Assessing the suitability of forest inventories for basis of spatial conservation prioritization

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Abstract:

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1. Introduction

2. Material and methods

3. Results

4. Discussion

Open data has a major role in the play in conservation planning and decision-making, because it enables equal access to best available data, it makes the supporting scientific analysis more transparent, and it enhances the repeatability of the whole process (**REF**). The last point is especially important for applied research supporting decision-making, because underlying may change objectives, data updates, and new information accumulates sometimes rapidly. Adaptivity and repeatability are crucial in translating regional planning into local action (Pressey et al. 2013) which in the context of the current work implies that the conservation prioritization methods would become an integral part of operative forest management planning.

Here we have shown that Zonation analyses based on open forest inventory data can produce informative results, but only on particular scales and when particular planning objectives are met. (**Add** assumptions about the accuracy of the data). The validation procedure we did relies on few key assumptions. First, if the index layers constructed from different input data sets truly reflect forest characteristics desirable for conservation purposes, then the sites in the validation data sets should receive high priority in the results. Second, we assume that the validation data sets actually describe location of high conservation value. Protected areas have traditionally been established on less productive soils (Scott et al. 2001; Elbakidze et al. 2013) and therefore it is likely that they usually do not represent the full spectrum of species or habitats in any given region. However, over a period of time being set-aside from the prevailing forest management regimes will produce resources such as dead-wood that many forest are depend on (Siitonen et al. 2000). Woodland key-habitats on the other hand are scattered more evenly over the landscape and according to recent meta-analysis (Timonen et al. 2011) they contain higher amounts of critical resources such as dead-wood and consequently larger number of species as well (**check** the details for Finland). On average the size of a WKH site is very small (0.67 ha in Finland (Timonen et al. 2010)) and thus they're capability to support populations in the long run in uncertain. METSO-programme has strict protocol for assessing the suitability of each site (**REF**?) and the monitoring studies done so far (**REF**?) have concluded that sites admitted into the programme indeed do have high conservation values.

Protected areas (PAs) did come out with relatively high priorities in variants based on MSNFI or MSNFI with classes (fig. 5A-5D). This is probably because PAs in South-Savo region - as in rest of the country - tend to have been set aside for a longer period of time resulting in quite mature forest structure, which is reflected in high values in the index layers (see XX) used as input. Sites acquired into METSO-programme had also relatively high median priorities potentially indicating that they contain similar features to the larger PAs. Woodland key-habitats have the smallest average size per site out of the three validation data sets and they constitute perhaps also the most heterogeneous (**REF**) group. The fact that the classified version of MSNFI had slightly higher median priorities (fig. 5i-5j) is most probably explained by that many of the rarer soil fertility classes (such as herb-rich and xeric soils) may also more often be designated as woodland key-habitats. Variants based on the more detailed data (V5 and V6) clearly outperform all variants based solely on the MSNFI data when compared against the validation data sets. Median priority is clearly higher for the variants based on the detailed data and furthermore, the priority rank distribution shows conspicuous peaks for the very highest priorities. Because of the more detailed and accurate data - also for the soil fertility classification - analysis are able to distinguish small-scale woodland key-habitats quite well.

The small effect of connectivity (V2, V4 and V6) has on the priority rank distributions of the validation data sets may feel slightly surprising. However, it is good to bear in mind that even combined the validation data sets cover only a small fraction of the total landscape (2.5%, see XX) and therefore the absolute amount of cells affected by connectivity transformation is low. Usually spatial conservation prioritization is concerned about the absolutely best part of the landscape, the defining what is the "best part" is a subjective decision. For example, METSO-programme has a defined objective for additional conservation in South-Savo, which correspond to ca. 5000 hectares or less than 0.5% of the total forest area (**CHECK**). On the other hand, if different conservation instruments are to employed over a significantly larger areas (Hanski 2011; Moen et al. 2014), we must in fact be looking at top fractions significantly higher than few percent. Over larger areas, the role of connectivity also becomes more apparent (fig. 2) as regions with higher density of high quality sites are emphasized. Emphasizing connectivity will almost certainly happen at the expense of local habitat quantity and quality (Hodgson et al. 2009). Increasing the priority of medium-quality forests that are well-connected will lower the value of other similar quality sites and possibly even poorly connected high-quality sites (fig. 2). Trade-offs introduced by taking into account connectivity will naturally depend on the implementation of a particular method (in or case Zonation), but the issues related to it are conceptually quite well understood (Hodgson et al. 2009; Arponen et al. 2012).

Highest and lowest fractions of landscape seem to be consistently more similar in terms of overlap measured by the Jaccard coefficient (fig. 3). It is not perhaps surprising given that the best parts of the landscape probably are best by a large margin and the worst parts probably do not have much forest at all. In none of the variant comparisons do the best and worst parts of landscape overlap much. From input data sets' perspective this can be considered a good thing, because such overlaps would imply serious risks of selecting poor sites if using the coarser data. Comparisons between the MSNFI and MSNFI with classes input data sets (V1 vs. V3 and V2 vs. V4) reveals interesting patterns caused by classification. (**EXPAND**)

Trade-offs introduced by using less accurate data are more case-specific, but it can be estimated. Conservation scientists, foresters and other practitioners are often faced with tight deadlines and limited budgets, and thus have to decide whether it is worth the time and money to try to secure access to more detailed data if coarser but easily available data exists. We found that using coarser MSNFI-data can lead to a serious drop in the representation of especially the less abundant biodiversity features such as the herb-rich and xeric forest types (fig. 4). For example, if we are interested in the best 10% of the landscape prioritization based on MSNFI with classes captures, on average, only half of the representation levels of the biodiversity features derived from the detailed data. For biodiversity feature on herb-rich soils, analysis based of MSNFI with classes captures less than 10% (**check** the exact figures) of representation levels. These differences are probably mostly due to less accurate soil fertility classification in the MSNFI data (…). For the rarest, and hence most valuable, soil fertility classes (herb-rich and xeric) MSNFI with classes performs slightly better than MSNFI without classes. Hence, an ecologically justified classification of the data can improve the results even if the quantitative information (i.e. the index values) is the same.

(A paragraph on the effects of segmentation?)

Given these results, it can be concluded that when using methodology we introduce in this paper here and the variations of it used before (Lehtomäki et al. 2009; Sirkiä et al. 2012) openly available MSNFI-data is best suited for situations where objective is to target regions with larger extents of mature forest. Therefore if the spatial prioritization includes objectives for detecting small scale biodiversity feature occurrences such as the WKHs, a more detailed input data set is clearly needed. Given the amount of available forest inventory data in countries like Finland and Sweden, it is very important that these data sources can be used also for conservation planning purposes for several reasons. First, since high-resolution, large-scale, and systematic observational biodiversity data is scarce (**REF**) suitable proxies for species and habitat occurrence are needed. Second, over 95% of the forest landscapes in Finland and Sweden is under silvicultural management (**CHECK** METLA 2013; Skogstyrelsen XXXX) which uses these data for operative planning. If conservation planning is to be integrated with other types of land use and natural resource planning, it would be

From conservation planning perspective it is crucial that forest inventory data sets collected contain a breadth of variables important for biodiversity also in the future.

Since the analysis based on MSNFI data do not perform as well as more detailed data… Should the more detailed data be opened? Or at least part of it.

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Tables

Figures

Figure 1. Schematics of the analysis setup. Different parts of the analysis were done in different software environments (see text). Analysis feature layers (index layers) were constructed from 3 different data sources (Table 1 and a condition layer (see text) was applied on all of them. Different Zonation analysis variants are indicated by arrows 1-4 (see Table 3) with closed circles indicating the analysis features used. Each analysis variant resulted in a priority maps (Figure 2) and feature-specific performance curves (Figure 3). For validation purposes, each rank priority map was compared to a set of independent validation data to determine the mean and the distribution of ranks (Figure 4).

Figure 2. Conservation rank priority maps.

Figure 3. Spatial overlaps of solutions based on different data sets and variants.

Figure 4. Performance curves for variant XXX (REPLACE "PERFORMANCE CURVES")

Figure 5. Distribution of rank priorities in comparison data sets.

Supplementary material

Building the ecological model Expert elicitation Figure S1: The benefit functions used to scale the perceived, expert opinion based conservation value (y-axis) to forest structural characteristics (x-axis) Segmentation of the MSNFI data

Analysis setup: Table S1: Feature weights Table S2: Connectivity matrix