounter success depends on general factors, irreducible to single indicators but affecting the entirety of the scorecard: those factors may be adequately represented by a multiplier of the total score. Multipliers are divided into bonuses (multiplier > 1) and penalties (multiplier < 1).

The impact of factors such as the exact form of the expected encounter and the attractability of the species to traps or lures, may affect the outcome of the expedition in a very radical way. For those reasons, in its current form, bonuses are conceived to potentially outweigh the penalties by increasing the total score of the indicators up to four times.

On the opposite, the penalties represent the level of inadequacy of the staff and of the equipment available, as well as the degree of elusiveness of the target species. As currently defined, their combined maximal weight is equal to two and half times the total score of the indicators. Taking for granted that, even in the worst case, the personnel and the equipment involved in the research are at least partly adequate to their respective tasks, and considering that species elusiveness is not absolute (in which case, the species would have never been discovered), no single penalty exceeds the unit. Each penalty provides a decrement ranging from zero in the optimal situation, to 0.75 or 0.825 of the total score in the worst case.

It's very obvious that even the multipliers can be freely customised in value, range and meaning, and that new multipliers may be added as deemed useful – despite being the fruit of a long reasoning on our part, our proposal can be improved and adapted to specific scenarios.

Currently, the EPS includes the following multipliers:

- **(BONUS) Objective** – which kind of evidence the expedition is aimed at: it's obvious that it would be much easier to collect, e.g., Snow Leopard footprints or photographs, than a live specimen. Considering capture as the default objective and the most difficult achievement, alternative objectives may increase, but not decrease, the ability to meet the desired species. Consequently, the objective-dependent multipliers start form 1.0 and are defined as follows:
  - Capture (dead or alive specimen): 1.0
  - Photograph or low distance (< 10m) audio recording: 1.25
  - Visual contact or high distance (> 10m) audio recording: 1.5
  - Collection of biological traces (exuviae, excrements, wads): 1.75
  - Collection of non-biological evidence (footprint casts, bird nests, marks such as scratches on tree barks): 2.0
- **(BONUS) Attractability to traps or lures** (light traps, audio calls, food lures, pheromone lures) – the ability to induce the target species to voluntarily reach the collection stations: it is equally obvious that such an ability would override most of the difficulties of proactive search. Metaphorically, we can consider traps and lures as some sort of extension of the proactive search range and of the search team size: they will not make an absent species magically appear, yet they may attract specimens within a given distance from the collection station. Considering that attractability may increase, but not decrease, the ability to meet the desired species, the multipliers start form 1.0 and are defined as follows:
  - Not attracted: 1.0
  - Moderately attracted: 1.33
  - Decidedly attracted: 1.66
  - Irresistibly attracted to traps: 2.0
- **(PENALTY) Elusiveness** – regardless of the specimen size, that has its specific indicator among the spatial parameters, specimen elusiveness can be considered as the inverse of attractability, and thus can only decrease the ability to meet the desired species. As a consequence, we may take it into account by reductive multipliers such as the following:
  - Highly elusive / mimetical / cryptical: 0.75
  - Mildly elusive / mimetical /cryptical: 0.5
  - Not elusive / brightly colored specimen (e.g. aposematic or vexillary colors): 0
- **(PENALTY) Degree of cultural/physical fitness of the team –** When considering the predictability of a new encounter obtained on purpose, we deem necessary to introduce a multiplier that takes into account both those factors, that will decidedly impact the potential success of any expedition. We consider this factor fundamental, to the point that perfect fitness is taken as default. Therefore, it's necessary to assign an overall average fitness value for the entire team, as follows:
  - Mostly untrained / unfit / perceptively hampered: 0.875
  - Overall, below average perceptive fitness, mobility and training: 0.75
  - Overall, average perceptive fitness, mobility and training: 0.50
  - Overall, above average perceptive fitness, mobility and training: 0.25
  - All specifically trained, no perceptive deficit and optimal fitness: 0

  Ponderation may change, considering that optimality criteria may vary both on the perceptive aspect - e.g. a minimal visual acuity suffices to detect an elephant-sized specimen and even a suboptimal hearing may suffice to detect a strong call such as a deer bellow - and on the cultural aspect.
- **(PENALTY) Degree of adequacy of technological equipment / tools used for evidence collection –** For all the search efforts requiring technological equipment / tools (e.g. microphones, optical equipment, light traps, fishing nets etc.) it's obvious that their adequacy for the specific task may determine the success of the expedition. Yet, the diversity of those equipment, each one described by its specific performance indexes, prevents us from going beyond the following vague generalization: equipment sub-optimality can only decrease the ability to obtain an encounter. The degree of sub-optimality is expressed by the following multipliers, where zero represents the equivalent state-of-the-art, optimal equipment that would have been used in the ideal case:

  ○ Mostly aged, limited or suboptimal equipment: 0.875
  ○ Overall, below average equipment completeness/performance: 0.75
  ○ Overall, average equipment completeness/performance: 0.50
  ○ Overall, above average equipment completeness/performance: 0.25
  ○ Ideal equipment completeness/performance: 0

Operationally, the multipliers are applied as follows:

- The TOTAL SCORE (TS) emerges from the compilation of the scorecard – in the best case, it will equal the MAXIMUM REFERENCE SCORE (MRS);
- bonuses (if applicable) are input – for each bonus, TS is multiplied by the applicable value, and each result concurs to the BONUS SCORE (BS);
- penalties (if applicable) are input – for each penalty, TS is multiplied by the applicable value, and each result concurs to the PENALTY SCORE (PS);
- The FINAL SCORE FS is calculated as TS + BS - PS. In its present form, under unfavourable circumstances penalties may exceed bonuses and, particularly when no bonus can be applied, the FS may even drop below zero, a situation that casts obvious doubts on the usefulness and the viability of an expedition.

Kingdom - or ecological niche-dependent indicators and multipliers

It's easy to observe that there are whole groups of indicators that can be applied, and need to be applied, to specific Linnaean kingdoms. As an example, the hypogeic nature of some plants or fungi may affect substantially the ease of collection; regardless of the kingdom, in any specimen that needs to be collected at ground level will require a higher effort both in search and in collection. For those reasons, one may choose where to include a new indicator among the spatial factors:

- Ecological niche occupation(4): Epigeic arboreal / Hypogeic (deep) / Undefined | Hypogeic (superficial) | Epigeic superficial or herbaceous | Epigeic shrub-like

or a corresponding multiplier:

- Epigeic arboreal / Hypogeic (deep) / Undefined 0.75
- Hypogeic (superficial) 0.5
- Epigeic superficial or herbaceous 0.25
- Epigeic shrub-like 0

By applying a well-chosen set of similar indicators or multipliers, the EPS (currently conceived for subaerial environments) may be adapted to speleological expeditions.

Impact of the search for different ontogenetic stages

Both holometabolous and heterometabolous arthropods may include pre-imaginal stages with ecological needs radically different from the adults' (e.g. Odonata). To some degree, this may also apply to those vertebrates that, as in the case of birds, may undergo radical ontogenetic changes and be collected as eggs as well as chicks or adults, with significantly different degrees of mobility and elusiveness, as well as in different environments.

We deem impossible to represent such a wide scope of variability by means of indicators or multipliers. Objectives as diverse as collecting eggs or pulli versus adult birds, or aquatic larvae versus flying insects, may deserve separate scorecards; an expedition aptly equipped to target one objective may miss the other.

By calibrating the EPS to the most difficult scenario, the researcher would obtain a "worst case" evaluation and, once on the field, consider easier opportunities (e.g. collecting butterfly eggs instead of adults). Again, it is difficult to convey flexibility in a closed-choice system such as a scorecard, and it will be up to any reader to adapt it to specific needs. The time needed to configure and fill more target-specific EPS is surely shorter than the time needed to implement a single EPS with the flexibility needed to manage radically different objectives.

Confidence Indexes

Coming to the relative value of the EPS scores, it is straightforward to affirm that when more than one EPS is compiled for a specific scenario, with each EPS representing a different organizational setup (see above, "Alternative Evaluations"), the best scoring EPS represents the most cost-effective option available for that specific scenario.

Prudence should govern any assertion about the objective value of FS, the EPS Final Score.

Assuming that the parameters are well-chosen and that the compiler is competent, the highest the FS, the highest is the likelihood of the accomplishment of a mission. It is equally safe to acknowledge that a poorly scoring EPS is an unequivocal sign of possible failure; a condition that will require a renegotiation of the objectives, or the methods, or the resources, or of them all. A poorly scoring EPS signals an expedition whose success may rely on serendipity alone. Prudence is the most obvious reasons why we cannot provide a general "safety threshold" above which success is granted:

- first and foremost, there is no way to grant the success of any field expeditions, including the best equipped and longest lasting: if the field trip objectives were attainable effortlessly, there would be no necessity of tools such as the EPS;
- EPS is a roadmap to transform serendipity in a predictable pattern, not to eliminate it. Serendipitous encounters occur routinely, both in poorly and in well structured expeditions;
- multipliers are necessary, but they may affect the results in such a radical way, that the FS may range from four times the maximum theoretical score MRS, to below zero. Even if it were possible to define numerical degrees of confidence for the TS (and this is not the case), they would lose any meaning once the multipliers are applied;

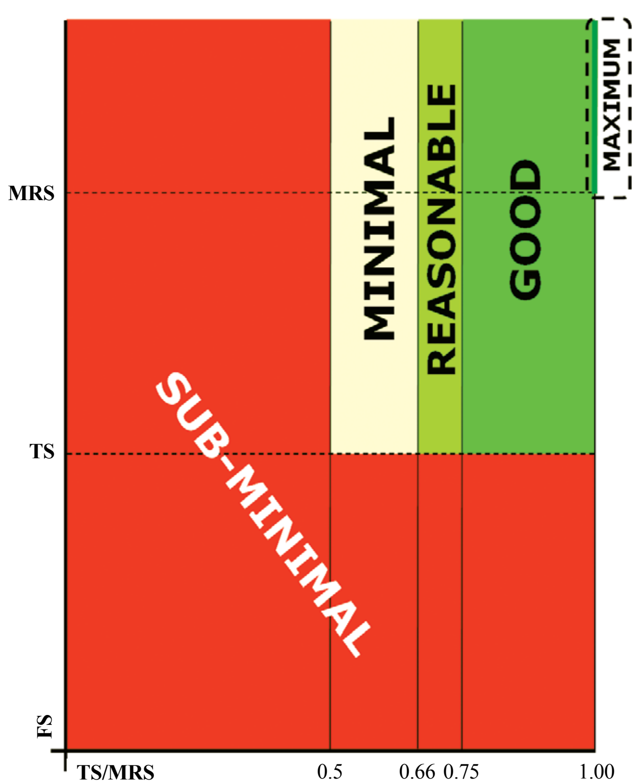
- a certain number of indicators are optional or inapplicable in some context; this condition hampers the definition of confidence thresholds both as absolute values and as percent values;
- any reader can customize or repurpose the EPS by adding new indicators or by eliminating existing indicators, thus nullifying possible standardization efforts such as predefined confidence thresholds;
- the method based on the EPS is virtually untested in the field, and currently no historical data exists.

For all these reasons, we propose and illustrate in Fig. 2 the following purely conventional and still untested set of confidence brackets, based on a Confidence Index provided by the TS and the FS and on the MRS, as described above: it goes without saying that the brackets can and should be adapted to the specificities of any customized EPS and to the sensibility of any researcher.

According to our still untested reasoning, success requires two conditions:

A. that the Total Score TS (sum of the indicators' scores) is at least 50% of the theoretical Maximum Reference Score MRS;
B. that bonuses outweigh penalties or balance them (in that case, Final Score FS will be equal to TS, or higher).

Fig. 2 – Confidence Threshold Space. Acronyms: TS, Total Score (sum of the indicator scores); MRS, Maximum Reference Score (total score when every indicator gets the maximum score); FS, Final Score (after the application of multipliers).



Current confidence thresholds are defined as follows:

- MAXIMUM DEGREE OF SUCCESS, when TS = MRS and FS > MRS;
- GOOD DEGREE OF SUCCESS, when TS >= 75% MRS and FS >= TS;
- REASONABLE DEGREE OF SUCCESS, when TS >= 66% MRS and FS >= TS;
- MINIMAL DEGREE OF SUCCESS, when TS >= 50% MRS and FS >= TS;
- Under the minimal degree of success, the possibility of failure is inversely proportional to the FS.

Only time will tell whether or not similar intervals of confidence may be considered fact-based.

Results

We provide in Table 1 a test application in four different scenarios, all related with the quest for *U. annae*. As a first application of the method, with no precedents, we still have to calibrate the system. Yet, it will be interesting to see how the card reacts to related scenarios, three of which already field tested in terms of scientific results. Multipliers as described above will not be applied to the scenarios, as long as they would equally affect each scenario and would not provide any additional information.

All the four EPS discussed were prepared subsequently to the visits, so they should not be considered as a planned test, but rather as sort of an example of application - the advantage being the fact that, knowing the result of the visits, we can relate the actual score with the one that would have been obtained if an EPS would have been prepared beforehand. Scenarios are summarized in Table 1:

- **Scenario A** is an EPS for a visit performed by Author 1 in 2016, at Arcu Correboi, locality cited in the 1881 paper - a visit based on the assumption that habitat information provided by Targioni-Tozzetti (1881) were good. The visit was unsuccessful due to what we now know are obvious reasons. The EPS would have scored 1195 out of 2000 points. The score represents 59.75% of the maximum.
- **Scenario B** is an EPS for the same visit of Scenario A, if performed today. Habitat and ecological constraints have dropped to zero, as long as Targioni-Tozzetti (1881) wrongly associated *U. annae* and Yew trees. Repeatability dropped to 33 because the last visit to the same place was fruitless. The score of 1062 represents 53.1% of the maximum.
- **Scenario C** is an EPS for a visit of Author 1, in late July 2019, to Carloforte, following the publication on Facebook of a picture assigned to *U. annae* in Buzzetti et al. 2019. The unsuccessful field trip encountered many obstacles including the fragmentation of private properties and the vegetation cover of the hilly ground. The plain area near Carloforte, boarding the lagoons,

showed the same fragmentation that made the visit to each garden impractical, to say the least. Sparse small patches of terrain out of the private enclosures did not provide an adequate search area. With a score of 595 on 2000 (29.75% of the maximum score), this expedition should have been avoided.

- **Scenario D** is an EPS for a visit of a team of the University of Sassari, in late July 2019, to Tepilora/ Crastazza, site of the serendipitous reappearance *U. annae* reported in Buzzetti et al. 2019. The preliminary EPS of the successful field trip scored a very promising 1345 on 2000 (67,25% of the maximum score, just above the "two thirds" threshold). The score would improve further 50 points if the whole score of 100 points would have been assigned to the Habitat /Ecological Constraints indicator (in fact, the specimens were captured just there in 2018), but still there is some habitat variability in the area, and the work to assign *U. annae* to his actual specific habitat is in progress.

Discussion

Our method is a tool to support the organization of field expeditions aimed at specimen collection, and to assess the likelihood of their success – a success that ultimately depends on the actual distribution of the target species in the real world. By choosing the values of some of the indicators in our scorecard, such as those about seasonality, repeatability, specimen mobility and ecological constraints, the compiler inputs his hypotheses about those factors. To be reasonable, such hypotheses should depend on direct experience and scientific literature, including works in the fields of Species Distribution Models (SDM) and Spatial / Distributional Ecology. As a consequence, even though our method has no relation with, nor immediate application in, those fields we deem appropriate to cite some suitable references.

These citations do not imply methodological affinity, nor commonality of purposes, between our tool and the references cited, but rather they are a tribute to the scholars such as Antoine Guisan and Loïc Pellissier, who designed and improved methods and protocols to deal with the uncertainties of numerical and spatial biodiversity. As mere examples, we list:

– The works published on "Ecology Letters" by Guisan & Thuiller (2005) and Guisan et al. (2013), respectively elucidating the SDM methodology and illustrating the role of Species Distribution Models in the guidance of conservation efforts, in the monitoring of invasive species, and emphasising the need of a better mutual understanding between decision-makers and species distribution modellers.

– The work by Williams (2009) that demonstrates the existence of a lower threshold in the number of occurrences required to build good species distribution models, such as those based on randomization and entropy, which use presence data and information about the background matrix where species do not occur.

– The work by Pellissier et al. (2010), centred on the distribution of the shrub *Empetrum nigrum* ssp. *hermaphroditum*, and 34 subordinate species in the tundra of northern Norway, that shed light on the relative importance of facilitation and competition in that species assemblage, and revealed how the predictions of subordinate species according to their traits or co-occurrence values can deliver better predictions about communities than those derived by the stacking of individual species predictions based on environmental predictors alone.

– The work by D'Amen et al. (2015), about the SESAM (Spatially Explicit Species Assemblage Modelling) framework, a combination of successive filters to the initial species source pool that combines different modelling approaches and rules, including macroecological models and a stacking of individual species distribution models, to obtain more realistic predictions of species assemblages.

– The work by McCune (2016) about the effectiveness of Species distribution models in targeting searches for populations of rare plant species even in fragmented, human-dominated landscapes.

While all those authors dealt with species distribution, our proposed method is not meant to deal with biodiversity, nor to provide quantitative or positional assessments. As clarified in the introduction, our EPS is just meant as a quick, first approximation approach for the assessment of the likelihood of the success of an expedition aimed at some form of specimen collection. The expected species distribution influences the compilation of the scorecard and must be known, or estimated, before applying our method.

Furthermore, unlike the works of the authors cited above, we are emphasising the impact of cognitive bias on any field research activity: those biases can be mitigated by providing a common reference frame for all the stakeholders involved in the field activities, and thus by directing their energies towards a more objective, less bias-prone evaluation of the likelihood of the expedition's success. Our method responds to this challenge by providing a configurable array of pre-set choices, compiled through a step-by-step questionnaire, and by including simple automated calculations.

The wide array of cognitive phenomena going under the name of "Collection Bias" and "Search Bias" encompasses all the arbitrary factors that may hamper data collection (in our case, the collection of live specimens of a given elusive species), by introducing misleading elements, including historical misunderstanding, as well as cognitive biases among which cognitive inertia, confirmation bias and hindsight bias.

- **Cognitive inertia** refers to the tendency for beliefs or sets of beliefs to endure once formed. In particular, cognitive inertia describes the human inclination to

rely on familiar assumptions and exhibit a reluctance and/or inability to revise those assumptions, even when the evidence supporting them no longer exists or when other evidence calls them into question.
- **Confirmation bias** (*sensu* Plous 1993) is the well-known tendency to search for, interpret, favour, and recall information in a way that confirms pre-existing beliefs or hypotheses. It is a type of cognitive bias and a systematic error of inductive reasoning. People display this bias when they gather or remember information selectively, or when they interpret it in a biased way. The effect is stronger for desired outcomes, emotionally charged issues, and for deeply entrenched beliefs.
- **Hindsight bias**, also known as the knew-it-all-along phenomenon or creeping determinism, refers to the common tendency for people to perceive events that have already occurred as having been more predictable than they actually were before the events took place (Fischhoff 1975).

Although we mentioned just three of the many cognitive biases underlying our conscious beliefs, this short overview should suffice to illustrate that, to some extent, expectations are not always fact based. Sure! The rarefaction of Yew Trees was the cause of the extinction of *U. annae*! What else?? We now know.
- Under confirmation bias, we do believe Targioni-Tozzetti;
- under cognitive inertia, regardless of the absence of findings, we continue to look for *U. annae* under the few relict Yew Trees;
- then, under Hindsight Bias, we may believe that we always knew that there was something wrong and yes, we should have noticed the problem before.

The subject of Dave Gray's Liminal Thinking (Gray 2016) is the complex intellectual activity needed to minimize reality distortion by removing prejudices and unjustified assumptions, and by getting rid of cognitive biases and restoring an objective field of view on any subject of research. Even though Gray's work is not specifically aimed at scientific research, nonetheless his warnings and suggestions may be applied to any field.

This is not the place to delve deeply into the theory of liminal thinking; it will suffice to propose the six principles on which that theory and its supporting practices are based. The six points that follow are a textual citation from http://liminalthinking.com/six-principles/ :
1. Beliefs are models. Beliefs seem like perfect representations of the world, but in fact they are imperfect models for navigating a complex, multidimensional, unknowable reality.
2. Beliefs are created. Beliefs are constructed hierarchically, using theories and judgments, which are based on selected facts and personal, subjective experiences.
3. Beliefs create a shared world. Beliefs are the psychological material we use to co-create a shared world, so we can live, work, and do things together. Changing a shared world requires changing its underlying beliefs.
4. Beliefs create blind spots. Beliefs are tools for thinking and provide rules for action, but they can also create artificial constraints that blind you to valid possibilities.
5. Beliefs defend themselves. Beliefs are unconsciously defended by a bubble of self-sealing logic, which maintains them even when they are invalid, to protect personal identity and self-worth.
6. Beliefs are tied to identity. Governing beliefs, which form the basis for other beliefs, are the most difficult to change, because they are tied to personal identity and feelings of self-worth. You can not change your governing beliefs without changing yourself.

The main novelty of Liminal Thinking is the criticism of any system of beliefs as the possible source of self-imposed, unperceived yet fully effective limitations in our scope of thought and action. The small revelations gained by the retrospective on the case of *U. annae*, show that we may, and should, apply such a level of criticism to widely held beliefs.

What use may a simple scorecard have in restoring a clearer understanding of our biases or misplaced beliefs? Well, when everything seems set up for the collection of a new specimen of a given species, yet one can not find it in repeated attempts; or when an extinct species pullulates unexpectedly, it seems that there are wrong assumptions to deal with. In the narrow sector of specimen collection under the authority of previous reports, the EPS may help to re-describe and re-discuss the frame of our expectation.

Conclusions

It is clear that the novel EPS scorecard is in its infancy, and some adjustments and rethinking shall be needed to improve its usefulness as an operational tool.

Yet, it is our impression that, if we had available a tool like the EPS, we might have performed a preliminary assessment of our previous expeditions that would have greatly helped in saving time and money, and would also helped us to identify which lines (and places) of field research to favour.

We strongly believe that the EPS can be repurposed, customized, and adapted to any field, even outside the zoological realm, where expeditions for specific target species are organized based on the evidence provided by previous reports: that may include Palaeontology, Archaeology and other Human Sciences.

Compiling an EPS may help overcome cognitive bias, including the most subtle and ill defined, that is hope, and provide a clearer, more rational basis for operational decisions.

Considering that our method and this paper in its entirety are the fruit of the reconsideration of the case of *Uromenus annae*, and to complement our criticism to the biased mindset of the researchers who followed his steps under the influence of cognitive biases, we deem necessary to point out the methodological errors by Targioni-Tozzetti (1881) in that specific case. Anybody can recognize as a major failure his incapacity to understand that under no circumstance correlation implies causation by default. None should postulate any kind of biological relation relying uniquely on the concomitant presence of two species in the same space and time, even less so when the number of observed specimens is low.

Targioni-Tozzetti (1881) observed just the coincident presence of a few specimens of the insect and Yew Trees, a common background at the times of the discovery, and never tried systematically to locate *U. annae* far from the Yew Trees, nor did observe any link between any fact in the biological cycle of *U. annae* and the *Taxus baccata* trees (e.g. feeding, egg deposition under the tree's bark, mimicry with the tree or with its parts...): this lack of proofs should have sufficed to take the wind out of the sails of the bio-ecological constraint hypothesis.

Also such a wrong inference is the effect of cognitive biases (including Availability Effect, making decisions based on immediate information or examples that come to mind; Recency Effect, where recent events are easier to remember, and can be weighed more heavily than past events or potential future events; Selection Bias, occurring when individuals or groups in a study differ systematically from the population of interest).

Furthermore, and even less excusably, Targioni-Tozzetti (1881) based his conclusions on a limited number of specimens, sufficient for a morphological description (which in fact is still valid today) but inadequate for substantiating a biological tie between *U. annae* and *T. baccata*, especially when no factual interaction between the two species was recorded.

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References

Britz A., Hundsdörfer U.F. 2020. Funding, training, permits—the three big challenges of taxonomy. Megataxa, 001 (1): 049–052.

Brunu A. 2011. Sistematica, distribuzione, ecologia e aspetti gestionali delle foreste di tasso (*Taxus baccata* L.) e agrifoglio (*Ilex aquifolium* L.) in Sardegna. Ph.D. Thesis, Università degli Studi di Sassari. Available on-line at: https://core.ac.uk/download/pdf11691345.pdf [Accessed June 14, 2020]

Buzzetti F.M., Brizio C., Fontana P., Massa B. 2019. A new voice from Sardinia: *Uromenus annae* (Targioni-Tozzetti, 1881) (Insecta: Orthoptera: Tettigoniidae: Bradyporinae: Ephippigerini). Zootaxa, 4560(2)**:** 311–320.

D'Amen M., Dubuis A., Fernandes R.F., Pottier J., Pellissier L., Guisan A. 2015. Using species richness and functional traits predictions to constrain assemblage predictions from stacked species distribution models. Journal of Biogeography, 42: 1255–1266. Doi: 10.1111/jbi.12485

Fischhoff B. 1975. "Hindsight ≠ foresight: The effect of outcome knowledge on judgment under uncertainty". Journal of Experimental Psychology: Human Perception and Performance, 1 (3): 288–299.

Fontaine B., Bouchet P., Van Achterberg K., Alonso-Zarazaga M.A, Araujo R., Aspöck U., Audisio P., Aukema B., Bailly N., Balsamo M., Ban, R.A., Barnard P., Belfiore C., Bogdanowicz W., Bongers T., Boxshall G., Burckhardt D., Camica, J.L., Chylarecki P., Crucitti P., Deharveng L., Dubois A., Enghoff H., Faube, A., Fochetti R., Gargominy O., Gibson D., Gibson R., Gómez López M.S., Goujet D., Harvey M.S., Heller K.G., Van Helsdingen P., Hoch H., De Jong H., De Jong Y., Karsholt O., Los W., Lundqvist L., Magowski W., Manconi R., Martens J., Massard J.A., Massard-Geimer G., Mcinnes S.J., Mendes L.F., Mey E., Michelsen V., Minelli A., Nielsen C., Nieto Nafría J.M., Van Nieukerken E., Noyes J., Pape T., Pohl H., De Prins W., Ricci C., Roselaar C., Rota E., Schmidt-Rhaesa A., Segers H., Zur Strassen R., Szeptycki A., Thibaud J.M., Thomas A., Timm T., Van Tol J., Vervoort W., Willmann R. 2007. The European Union's 2010 target: putting rare species in focus. Biological Conservation, 139: 167–185..Available on-line at: https://www.researchgate.net/publication/222895960_The_European_union's_2010_target_Putting_rare_species_in_focus [Accessed June 14, 2020]

Fontaine B., Van Achterberg K., Alonso-Zarazaga M.A., Araujo R., Aspöck H., Aspöck U., Audisio P., Aukema B., Bailly N., Balsamo M., Bank R.A., Belfiore C., Bogdanowicz W., Boxshall G., Burckhardt D., Deharveng L., Dubois A, Enghoff H., Fochetti R., Fontaine C., Gargominy O., Gomez Lopez M.S., Goujet D., Harvey M.S., Heller K.-G., Van Helsdingen P., Hoch H., De Jong Y., Karsholt O., Los W., Magowski W., Massard J.A., Mcinnes S.J., Mendes L.F., Mey E, Michelsen V., Minelli A., Nieto Nafria J.M., Van Nieukerken E.J., Pape T., De Prins W., Ramos M., Ricci C., Roselaar C., Rota E., Segers H., Timm T., Van Tol J., Bouchet P., 2012. New Species in the Old World: Europe as a Frontier in Biodiversity Exploration, a Test Bed for 21st century Taxonomy. PLOS Biology, 7(5): e36881. Doi: 10.1371/journal.pone.0036881

Fontana P., Buzzetti F.M. 2001. On the identity of *Ephippigera annae* Targioni-Tozzetti, 1881. Atti dell'Accademia Roveretana degli Agiati, Classe di Scienze Matematiche, Fisiche e Naturali, ser. 8, 1, B: 53–66.

Gray D. 2016. Liminal Thinking: Create the Change You Want by Changing the Way You Think - Two Waves Books. ISBN: 1-933820-46-2.

Guisan A., Thuiller W. 2005. Predicting species distribution: Offering more than simple habitat models. Ecology Letters, 8: 993–1009. Doi: 10.1111/j.1461-0248.2005.00792.x

Guisan A., Tingley R., Baumgartner J.B., Naujokaitis-Lewis I., Sutcliffe P.R., Tulloch A.I.T., Regan T.J., Brotons L., McDonald-Madden E., Mantyka-Pringle C., Martin T.J., Rhodes J.R., Maggini R., Setterfield S.A., Elith J., Schwartz M.W., Wintle B.A., Broennimann O., Austin M.P., Ferrier S., Kearney M.R., Possingham H.P., Buckley Y.M. 2013. Predicting species distributions for conservation decisions. Ecology Letters, 16: 1424–1435.

Huff J.O., Huff A.S., Thomas H. 1992. Strategic renewal and the interaction of cumulative stress and inertia. Strategic Management Journal, 13 (S1): 55–75.

Kahneman D. 2000. Evaluation by Moments: Past and Future -

Chapter 38 in: Kahneman D. & Tversky A. (Eds), Choices, Values and Frames, New York: Cambridge University Press.
Kuhn T.S. 1970. The Structure of Scientific Revolutions, Chicago: The University of Chicago Press.
Liu M., Sabatelli S., Mancini E., Trizzino M., Huang M., Cline A.R., Audisio P. 2019. Rediscovery of *Brassicogethes salvan* (Coleoptera: Nitidulidae, Meligethinae) in the south-western Alps. Insect Conservation and Diversity, 12: 80–87. Doi: 10.1111/icad.12317
McCune J.L. 2016. Species distribution models predict rare species occurrences despite significant effects of landscape context. Journal of Applied Ecology, 53: 1871–1879. Doi: 10.1111/1365-2664.12702
Multiple Authors. 2018. Database of Monumental Trees of Sardinia. Available on-line at: http://dati.regione.sardegna.it/dataset/elencoregionale-alberi-monumentali-ditalia-legge-14-gennaio-2013-n-10-dm-23-ottobre-2014 [Accessed June 14, 2020]
Paule L., Gomory D., Longauer R. 1993. Present distribution and ecological conditions of the English yew (*Taxus baccata* L.) in Europe. Paper for the International Yew Resources Conference, Berkley, CA, March 12-13.
Pellissier L., Bråthe K.A., Pottier J., Randin C.F., Vittoz P., Dubuis A., Yoccoz N.G., Alm T., Zimmermann N.E., Guisan A. 2010. Species distribution models reveal apparent competitive and facilitative effects of a dominant species on the distribution of tundra plants. Ecography, 33: 1004–1014. Doi: 10.1111/j.1600-0587.2010.06386.x
Plous S. 1993. The Psychology of Judgment and Decision Making. McGraw-Hill. ISBN: 9780070504776, 233
Schneiderman A.M. 2006. Analog Devices: 1986-1992, The First Balanced Scorecard. Available on-line at: https://web.archive.org/web/20131225101701/http://www.schneiderman.com/Concepts/The_First_Balanced_Scorecard/BSC_INTRO_AND_CONTENTS.htm [Accessed June 14, 2020]
Targioni-Tozzetti A. 1881. *Orthopterorum Italiae species novae in collectione R. Musei Fiorentini digestae*. Bullettino della Società entomologica italiana, Firenze, 13: 180–186.
Schvartzman J.M., Schvartzman J.B. 2008. How do we ask for money? A view of funding for basic research. EMBO Reports, 9(3): 216–220.
Williams J.N., Seo C., Thorne J., Nelson J.K., Erwin S., O'Brien J.M., Schwartz M.W. 2009. Using species distribution models to predict new occurrences for rare plants. Diversity and Distributions, 15: 565–576. Doi: 10.1111/j.1472-4642.2009.00567.x