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Relative Quantitative Reference Approach for Naturalness Assessments of forests

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ABSTRACT

Naturalness assessments are required for the evaluation of conservation schemes and programmes such as large-scale IUCN protected areas (National Parks) where nature restoration is a main management objective. More than 99% of the landscapes of Central Europe lost their reference sites for naturalness assessments with cutting of the last virgin forests. We present the Relative Quantitative *R*eference *A*pproach for *N*aturalness *A*ssessments (RANA), a method for overcoming the lack of virgin forests using a surrogate reference for forested landscapes. RANA combines heterogeneously scaled bio-important variables. We tested the RANA in the Bavarian Forest National Park, Germany, with an assumed naturalness gradient in different park zones. The results demonstrate that the RANA is a highly sensitive method for evaluating ecosystem responses to forest restoration and conservation.

1. Introduction

1.1. The missing reference

With the presence of man, virgin forests could not persist during the last 12,000–15,000 years of reforestation after the ice age in many regions in Europe because of increasing land-use pressure. Today, only very small remnants of European forests are considered to be virgin, and these areas are mainly clustered in eastern Europe (Leibundgut, 1982; Parviainen, 2005). Additionally, the histories of forests currently assumed to be virgin forests are not completely known. Therefore, for most parts of Europe we cannot reconstruct the historical or potential current natural forest composition and structure in a scientifically reliable and comprehensive way.

One main challenge of society today is to protect the natural benefits that fauna and flora provide to man by halting the loss of biodiversity (CBD, 1992; GSPC, 2002; Balmford et al., 2005). A major reason for the biodiversity decrease worldwide is habitat degradation and loss (Foley et al., 2005). Forest management practices often favour tree plantations with non-native tree species and prefer homogenous forests. Thus, the lack of deadwood, natural gaps with pioneer species and structural heterogeneity in forest stands result in reduced forest biodiversity (BfN, 2002, p. 80). However, forest management that mimics natural processes and states of virgin forests hinders the ongoing biodiversity loss (e.g. Winter and Möller, 2008; Michel and Winter, 2009).

But how can we clearly depict or estimate the naturalness without knowing what nature would have produced in the absence of human impacts? Without knowing nature's reference values for original landscapes and virgin forests, the challenging task of preserving or restoring habitats is only partially feasible. The missing reference information has resulted from an historical failure to conserve natural areas and generally hinders quality assessments of management practices that attempt to mimic natural forest processes.

Because of high population density with the associated high land-use pressure, in central Europe we do not have Wilderness Areas satisfying the standards of the International Union for Conservation of Nature (IUCN) category I (IUCN, 1994). For example, in Germany, harvests have been halted in the remaining most natural lowland and mountain forests areas for only a little more than a century. Thus, in our study, we focussed on a National Park (NP), IUCN category II, under the assumption that it features maximum naturalness in central Europe. Management of predominately forested NPs in accordance with naturalness objectives has not yet been monitored in detail. Administrations of NPs, which were established in anthropogenic formed landscapes (so-called "Development NPs"), often try to increase the naturalness of the area before determining the unmanaged core zone according to the IUCN guidelines (Bibelriether et al., 1997, p.14). However, existing evaluation tools for large-scale protected areas do not focus on naturalness assessments of forests (e.g. Scholz et al., 2002; Bader, 2005; Lu et al., 2007), are not standardised or lack the statistical power to detect changes (Mahan et al., 2007).

One of the main objectives of NP administrations, however, should be monitoring based on the IUCN and NP regulations and programmes, which includes recording relevant data on ecosystem development. The data must facilitate the assessment of habitat

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quality and anthropogenic impact (Legler, 2006, pp. 35f) – with the understanding that the main management objective of a NP is development and preservation of natural integrity (Karr, 1990; Wilderness protection IUCN, 1994; BNatSchG, 2002, §24).

1.2. Culture and nature

Culture and nature have been described as a pair of opposites since antiquity (Hofmann et al., 2006; Fig. 1). The theoretical focus of naturalness is opposite that of hemeroby which focuses on the prevalence of man's activity. Naturalness thus depicts the distance between the current and the potential natural status. Although man is part of nature, we separate nature from culture. From this point of view, nature would be the status quo of the earth with negligible human impact on the biocoenoses (Fig. 1; Remmert, 1987; Scherzinger, 1997). Therefore, the today's conservation approach is not to exclude man from NPs (Folke, 2006), but rather to at least partially decrease his impact and absolute dominance in accordance with the regulation of the IUCN category 'National Park'.

Considering the global human distribution, the resulting extremely high consumption of natural resources, and the consequent production of globally distributed emissions connected with global climate changes (IPCC, 2007), Remmert (1987, p. 172) asserted that untouched nature no longer exists anywhere on earth (Fig. 1). We have no habitats left on earth untouched by emissions, so a reference with 100% nature can no longer be found for naturalness assessments. Additionally, the scientific reliability of virgin forests located far away from study sites as references are relative because of factors such as different climatic and growing conditions, differences in the natural plant communities, differences in topology and sea level. Without comparable virgin forests close to study sites, the utility of distant virgin forests as references cannot be assessed. How is it possible to measure the naturalness status of a landscape without comparable virgin forests?

1.3. Approaches for studying naturalness

Currently published papers mention the term *naturalness* mainly without reference to an assessment method (Hancock et al., 2009; Roberge et al., 2008; Winter and Möller, 2008). Other papers focus on developing forest indicators for assessing naturalness (e.g. Liira and Sepp, 2009; Uotila et al., 2002) mostly by comparative studies that investigate forests that are assumed to be more or less natural (e.g. Heino et al., 2009; Liira et al., 2007). McRoberts et al. (submitted for publication) and Gibbons et al. (2008) present methods for identifying forest plots or stands with the greatest naturalness without using pre-established naturalness classes. Only a few approaches assess naturalness using a gradient from low to high naturalness with discrete categories (Heino et al., 2009; Smelko and Fabrika, 2007) or in a metric gradient (McRoberts et al., submitted for publication; Smelko and Fabrika, 2007). In summary, most naturalness studies focus on detecting reliable naturalness indicators and on describing reference forests with a high naturalness. Both are basic steps that are necessary before developing an applicable naturalness assessment approach.

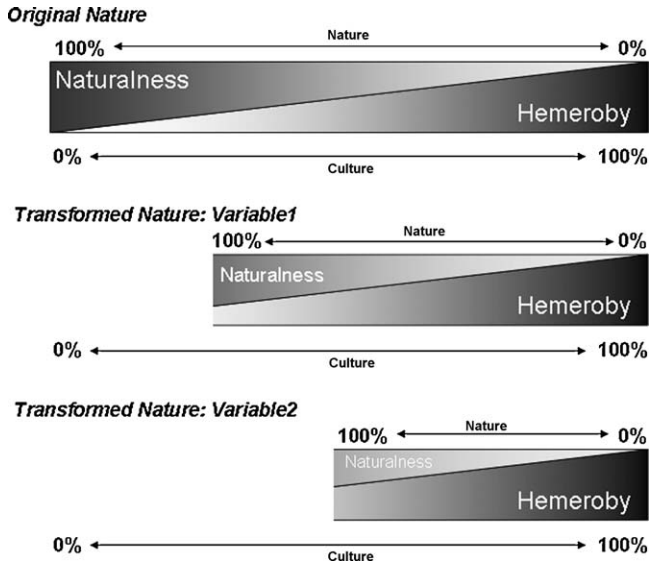

Fig. 1. Theory on the Relative Quantitative Reference Approach on Naturalness Assessments.

Extensive approaches to assessing naturalness are presented by Smelko and Fabrika (2007), Tierney et al. (2009) and Grabherr et al. (1998). The authors of the first paper developed an extensive approach on the numerical conversion of the categorical ecological evaluation of Natura 2000 site. However, they do not present an approach to improve the Natura 2000 assessment itself. In the second study, the ecological integrity of protected areas is assessed resulting in only three naturalness categories. The most extensive assessment approach is a study on the Austrian forests (Grabherr et al., 1998) that is based on the hemeroby concept. Hemeroby is a measure that assesses the effects of past and present human influence on ecosystems (Jalas, 1955; Sukopp, 1976; Grabherr et al., 1998). The Austrian hemeroby approach does not require natural forest reference sites because the approach focuses on the human impact but not on detailed features of reference sites. However, Grabherr et al. (1998) used the potential natural forest vegetation as a theoretical reference state.

1.4. The Relative Quantitative Reference Approach for Naturalness Assessments (RANA) of Forests

Anderson (1991) noted that an assessment of the degree "to which [an eco]system would change if humans were removed from the scene" is a strictly hypothetical model without quantitative (measurable) variables. However, the Relative Quantitative Reference Approach for Naturalness Assessments (RANA) presents an estimator of naturalness based on definitions of no naturalness (0%) and full naturalness (100%) with an intervening continuum but with a variable 100% benchmark (Fig. 1), here calculated for a forested NP. Based on preceding definitions, 0% naturalness of a habitat is equivalent to 100% hemeroby. Even the greatest naturalness includes a certain direct or indirect impact by man. The least impact of man on the environment can thus be defined as the greatest, most distinct and scientifically reliable reference for an area (Fig. 1).

For our RANA, we establish five general requirements:

(1) RANA focuses mainly on already existing monitoring data.
(2) Additionally required data are simple to record in the field.
(3) Calculation procedures are simple; thus, the method may be used easily for assessing in forest management and nature conservation.
(4) The naturalness assessment is based on a continuous, quantitative metric.
(5) The assessment includes a defined approach to determine the references.

The RANA includes two relative components:

(1) The range of 0–100% naturalness is defined by the extremes of the environment status of the study area, e.g. big city to virgin