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VIEWPOINT

Characteristic and derived diversity: implementing the species pool concept to quantify conservation condition of habitats

Aveliina Helm[1]*, Martin Zobel[1], Angela T. Moles[2], Robert Szava-Kovats[1] and Meelis Pärtel[1]

[1]*Institute of Ecology and Earth Sciences, University of Tartu, Lai 40, 51005, Tartu, Estonia,* [2]*Evolution & Ecology Research Centre, School of Biological, Earth and Environmental Sciences, The University of New South Wales, Sydney, NSW 2052, Australia*

*Correspondence: Aveliina Helm, Institute of Ecology and Earth Sciences, University of Tartu, Lai 40, 51005 Tartu, Estonia.
E-mail: aveliina.helm@ut.ee

ABSTRACT

Anthropogenic environmental changes in climate, land use and disturbance regimes, as well as mass propagule transport are having dramatic effects on many ecosystems. Both conservationists and ecologists need ecologically relevant metrics to quantify the condition of plant and animal communities. However, current metrics fail to address the invasion of species native to different community types in the same region, even though these ‘native aliens’ can serve as valuable indicators of recent changes in habitat condition. We propose a novel approach to reconceptualize community biodiversity based on the composition of historically developed habitat-specific species pools. Total observed community diversity can be divided to characteristic diversity, consisting of species belonging to habitat-specific species pool, and derived diversity, consisting of either native or non-native species not typical to a given community and whose presence is driven by adverse human impact. Characteristic and derived diversity in communities have different historical backgrounds; thus, the ecological patterns of these components, effects on ecosystem functioning as well as actions necessary for their conservation are likewise different. We propose the Index of Favourable Conservation Status – the log ratio of characteristic to derived diversity – as an easily quantified, ecologically relevant and universal indicator of biodiversity integrity and community condition. The Index of Favourable Conservation Status provides valuable information on habitat conservation needs and recent adverse human impact in relative terms and can be compared between regions and across a wide range of ecosystems. It can also be used to monitor restoration success or characterize biodiversity degradation. We present standardized procedure of determining habitat-specific species pools and bring several examples of how the concept of characteristic and derived diversity can be applied in conservation and research and how expert knowledge on habitat-specific species pool composition can expand our understanding of community biodiversity.

Keywords

Anthropogenic impact, biodiversity index, biodiversity integrity, biological invasions, community composition, native and non-native invaders, species pools.

TOTAL NATIVE BIODIVERSITY AND THE RATIO OF NATIVE TO NON-NATIVE SPECIES CAN FAIL AS MEASURES OF HABITAT CONDITION

Human-related changes in environmental conditions and dramatically enhanced dispersal over great geographic distances have provided the opportunity for species to establish in communities where they were previously absent (Hobbs *et al.*, 2009; Cameron & Bayne, 2012). In this context, the invasion by non-native species has received the most attention due to its unambiguous anthropogenic cause, observable and strong effects on ecosystems (Sax & Gaines, 2003; Vilà *et al.*, 2011) and negative public perception (Simberloff *et al.*, 2013). However, changes in abiotic and biotic

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conditions also make communities susceptible to 'native introductions' by species from other local habitat types (Valéry *et al.*, 2009, 2013). Although the effects of non-native species invasions on ecosystems are considered to be substantially greater (Simberloff *et al.*, 2012), the ecological consequences and causes of the arrival of untypical native species also merit discussion (Davis *et al.*, 2011; Valéry *et al.*, 2013). Invasion of untypical species can also reflect in total species number – another widely used indicator of community conservation value – and in some cases, lead to erroneous conclusions. For example, in dry calcareous semi-natural grasslands in Estonia and Sweden, total plant species richness has shown to increase temporarily following the cessation of traditional habitat management due to the invasion of shade-tolerant forest species and habitat generalist species that benefit from increasing shrub cover (Rejmánek & Rosén, 1988; Pärtel *et al.*, 1999; Kasari *et al.*, 2013). It can take several decades before the eventual extinction of light-demanding grassland species, resulting in temporarily high total species number in communities that actually have urgent conservation need (Helm *et al.*, 2006).

Here, we show that the focus on total observed native diversity or on alien versus native diversity in community ecology can be complemented by an approach that considers recent invasions and historical role of species in ecosystems. Defining the habitat-specific species pools for communities allows us to quantify the historical and recent (human-related) components of observed biodiversity. The historically developed habitat-specific species pool is a set of species that occur naturally in the region, are able to disperse to studied habitat and have life history characteristics that enable them to establish, survive and reproduce under environmental conditions that are typical to the particular habitat (Eriksson, 1993; Pärtel *et al.*, 1996, 2011). The development of the species pool of each community represents a long-term process, led by evolutionary and dispersal events (Zobel *et al.*, 2011). Ecological relationships, assembly rules and species' temporal dynamics in habitats are related directly to the composition of community species pool (Lessard *et al.*, 2012). Therefore, it is of utmost importance to consider the habitat-specific species pool when studying the diversity or planning conservation of natural communities (Cam *et al.*, 2000; Pärtel, 2014).

CHARACTERISTIC AND DERIVED DIVERSITY

We suggest a reconceptualization of total observed community biodiversity into two components – characteristic and derived diversity. *Characteristic diversity* consists of those species that belong to a habitat-specific species pool and are currently present in a particular habitat (Fig. 1). We define characteristic diversity as the component of biodiversity that represents to the best of our knowledge the natural and typical part of a particular community, including both rare and common native species. How this 'natural state' is defined depends on a region, ecosystem, existing knowledge and conservation targets, but characteristic diversity would mostly be typical to given habitat type without recent human-induced environmental changes. In the context of habitat conservation, researchers and managers may be particularly interested in the composition of species pool during the period of interest (for example in pre-European times or in times prior to the onset of intensive agriculture). Ideally, communities would contain only species that belong to their species pool, making their characteristic diversity equal to the observed total diversity. The term 'characteristic' is also previously used in ecological literature to depict the desired and typical part of biodiversity, for example as put by G. C. Ray: 'The description of characteristic diversity – including indicator and keystone species – must be our immediate focus, and the preservation of that diversity our ultimate challenge' (Ray, 1988, pp. 42). The identification of 'original' species pool of habitats has likewise been suggested to be essential in determining conservation need and tools (Cam *et al.*, 2000).

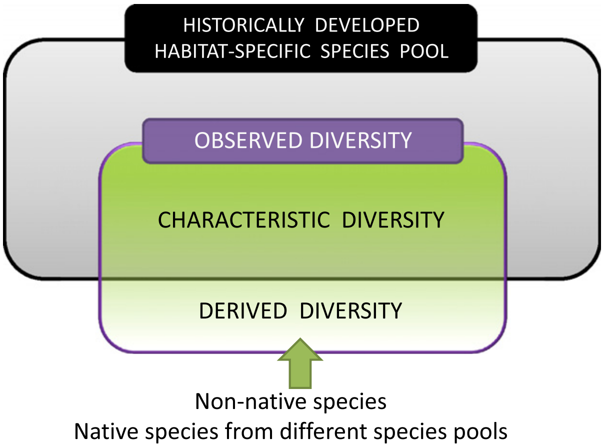

Figure 1 Conceptual figure featuring characteristic and derived diversity. Total observed diversity (smaller square) consists of both characteristic and derived diversity. Characteristic diversity comprises species that belong to habitat-specific species pool (larger square) and are currently present in a given community. The historically developed habitat-specific species pool is a set of species that occur naturally in the region, are able to disperse to a specific habitat and have life history characteristics that enable them to establish, survive and reproduce under environmental conditions that are typical of the particular habitat. Derived diversity is part of total observed diversity, but consists of species that do not belong to the habitat-specific species pool of a given community, notably exotics and native 'aliens' from other habitats.

However, we often record species in biodiversity surveys that are not historically characteristic of the studied community, but derive due to anthropogenic causes and environmental change from either other habitat types or other geographic regions. These species can serve as valuable indicators of adverse changes in habitat condition. We assign these species to *derived diversity*, as they are novel to the community and do not belong to the habitat-specific species pool. Derived diversity includes not only non-native species from different geographic regions, but also native 'aliens' that are either specialist species from other habitat types (including weeds, opportunistic species) or generalist species that are otherwise widespread, but have not historically been part of this particular habitat. The new term *derived diversity* stems from the concept of derived habitats such as derived grasslands where human impact has profoundly changed the fire and grazing regime of natural grasslands, resulting in altered species composition and augmented occurrence of non-native species (Groves, 2000), or derived forests and scrubs that depict degraded state of previously good-quality forest habitats (Putz & Redford, 2010).

There are variety of processes that can lead to infiltration of habitats by species belonging to derived diversity, including change in physical–chemical conditions of communities (e.g. Duprè *et al.*, 2010), change in historically developed disturbance regimes (Moles *et al.*, 2012), fluctuation in resource availability (Davis *et al.*, 2000), habitat alteration by invasive species (Vilà *et al.*, 2011) and change in the surrounding landscape (Wiser & Buxton, 2008). In addition, derived diversity may increase with the loss of characteristic species and resulting reduced invasion resistance (Zavaleta *et al.*, 2010), excessive flow of alien diaspores (i.e. propagule pressure, Simberloff, 2009), climate change (Williams & Jackson, 2007; Lenoir *et al.*, 2010) and habitat loss and fragmentation (Helm *et al.*, 2006). Facilitation by already established new species and promotion via development of new biotic relationships can increase the habitat susceptibility to additional species (Stevens & Beckage, 2009).

Most of the above-mentioned reasons are triggered by adverse human impact during the Anthropocene (Ellis *et al.*, 2010). Thus, an increasing number of derived species can indicate recent environmental changes and anthropogenic impact. Increasing dominance of derived species can also lead to variety of functional and structural alterations in ecosystems. For example, the human-induced encroachment of indigenous shrubs to semi-arid and arid grasslands around the world has increased net ecosystem productivity and significantly altered the quantity and distribution of soil and plant C and N pools (Eldridge *et al.*, 2011). With increasing derived diversity, novel traits and novel phylogenetic lineages are introduced to the community, possibly inducing a change in functional community structure and diversity (Mouillot *et al.*, 2013). Eventually, novel ecosystems can develop from combinations of species that have never coexisted previously (sensu Hobbs *et al.*, 2009), resulting in long-term effects on the local network of biotic interactions and the intrinsic dynamics of the ecosystems. If there are more generalists among derived diversity than among characteristic diversity, the invasion is likely to result in local and regional biotic homogenization (Clavel *et al.*, 2011). From a conservation perspective, knowledge of the identity and effect of novel species in the ecosystems by quantifying derived diversity allows us to detect habitat alteration and employ conservation actions when necessary.

The idea of identifying native species that could serve as indicators of human influence is not utterly new. In a number of Central and Eastern European countries, the synanthropic component of native floras has been distinguished. For instance, native plant species that benefit from human-related disturbances are described as apophytes (Wittig, 2004; Sukopp, 2006). Similarly, specialist versus generalist species can be distinguished according to the width of their ecological niches and are thought to be differently influenced by anthropogenic changes (Krauss *et al.*, 2004; Devictor *et al.*, 2008). Our approach provides a broader and more ecological distinction that is built on historical assembly and development of communities rather than properties of individual species. The concept of derived and characteristic diversity allows us to encompass both native and non-native invaders and is also applicable to animal communities.

QUANTIFYING CHARACTERISTIC AND DERIVED DIVERSITY

Composition of habitat-specific species pools, as well as conservation targets, is unique for each region and habitat. Characteristic diversity can only be described when there is knowledge of the composition of the habitat-specific species pool of a particular habitat in its desired conservation state.

We hereby propose standardized workflow that can be used to estimate the composition of habitat-specific species pools (Fig. 2). In the described approach, the first and the last steps are inevitable, that is, it is always necessary to determine the range of species (step 1) and use local experts to confirm the species list (step 3). Step 2 lists number of approaches encompassing ecological filters that can be selected depending on the availability of background information. They are broadly listed in an order of preferential use, that is, more informative are listed first. Alternatively, in case there is information available to use several approaches on step 2, they can be applied consecutively to elaborate the selection based on previous filter(s). The use of ecological filters should always be pursued while determining species pools. However, in regions and habitats where the amount of existing information is very poor, only steps 1 and 3 can be applied to determine species pool composition until additional data are accumulating.

Standardized workflow to determine habitat-specific species pool composition:

1. The first and obligatory step is to identify a range of species that occur naturally in a region from where they can potentially disperse to a given community. This region can be, for example, a small country, a county, a nature reserve or a single relatively uniform biogeographic region (Pärtel *et al.*, 1996, 2011).

2. Application of ecological filters depending on the availability of information and objectives of study. To obtain a representative estimate of characteristic diversity, filters 2b-2d have to be applied to good-quality habitat patches.

a. Use of species-specific information on habitat requirements. Species habitat requirements, preference of certain environmental conditions or an affiliation to particular habitat type are available in number of databases. For

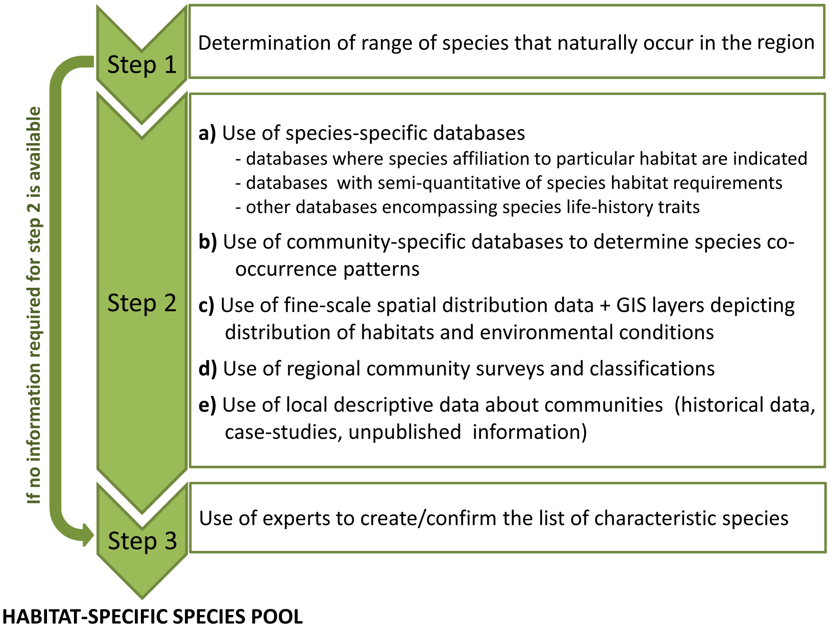

Figure 2 Standardized procedure to identify species pool composition. Step 1 and step 3 are inevitable and have to be always applied. Step 2 provides several approaches that can be selected depending on the availability of background information for particular region and habitat. More informative approaches are listed first, but if suitable information is available, each step can also be sequentially applied to elaborate the selection based on previous stage. In case there is no ecological information available, one can move from step 1 straight to step 3. See the main text for more detailed descriptions.

example, there is existing semi-quantitative information about habitat requirements available for plants in Central Europe (Ellenberg *et al.*, 1991), Italy (Pignatti *et al.*, 2005) or UK (Hill *et al.*, 1999). Lists of typical habitats for European plants can be found in several databases, e.g. BiolFlor (Klotz *et al.*, 2002); Grime (2006), and such information is becoming increasingly available for other species groups (e.g. Speight, 2012). Species habitat requirements have been used in number of studies to determine habitat-specific species pools (Kelt *et al.*, 1995; Pärtel *et al.*, 1996; Duprè, 2000; Diekmann, 2003; Chessman & Royal, 2004; Harrison & Grace, 2007; Sádlo *et al.*, 2007; Zobel *et al.*, 2011; de Bello *et al.*, 2012). In many regions and for many species groups, this approach can still be impracticable due to a lack of data. However, we believe that together with increasing knowledge of natural communities world-wide, information on species habitat requirements is starting to accumulate.

b. Use of community-specific databases to determine species co-occurrence patterns (Ewald, 2002; Münzbergová & Herben, 2004; Pärtel *et al.*, 2011; González-Caro *et al.*, 2012; Lessard *et al.*, 2012). This approach requires a large dataset of species-site descriptions from good-quality habitat patches to identify species belonging to the habitat-specific species pool. Where available, large compilations such as Global Index of Vegetation-Plot Databases (Dengler *et al.*, 2011) can be helpful.

c. Use of fine-scale spatial species distribution data and GIS layers of environmental data to link species occurrence to environmental conditions and habitat distribution. As data with necessary precision are increasingly available in well-studied regions, distribution modelling can serve as a valuable tool to reveal patterns of species assemblages (Elith & Leathwick, 2009; Guisan & Rahbek, 2011; Mokany & Paini, 2011).

d. Use of regional community surveys and classifications. An inventory of species encountered in a specific habitat type, or habitat classifications studies typically present a list of characteristic species for particular community type (Cam *et al.*, 2000; Duprè, 2000; Tofts & Silvertown, 2002; Losvik, 2007; Sádlo *et al.*, 2007; Kirmer *et al.*, 2008). This information can also be obtained from increasingly available data papers (Chavan & Penev, 2011). Some authors have also used ‘reference sites’ to quantify species composition of good-quality habitat patches and applying the results to assess the change in degraded sites (Hughes *et al.*, 1986; Zampella & Bunnell, 1998).

e. Use of local descriptive data about communities. Historical species lists from the same sites enable to evaluate recent changes in species composition due to adverse human impact (Saar *et al.*, 2012). Materials from case studies or unpublished information that is kept in data repositories or by individual researchers can help to assess the species pool composition.

3. Use of experts to confirm the list of characteristic species should always be final, essential step (Sádlo *et al.*, 2007).

Following the identification of the species pool, all species that are present in the observed community, but do not belong to the characteristic species pool, should be assigned to derived diversity.

The period of infiltration of derived diversity in most regions can coincide with the increase in human population density, related habitat loss and changes in environmental conditions of historically developed habitats. However, numerous ecosystems in Europe and Asia have developed during long-term human influence in the landscape, and moderate anthropogenic impact is a key component necessary for their persistence (Blondel, 2006; Ellis & Ramankutty, 2008). For example, historical land use and related facilitation of invasions from different species pools has resulted in the development of semi-natural grassland habitats in Europe, harbouring remarkable biodiversity (Poschlod *et al.*, 2009; Eriksson, 2013). To determine the derived and characteristic diversity in ecosystems that have evolved hand-in-hand with humans, it is necessary to match the habitat quality requirements with the onset of rapid changes in traditional land use, that is intensification of agriculture (Duprè *et al.*, 2010).

In summary, the identification of species pools requires a good knowledge of the local biota and its dynamics. We call on experts and ecologists world-wide not only to focus on ecological patterns, but also always to note thoroughly and publish the underlying biodiversity data to increase the general knowledge of biodiversity patterns. We would also encourage researchers to publish a thorough description of their chosen methodology in any publication that deals with habitat specificity or with characteristic versus derived diversity.

Native and non-native species can have ecologically relevant differences in their life history traits (Knapp & Kühn, 2012). Non-native species have arrived mostly via anthropogenic pathways, they can lack natural enemies in the new environment, and they are more likely to turn invasive than native colonizers (Knapp & Kühn, 2012; Simberloff *et al.*, 2012; Simberloff & Vitule, 2014). Thus, in regions and communities where derived diversity consists of native and non-native species, separate analysis of both can additionally reveal trends in ecosystem invasibility and colonization processes.

APPLYING THE INDEX OF FAVOURABLE CONSERVATION STATUS

For conservation and scientific purposes, we suggest using the Index of Favourable Conservation Status (FCS_i = log (characteristic/derived)), that is, the log ratio of characteristic diversity to derived diversity. This index can describe the ongoing dynamics and habitat condition in relative terms. Metaphorically, this metric captures the fact that the addition of a dozen new species would likely have a considerably greater effect on a species-poor community with ten characteristic species than on a diverse community with hundred of characteristic species. To avoid the limitations of division by zero, both numerator and denominator should be increased by one in case there are no derived species in studied community. As with a large proportion of non-native species in the habitat (Sivicek & Taft, 2011; Catford *et al.*, 2012), a low Index of Favourable Conservation Status can indicate habitat degradation and the necessity for conservation management. Our index can be used as a tool to evaluate the biodiversity recovery following habitat restoration. For example, it can be applied to measure the status of habitat biodiversity and serve as an operational indicator for the Aichi Biodiversity Targets, required by the EU strategic Plan for Biodiversity 2011–2020 (Secretariat of the Convention on Biological Diversity, 2010).

In contrast to simple proportions, the log ratio between characteristic and derived species richness provides not only a measure of relative difference independent of species richness (Szava-Kovats *et al.*, 2012), but places the data in an unbounded line in real space (theoretically from $-\infty$ to $+\infty$), which is a fundamental assumption for all conventional statistics (Bacon-Shone, 2011). As such, the metric displays an effect size like a log odds ratio (Koricheva *et al.*, 2013). When FCS_i is < 0, the characteristic diversity constitutes less than half of the total community diversity. A similar assessment of community status can be performed using species compositional data by calculating characteristic and derived diversity as 'effective species numbers' (Hill, 1973).

We provide an example of the additional insight gained from using the Index of Favourable Conservation Status by examining vascular plant and bryophyte species composition in polluted and intact peat bogs data (Paal *et al.*, 2010; Fig. 3). Peat bogs in Estonia are very well studied, and the species pool composition characteristic of disturbance-free raised bogs has been thoroughly compiled through extensive botanical surveys by habitat experts (Paal & Leibak, 2011). Since the 1950s, many native calciphilous species, including protected orchids from nearby grassland habitats, have invaded the Sphagnum-dominated ombrotrophic (raised) bogs due to alkaline pollution from oil-shale-fuelled power plants (Paal *et al.*, 2010). Although total observed species diversity is even greater in polluted bogs than in pristine bogs (Welch two-tailed t-test, vascular plants: $t = 3.14$, d.f. = 4.9; $P = 0.026$; bryophytes: $t = 2.26$, d.f. 8.62, $P = 0.05$), the Index of Favourable Conservation Status (FCSi – the log ratio of characteristic:derived diversity) reveals a substantial decline of biodiversity integrity in polluted bogs (vascular plants: $t = -2.65$, d.f. = 5.09, $P = 0.044$; bryophytes $t = -5.45$, d.f. = 8.95, $P < 0.001$). Consequently, total biodiversity as an index would lead us to conclude that the polluted bogs exhibit good-quality habitat with no pressing need for conservation, especially given that no non-native species are present. Interestingly also, the plant characteristic diversity has even increased also in polluted bogs, which might be related to additional niche construction for bog species in more calcareous habitats (Ewald, 2003). However, as the derived diversity has increased even more, Index of Favourable Conservation Status allows us to distinguish the effects of pollution on biodiversity integrity.

Other similarly straightforward examples in which the Index of Favourable Conservation Status can provide useful

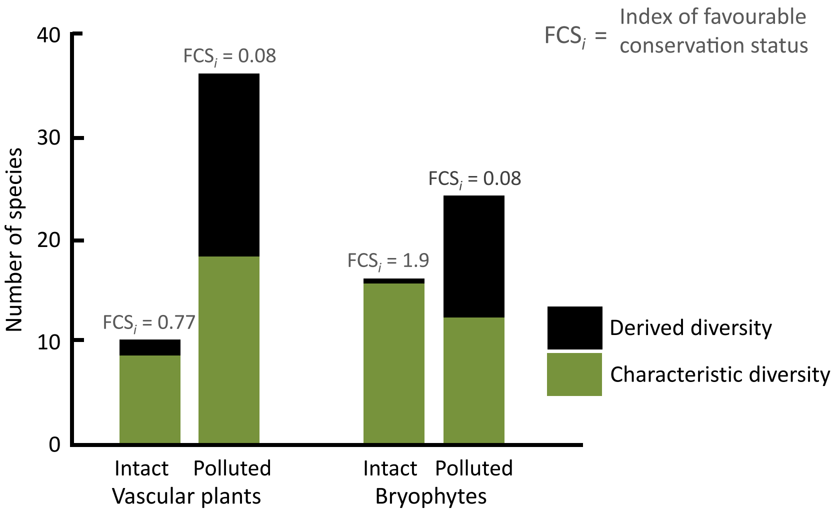

Figure 3 An example of a lower Index of Favourable Conservation Status in degraded raised bogs where current conservation measures have been insufficient. Alkaline fly ash pollution has triggered an invasion of native calciphilous bryophytes and vascular plants that are historically characteristic of nutrient-rich and calcareous subneutral wet meadows or rich fens. Figure is based on Table 3 in Paal *et al.* (2010); see main text for statistics.

information on the change of integrity of community biodiversity include the establishment of shade-tolerant understorey species from nearby forests in unmanaged grasslands in Europe (Duprè *et al.*, 2010) or plant species from saline coastal communities finding a new habitat in salt-polluted grasslands adjacent to motorways (Scott & Davison, 1985).

As the Index of Favourable Conservation Status compares the characteristic and derived diversity in terms of a ratio, it is independent of total species number and can be applied to a range of ecosystems, including both plant and animal communities, in aquatic and terrestrial environments. The Index of Favourable Conservation Status could be applied to measuring climate-induced changes in coral reef assemblages (Yakob & Mumby, 2011), to quantifying the shift in nematode communities due to pollution (Bongers & Ferris, 1999) or assessing the impact of change in pollinator and pollinated plant communities on mutualistic networks (Carvalheiro *et al.*, 2008). For instance, Zampella & Bunnell (1998) have studied aquatic degradation in streams in Pinelands, New Jersey (USA), and found that in streams degraded by eutrophication due to agricultural and urban pollution, species richness of fish had not declined, but they were more colonized by non-Pineland (both native and non-native) species. Application of Index of Favourable Conservation Status in this case can reveal relative decline in restricted native (i.e. characteristic) fish species and emphasize the necessity of conservation.

ECOLOGICAL PATTERNS OF CHARACTERISTIC AND DERIVED DIVERSITY

Quantification of characteristic and derived diversity has also high theoretical significance in aiming to understand ecological relationships and patterns. Establishment success of species belonging to derived diversity can be considered a natural experiment that tests community saturation (Stohlgren *et al.*, 2008) and creates opportunities for rapid evolution of both the invading species and the recipient community (Phillips & Shine, 2006).

Due to their different historical backgrounds, characteristic and derived diversity can exhibit dissimilar relationships with environmental and landscape parameters. In a number of publications, species–area relationships, the effect of habitat loss on diversity or occurrence of extinction debt have been detected only when researchers have defined a habitat-specific species pool (e.g. Steffan-Dewenter, 2003; Krauss *et al.*, 2010; Cousins & Vanhoenacker, 2011; Matthews *et al.*, 2014). Dynamics of species diversity might not be observable immediately following environmental change, as compositional instability can result from extinction debt or colonization credit (Kuussaari *et al.*, 2009; Jackson & Sax, 2010). Such time-lags in species response to environmental change create a challenge in the observations and interpretation of compositional dynamics (Bertrand *et al.*, 2011). In Figure 4, we use data from fragmented and deteriorated calcareous grasslands in Estonia (originally published in Helm *et al.*, 2006; Krauss *et al.*, 2010; Sang *et al.*, 2010) to demonstrate how the detection of the species–area relationship and species time-lag can depend on which biodiversity components are considered. Only native plant and butterfly species occur in these grasslands, and the composition of characteristic diversity was determined by local habitat experts who selected typical species of the total species lists by engaging both their expert assessment and previously available information such as data from numerical habitat classification for calcareous grasslands in Estonia, habitat surveys and monitoring. In these grasslands, the rapid loss of habitat area during previous decades has resulted in extinction debt, and there is no positive relationship between current habitat area and characteristic plant richness (Helm *et al.*, 2006). At the same time, the derived diversity is negatively related to current habitat area, thus inducing a significant relationship with total diversity (Fig. 4, left column). Higher derived diversity in smaller habitat fragments is a result of their greater perimeter–area ratios and otherwise poorer quality. Butterflies, that is, species with shorter life cycles than plants, exhibit no extinction debt, but the relationship with current habitat area is significant only for specialized calcareous

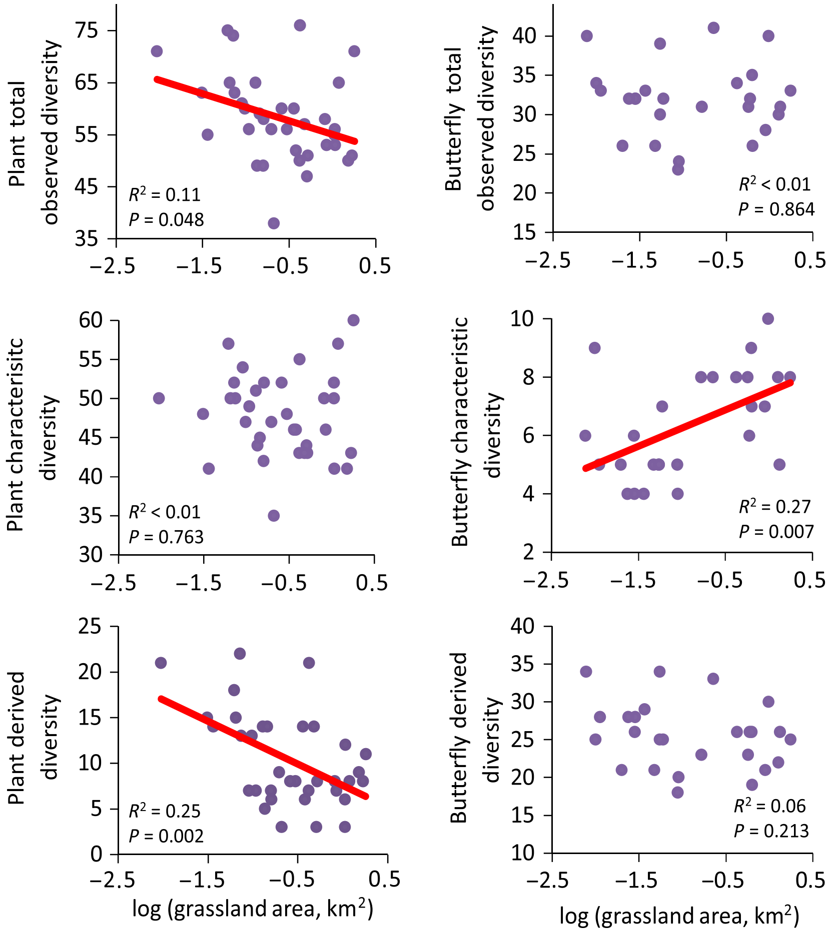

Figure 4 Characteristic and derived diversity can exhibit contrasting ecological relationships due to their dissimilar background in their development. In highly fragmented alvar grasslands in Estonia, total observed diversity, derived diversity and characteristic diversity of plants (left column) and butterflies (right column) are related differently to current habitat area. Regression lines depict statistically significant relationships with corresponding *P*-values and coefficients of determination (R^2). Figure is based on data presented in Helm *et al.* (2006), Sang *et al.* (2010) and Krauss *et al.* (2010) with the permission of data owners. See main text for the explanations of observed patterns.

grassland species (Fig. 4, right column). In this case, pooling derived and characteristic diversity and examining total diversity alone would have hidden some of the mechanisms underlying biodiversity patterns. The Index of Favourable Conservation Status is positively related with remaining habitat area in both datasets (R^2 = 0.20 for plants and R^2 = 0.33 for butterflies), indicating greater biodiversity integrity in currently larger habitats although the occurrence of extinction debt hides this pattern from direct observation of characteristic or total species richness.

In conclusion, environmental changes can render communities susceptible to invasion by both non-native species as well as native species from different habitats. Knowledge of the habitat-specific species pool composition is vital for efficient habitat conservation. Quantifying only observed total (native) diversity as a biodiversity measure can lead to erroneous conclusions about habitat condition and conservation value, as decreases in the characteristic diversity can be masked by increase in derived diversity. The Index of Favourable Conservation Status, that is, log ratio of characteristic:derived diversity, can serve as an efficient biodiversity metric to monitor biodiversity and explore past and future species extinctions. Measured over time, a decrease in the Index of Favourable Conservation Status indicates community alteration. The distinction between characteristic and derived diversity is necessary to understand fully various ecological processes within and among communities, for planning habitat restoration and evaluating restoration success, for estimating the impact of invading species or for recognizing novel species assemblages.

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BIOSKETCH

Aveliina Helm is a plant ecologist interested in the development and drivers of biodiversity. Specifically, she is exploring historical and current anthropogenic impact on plant diversity at different scales. Much of her work is focused on conservation of semi-natural grassland habitats and cultural landscapes in Estonia. She is the member of the Macroecology workgroup in University of Tartu, led by Professor Meelis Pärtel. Details of the workgroup can be found at http://www.botany.ut.ee/macroecology/en/.

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