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A method for selecting plant species for reintroduction purposes: A case-study on steppe grassland plants in Thuringia (Germany)

Eine Methodik zur Auswahl von Pflanzenarten für Wiederansiedlungen: Fallstudie am Beispiel der Steppenrasen Thüringens (Deutschland)

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Abstract

Reintroductions of plant species are increasingly popular in conservation practice. Steppe grasslands contain many rare and endangered plant species that are potential objects for such reintroductions. Most reintroduction projects, however, can only target a restricted number of species, which raises the question of how species should be prioritised. Here, we present a method to select priority species for reintroduction based on species' characteristics that are widely used in conservation practice. We first determined the local species pool containing those vascular plant species that occurred both in our target region (Thuringia, Germany) and target habitat (steppe grasslands), yielding 369 species. With the help of an a priori filter that selected currently endangered species with limited distribution, 136 potential target species were determined. These potential target species had experienced stronger decline, had a narrower phytosociological amplitude and were more likely to be species of the *Festuco-Brometea* class and the *Festucetalia valesiacae* order than non-target species. Potential target species were then ranked by a points system based on ten conservation-relevant characteristics of the species from the categories 'threat and protection status', 'distribution and decline', and 'habitat affiliation'. In the ranking, six steppe grassland plant species (*Astragalus exscapus*, *Bothriochloa ischaemum*, *Prunella laciniata*, *Pulsatilla pratensis* subsp. *nigricans*, *Scorzonera purpurea*, and *Seseli hippomarathrum*) achieved the highest scores. An additional seven species not specifically characteristic for steppe grasslands also scored highly. A post hoc evaluation of these 13 highest scoring species based on additional conservation criteria left five species (*Astragalus exscapus*, *Linum leonii*, *Orchis morio*, *Pulsatilla pratensis* subsp. *nigricans* and *Scorzonera purpurea*) as species with highest priority for reintroductions and another five species as highly suitable for reintroductions. Associations between the ranking order and different ranking criteria revealed that a species' threat and rarity in Thuringia and its protection status had the highest representation in the ranking, followed by threat in Germany, regional decline and habitat affiliation. In contrast, international threat and responsibility of Thuringia for its conservation had only low representation in the ranking, probably because these characteristics applied to only a few species. The ranking list gives a selection of species for reintroductions, which combined with additional information based on comprehensive local and floristic knowledge, allows the identification of the species with the highest priority. Our method can be transferred to other regions or habitat types.

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Erweiterte deutsche Zusammenfassung am Ende des Manuskripts

1. Introduction

Reintroductions of plant species are an important issue in conservation practice (MAUNDER 1992, FALK 1996, GODEFROID et al. 2011) and are increasingly conducted in Central Europe (LÜTT 2009, THORMANN & LANDGRAF 2010, NOËL et al. 2011). Reintroductions can serve different purposes: on the one hand, plant communities can be restored by introducing a complete set of species via various grassland restoration methods (HEDBERG & KOTOWSKI 2010, KIEHL et al. 2010, TÖRÖK et al. 2011). For the restoration of ecosystem functions on the other hand, reintroductions of single key species may be important – examples are the reintroduction of *Calluna vulgaris* in degraded heath landscapes (MITCHELL et al. 2008) and the reestablishment of *Sphagnum* species in order to regenerate bogs (GRAF & ROCHEFORT 2010). Finally, rare or locally extinct species can be reintroduced for species conservation purposes, like *Pulsatilla patens* in the Munich gravel plain (KIEHL & RÖDER 2008), *Gladiolus imbricatus* in alluvial landscapes in Estonia (JÕGAR & MOORA 2008) or *Vitis vinifera* subsp. *silvestris* in the Middle Rhine Valley (ARNOLD et al. 2005).

Concerning reintroductions of single rare or endangered species, one major question arises, namely how to select priority species for reintroduction. Although most conservation measures are conducted as part of local nature conservation projects and thus species pools are limited from the beginning (BRUDVIG & MABRY 2008), a further restriction to species particularly in need of and suitable for reintroduction needs to take place due to usually limited project resources. These selections should be based on empirical methods.

One possible approach would be a selection of species by their biological and ecological traits such as dispersal ability or width of ecological niche (BRUDVIG & MABRY 2008). This idea is based on the fact that e.g. specialised species with low dispersal ability have difficulties recolonising former habitats and might therefore be dependent on artificial dispersal by reintroduction measures (PYWELL et al. 2003). However, for many species sufficient information on biological and ecological traits is not available. Another way of determining potential target species is to evaluate plant species by criteria also used in applied conservation. For example, Red List status describes the species' threat at regional, national, and international scales and thus also forms the basis of determining target species in flora protection schemes (e.g. RAAB & ZAHLHEIMER 2005, SEITZ 2007). However, Red Lists only give a coarse estimation of the degree of threat of a species. Consequently, in order to differentiate more precisely between species, more detailed information on rarity and decline of a species is needed. This information is e.g. available from floristic atlases (for Germany e.g. NETPHYD & BFN 2013). Besides distribution and degree of threat of a species, also the responsibility of a region for the long-term survival of a species is important for its conservation (WELK 2002, RAAB & ZAHLHEIMER 2005, ZÜNDORF et al. 2006). Finally, the legal protection status of a species may affect its conservation value. However, at least in Germany, the protection status of a species is often based rather on social consensus and its perceived attractiveness than on its real threat. The attitude of society to a species can nevertheless play a role in the selection of a species worth reintroducing e.g. via willingness to spend money on nature conservation purposes (IUCN 1998).

A necessary requirement for the selection of target species is the suitability of the available habitat (LAWRENCE & KAYE 2011). This requirement is fulfilled if the targeted species and plant community match in phytosociological terms. In addition, the phytosociological affiliation of the species allows us to distinguish e.g. between specialised species that are bound to a single community and more generalised species occurring in several plant communities. Moreover, this phytosociological approach helps to restore a community and thus may increase its value. Currently, the number of characteristic species in Habitats Directive mapping is essential for characterising and evaluating single habitats (e.g. TLUG 2001). In Central Europe, community affiliation of plant species is well documented by phytosociological surveys (OBERDORFER 2001, ELLENBERG et al. 2001), and therefore it is a good basis from which to determine target species for reintroductions depending on vegetation types. In general, specialised species that are restricted to a few vegetation types are more prone to extinction than generalist species occurring in several vegetation types (FISCHER & STÖCKLIN 1997, DUPRÉ & EHRLEN 2002).

Continental steppe grasslands are an important habitat type in Central Europe. They harbour many rare and endangered plant species and are listed as priority habitat types (6240* Sub-pannonic steppic grasslands) in annex I of the Habitats Directive (EUROPEAN UNION 1992). Of the 1,000 ha of steppe grasslands that still exist in Germany (SSYMANK 2013), about 450 ha are located in the Federal State of Thuringia (WESTHUS 2013). As remnants of the postglacial steppes, they are isolated to a certain degree due to natural conditions (BECKER 2003, 2010). In addition, they have suffered from abandonment or intensification of the formerly extensive land use, resulting in a loss of area and degradation since the mid-20th century (cf. POSCHLOD & WALLIS DE VRIES 2002 for dry grasslands in general). In particular, the decline of extensive grazing by sheep and goats has recently started to threaten the flora of steppe grasslands. As a consequence of habitat decline and deterioration, many steppe plants now exist only in few and often small populations that are increasingly threatened by demographic and environmental stochasticity (MENGES 1991). Moreover, in Central Europe, many steppe plant species are not able to compensate for extinctions by founding new populations in suitable habitats due to the isolation of steppe grassland remnants. This is especially true for species with low dispersal abilities (OZINGA et al. 2005), but also plants with higher dispersal potential often cannot recolonise their former habitats, as long-distance dispersal is no longer effective in an increasingly fragmented landscape, which is particularly true for isolated grassland sites (PURSCHKE et al. 2012). As most grassland species do not form persistent seedbanks, restoration of grasslands cannot always simply rely on spontaneous re-establishment or methods facilitating the establishment by seeds in the soil (BOSSUYT & HERMY 2003). Reintroductions of species in steppe grasslands can therefore be beneficial for two reasons: they can help to conserve species by transferring them into suitable habitats that could not be recolonised by the species independently. In addition, typical and endangered steppe plant species that are brought into depleted steppe habitats can enhance their value and ensure that they are recognised as habitat type 6240* by the Habitats Directive. Currently, reintroductions of steppe plants have been conducted as part of the LIFE project "Protection and development of steppe grasslands in Thuringia" (BAUMBACH 2013, KIENBERG et al. 2013). The present study was conducted in association with this LIFE project.

Here, we present a method to select priority plant species for reintroductions from a regional species pool using the steppe grasslands of Thuringia as an example. For this purpose, a ranked species list was constructed using several characteristics of the species. Apart from a few existing empirical ranking methods in the field of plant conservation in Central Europe (e.g. ROSENTHAL 2003), to our knowledge, this is the first study specifically focussing on how to select target species for reintroductions.

2. Methods

2.1 Study area

At 16,173 km², Thuringia is one of the smaller states in the Federal Republic of Germany but it harbours, together with the state of Saxony-Anhalt, the highest proportion of steppe grasslands nationwide. The steppe grasslands in Thuringia are concentrated in the Thuringian Basin and its margins, where summers are dry and warm. At the northern border of the Thuringian Basin, the Zechstein gypsum belt of the Kyffhäuser Mountains forms the hotspot of steppe flora in Thuringia (BECKER et al. 2011, WESTHUS 2013). In addition, scattered steppe grasslands surrounded by intensively used agricultural landscape can be found in the inner Thuringian Basin, on Keuper clay soils. These stands are less species-rich than the stands in the Kyffhäuser Mountains; however, due to their size they are not less important (BAUMBACH 2013). Smaller steppe grasslands occur at the southern border of the Harz Mountains (on *Zechstein* gypsum), on the Bottendorf Hills in the Unstrut valley [on *Zechstein* and red bed (*Rotliegend*) conglomerate] and at the Finne tectonic disruption zone (on shell limestone). In Central Europe, Thuringia contains both large variety and extent of steppe vegetation and is therefore particularly suitable for our study.

2.2 Ranking procedure

Ranking of species was carried out in three steps. In the first step, the **regional species pool** of dry grasslands of Thuringia was defined as a basis for further selection. Second, the regional species pool was reduced by an **a priori filter** which comprised of a small set of criteria related to conservation value. Third, the remaining species were **ranked** according to ten criteria. Finally, the highest ranked species were evaluated against additional aspects of conservation, this post hoc evaluation is described in the discussion (Fig. 1).

The **regional species pool** was defined as all species that occurred in the study region (Thuringia) as well as in the target community (dry grasslands of the class *Festuco-Brometea*). Species that occurred in Thuringia were identified with the 'Flora of Thuringia' (ZÜNDORF et al. 2006), and those in the *Festuco-Brometea* in Germany with the BIOLFLOR data base (KLOTZ et al. 2002).

The regional species pool was reduced by an **a priori filter** in order to exclude common, not endangered, and non-indigenous plant species (Fig. 1). First, all species were defined as **potential target species** that were considered as being the global responsibility of Thuringia by ZÜNDORF et al. (2006) based on WELK (2002) and WESTHUS & FRITZLAR (2002). Species that did not meet this criterion were only considered as potential target species when they were indigenous to the target area, occurred in less than 10% (less than 59) of 1 : 25,000 topographic map quadrants of Thuringia (1 TMQ ≈ 30 km²) and were classified at least as vulnerable in the Red Lists of Thuringia (KORSCH & WESTHUS 2011) and/or Germany (KORNECK et al. 1996).

Potential target species were **ranked** with the help of a twelve points system. Points were awarded for species for ten criteria in the three categories 'threat and protection status' (five criteria), 'distribution and decline' (two criteria) as well as 'habitat affiliation' (three criteria); each fulfilled criterion translated into one point, but in the category 'distribution and decline' each fulfilled criterion translated into up to two points (Fig. 1, Table 1). The awarding of up to two points for each fulfilled criterion in the category 'distribution and decline' reflects the rarity and the endangerment of a species on multiple levels and thus in a finer resolution. In addition, particularly rare and strongly declining species are given a higher weight. After awarding up to twelve points, species were ranked in decreasing order according to their total score. Nomenclature of species follows WISSKIRCHEN & HAEUPLER (1998).

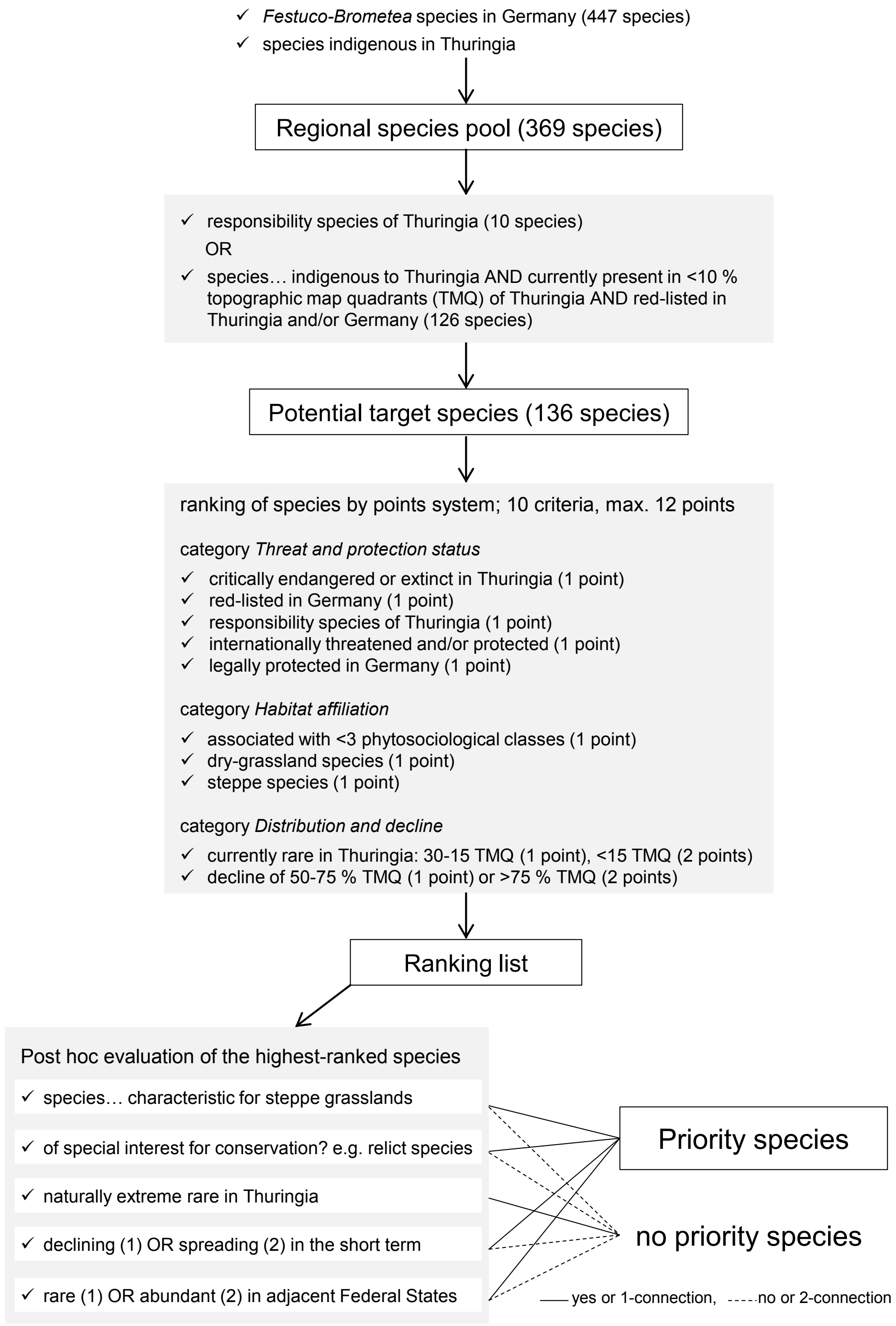


Fig. 1. Schematic diagram of the selection process to identify priority species for reintroductions into steppe grasslands in Thuringia, Germany.

Abb. 1. Flussdiagramm des Auswahlprozesses von prioritären Arten zur Wiederansiedlung in thüringischen Steppenrasen.

Table 1. Criteria used to award points for ranking 136 potential target species for reintroduction in steppe grasslands in Thuringia. The first five criteria assessed 'threat and protection status' of a species, followed by two criteria of 'distribution and decline' in Thuringia and then three criteria that as-sessed 'habitat affiliation'. For each met criterion, one point (in exceptional cases two points) was awarded. A species could achieve up to twelve points.

Tabelle 1. Kriterien für die Punktevergabe zur Erstellung einer Rangliste für 136 potentielle Zielpflanzenarten zur Wiederansiedlung in Steppenrasen in Thüringen. Mithilfe der ersten fünf Kriterien werden die Gefährdung und Schutzwürdigkeit einer Art bewertet, durch die nächsten beiden Kriterien werden ihre Seltenheit und ihr Rückgang in Thüringen sowie durch die letzten drei Kriterien ihre Bindung an Trockenrasen eingeschätzt. Je erfülltes Kriterium wurde ein Punkt (in Ausnahmen zwei Punkte) vergeben. Eine Art konnte maximal zwölf Punkte erreichen.

Category / Criterion	Points awarded if…	Reference
A) Threat and protection status		
1) Extinct or critically endangered in Thuringia	Red List Status in Thuringia 0 or 1 = 1 point	KORSCH & WESTHUS (2011)
2) Red List Germany	Red List Status in Germany 0 to 3 = 1 point	KORNECK et al. (1996)
3) Legally protected in Germany	Legally protected in Germany = 1 point	BMBV(2005)
4) Internationally endangered/protected	Worldwide or Europe-wide endangered or listed on annex II of the EU habitat directive = 1 point	EUROPEAN UNION (1992), WELK (2002)
5) Responsibility of Thuringia	Particular responsibility of Thuringia for global survival of a species = 1 point	WESTHUS & FRITZLAR (2002), ZÜNDORF et al. (2006)
B) Distribution and decline		
6) Currently rare	Number of topographic map quadrants occupied after 1990 < 30 = 1 and < 15 = 2 points	KORSCH et al. (2002)
7) Decline of at least 50 % or of at least 75 %	Number of extinct topographic map quadrants/number of all former occupied topographic map quadrants ≥ 0.5 = 1 point and ≥ 0.75 = 2 points	KORSCH et al. (2002)
C) Habitat affiliation		
8) Phytosociological classes	Number of associated phytosociological classes < 3 = 1 point	KLOTZ et al. (2002)
9) Character species *Festuco-Brometea*	Character species or frequent occurrence in the *Festuco-Brometea* class or any subordinate syntaxa of this class = 1 point	OBERDORFER (2001), WESTHUS (2013), BFN (2014a)
10) Character species *Festucetalia valesiacae*	Character species or frequent or regular occurrence in the *Festucetalia vale-siacae* order or any subordinate syntaxa of this order as well as species that are in Thuringia largely restricted to steppe grasslands = 1 point	OBERDORFER (2001), WESTHUS (2013), BFN (2014a)

For the a priori filter and the ranking criteria of the category ‘distribution and decline’, the number of currently and former occupied topographic map quadrants was obtained from the ‘Distribution atlas of ferns and flowering plants of Thuringia’ (KORSCH et al. 2002). A topographic map quadrant was counted as currently occupied if a species’ occurrence was documented in the quadrant by field surveys or herbarium records after 1990. In general, escapes or synanthropic species were not included because they presumably originated from gardens or were intentionally planted. Non-indigenous species – e.g. escapes or relicts of cultivations according to ZÜNDORF et al. (2006) – were also excluded from the study. Earlier records were treated as extinct occurrences and the corresponding topographic map quadrant was counted as formerly occupied.

For the category ‘habitat affiliation’, classification of plants into phytosociological classes and orders followed the Floraweb database (BfN 2014a) and OBERDORFER (2001). Dry grassland plant species were defined as character species of the *Festuco-Brometea* Br.-Bl. & Tx. Ex Klika & Hadač 1944 class or as species that had frequent occurrence in this class. Steppe plant species were defined as species that were character species of the *Festucetalia valesiacae* Soó 1947 order (including subordinate syntaxa) as well as species with a frequent or at least regular occurrence in steppe grasslands. Additionally, species that were listed as steppe plants by WESTHUS (2013) were added (*Botriochloa ischaemum*, *Pseudolysimachion spicatum*, *Pulsatilla pratensis* subsp. *nigricans*, *Rapistrum perenne*, and *Viola rupestris*). All steppe plant species were also defined as dry grassland species, so they were awarded at least two points in the category ‘habitat affiliation’.

2.3 Evaluation of the ranking

First, it was tested whether the potential target species selected by the a priori filter differed from the non-target species of the regional species pool in any other criteria than the ones used by the filter. Single factor analyses of variance (ANOVA) were conducted to test differences between the two species groups of the pre-selection (“target” *vs*. “non-target”) in (1) proportion of extinct topographic map quadrants in Thuringia and (2) the number of phytosociological classes a species is associated with. We also tested by chi square tests if (3) the distribution of habitat-specific species differed between “target” and “non-target” species sets. Habitat-specific species were plant species that were character species or had a frequent occurrence in either the *Festuco-Brometea* class or the *Festucetalia valesiacae* order.

Subsequently, it was tested to what extent the ranking list reflected the criteria of conservation value. To do so, ten linear contrast analyses were used with information on species as dependent variables and the rank as explanatory variable. Analyses tested for linear trends between the ranks, i.e. if a variable increased or decreased significantly with the rank. The ranking list was evaluated with ten contrast analyses including the dependent variables “Red List Status in Thuringia” (0 to 3), “Red List Status in Germany” (1 to 3), “Responsibility of Thuringia” (no = 0 or yes = 1), “Internationally endangered” (no = 0 or yes = 1), “Legally protected in Germany” (no = 0 or yes = 1), “Number of currently occupied topographic map quadrants” (0 to 58), “Proportion of extinct topographic map quadrants” (0% = no decline to 100% = extinct), “Number of associated phytosociological classes” (1 to 8), “Species of the *Festuco-Brometea*” (no = 0, yes = 1), “Species of the *Festucetalia*” (no = 0, yes = 1) and the factor “Rank”. All analyses were conducted with IBM SPSS 21.0 (IBM CORP. 2012).

3. Results

3.1 Ranking and scores

The regional species pool comprised of 369 vascular plant species of which 136 potential target species had been selected by the a priori filter, including ten responsibility species and 40 diagnostic species for steppe grasslands.

Table 2. Extract of the ranking of potential target plant species for reintroduction in steppe grasslands in Thuringia. Species are ranked according to their total scores in three categories of criteria (see Tab. 1). RLT = Red List Status in Thuringia (0 = extinct, 1 = critically endangered, 2 = endangered, 3 = vulnerable, R = rare); RLG = Red List Status in Germany (1 = critically endangered, 2 = endangered, 3 = vulnerable, G = endangerment assumed); § = legally protected in Germany (§ = specially protected, §§ = strictly protected); INTER = Internationally endangered (Crglob = critically endangered global, Englob = endangered global, Eneur = endangered Europe wide, FFH = species of annex II of the EU's Habitats Directive); SRT = Special responsibility of Thuringia for world's population; TMQ = Number of currently occupied topographic map quadrants in Thuringia; DECL = Proportion of extinct topographic map quadrants in Thuringia in percent; CL = Number of phytosociological classes with which a species is associated in Germany; FB = Association of species with *Festuco-Brometea* (Ch = character species, Fq = frequent occurrence; Fv = Species associated with *Festucetalia valesiacae*); FV = Association of species with *Festucetalia valesiacae* (Ch = character species, Fq = frequent occurrence, Rg = regular occurrence, Th = in Thuringia restricted to steppe grasslands); P = Total score of achieved points. Only species of the four highest ranks are presented (ten criteria, max. 12 points). Steppe species of the *Festucetalia valesiacae* are presented in bold letters.

Tabelle 2. Auszug aus der Rangliste von potentiellen Zielpflanzenarten für Wiederansiedlungen in thüringischen Steppenrasen. Die Arten sind nach der höchsten Gesamtsumme an erfüllten Kriterien aus drei Kategorien angeordnet (s. Tab. 1). RLT = Status auf der Roten Liste Thüringens (0 = ausgestorben, 1 = vom Aussterben bedroht, 2 = stark gefährdet, 3 = gefährdet, R = extrem selten); RLG = Status auf der Roten Liste Deutschlands (1 = vom Aussterben bedroht, 2 = stark gefährdet, 3 = gefährdet, G = Gefährdung anzunehmen); § = Gesetzlicher Schutz in der Bundesrepublik Deutschland (§ = besonders geschützt, §§ = streng geschützt); INTER = Internationale Gefährdung (Crglob = global vom Aussterben bedroht, Englob = global gefährdet, Eneur = europaweit gefährdet, FFH II = Art des Anhangs II der Fauna-Flora-Habitatrichtlinie der EU); SRT = Besondere Verantwortlichkeit Thüringens für den Weltbestand; TMQ = Zahl der aktuell besiedelten Messtischblattquadranten in Thüringen; DECL = Rate des Rückgangs an Messtischblattquadranten in Thüringen in Prozent; CL = Anzahl der pflanzensoziologischen Klassen, welche die Art in Deutschland besiedelt; FB = Vorkommen der Art in den *Festuco-Brometea* (Ch = Kennart, Fq = Schwerpunktvorkommen, Fv = Vorkommen in *Festucetalia valesiacae*); FV = Vorkommen der Art in den *Festucetalia valesiacae* (Ch = Kennart, Fq = Schwerpunktvorkommen, Rg = Hauptvorkommen, Th = in Thüringen beschränkt auf Steppenrasen); P = Gesamtzahl an erreichten Punkten. Dargestellt sind nur die Arten der ersten vier Ränge (zehn Kriterien, max. 12 Punkte). Steppenrasenarten der *Festucetalia valesiacae* sind fettgedruckt.

Species	RLT	RLG	§	INTER	SRT	TMQ	DECL	CL	FB	FV	P
→ *Rank 1*											
Seseli hippomarathrum	**0**	**2**	**–**	**–**	**–**	**0**	**100**	**2**	**Fv**	**Ch**	**9**
→ *Rank 2*											
Allium strictum	0	2	§	–	–	0	100	2	–	–	8
Astragalus exscapus	**2**	**3**	**–**	**Englob**	**yes**	**4**	**43**	**2**	**Fv**	**Fq**	**8**
Bothriochloa ischaemum	**2**	**3**	**–**	**–**	**–**	**6**	**89**	**1**	**Fv**	**Th**	**8**
Dianthus seguieri	1	2	§	–	yes	2	80	4	–	–	8
Gladiolus palustris	0	2	§	FFH	–	0	100	3	–	–	8
Herminium monorchis	1	2	§	–	–	6	82	3	Ch	–	8
Linum leonii	2	2	§	Englob	yes	5	17	2	Ch	–	8
Orchis morio	1	2	§	–	–	14	92	3	Ch	–	8
Prunella laciniata	**1**	**3**	**–**	**–**	**–**	**10**	**74**	**2**	**Fv**	**Rg**	**8**
Pulsatilla pratensis subsp. nigricans	**2**	**2**	**§**	**–**	**–**	**4**	**69**	**2**	**Fv**	**Th**	**8**
Scorzonera purpurea	**2**	**2**	**§§**	**–**	**–**	**7**	**61**	**2**	**Fv**	**Ch**	**8**
Spiranthes spiralis	1	2	§	–	–	6	92	3	Fq	–	8
→ *Rank 3*											
Allium sphaerocephalon	1	3	–	–	–	4	69	2	Ch	–	7
Anacamptis pyramidalis	2	2	§	–	–	4	84	3	Ch	–	7

Species	RLT	RLG	§	INTER	SRT	TMQ	DECL	CL	FB	FV	P
Armeria maritima subsp. elongata	1	3	§	–	–	4	85	5	–	–	7
Biscutella laevigata	2	2	§	Crglob	yes	1	67	6	–	–	7
Botrychium matricariifolium	1	2	§§	Eneur	–	4	69	3	–	–	7
Campanula bononiensis	**2**	**2**	**§**	–	–	**10**	**55**	**3**	**Fv**	**Rg**	**7**
Dactylorhiza sambucina	1	3	§	–	–	16	84	5	Ch	–	7
Euphorbia seguieriana	**2**	**3**	–	–	–	**6**	**67**	**2**	**Ch**	**Ch**	**7**
Gentiana verna	1	3	§	–	–	2	75	3	–	–	7
Gymnadenia odoratissima	0	3	§	–	–	0	100	4	–	–	7
Hieracium echioides	**2**	**3**	–	–	–	**1**	**67**	**2**	**Fv**	**Rg**	**7**
Himantoglossum hircinum	3	2	§	–	–	10	67	2	Ch	–	7
Minuartia hybrida	1	3	–	–	–	3	91	2	–	–	7
Muscari comosum	2	3	§	–	–	6	80	4	Fq	–	7
Orchis ustulata	2	2	§	–	–	14	75	2	Ch	–	7
Potentilla rupestris	1	3	–	–	yes	3	82	4	–	–	7
Pulsatilla vernalis	0	1	§§	–	–	0	100	5	–	–	7
Stipa pulcherrima	**3**	**2**	**§**	–	–	**11**	**42**	**1**	**Fv**	**Ch**	**7**
Stipa pennata	**3**	**3**	**§**	–	–	**17**	**50**	**2**	**Fv**	**Ch**	**7**
Stipa tirsa	**3**	**3**	**§**	–	–	**5**	**0**	**1**	**Fv**	**Ch**	**7**
Veronica prostrata	**2**	**3**	–	–	–	**13**	**70**	**1**	**Fv**	**Ch**	**7**
→ Rank 4											
Aceras anthropophorum	R	3	§	–	–	2	33	2	Ch	–	6
Achillea setacea	**3**	**3**	–	–	–	**5**	**55**	**3**	**Fv**	**Ch**	**6**
Armeria maritima subsp. bottendorfensis	R	3	§	Englob	yes	2	0	5	–	–	6
Carex supina	**3**	**3**	–	–	–	**7**	**13**	**1**	**Fv**	**Ch**	**6**
Coeloglossum viride	2	3	§	–	–	9	93	4	–	–	6
Equisetum ramosissimum	1	3	–	–	–	1	0	2	Fq	–	6
Globularia bisnagarica	3	3	§	–	–	10	23	2	Ch	–	6
Helianthemum canum	3	3	§	–	yes	11	35	3	Ch	–	6
Helichrysum arenarium	2	3	§	–	–	10	85	4	–	–	6
Hieracium caesium	2	3	–	–	–	3	63	2	Fq	–	6
Hieracium leptophyton (bauhini > pilosella)	2	G	–	–	–	1	91	1	–	–	6
Muscari tenuiflorum	2	3	§	–	–	4	43	2	Fq	–	6
Nepeta pannonica	**1**	–	–	–	–	**1**	**0**	**2**	**Fv**	**Rg**	**6**
Orobanche artemisiae-campestris	**3**	**2**	–	–	–	**5**	**44**	**2**	**Fv**	**Fq**	**6**
Pseudolysimachion spicatum	**2**	**3**	**§**	–	–	**21**	**56**	**3**	**Fv**	**Th**	**6**
Seseli annuum	**2**	**3**	–	–	–	**25**	**57**	**2**	**Fv**	**Fq**	**6**
Silene otites	**3**	**3**	–	–	–	**14**	**50**	**4**	**Fv**	**Ch**	**6**
Tephroseris integrifolia	**2**	**2**	–	–	–	**6**	**67**	**3**	**Fv**	**Ch**	**6**
Thesium linophyllon	**2**	**3**	–	–	–	**22**	**65**	**1**	**Fv**	**Ch**	**6**
Viola rupestris	**2**	**3**	–	–	–	**12**	**59**	**3**	**Fv**	**Th**	**6**

In the ranking, *Seseli hippomarathrum* reached the highest score, with nine out of twelve points (Table 2). Another five steppe species were ranked second (*Astragalus exscapus*, *Bothriochloa ischaemum*, *Prunella laciniata*, *Pulsatilla pratensis* subsp. *nigricans* and *Scorzonera purpurea*). In addition, seven species that were not diagnostic for steppe grasslands reached second rank. 21 species (including seven steppe species) reached third and 20 (including ten steppe species) fourth rank.

3.2 Differences in characteristics used in the ranking between pre-selected potential target species and non-target species

The proportion of extinct topographic map quadrants was more than twice as high in potential target species than in non-target species (Fig. 2a) and potential target species occurred in fewer phytosociological classes than non-target species (Fig. 2b). The proportion of species diagnostic for the *Festuco-Brometea* class was slightly higher (42% *vs.* 32%), and for the order *Festucetalia valesiacae* much higher (19% *vs.* 5%) in potential target species (Fig. 3).

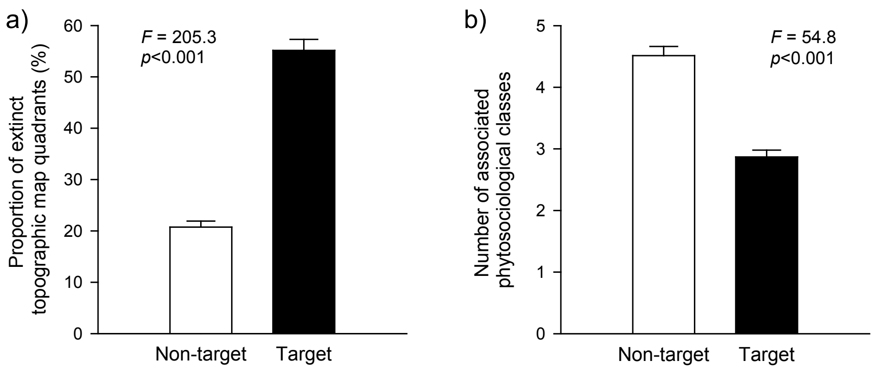


Fig. 2. Comparison of 136 potential target species for reintroduction and non-target species that occur in dry grasslands in Thuringia: a) percentage of extinct topographic map quadrants, b) number of phytosociological classes in which the species occur. Average values and standard errors are given.

Abb. 2. Vergleich zwischen den 136 potentiellen Zielarten für Wiederansiedlungen in Steppenrasen und den Nicht-Zielarten, die ebenfalls in Trockenrasen in Thüringens vorkommen: a) Prozentualer Anteil an ausgestorbenen Messtischblattquadranten, b): Anzahl der pflanzensoziologischen Klassen, in denen die Arten vorkommen. Dargestellt sind Mittelwerte und Standardfehler.

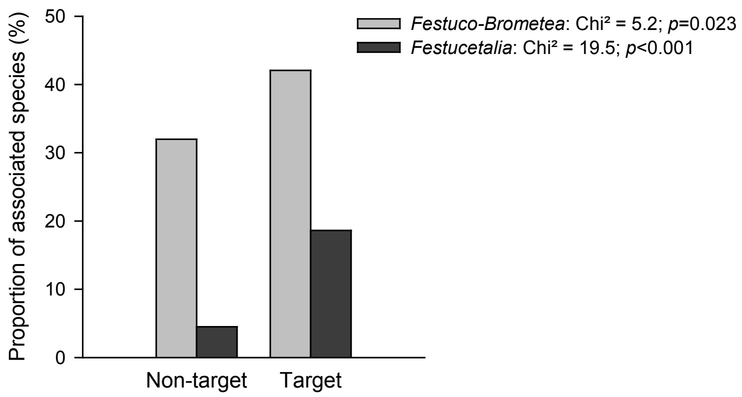


Fig. 3. Proportion of species characteristic for the *Festuco-Brometea* class and the *Festucetalia valesiacae* order, respectively, among 136 selected potential target species for reintroductions in steppe grasslands in Thuringia and the 233 non-target species.

Abb. 3. Anteil der Kennarten der Klasse *Festuco-Brometea* bzw. Ordnung *Festucetalia valesiacae* an den 136 ausgewählten Zielarten für Wiederansiedlungen und den 233 nicht-ausgewählten Arten.

3.3 Relationship between criteria of conservation value and ranks of species

All ten criteria of conservation value were significantly linearly correlated with rank order of the species. Degree of threat based on the Red Lists of Thuringia and Germany, proportion of species protected by law and proportion of responsibility species as well as proportion of globally endangered species increased with the ranking order (Fig. 4a–e). The number of currently occupied topographic map quadrants decreased with the ranking order, while proportion of extinct topographic map quadrants increased (Fig. 4f, g). Number of associated phytosociological classes decreased and proportion of *Festuco-Brometea* and *Festucetalia valesiacae* species increased with rank (Fig. 4h–j).

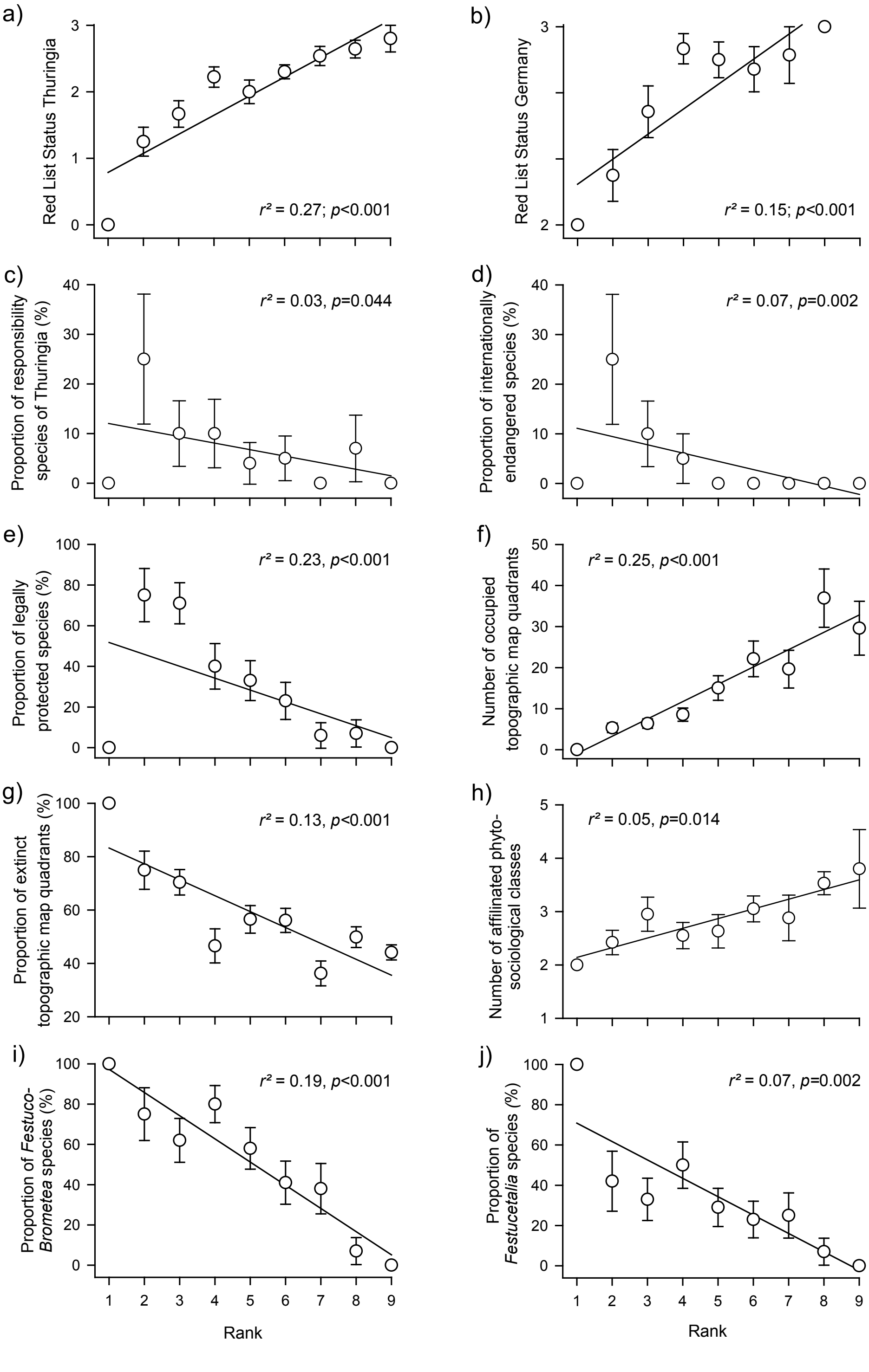
The proportion of variation explained by the rank of a species differed between criteria of conservation value. Explained variation was highest for the Thuringian Red List Status ($r^2 = 0.27$), followed by the number of occupied topographic map quadrants ($r^2 = 0.25$) and protection by law ($r^2 = 0.23$). Further, the rank order was associated with the proportion of *Festuco-Brometea* species ($r^2 = 0.19$), Red List Status in Germany ($r^2 = 0.15$) and proportion of extinct topographic map quadrants ($r^2 = 0.13$). The ranking had only low explanatory values for proportion of responsibility species ($r^2 = 0.03$), internationally endangered species ($r^2 = 0.07$) and *Festucetalia* species ($r^2 = 0.07$), and number of phytosociological classes ($r^2 = 0.05$).

4. Discussion

4.1 Post hoc evaluation of the highest ranked species

The ranking list gave a selection of 13 species ranked either first or second and another 21 species ranked third, and so considerably narrowed down the list of potential priority species for reintroductions in Thuringian steppe grasslands. In the following, that list will be evaluated on basis of further local floristic knowledge and conservation aspects. The following main questions were asked: 1) Which of the highest ranked species are characteristic for steppe grasslands or at least for dry grasslands in Thuringia? 2) Did the natural range of a species in Thuringia cover only an extreme small area? 3) Is the species rare or abundant in the adjacent Federal States (mainly in Saxony-Anhalt which harbours extensive steppe grasslands close to the Thuringian border)? 4) Did the species decline or spread recently? 5) Are the species of special interest for conservation e.g. relict species or species that reach their most western distribution in Thuringia?

Among the highest ranked species were the characteristic species of steppe grasslands *Seseli hippomarathrum* (first rank), *Astragalus exscapus*, *Bothriochloa ischaemum*, *Prunella laciniata*, *Pulsatilla pratensis* subsp. *nigricans*, and *Scorzonera purpurea* (all second rank). *Seseli hippomarathrum* is currently considered extinct in Thuringia and therefore potentially prioritised for reintroductions. However, this species only occurred formerly in a very small area at the northern border of Thuringia (KORSCH et al. 2002, ZÜNDORF et al. 2006) which argues against extensive (re-)introductions of this species in this Federal State. In addition, the species is present in many large populations in the Federal State of Saxony-Anhalt in close vicinity to the former Thuringian population (NETPHYD & BFN 2013, own observations) so that a reintroduction in Thuringia does not seem to be necessary for the species' long-term survival in Central Germany. Thus, despite its ranking as the top species, we assess *Seseli hippomarathrum* as a suitable but not a priority species for reintroductions in Thuringia.



a)
Red List Status Thuringia
r² = 0.27; p<0.001
b)
Red List Status Germany
r² = 0.15; p<0.001
c)
Proportion of responsibility species of Thuringia (%)
r² = 0.03, p=0.044
d)
Proportion of internationally endangered species (%)
r² = 0.07, p=0.002
e)
Proportion of legally protected species (%)
r² = 0.23, p<0.001
f)
Number of occupied topographic map quadrants
r² = 0.25, p<0.001
g)
Proportion of extinct topographic map quadrants (%)
r² = 0.13, p<0.001
h)
Number of affilinated phyto-sociological classes
r² = 0.05, p=0.014
i)
Proportion of Festuco-Brometea species (%)
r² = 0.19, p<0.001
j)
Proportion of Festucetalia species (%)
r² = 0.07, p=0.002
Rank
Rank

Among the other priority species, *Astragalus exscapus* and *Scorzonera purpurea* stand out. Both are typical steppe species with relict character and a strong association with steppe grasslands. Additionally, Thuringian populations of these species form the western border of their distribution range and *A. exscapus* is endangered worldwide, so that Thuringia has a particular responsibility for the species' long term survival (SCHNITTLER & GÜNTHER 1999). Both species are attractive so that reintroductions would probably be appreciated by society. For all these reasons, we assessed *A. exscapus* and *S. purpurea* as priority species for reintroductions in Thuringia and therefore selected them as target species within a currently conducted reintroduction project (KIENBERG et al. 2013). This reintroduction project is associated with the LIFE project "Conservation and development of steppe grasslands in Thuringia" (BAUMBACH 2013), ensuring both support and management of the sites and therefore we expect successful reintroductions of these species. Especially *A. exscapus* may profit from reintroductions, because its low dispersal ability (BECKER 2010) could be compensated in this way. In addition, we attempt to reintroduce another priority species selected by our ranking: *Pulsatilla pratensis* subsp. *nigricans*. In Thuringia, this species is also limited to steppe grasslands and has suffered from severe declines in the last decades. Nowadays it exists in no more than ten mostly small populations (unpublished data).

We were surprised by the high rank of *Bothriochloa ischaemum* in the list, probably because grass species are often less endangered or because this species is not particularly rare. The distribution atlas of plants in Thuringia, however, reveals that *B. ischaemum* currently occupies only six of the originally 47 topographic map quadrants, meaning a decline of 87%. Further assessment is needed to determine whether decline in this species simply resulted from insufficient survey activity over the last 15 years, or which other reasons are responsible for the decline so that possible reintroductions can be successful.

It is furthermore uncertain whether *Prunella laciniata* can be regarded as a priority species for reintroductions in steppe grasslands in Thuringia. Although it occurs in steppe grasslands in Germany, due to its submediterranean distribution it is not limited to this grassland type. Rarity and threat of the species in Thuringia indicate a need for reintroduction measures. However, these should rather be implemented in submediterranean dry grasslands than in steppe grasslands.

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Fig. 4. Relationships between ten value-giving characteristics of conservation and species' rank in the list of potential target species for reintroduction in Thuringian steppe grasslands. In a) the included Red List Status Thuringia ranges from 0 = extinct to 3 = vulnerable, and in b) the Red List Status Germany ranges from 2 = endangered to 3 = vulnerable. For all characteristics see Table 1. Average values and standard errors are given as well as proportions of the explained linear relationship (r^2) and significances (p) of the association tested by linear contrast analyses. The single first rank dot represents *Seseli hippomarathrum*.

Abb. 4. Zusammenhang zwischen zehn wertgebenden Kriterien aus dem Bereich „Gefährdung und Schutz" und dem Rang in der Liste der potentiellen Zielpflanzenarten zur Wiederansiedlung in Steppenrasen in Thüringen. Der Status auf der Roten Liste Thüringens reicht von 0 = ausgestorben bis 3 = gefährdet und der Status auf der Roten Liste Deutschlands von 2 = stark gefährdet bis 3 = gefährdet. Alle anderen Kriterien s. Tabelle 1. Dargestellt sind Mittelwerte und Standardfehler sowie der Anteil der erklärten linearen Beziehung (r^2) und die Signifikanzen (p) der Zusammenhänge, welche mit linearen Kontrastanalysen getestet wurden. Der erste Rang wird nur durch die einzelne Art *Seseli hippomarathrum* repräsentiert.

Three species that were also ranked second besides the mentioned characteristic steppe plants – *Allium strictum*, *Dianthus seguieri*, and *Gladiolus palustris* – stand out since they do not occur in steppe grasslands in Thuringia. Therefore these species cannot be regarded as potential target species for reintroduction in this habitat type in Thuringia. They can, however, occur in *Festuco-Brometea* communities in other parts of Germany and were therefore integrated into our regional species pool. In the a priori filter they were selected as potential target species due to their rarity and threat. Subsequently, they were ranked high because they met several criteria. A (theoretical) approach to exclude them from the regional species pool would have been to explicitly focus on species that occur in Thuringian dry and steppe grasslands. Such a (complete) list, however, does not exist for Thuringia and therefore an exclusion of these species from the start was not possible.

Finally, several other species that ranked second were typical of submediterranean dry grasslands and occur only occasionally in steppe grasslands: *Herminium monorchis*, *Linum leonii*, *Orchis morio*, and *Spiranthes spiralis*. For these species, it should be assessed for the specific area whether reintroductions should be conducted. *Linum leonii*, which is endemic to central Europe, and *Orchis morio*, which is endangered, may well be considered for reintroductions in selected steppe grasslands in Thuringia. For *H. monorchis* and *S. spiralis*, reintroductions may be more worthwhile in submediterranean dry grassland types.

The 21 species ranked in third position also include species suitable for reintroductions in Thuringia's steppe grasslands, such as *Euphorbia seguieriana*, *Veronica prostrata* subsp. *prostrata*, *Seseli annuum*, and *Thesium linophyllon*, which show a severe decline throughout the area. In contrast, feather grasses of the *Stipa* genus show tendencies of spontaneous spread rather than decline in Thuringia and therefore they currently do not need to be reintroduced (HOFMANN et al. 2008).

Like *Dianthus seguieri* and *Gladiolus palustris* on the second position, there were also species ranked third that did not score in the category 'habitat affiliation'. These were for example *Armeria maritima* subsp. *elongata*, *Biscutella laevigata*, *Botrychium matricariifolium*, and *Potentilla rupestris*. Without considering habitat affiliation, these species would be ranked as priority species for reintroductions in Thuringia. *Biscutella laevigata* indeed could be a target for reintroduction because the species is very rare in Thuringia and in addition strongly associated with *Festuco-Brometea*, although not in steppe grasslands but in dealpine *Sesleria* grasslands of the *Mesobromion* alliance in the *Brometalia* order (BECKER 1996).

Post hoc evaluation showed that 10 of the 13 highest ranked species could be regarded either as priority species (*Astragalus exscapus*, *Linum leonii*, *Orchis morio*, *Pulsatilla pratensis* subsp. *nigricans* and *Scorzonera purpurea*) or as highly suitable species (*Bothriochloa ischaemum*, *Herminium monorchis*, *Prunella laciniata*, *Seseli hippomarathrum* and *Spiranthes spiralis*) for reintroductions. Some of the 21 species that ranked third could also be regarded as suitable for reintroductions. The three highest ranked species that cannot be regarded as potential target species for reintroduction in steppe grasslands in Thuringia could have been easily removed by a mechanistic approach if there had been a complete list of Thuringian dry grassland plant species. Some fine tuning using additional aspects of conservation based on local floristic knowledge helped to further prioritise among the highest ranked species. However, in general the ranking list fulfilled its purpose.

4.2 Main problems of species prioritisation

Examining the final ranking list, we faced two methodological problems and one limitation: The first and most important was how to cope with differences in association to steppe grasslands between species. Although the species diagnostic for steppe grasslands were preferred by awarding more points, some species not diagnostic for steppe grasslands and also not suitable for reintroduction in this habitat type in Thuringia were still ranked high. To prevent this, the steppe plants could have been extracted from the list and consequently only these species would have been considered for reintroductions. A disadvantage of this might be that plant species like *Linum leonii* or *Orchis morio* that are even more endangered but occur in a broader spectrum of dry grassland types would not be considered, even if these species are well adapted to steppe grassland habitats.

The second problem that occurred was that we could only consider local threat in Thuringia as well as national threat in Germany. As a consequence, a species extinct in Thuringia but still frequent in the neighbouring state of Saxony-Anhalt was the highest ranked species in our ranking list. This is, however, a common problem of prioritising species in administrative units, which frequently do not conform to biogeographic regions (MOILANEN & ARPONEN 2011).

Finally, a limitation of our ranking list is that it does not show which species to reintroduce into which area. For this, historic floras with information on the former habitats can be used. For our study, several such old floras do exist including many records of extinct populations, the oldest of them (THAL 1588, RUPP 1726) are among the oldest floras worldwide. Also recent floras can be consulted that include historic data such as the Flora of Thuringia (ZÜNDORF et al. 2006) or the Flora of the Kyffhäuser Mountains (BARTHEL & PUSCH 1999). New introductions in areas not formerly colonised, in contrast, should only be conducted if former habitats are destroyed and former distribution is known in detail in order to avoid changes of natural species ranges (see guidelines for reintroduction of the IUCN 1998 or remarks in KIENBERG et al. 2013).

4.3 Evaluation of ranking methods and criteria

Filtering methods to extract potential target species for reintroduction from larger species pools have been proven to be successful in former studies (ROSENTHAL 2003, BRUDVIG & MABRY 2008). Here, the combination of several criteria in an a priori filter reduced the regional species pool by more than 60% in a meaningful manner, and thus makes it more manageable for further assessment.

Evaluation of the ranking showed significant relationships between all criteria and rank, i.e. high ranked species were more rare and endangered, showed a stronger decline, had a narrower niche, and were associated with steppe grasslands more strongly. Therefore, in general, our ranking can be considered meaningful for conservation purposes. However, the relationships differed in their strength between the criteria. Variables with the strongest relationships to rank order were Red List Status in Thuringia and local rarity, as well as protection status of a species. In contrast, the responsibility of Thuringia for the world's population as well as degree of international threat of a species only had a small influence on the rank of a species. The latter was mainly due to the fact that only a few species were internationally threatened or protected, e.g. in our list only *Gladiolus palustris* occurred as an annex II species of the European Habitats Directive, and Germany was responsible for the long-term survival of only another three species (*Astragalus exscapus*, *Crepis mollis*, and

Scabiosa canescens) (BfN 2014b). In addition, threat in Thuringia and association with steppe grasslands varied highly between those species, and therefore their suitability for reintroductions in that area and habitat type was also very diverse.

In general, globally threatened species and/or species with local occurrences of global importance are treated as priority species in nature conservation. One – although not empirical – approach to this is the annex of the European Habitats Directive (EUROPEAN UNION 1992). Another example is the Federal programme of biodiversity (BfN 2014b) that implements specific conservation measures for 15 plant species for which Germany is responsible. In addition, in other rankings that prioritise species for reintroduction and are based on empirical methods, global threat and responsibility for the world's population had an outstanding importance (e.g. WELK 2002 for Germany and GAUTHIER et al. 2010 for two regions in Southern France). However, the focus on species of global importance is insufficient. There are some general advantages to protect especially locally endangered species in a certain region like conserving genetic variation, functions of ecosystems and species of local value (HUNTER & HUTCHINSON 1994). In our case, steppe plant species are an important part of the natural heritage and cultural history of Thuringia, both from an evolutionary and conservation point of view.

Especially for reintroductions, species should be extinct or endangered in the targeted region. Consequently, if a region has a global responsibility for a species that is not locally extinct or endangered, conservation measures should mainly focus on conserving existing populations instead of conducting reintroductions. As our ranking list provides instructions for reintroductions but does not show order of local importance of species in general, we assume it is justified that the ranking assigned high weight to local threat. In addition, reintroductions should not only be considered for species with a strong local decline but should also focus on the ones among them for which intact habitats are still available. This accounts for our priority species *Astragalus exscapus*, *Pulsatilla pratensis* subsp. *nigricans*, and *Scorzonera purpurea* that we currently try to reintroduce in areas where they are extinct but which are probably still suitable, i.e. where there are extensive intact steppe grasslands (BAUMBACH 2013, KIENBERG et al. 2013).

A few examples of rankings to select priority species in general are known on national (WELK 2002) and international (see review of ARPONEN 2012) levels, but using different methods. We suggest that – especially for nature conservation on a regional level – approaches like ours that are limited to a certain region (Thuringia), to a certain habitat type (steppe grasslands) and also to a certain type of conservation measure (reintroductions) are important to select those species that are particularly suitable.

Due to its use of widely available and broadly relevant information, this method can easily be applied to evaluations of plant reintroduction in other habitats in Central Europe, and potentially also outside of Europe.

5. Conclusions

Ranking lists based on point systems can reveal important insights into the need for protection of various species. The mechanistic approach of empirical rankings is especially valuable as it draws attention to species which are at risk of being overseen by experts. The database used in this study, which can be requested from the authors in Excel format, also allows the ranking to be altered by omitting or including further criteria, and may thus also serve other conservation purposes. The danger of masking normative requirements of an apparently objective ranking list can be outbalanced by being checked or validated by experts before starting a concrete measure. Especially for reintroductions, species should be extinct or endangered in the targeted region. If a viable population exists in the region, conservation measures should mainly focus on conserving existing populations instead of conducting reintroductions.

Erweiterte Deutsche Zusammenfassung

Einleitung – Wiederansiedlungen von Pflanzenarten stellen eine verbreitete Methode im Artenschutz dar, die auch in Mitteleuropa zunehmend praktiziert wird (GODEFROID et al. 2011). In Steppenrasen, die innerhalb Deutschlands in Thüringen einen Verbreitungsschwerpunkt besitzen, finden sich besonders viele seltene und gefährdete Pflanzenarten, die für Wiederansiedlungen in Frage kommen. Bei der Wiederansiedlung von seltenen und gefährdeten Pflanzenarten stellt sich zu Beginn einer Maßnahme zunächst die Frage nach der konkreten Auswahl der Arten, die wieder angesiedelt werden sollen. Meist ist das in Frage kommende Artenspektrum deutlich zu groß und es muss eine starke Auswahl stattfinden. Diese Auswahl sollte auf nachvollziehbaren, empirischen Methoden beruhen.

Wir stellen hier am Beispiel der Steppenrasen Thüringens eine Auswahlmethodik vor, um prioritäre Arten für Wiederansiedlungen aus dem regionalen Artenspektrum zu bestimmen. Für diesen Zweck wurde anhand wertgebender Merkmale eine Rangliste nach einem Punktesystem erstellt, um die prioritären Arten für Wiederansiedlungsmaßnahmen zu erkennen. Nach unserem Wissen handelt es sich um die erste Studie speziell zur Auswahl von Zielarten zur Wiederansiedlung.

Methoden – Die Rangliste der Zielarten zur Wiederansiedlung wurde in drei Schritten erstellt (Abb. 1). Im ersten Schritt wurde das regionale Artenspektrum der Trockenrasen Thüringens und damit die grundlegende Auswahlgruppe an Arten definiert. Im zweiten Schritt wurde das regionale Artenspektrum durch einen A-priori-Filter weniger wertgebender Merkmale verkleinert und somit ein Spektrum an potentiellen Zielarten definiert. Im dritten und letzten Schritt wurden für die potentiellen Zielarten zehn wertgebende Merkmale aus den Bereichen Gefährdung und Schutz, Verbreitung und Rückgang und Habitatbindung abgefragt und danach Punkte vergeben (Tab. 1). Die Punkte wurden für jede Pflanzenart summiert und die Arten nach ihrer Punktzahl in einer Rangliste geordnet. Schließlich wurden die Arten auf den höchsten Plätzen der Rangliste mithilfe weiterer Aspekte des Artenschutzes hinsichtlich ihrer Bedürftigkeit und Eignung zur Wiederansiedlung evaluiert, um unter diesen prioritäre Arten zur Wiederansiedlung zu definieren (Abb. 1).

Zur statistischen Evaluation des Zusammenhangs zwischen wertgebenden Merkmalen und Auswahlliste wurde zunächst getestet, ob sich die mithilfe des A-priori-Filters ausgewählten potentiellen Zielarten für Wiederansiedlungen von den nicht-ausgewählten Arten des regionalen Artenspektrums hinsichtlich einiger wertgebender Merkmale unterschieden. Anschließend wurde für die erstellte Rangliste getestet, inwieweit sie die wertgebenden Kriterien wie z. B. den Rückgang, die Gefährdungssituation oder die Habitatbindung einer Art adäquat wiedergibt. Daneben wurde die Eignung der am höchsten gelisteten Arten zur Wiederansiedlung in Steppenrasen in Thüringen mithilfe zusätzlicher wertgebender Kriterien (z. B. Bindung an Steppenrasen und Trockenrasen in Thüringen, aktueller Rückgang der Art, Seltenheit in benachbarten Bundesländern) evaluiert und bewertet.

Ergebnisse – Das regionale Artenspektrum bestand aus 369 Gefäßpflanzenarten, von denen 136 Arten mithilfe des A-priori-Filters als potentielle Zielarten ausgewählt wurden. Darunter waren zehn Verantwortungsarten Thüringens und 40 Kennarten der Steppenrasen. *Seseli hippomarathrum* erreichte in der Rangliste den ersten Rang mit neun von zwölf möglichen Punkten (Tab. 2). Fünf Arten der Steppenrasen erreichten den zweiten Rang (*Astragalus exscapus*, *Bothriochloa ischaemum*, *Prunella laciniata*, *Pulsatilla pratensis* subsp. *nigricans* und *Scorzonera purpurea*). Hinzu kamen sieben weitere Arten, die keine Kennarten der Steppenrasen waren, auf den zweiten Rang. 21 Arten (davon sieben Steppenrasenarten) erreichten den dritten, und 21 Arten (davon zehn Steppenrasenarten) den vierten Rang. Die Evaluation mithilfe der zusätzlichen Kriterien zeigte, dass zehn der 13 am höchsten bewerteten Arten als prioritäre Arten (*Astragalus exscapus*, *Linum leonii*, *Orchis morio*, *Pulsatilla pratensis* subsp. *nigricans* und *Scorzonera purpurea*) oder zumindest geeignete Arten (*Bothriochloa ischaemum*, *Herminium monorchis*, *Prunella laciniata*, *Seseli hippomarathrum* und *Spiranthes spiralis*) für eine Wiederansiedlung in den Steppenrasen Thüringens in Frage kommen. Drei hoch gelistete Arten (*Allium strictum*, *Dianthus seguieri*, *Gladiolus palustris*) wurden mithilfe der zusätzlichen Kriterien als nicht für eine Wiederansiedlung in den Steppenrasen Thüringens in Frage kommend bewertet.

Der Rückgang in Thüringen war bei den potentiellen Zielarten mehr als doppelt so hoch als bei nicht-ausgewählten Arten und potentielle Zielarten kamen in weniger pflanzensoziologischen Klassen vor als nicht-ausgewählte Arten (Abb. 2). Die potentiellen Zielarten zeigten zudem höhere Anteile an Kennarten der Trockenrasen (*Festuco-Brometea*) (42 % *vs*. 32 %) und an Kennarten der Steppenrasen (*Festucetalia valesiacae*) (19 % *vs*. 5 %) als die nicht-ausgewählten Arten (Abb. 3).

Es bestand ein signifikanter linearer Zusammenhang zwischen allen zehn wertgebenden Kriterien und dem Rang einer Art auf der Rangliste (Abb. 4). Der Gefährdungsgrad auf den Roten Listen Thüringens und Deutschlands, der Anteil an gesetzlich geschützten Arten und der Verantwortlichkeitsarten Thüringens sowie der Anteil global gefährdeter Arten stieg mit dem Rang an. Während die Anzahl der aktuell besiedelten Messtischblattquadranten (MTBQ) mit dem Rang abnahm, nahm der Anteil an ausgestorbenen MTBQ mit dem Rang zu. Die Anzahl der besiedelten pflanzensoziologischen Klassen nahm mit dem Rang ab, der Anteil der *Festuco-Brometea* und der *Festucetalia valesiacae*-Arten nahm mit dem Rang zu.

Diskussion und Schlussfolgerungen – Bei der Betrachtung der fertigen Rangliste zeigten sich zwei methodische Probleme und eine Beschränkung: Das erste und wichtigste Problem war die unterschiedlich starke Bindung der Arten an Steppenrasen. Obwohl die Kennarten der Steppenrasen durch die Punktevergabe bevorzugt wurden, rangierten einige Arten, die nicht unbedingt für eine Wiederansiedlung in Steppenrasen geeignet sind, hoch. Um dies zu verhindern, hätte die Auswahlgruppe auf ausschließlich Pflanzen der Steppenrasen eingeschränkt werden können; dies hätte jedoch wiederum zur Folge, dass gut geeignete, aber nicht auf Steppenrasen spezialisierte Arten unberücksichtigt geblieben wären. Das zweite Problem war, dass wir nur die lokale Gefährdung der Arten in Thüringen sowie die nationale in Deutschland berücksichtigen konnten. Als eine Konsequenz war eine Art, die in Thüringen zwar ausgestorben, aber im benachbarten Sachsen-Anhalt noch häufig ist, die am höchsten bewertete Art in unserer Rangliste. Solche Fälle sind ein regelmäßiges Problem bei Naturschutzmaßnahmen, da politisch-administrative Einheiten häufig nicht mit den naturräumlichen Einheiten übereinstimmen (MOILANEN & ARPONEN 2011). Drittens und letztens stößt unsere Rangliste bei der Verfügbarkeit von geeigneten Habitaten an ihre Grenzen: Obwohl unsere prioritären Arten zurückgehen und geeignete Habitate noch verfügbar sind, zeigt unsere Rangliste nicht, welche Arten auf welchen Flächen am besten wieder angesiedelt werden können. Hierzu muss z. B. auf alte Kartierungen und Floren zurückgegriffen werden.

Die wertgebenden Merkmale, die am stärksten durch den Rang einer Art auf der Rangliste repräsentiert wurden, waren die lokale Gefährdung und Seltenheit der Arten in Thüringen sowie ihr Schutzstatus. Im Gegensatz dazu wurden die Verantwortlichkeit Thüringens für den Erhalt einer Art sowie der international Gefährdungsgrad in geringerem durch den Rang einer Art repräsentiert, was wahrscheinlich daran lag, dass nur wenige Arten diese Kriterien erfüllten. Generell spricht einiges dafür, auch lediglich lokal gefährdete Arten in einer Region zu schützen, um beispielsweise genetische Varianten oder Arten mit besonderer lokaler Bedeutung zu erhalten (HUNTER & HUTCHINSON 1994). Im vorliegenden Fall sind die Arten der Steppenrasen ein bedeutender Teil des Naturerbes und der Kulturgeschichte Thüringens.

Auf nationaler oder internationaler Ebene (siehe Übersicht in ARPONEN 2012 und für Deutschland: WELK 2002) sind einige wenige Beispiele von Ranglisten zur allgemeinen Festlegung von prioritär schutzwürdigen Arten bekannt. Wir erachten aber gerade Ansätze wie unseren, der sich auf einen bestimmte Region (Thüringen), einen bestimmten Habitattyp (Steppenrasen) und auch eine bestimmte Form von Artenhilfsmaßnahmen (Wiederansiedlung) bezieht, für den Naturschutz auf regionaler und lokaler Ebene als wichtig, um zielgenau Arten festzulegen, für die solche Maßnahmen in Frage kommen. Die hier vorgestellte Methodik kann prinzipiell auf andere Regionen oder Lebensräume übertragen werden.

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