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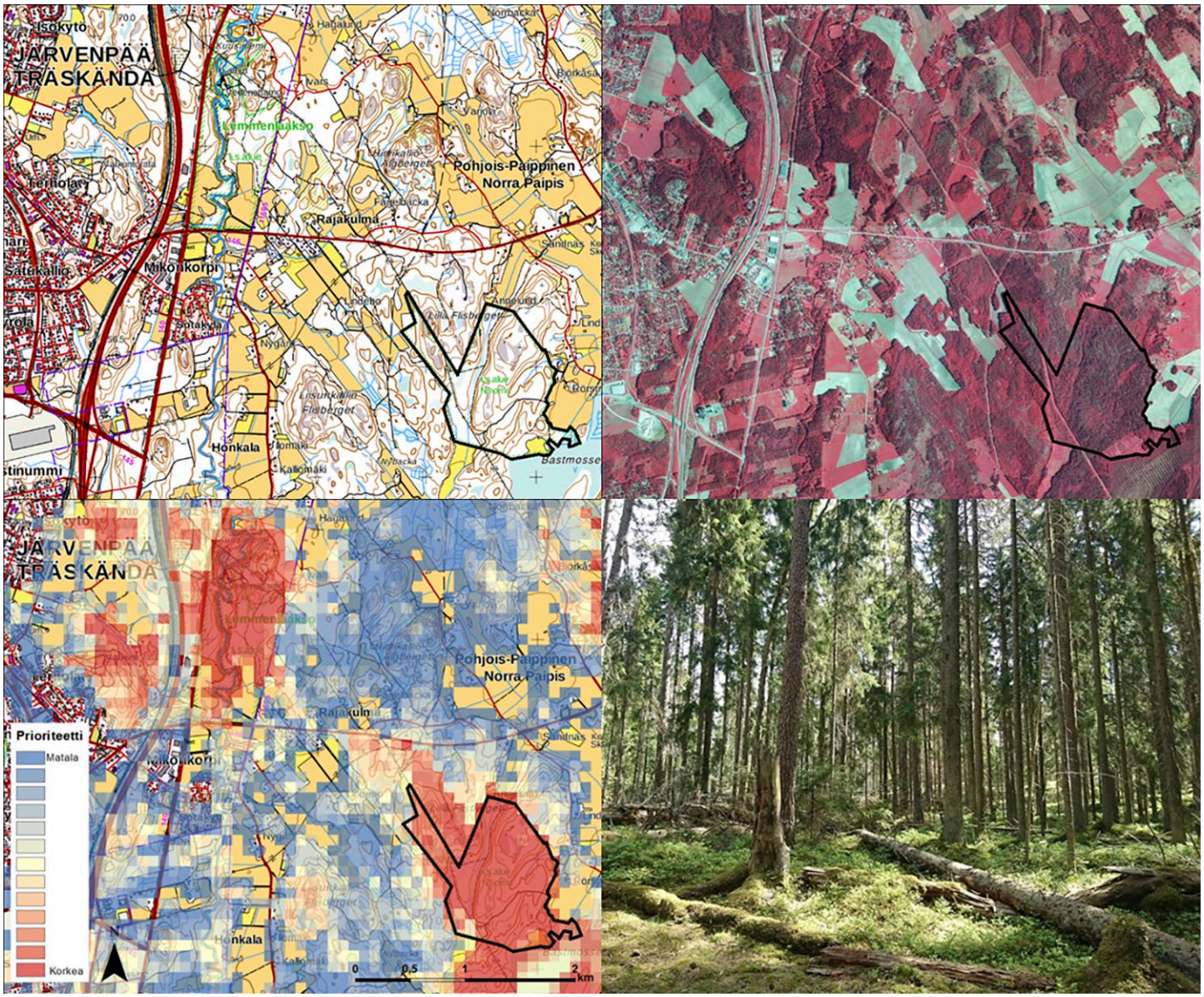
Ecological decision analysis in support of societal decision making

Final report of the MetZo-II project



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Final report of the MetZo-II project

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Abstract

The MetZo II -project has applied ecological decision analysis to support societal decisions about nature conservation and land use. Spatial prioritization analyses implemented within the project using the Zonation approach have been utilized, e.g., in the South Finland Forest Biodiversity Program (METSO), in the targeting of habitat restoration for Natura 2000 areas, and in land use zoning. Additionally, design principles have been developed for biodiversity offsets, which are currently under active consideration in Finland. Background work by MetZo II has created opportunities for other projects.

Forest analyses have provided administrators and land owners materials that support on-the-ground conservation decisions done as part of METSO. The Natura 2000 analyses have sought cost-effective opportunities for habitat management and restoration. Materials developed in the project have been used to assist zoning. The project has also participated in the planning of the expansion of the national peatland protection program, and marine spatial analyses implemented in association with MetZo II are groundbreaking in quality.

The MetZo-II project has been primarily funded by the Finnish Ministry of the Environment and it has been run by the Metsähallitus Parks and Wildlife Finland, the Finnish Environment Institute and the University of Helsinki.

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Tiivistelmä

MetZo II -projekti soveltaa ekologista päätösanalyysiä yhteiskunnallisen, lähinnä luonnonsuojelua ja maankäyttöä koskevan, päätöksenteon tueksi. Projektissa Zonation-menetelmällä tuotettuja priorisointeja on hyödynnetty mm. Etelä-Suomen metsien monimuotoisuusohjelmassa (METSO), Natura 2000 -alueiden hoidon kohdennuksessa sekä kaavoituksessa. Lisäksi projektissa on esimerkiksi kehitetty suunnitteluperiaatteet ekologiselle kompensaatiolle, jonka käyttöönotosta keskustellaan parhaillaan aktiivisesti. Projektin puitteissa tehty kehitystyö on luonut toimintaedellytyksiä muille hankkeille.

Metsäanalyysien tavoitteena on ollut tukea METSOn toteutusta ja Suomen metsien suojelualueverkoston vahvistamista tarjoamalla apumateriaalia maanomistajien kanssa asioiville. Natura 2000 -analyyseissä on etsitty luonnonhoito- ja ennallistamisalueita, joilla tehtävät toimenpiteet tuottaisivat suuren ekologisen hyödyn suhteessa kustannuksiin. Hankkeessa tuotettuja aineistoja on hyödynnetty myös kaavoituksen apuna. Hanke on myös osallistunut soidensuojelun täydennysehdotuksen suunnitteluun ja tukenut jopa maailman mittakaavassa erityisen hienoja merialueanalyysejä.

MetZo II -projekti (2015–2019) on suurimmalta osin ympäristöministeriön rahoittama ja se on toteutettu Metsähallituksen, Suomen ympäristökeskuksen (SYKE) ja Helsingin yliopiston johdolla.

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Projektet MetZo II tillämpar ekologisk beslutsanalys som stöd för samhälleligt beslutsfattande som i synnerhet rör naturvård och markanvändning. De prioriteringar som i projektet tagits fram med Zonation-metoden har utnyttjats bl.a. i handlingsplanen för den biologiska mångfalden i skogarna i södra Finland (METSO), i riktandet av vårdåtgärder i Natura 2000-områden och i planläggningen. Inom projektet har det dessutom också utarbetats planeringsprinciper för ekologisk kompensation, vars tillämpning man i dag aktivt diskuterar. Det utvecklingsarbete som utförts inom ramen för projektet har skapat verksamhetsförutsättningar för andra projekt.

Målet med skogsanalyserna har varit att stödja genomförandet av METSO-handlingsplanen och ett starkare nätverk av skyddsområden i de finska skogarna genom att man erbjudit stödmaterial till dem som samarbetar med markägare. I Natura 2000-analyserna har det lagts fram förslag på områden där det kunde genomföras naturvårdande skötsel och restaureringsåtgärder, och där åtgärderna beräknas ge stor ekologisk nytta i förhållande till kostnaderna. De material som tagits fram inom projektet har också varit till hjälp i planläggningen. Projektet har också deltagit i planeringen av ett förslag till komplettering av myrskyddet och bidragit till havsområdesanalyser som är högklassiga till och med i global jämförelse.

Projektet MetZo (2015–2019) har till största delen finansierats av miljöministeriet och genomförts under ledning av Forststyrelsen, Finlands miljöcentral (SYKE) och Helsingfors universitet.

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Contents

1 Introduction

Due to increasing consumption and pressures towards our environment, the maintenance of ecosystems and ecosystem services delivered by ecosystem processes has become one of humanity's biggest challenges. Even when the halting of environmental decline has been signed into political agreement globally, in the EU and nationally in Finland, both populations and habitats continue to decline according to most recent evidence. Broad understanding and quality of information become central when difficult problems need to be addressed, and competent analysis is relevant also for the achievement of our biodiversity objectives. The national ecological decision analysis project, MetZo, which started in 2010 has produced a large number of analyses that facilitate accounting of ecological values in societal decision making. Training courses, presentations and stakeholder interaction have improved our collective ability to utilize quantitative ecological analysis in decision making.

The MetZo-II project (2015-2019) has developed Zonation analyses to support decisions around voluntary forest conservation (the METSO program), for targeting of habitat restoration of Natura 2000 areas, and to assist with zoning. (For Zonation see Appendix.) The longest-running analyses have been around forest conservation, which is where the name of the project, MetZo (METSO+Zonation) originates from. These analyses, which have continued to improve over ten years, support the implementation of METSO by providing useful spatial information to experts who interact with land owners around forest conservation decisions. So far, five analysis sets have been implemented for this purpose and the latest analysis maps, which were completed in 2018, have been made open access available for everyone.

Just like the earlier MetZo 2010-2014 project, MetZo-II has helped other initiatives, including such as the SmartSea strategic council project around marine spatial planning and the IBC-carbon strategic council project, which focuses on synergies between biodiversity conservation and storage and sequestration of carbon in Finnish forests.

Spatial prioritization is one manifestation of ecologically based decision analysis, but also other forms of analysis have been supported as part of MetZo. MetZo-II has, for

instance, supported societal decision making via development of scientifically justified but practical design principles for biodiversity offsets, which are being considered in Finland right now. Biodiversity offsetting is one of novel conservation tools that are taking off globally. Offsets use habitat restoration or conservation to compensate harmful ecological impacts caused by construction, land conversion or other such activities. Prioritization of management is yet another form of ecological decision analysis: a low hanging fruit approach to the management of EU Natura 2000 habitats has also been developed. Additionally, collaborations have been started to determine the cost-effectiveness of habitat management and restoration on protected area managed by Metsähallitus, the organization in charge of both protected areas and production forests owned by the state.

Development of analyses has increased awareness that good analysis requires skills in multiple fields, including geographic information systems, ecology and the spatial prioritization analysis itself. This is a surprise to many who have seen Zonation as a straightforward step towards a data-centric world, in which subjectivity becomes reduced via utilization of broad-scale GIS data about species, habitats and other biodiversity features. It is an important additional benefit that co-design of analyses enables structured dialog between interest groups, it provides them new understanding and insight, and generates good contacts, partnerships and networking. Co-design and implementation of analyses facilitates their take-up by end users, although some analysis and modelling elements are naturally complex in a challenging manner. Understanding biodiversity value and conservation priorities is much easier in some environments than others. Furthermore, an apparently simple proposition may turn out quite complicated, partially because of the inevitable subjective preferences and conflicting opinions around nature, nature conservation and utilization of natural resources, underlining the importance of functional knowledge transfer between analysis experts and the multiple stakeholders.

The MetZo-II project has been funded by the Ministry of Environment. Matching funding has been provided by the Finnish Environment Institute, Metsähallitus Parks and Wildlife Finland, Universities of Helsinki and Jyväskylä, and the Ministry of Agriculture and Forestry. In the future, decision support will be increasingly targeted to broad societal challenges faced by Finland and the EU at large.

2 MetZo II – Examples of analyses enabled by the project

2.1 Targeting of habitat restoration and management in the Finnish Natura 2000 network

Objectives and context. The aim of this study, which was done during 2016-2018, was to prioritize habitat restoration and management inside and between Natura 2000 areas. Results of the analysis are used for targeting of restoration and management in the Parks & Wildlife Finland, for evaluation of national scale operational costs on protected areas, and e.g. selection of Natura 2000 areas in LIFE applications to the EU. In this analysis highest priorities were given to areas that host comparatively many endangered species or habitats, that are of comparatively scarce / damaged Natura habitat type, and where cost-effectiveness of restoration and management is high.

Analysis area. The Zonation analysis covered all protected Natura 2000 sites in Finland, including both private conservation areas and those administered by Parks and Wildlife Finland. Analysis covered those Natura 2000 habitat types that have information in the SAKTI spatial data base of the environmental administration. Such information was available for 1 541 Natura 2000 areas that cover 610 000 spatially defined Natura 2000 habitat patches and 40 800 km^2. Analysis resolution was 50 × 50 meters.

Analysis structure. Most commonly spatial prioritization utilizes distribution maps for species and habitat types. The basic information for the present analysis was the distributions and current condition of Natura 2000 habitats and the known occurrences of endangered species on the Natura 2000 sites. However, the analysis also included a substantial spatial information that is less commonly available: the expected improvement in habitat condition following habitat restoration or management. The two major analysis outputs were i) a map of management priority between Natura 2000 areas and ii) a priority map of occurrences of Nature 2000 habitats and endangered species. Costs of action

were accounted for in analysis, which is very important for analyses of restoration and management, because the per-hectare cost of action can vary significantly depending on habitat, location and action. Zonation-technically, effects of restoration and management were modeled via condition layers. A hierarchic analysis structure was employed to account for complementarity with Natura 2000 areas that remain in natural condition.

Primary data. The SAKTI data base (Natura 2000 areas, their habitat types and information about representativeness and condition). The HERTTA database for observations about occurrences of endangered species. Costs and ecological effects of action were primarily derived from the report of the Finnish Habitat Restoration Prioritization Working Group (Kotiaho et al. 2016).

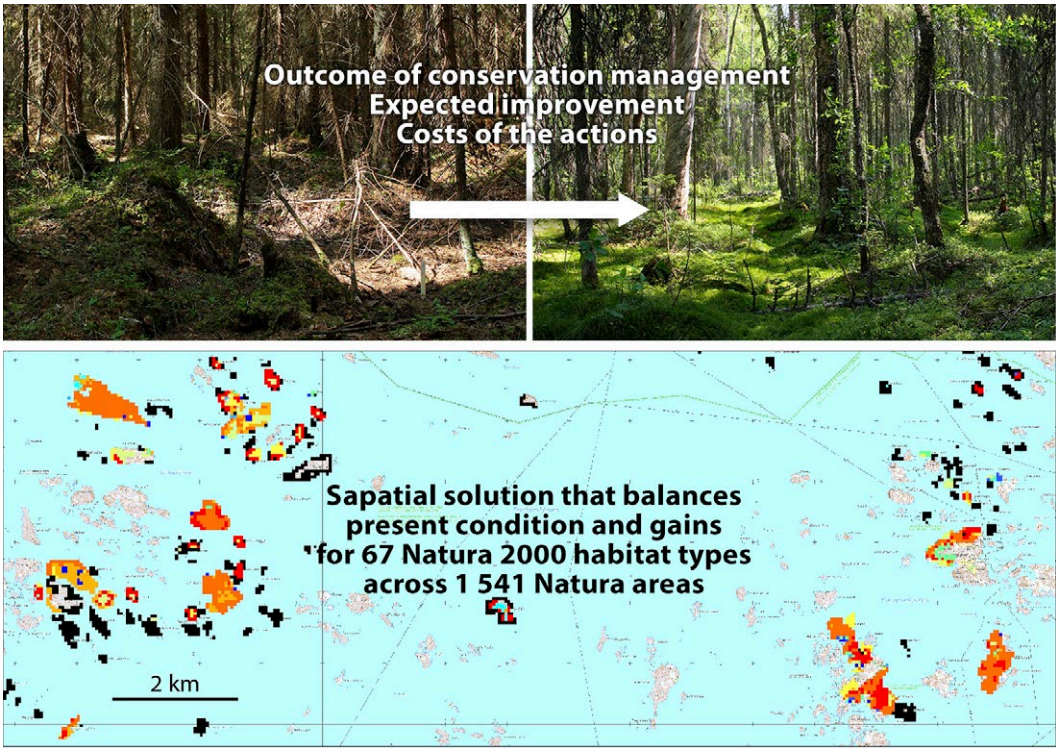

Figure 1. The analysis combined GIS data for Natura 2000 habitats and the condition of protected Natura 2000 areas. Information about costs and effectiveness of alternative restoration and management actions were sourced from the Finnish Restoration Prioritization Project, in which 100 habitat and species experts contributed their knowledge. (Metsähallitus, National Land Survey of Finland. Photos: Santtu Kareksela)

References:

- Kareksela, S., Hokkanen, M., Päivinen, J., Lahtinen, A., Haapalehto, T., Raatikainen, K. M. & Koskela, K. 2017. Ranking Natura 2000 habitats and Natura 2000

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- Kotiaho, J. S., Kuusela, S., Nieminen, E., Päivinen, J. & Moilanen, A. 2016. Framework for assessing and reversing ecosystem degradation: Report of the Finnish restoration prioritization working group on the options and costs of meeting the Aichi biodiversity target of restoring at least 15 percent of degraded ecosystems in Finland. Reports of the Ministry of the Environment, 15en | 2016. http://julkaisut.valtioneuvosto.fi/handle/10024/74862

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2.2 Identification of forest areas important for biodiversity in Finland

Objectives and context. The aim of these analyses, which were implemented 2015-2018, was to provide spatial data about forest conservation value to help experts with the implementation of the voluntary forest conservation program, METSO. The main objective was to find previously unrecognized forest areas that are rich with different types of dead wood, connected with other high-quality forest areas including conservation areas, and thus potentially support high species richness and rarity. An important additional objective was to bring new information about forest conservation value to forest owners. These analyses were the fifth round of development around forest conservation prioritization in Finland. As a positive, it was now possible to make the analysis maps freely available for everyone. Previously, owners of high conservation value forest have been contacted individually by forest conservation experts.

The forest prioritization analyses have been used to assist with zoning, in other forms of broad-scale land use planning, and in communications with individual forest owners. Additionally, a marking for "potential high biodiversity value site" has been added to the forest owner's metsaan.fi service maintained by the Finnish forest center. It is hoped this will prompt forest owners to offer their biodiversity-wise most valuable forests for protection via METSO.

Analysis area. The analyses covered all of forested Finland (283 894 km^2, 84 % of Finland), excluding the Åland islands. To understand national vs regional conservation priorities,

the analyses were replicated both nationally and for each province separately. Analysis resolution was 96 x 96 meters.

Analysis structure. Data was selected to represent forest biodiversity as broadly as possible (below). Six different, incrementally more complex, analysis variants were run using Zonation. First forest value was examined based on dead wood potential alone. Next habitat condition was reduced in areas where forest management operations, such as clear cut or drainage, had reduced the ecological (biodiversity) condition of the forest. Then, various forms of connectivity were added into analysis, including internal connectivity of the forest, connectivity to key forest biotopes defined by the Forest Act, and connectivity to exiting permanent conservation areas. Finally, known occurrences of Red-Listed forest species were accounted for.

Primary data. The analyses are based on ground survey forest data from the Finnish Forest Center, data from the production forests of Metsähallitus, data bases of the environmental administration, and the multi-source national forest inventory data from the Natural Resources Institute Finland (LUKE). Basic factors accounted for each forest plot included soil fertility, age and thickness of trees, and tree species composition. Dead wood potential was estimated using MOTTI forest growth simulator, developed by the Natural Resources Institute Finland. The history of forest management was included via effects on forest condition and known locations of endangered species (Hertta database) were accounted for as well.

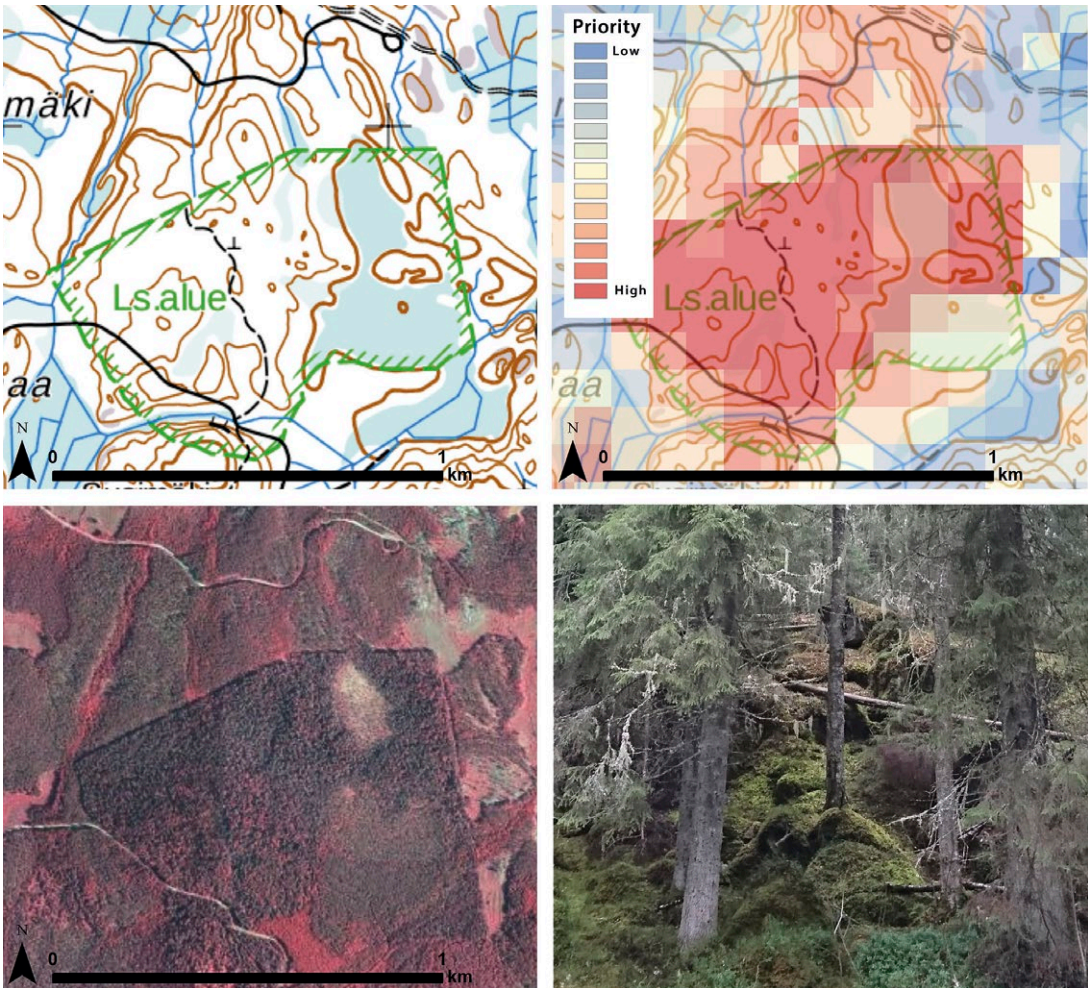

Figure 2. The old forest conservation area of Susimäki, when seen on a topographic map, on a Zonation analysis map, in an aerial photo and in a photograph. The objective of prioritization is to identify areas important to forest biodiversity. Top priority areas typically include mixed tree species composition and structure, various types of dead wood, and a comparatively high volume of trees in general. Despite being valuable for biodiversity, the south-eastern part of Susimäki receives lower priorities because it has less dense forest.(Finnish Environment Institute, Metsähallitus, Finnish Forest Centre, Natural Resources Institute Finland, National Land Survey of Finland. Photo: Ninni Mikkonen)

References and links:

- Mikkonen, N., Leikola, N., Lahtinen, A., Lehtomäki, J. & Halme, P. 2018. Monimuotoisuudelle tärkeät metsäalueet Suomessa. Puustoisten elinympäristöjen monimuotoisuusarvojen Zonation -analyysien loppuraportti. (Engl. ~"Finnish forest areas important for biodiversity: final report of Zonation

analyses") Suomen ympäristökeskuksen raportteja 9 | 2018. 99 s. https://helda.helsinki.fi/handle/10138/234359

- Do you know the conservation potential of your forest? Information document to forest owners. http://www.metsonpolku.fi/download/noname/%7B3B0F7A95-B3B5-42B9-A2E2-E565EA212952%7D/143682
- Additional information and links to GIS data: https://www.syke.fi/en-US/Research__Development/Ecosystem_services/Specialist_work/METSO_Programme/Zonation_supporting_METSO

More information. Expert Ninni Mikkonen (Finnish environment center SYKE, ninni.mikkonen@ymparisto.fi), Research Director Atte Moilanen (Univ. Helsinki, atte.moilanen@helsinki.fi), Senior Scientist Niko Leikola (Finnish environment center, niko.leikola@ymparisto.fi)

2.3 Zonation analyses in support of zoning in Southern Finland

Objectives and context. These analyses were done to support planning of zoning in the province of Uusimaa, Southern Finland, including the capital district. Three separate analyses were implemented: identification of regional biodiversity priority areas, identification of ecological networks, and evaluation of the expected ecological impacts of the 2050 zoning plan proposal. Biodiversity core areas were identified so that they can be secured in zoning. The remaining most important ecological networks were identified together with opportunities for habitat restoration around degraded bottlenecks of the networks.

Analysis area. The land area of the province of Uusimaa, 9 097 km^2, at a spatial resolution of 1 hectare. A buffer of 15 km to the neighboring provinces was included in some analyses, so as to account for connectivity via neighboring provinces. Marine areas were not included.

Analysis structure. A significant amount of biodiversity data was collated so that the Zonation analyses would be representative of biodiversity as a whole. Also the protected area network and impacts of present land use were accounted for. Relative weighting of species and habitats and scaling of ecological connectivity were decided in a panel of 20+ experts. An information card, which describes ecological values in detail, was produced for each area identified as important. The Zonation priority ranking and range size rarity maps were combined in a novel manner in the analysis of ecological networks. Also the corridor-building facility of Zonation was utilized. Zonation post-processing analyses were utilized

extensively to extract site-specific information about core biodiversity areas and expected effects of the new zoning plan.

Primary data. Dozens of layers of data about distributions of species, species groups, environments and geodiversity were collated for Uusimaa (Kuusterä et al. 2015). These layers were obtained from several sources in the environmental administration, regional NGOs, and research institutes (e.g., Parks and Wildlife Finland, the Finnish Environment Institute, the regional environment center, etc.). These data include both ground survey inventories and interpretations of satellite imagery (forest data, CORINE land use).

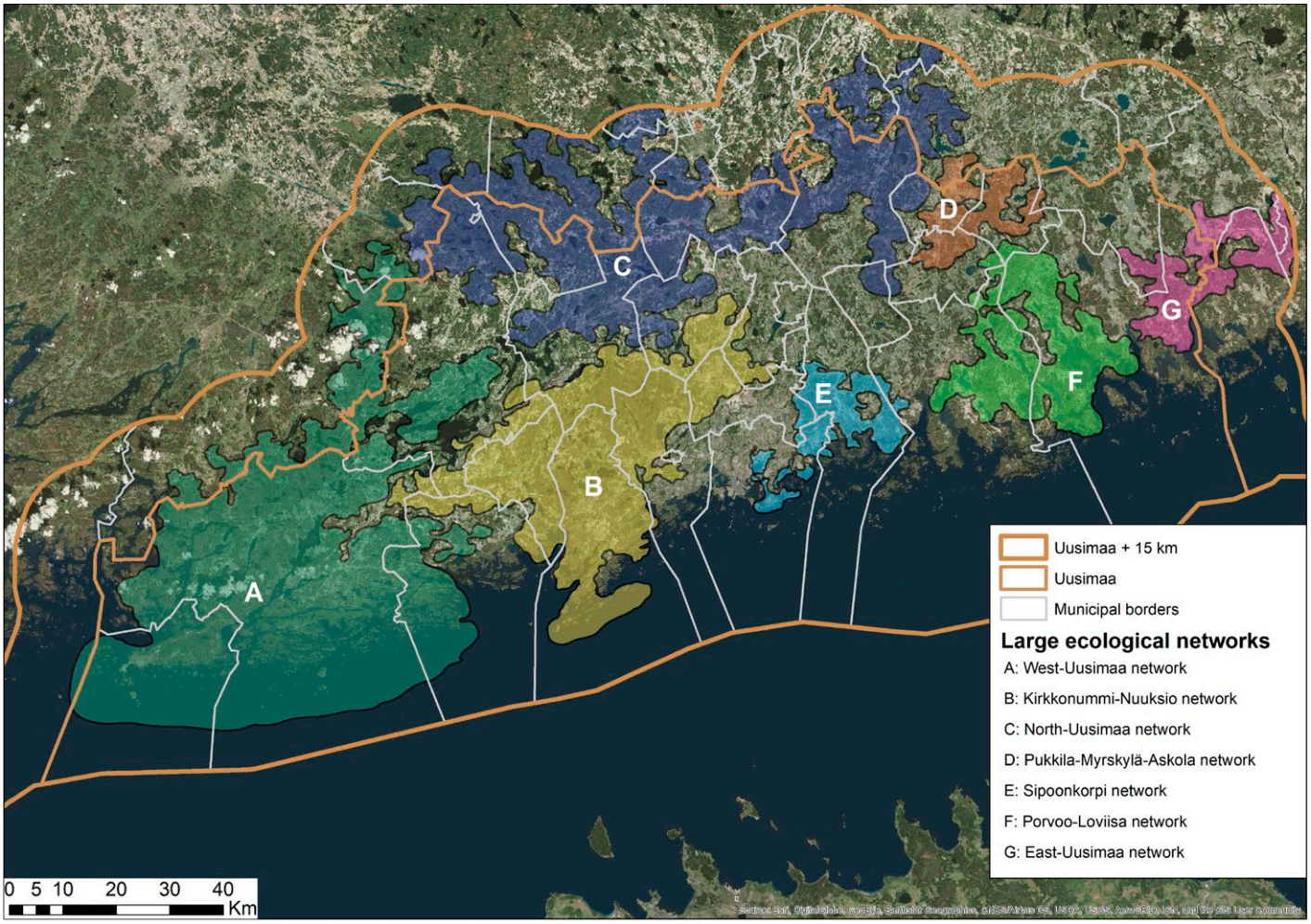

Figure 3. The large ecological networks of Uusimaa based on analyses of (Jalkanen et al. 2018). Strong human influence in the area has degraded connections between the networks (Jalkanen et al. 2018).

Zoning reports (all open access, but in Finnish)

- Kuusterä, J., Aalto, S., Moilanen, A., Toivonen, T., & Lehtomäki, J. 2015. Uudenmaan viherrakenteen analysointi Zonation-menetelmällä. Uudenmaan liiton julkaisuja E 145 – 2015. (Engl. ~"Analysis of the green infra of Uusimaa using Zonation")
- Faunatica Oy & Uudenmaan liitto 2016. Uudenmaan viherrakenteen analysointi Zonation-menetelmällä. Kohdekuvaukset. Uudenmaan liiton julkaisuja E 173. (Engl. " Analysis of the green infra of Uusimaa using Zonation: descriptions of priority areas")
- Jalkanen, J., Moilanen, A., & Toivonen, T. 2018a. Uudenmaan ekologiset verkostot Zonation-analyysien perusteella. Uudenmaan liiton julkaisuja E 194. (Engl. "The ecological networks of Uusimaa based on Zonation analyses")
- Jalkanen, J., Moilanen, A., & Toivonen, T. 2018b. Uusimaa-kaavan 2050 luontovaikutusten arviointi Zonation-analyyseihin perustuen. Uudenmaan liiton julkaisuja E 205. (Engl. ~"Evaluation of the expected ecological impacts of the Uusimaa 2050 zoning plan proposal")

More information. Research Director Atte Moilanen (University of Helsinki, atte.moilanen@helsinki.fi), Environment Expert Silja Aalto (Regional Council of Southern Finland, Uudenmaan liitto UML, silja.aalto@uudenmaanliitto.fi), Director of Zoning Ilona Mansikka (UML), Environmental Expert Lasse Rekola (UML, lasse.rekola@uudenmaanliitto.fi), Professor Tuuli Toivonen (University of Helsinki, tuuli.toivonen@helsinki.fi), PhD student Joel Jalkanen (Univ. Helsinki, joel.jalkanen@helsinki.fi)

2.4 Evaluation of the Finnish marine protected area network and identification of priority areas of underwater biodiversity

Objectives and context. The aim of this study, which was done 2017-2018, was to identify underwater biodiversity priority areas both inside and outside of marine protected areas. Additionally, the representativeness of the present marine protected area (MPA) network was evaluated, the ability of the EU Natura 2000 habitats to act as biodiversity surrogates was evaluated, and high-quality expansions for the MPA network were identified. This analysis is used in marine spatial planning to guide decisions about marine zoning and in the planning of conservation including restoration of marine habitats.

Analysis area. The Finnish exclusive economic zone, 81 500 km^2. Analysis resolution was 40 × 40 meters.

Analysis structure. The Zonation analysis was based on distributions of Natura 2000 habitats, distributions of endangered marine habitat types (following 2018 red list), distributions of rare and endangered species, key species, invasive species and a representative set of other species or species groups (~100 taxons). Species-level information was derived from the VELMU database of occurrences of marine species. Loss of habitat quality due to human pressures and natural causes (e.g. hypoxia, invasive species) was also accounted for. In prioritization 1) the top 1% of unprotected areas outside the present MPA network was identified, 2) priority areas of underwater biodiversity were identified irrespective of present level of protection, 3) top priority areas outside habitats directive habitats were identified, and 4) the condition of habitats directive habitats was evaluated. Item 4 assists both with the national reporting about habitats directive habitats and in the targeting of habitat restoration in marine areas. Zonation-technically, the present MPA network was accounted for via hierarchic analysis, the condition of habitats directive habitats was evaluated in post-processing, and top-priority MPA expansion areas were identified as those unprotected areas that receive highest priority ranks in Zonation analysis.

Primary data. Modelled species and habitat distributions based on 140.000 species point observations from VELMU. Analysis background variables, approximately 50 variables in a 20m grid across the Finnish marine areas. Data from the environmental administration about habitats directive habitats and protected areas (Nature 2000 habitats, private, national protected areas, important bird areas (IBAs), HELCOM MPAs, national parks.

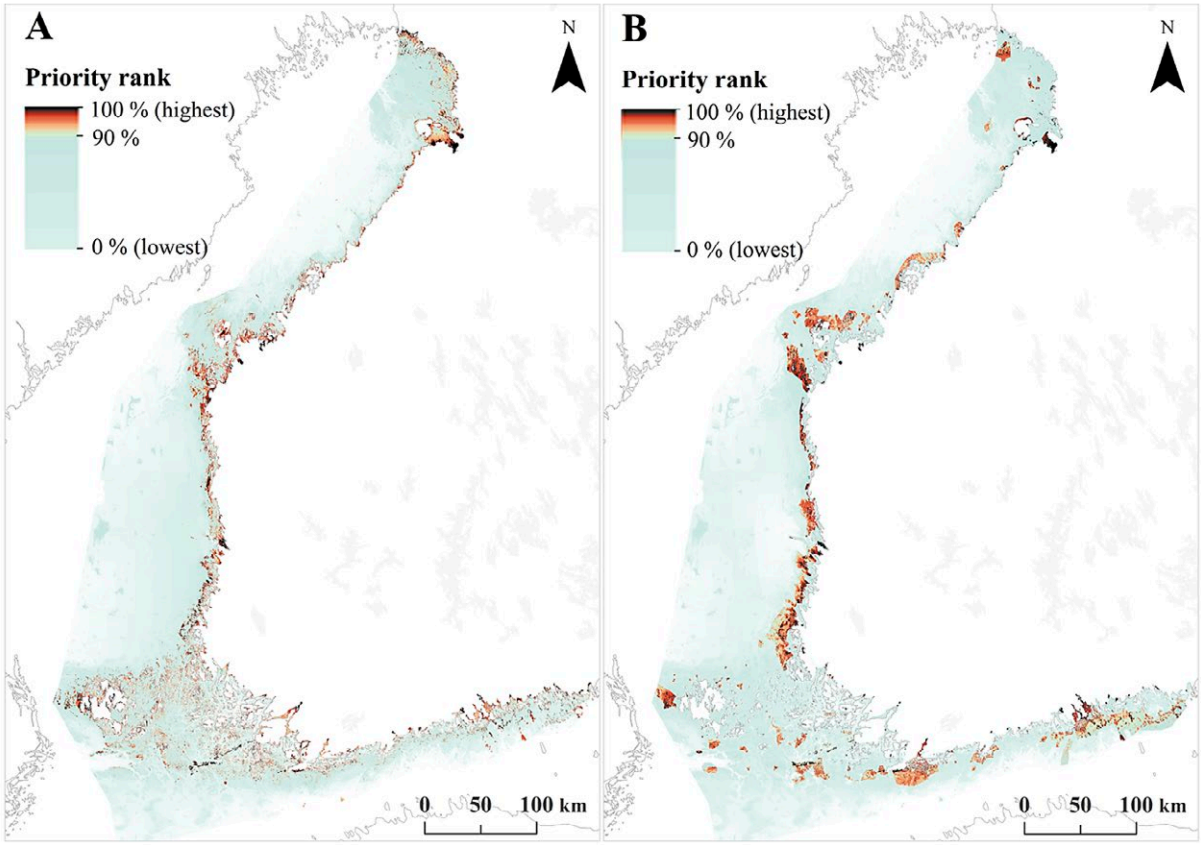

Figure 4. A) Priority areas of underwater biodiversity. B) Ideal expansion areas for the present protected area network. (Virtanen et al. 2018)

Reference

- Virtanen, E. A., Viitasalo, M., Lappalainen, J. & Moilanen, A. 2018. Evaluation, gap analysis, and potential expansion of the Finnish marine protected area network. Frontiers in Marine Science, 5: article 402. https://www.frontiersin.org/articles/10.3389/fmars.2018.00402/full

More information. Researcher Elina Virtanen (Sustainable Use of the Marine Areas, Marine Research Centre, Finnish Environment Institute ; elina.a.virtanen@ymparisto.fi), Research Professor Markku Viitasalo (same; markku.viitasalo@ymparisto.fi), and Research Director Atte Moilanen (Univ. Helsinki, atte.moilanen@helsinki.fi)

2.5 The effect of voluntariness on the ecological effectiveness and cost-efficiency of mire protection

Objectives and context. The aim of this study, which was done during 2017–2019, was to compare the ecological and economic consequences of voluntary vs. forced participation in mire conservation (forced meaning that landowners can be forced to assign their land to conservation purposes according to the Finnish Nature Conservation Act, but they are compensated for it). Results of the study have been communicated to the environmental administration and to politicians, with the aim of influencing decisions around mire conservation in Finland. A scientific publication about this study is in preparation.

Analysis area. Protected mires and candidates for new conservation areas identified in the Supplemental Mire Conservation Program (SMCP), which covers the whole of Finland except for the Åland Islands and Northern Lapland. The area of mires included in analyses was 929 000 hectares. Analysis resolution was 50x50 meters.

Description of analyses. This study investigated how peatland conservation would be impacted by effects of variable land owner willingness to participate in conservation efforts. How would the costs and effectiveness of the mire protection expansion program be influenced, depending on how land owner opinion is accounted for? Three scenarios were compared: 1) fully voluntary participation by landowners, 2) landowners' resistance to protection is noted but the mire may nevertheless be protected if it hosts highly valuable biodiversity, and 3) forced protection based on the Nature Conservation Act with no acknowledgment of the attitude of landowners. With respect to biodiversity values, data were included about mire habitat types; occurrences of species of plants, mosses, and birds; small waters; connectivity between other mires; and potentially lowered condition by existing drainage. Costs of conservation (including costs of land and tree stand plus administrative overheads) and landowners' resistance to protection were also included as continuous planning unit level variables. The first scenario (voluntary conservation) turned out expensive and ecologically ineffective. The third scenario (forced conservation) was inexpensive and ecologically effective, but encountered substantial resistance from landowners. The second scenario, in which resistance to protection was partially avoided, was able to find a favorable balance between conservation effectiveness, costs and resistance. In this scenario, ecological effectiveness was almost as high as with fully forced conservation, and costs were between voluntary and forced conservation, but the landowners' resistance to protection remained low.

The special characteristic of this Zonation analysis was the combination of three different types of data: biodiversity, costs and landowners' resistance to protection. Resistance was included as a continuous variable, which made it possible to analyze how the amount of resistance varies between scenarios jointly with the quality of conservation outcome

and costs. In other words, trade-offs between biodiversity, costs and resistance could be quantified.

Primary data. Large set of biodiversity inventories implemented for the SMCP (see above and Alanen and Aapala 2015), and a questionnaire sent to landowners by the Ministry of Environment in 2015 asking the willingness of landowners to participate voluntarily in SMCP. Field surveys were done on approximately 1 200 mires that covered 180 000 hectares. The questionnaire was sent to all provinces except Åland, Lapland, Kainuu and Northern Ostrobothnia, the response rate being 42%. Based on these replies, the degree of resistance to protection was extrapolated also for such candidate mires where information about resistance was not available.

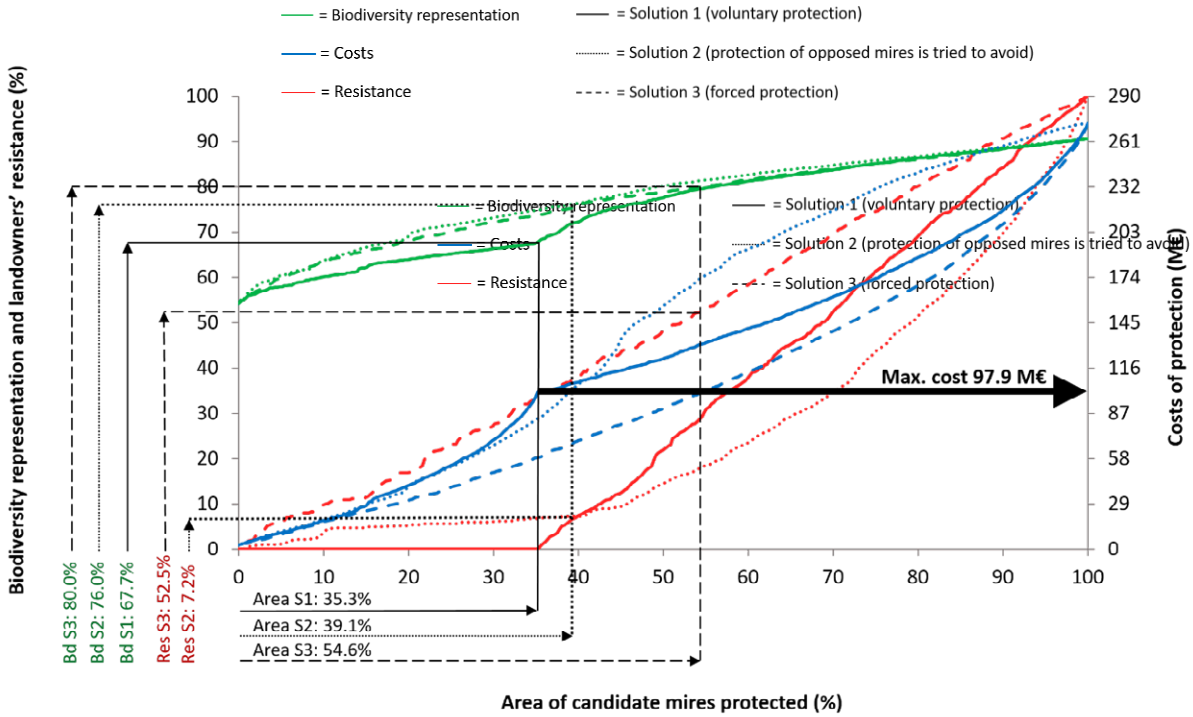

Figure 5. **Three-way interactions are not easy to interpret. Here 97.9 million euros, the costs of scenario 1 (voluntary protection), was set to define the maximum for protection in every scenario (black thick arrow). Two other scenarios are compared accordingly. Green lines represent protected biodiversity representation in each scenario, blue lines represent the amount of costs, and red lines represent the amount of landowners' resistance to protection of their land. Scenario 1 (voluntary protection) protects 35.3% of SMCP candidate mires' area and 67.7% of biodiversity representation included to the analysis, resistance being 0% (thin lines). With same price, scenario 2 (which tries to avoid protection of opposed mires) protects 39.1% of candidate mires' area and 76.0% of biodiversity representation, but 7.2% of landowners opposes protection of their land (thin dotted lines). Respectively, scenario 3 (forced protection) protects 54.6% of candidate mires' area and 80.0% of biodiversity representation, but already 52.5% of landowners opposes protection (thin dash lines). The analysis included both existing protected mires and candidate mires for protection, but just area of candidate mires is shown. Therefore, curves for biodiversity representation do not start from 0%, but from 53.7%.**

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More information. Researcher Eini Nieminen (University of Jyväskylä, School of Resource Wisdom, eini.m.nieminen@jyu.fi) and Prioritization Specialist Santtu Kareksela (Parks & Wildlife Finland, santtu.kareksela@metsa.fi).

2.6 Biodiversity offsets

Objectives and context. This work is of different nature than the other examples included in this report: the question is about conceptual and methodological development instead of an on-the-ground application of ecological decision analysis. Biodiversity offsetting (ecological compensation) is about use of protection or restoration measures to compensate for damage to biodiversity caused by, e.g., construction activity. One central concept of offsetting is no net loss (NNL), which means that all damage must be fully compensated for via improvements in the ecological quality of the environment elsewhere.

Adoption of offsetting is presently under active discussion in Finland, but clear operational guidelines about the planning of offsets are missing (both in Finland and internationally). As response to this demand, this study was able to partition the planning of offsets into 15 operationally significant decisions. These guidelines serve both the Finnish environmental administration and the international scientific community. Implementation of offsets is presently discussed in many countries. Even so, international experiences about offsetting are poor, and failure of planning or implementation has been commonly observed to lead to ecological net loss.

About the implementation of offsets. Significant information is needed for competent planning of offsets. First, the nature of the impact area must be surveyed so that the damage can be quantified. Second, it must be estimated how much ecological improvement can be expected from the protection and restoration actions done as offsets. In other words, what is the net effect of compensation actions? This assessment

is complicated by difficulties in the measurement of biodiversity, uncertainties about consequences of offset action, time delays and shifts in human pressures due to land use restrictions. The figure below summarizes fifteen significant decisions in the planning of biodiversity offsets, which impact the credibility, options, feasibility, area multipliers and costs of offsetting,

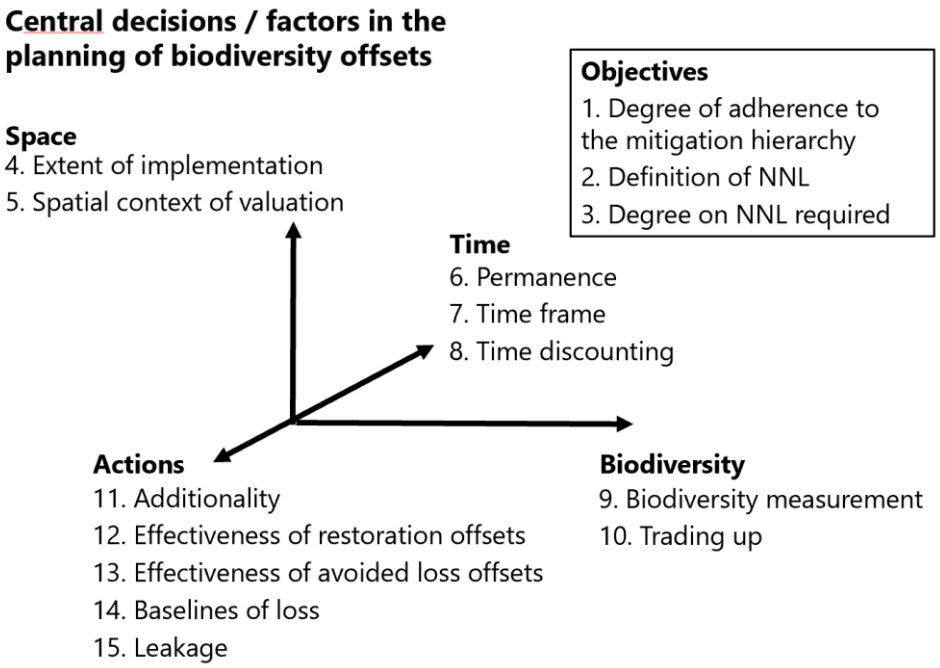

Figure 6. The fifteen important questions of biodiversity offsets (Moilanen and Kotiaho 2018b).

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More information. Research Director Atte Moilanen (atte.moilanen@helsinki.fi) and Professor Janne Kotiaho (janne.kotiaho@jyu.fi).

2.7 International collaborations

Objectives and context. Normal international benchmarking, development, research collaboration, and researcher training are part of MetZo. The aim is to improve the quality of work, disseminate information about it and to train researchers in ecological decision analysis. There are operations both in Europe and globally.

Ecologically based land use planning. Applications of Zonation are implemented across the world. For example, all provinces of New Zealand will soon have used Zonation to develop ecologically based land use plans. Below, recent citations are given to applications of spatial prioritization in the EU (Kukkala et al. 2016), Uruguay (Di Mininn et al. 2016) and Japan (Lehtomäki et al. 2019). At the end of 2018, a collaboration was started between Moilanen and Swiss parties wishing to implement spatial prioritization. A BioDiversa project, FutureWeb (2019-2021), concerns species, climate change, food webs, ecosystem services and land use change in Europe.

Activities in Europe. MetZo with the lead of Parks and Wildlife Finland has participated in EU activities. Santtu Kareksela (PWF) coordinates Natura 2000 biogeographic process collaboration in the boreal zone (Finland, Estonia, Sweden, Latvia, Lithuania), with the aim of identifying joint priorities across the northern areas of EU. Methods developed for this purpose by Kareksela and Moilanen include analyses for prioritization of management and restoration of Natura 2000 areas. These analyses have been presented in several conferences, the meetings of the Natura 2000 BG process in Lithuania and Finland, and to the representatives of the European Commission both in an EU-Finland bilateral meeting and the meetings of the Priority Action Framework. MetZo was one of the organizers of the meeting of EUROSITE and the Natura 2000 BG process in the Nuuksio national park about ecological compensation. Prioritization methods developed in Finland have generated broader interest by the European Commission and use of the analyses in EU is being advanced e.g. via the Natura 2000 BG process. For example, collaborations are on their way with the Estonians and also Sweden and Latvia have expressed interest.

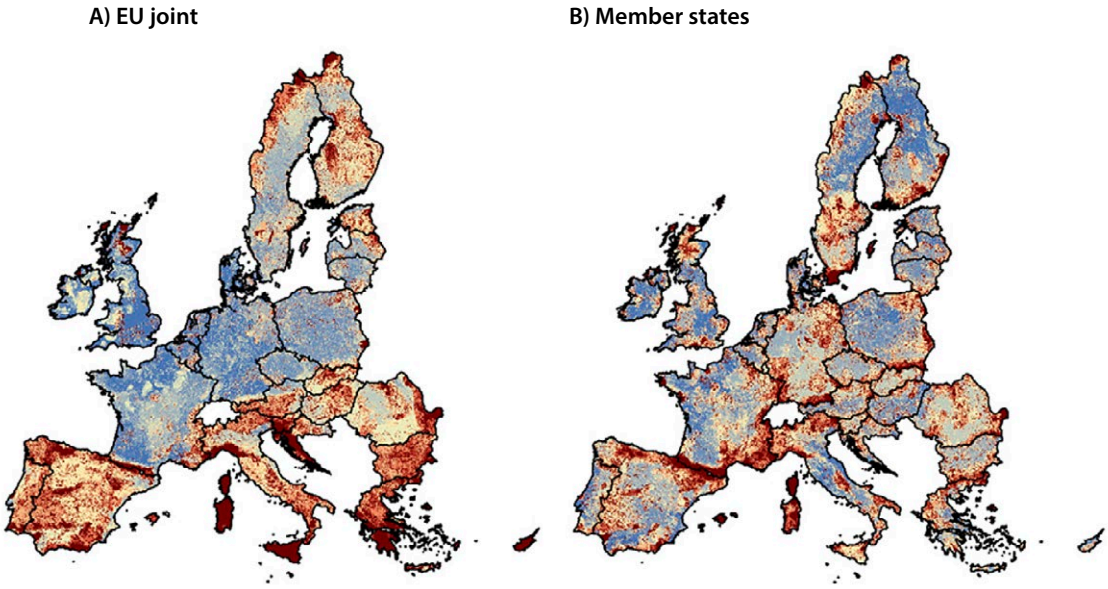

Figure 7. EU conservation priority areas (A) across EU and (B) in each member country when only considering species distributions in the country. The country-specific prioritization is inefficient and leads to artefacts at country borders. The whole-EU prioritization is area-efficient in covering biodiversity but uneven between countries (Kukkala et al. 2016)

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3 Collaborations with other projects

It has been the nature of MetZo that it has connections with many other projects, in which similar methods are utilized. Resources (money, people, time) available for ecologically based decision analysis are limited, which makes it important that data and methods are developed stepwise, according to the present need, building on past experience, and keeping future applications in mind. This chapter summarizes projects that have benefited from expert knowledge and data accumulated as part of MetZo and MetZo-II. These projects have in return developed new data and analyses that make future developments easier. Successful collaboration between many organizations and projects has been widely acknowledged as a strength of the MetZo projects.

3.1 NATNET LIFE+ (2012–2017)

NATNET was an EU-funded project, "Increasing the ecological connections and coherence of the Natura 2000 network in South-West Lapland", coordinated by the Lapland Centre for Economic Development, Transport and the Environment. Its aim was to increase ecological connections between and around protected Natura 2000 sites in the region of South-West Lapland. During the project, approximately 2 800 hectares of new private conservation areas were established. Habitat management and/or restoration were implemented in an area of over 1 100 hectares, primarily to improve biodiversity in managed production forests. In this project, ground operations were heavily guided by Zonation analyses.

NATNET was supported by EU LIFE+.

3.2 Multi-forest initiative (2016–2018)

Multi-forest (Fin., monimetsä) searched for and investigated methods of habitat management that are effective, follow regulations, but have been poorly adopted in

practice. Implementation bottlenecks were removed by developing and testing new ways of implementing forest management. Some of the methods identified were taken for ground implementation at the national scale. Multi-forest was a joint venture between Tapio Ltd (forest advisory and consulting) and the Finnish Forest Centre.

Multi-forest was supported by the Ministry of Agriculture and Forestry.

3.3 Digigameforest (2017–2019)

Digigameforest (Fin. Digiriistametsä) evaluates the suitability of forest areas to support viable populations of grouse, based on GIS data from the Finnish Forest Centre and Zonation analysis. The aim of the project is to identify forested environments suitable for various species of grouse (incl. grouse, capercaillie, etc.) and to take this information into the forest owner's online service, metsaan.fi. Digigameforest is a joint initiative between the Finnish Forest Centre and the Finnish Wildlife Agency.

Digigameforest is supported by the Ministry of Agriculture and Forestry.

3.4 SUMI: Protected area network in a changing climate (2016–2019)

The aim of SUMI was to analyze the performance of the present protected area network when pressured by climate change and land use change. New information was obtained about the sensitivity of species and habitat types to climate change and about the expected ability of protected areas to maintain populations of endangered and protected species and habitats. SUMI utilized results from the Finnish forest biodiversity Zonation analyses (Section 2.2) and results from SUMI will feed back into future Zonation analyses.

This project is supported by the Ministry of the Environment.

3.5 VeriZona: Verification of forest Zonation analyses in Uusimaa (2017–2019)

VerZona is about the verification of the national forest biodiversity Zonation analyses (Section 2.2) in the Uusimaa province, where high-quality on-the-ground sampling

of forest specialist species is available. Ground data is compared to Zonation priority rank maps and the performance of Zonation analysis variants is analyzed. There is a special focus on the endangered species of spruce-dominant forests. This project is a collaboration between the Finnish Environment Institute and the Natural Resources Institute Finland.

VeriZona is supported by the Kone Foundation.

3.6 SmartSea: marine spatial planning in Finland (2015–2020)

SmartSea is a large Strategic Council project, which seeks improved information basis and alternatives for the utilization and future of the Finnish marine areas and the Bay of Bothnia in particular. Part of this project is conflict resolution between biodiversity conservation and economic utilization of marine waters. Zonation analyses about marine conservation priority areas have been implemented as part of SmartSea. These analyses base on the massive species sampling implemented by the Finnish underwater biodiversity sampling project, VELMU. VELMU has taken over 150 000 standardized biodiversity samples, based on which statistical distribution models for species and habitats have been fitted. A major analysis and proposal for the development of the marine protected area network has already been completed (Section 2.4) and forthcoming analyses include one that identifies areas ecologically, economically and societally suitable for the establishment of marine wind power parks. Zonation-based marine spatial planning done as part of SmartSea is world-leading in quality.

This project is supported by the Strategic Research Council that operates in association with the Academy of Finland.

3.7 IBC-Carbon – Integrated Biodiversity Conservation and Carbon Sequestration in the Changing Environment (2018–2023)

IBC-Carbon investigates forest biodiversity and carbon using, e.g., forestry data, remote sensing and biodiversity modelling. Forest growth, effects of forest management, climate change, and carbon sequestration are linked with investigation of forest biodiversity. IBC-Carbon supports MetZo, because IBC-Carbon utilizes data and analyses developed in MetZo, and because data and analyses developed in IBC-Carbon will help improve

analyses done in MetZo. Another topic investigated by IBC-Carbon is biodiversity offsets, methods for which have already been developed by MetZo-II (Section 2.6).

This project is supported by the Strategic Research Council that operates in association with the Academy of Finland.

3.8 Better utilization of national species data (2019–2022)

This initiative lead by the Finnish Natural History Museum has received major funding for the second development phase of the Finnish Biodiversity Information Facility. Part of this large effort is improvement of the usability of nationally available species data, lead by Research Director Moilanen. Results of this project are intended to benefit both research and decision support, e.g. in zoning. Expected developments include species distribution modelling and integrated analysis products (e.g., Zonation) that process large amounts of species data into forms directly usable elsewhere, including in projects such as MetZo.

This effort is funded by the Academy of Finland and natural history museums and universities that are part of the consortium.

3.9 Utilization of peatland restoration monitoring data (2019–2022)

The Parks & Wildlife Ecosystem Monitoring Group is developing ways to improve the cost-effectiveness of peatland restoration based on information available from monitoring of previously restored peatlands. Also, due to increased expectations placed on peatland restoration, gaps are identified in the data needed for the targeting and design of restoration action. Information about expected consequences of climate change are being integrated in management recommendations as well (Section 3.4). The main responsibility in this project lies with Parks and Wildlife Finland, with participation from the Finnish Environment Center and the Finnish Meteorological Institute.

This project is supported by the Kone Foundation.

3.10 Next generation methods for ecologically based land use planning (2019–2023)

The Kone Foundation has awarded a significant funding (11 person years) for the development of next generation, ecologically based land use planning methods (the so-called Zonation 5 project). A significant novelty in these methods will be analysis and optimization of zoning to multiple alternative land uses.

This project was supported by the Kone Foundation.

3.11 BioDiversa EU-collaboration: climate change and food webs in Europe (2019–2021)

Research Director Atte Moilanen participates in the European BioDiversa/FutureWeb project, which is about climate change, its effects on species distributions, food webs and ecosystem services in Europe. This project may produce information about species and ecological communities across Europe, also relevant for Finland, both now and in the future.

FutureWeb is funded by the EU and the international BioDiversa network as well as the Academy of Finland.

4 Publications, training courses and presentations

4.1 Scientific publications

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4.3 Theses

Hohti, J. 2016. METSO-ohjelman laadun arviointi ja vapaaehtoisen luonnonsuojelun ekologiset vaikutukset suojelualue¬verkos¬toon. (Engl. ~"Evaluation of the quality of the Finnish voluntary forest conservation program, METSO.") MSc thesis, Univ. Jyväskylä, Dept. Biological and environmental sciences. 47 pp.

Hesso, J. Luonnon monimuotoisuuden ja ekosysteemipalveluiden väliset allokaatiokustannukset kaupunkien viherrakennesuunnittelussa. (Engl. ~"Costs of allocation to biodiversity vs ecosystem services in urban green infra. ") MSc thesis, Univ. Jyväskylä, Dept. Biological and environmental sciences. 50 pp.

Jalkanen, J. 2016: Pääkaupunkiseudun viherrakenteen arvotus Zonation-menetelmällä. (Engl. ~"Analysis of the green infrastructure of the capital district using Zonation") MSc thesis. Univ. Helsinki, Dept. BioSciences. 80 pp. + 27 pp appendix.

Kukkala, A. 2017: Spatial conservation planning for biodiversity and ecosystem services – from concepts and methods to policy agendas in the European Union. PhD thesis, Univ. Helsinki, Dept. Geosciences and geography, A49 / Helsinki 2017. 155 pp.

Roström, H. 2017. Metsäisten elinympäristöjen suojeluarvot – valtakunnallinen ja alueellinen vertailu. (Engl. ~"Conservation value in forests: comparison of regional vs national values.") MSc thesis, Univ. Turku, Dept. Geography and Geology. 53 pp.

Veach, V. 2017. Informing Conservation Decision Making: Macro-ecological Indexes and Threats in Global Spatial Conservation Prioritization. Licentiate thesis, University of Helsinki, Dept. Biosciences.

4.4 Training courses

A series of training courses about ecological decision analysis and Zonation has been run for national and regional authorities working with biodiversity conservation, forestry, or other forms of land use planning. All these events have been in Finnish. People with

substantial involvement in training activities include Ninni Mikkonen, Santtu Kareksela, Kaisa Raatikainen and Marja Hokkanen.

4.5 The most important presentations, etc.

While the majority of presentations have been in Finnish, this list only shows the ones given in English. Additionally, there have been dozens of presentations given to regional and national authorities, who work with conservation or other land use decisions.

Kareksela, S., Aapala, K., Alanen, A., Haapalehto, T., Kaakinen, E., Kämäri, I., Lahti, T., Lehtomäki, J., Leikola, N., Mikkonen, N., Moilanen, A., Salminen, Tuominen, S. & Virkkala, R. 2015. Conservation and Restoration in Decision-making Combining decision support tools and local expertise when targeting complementarity and individual hotspots. Poster in the European Conference on Ecological Restoration (SER). Manchester, UK.

Kareksela, S., Hokkanen, M., Päivinen, J., Lahtinen, A., Haapalehto, T., Raatikainen, K. M. & Koskela, K. 2018. Ranking Natura 2000 habitats and Natura 2000 areas for nature. Poster in the European Congress for Conservation Biology (ECCB), Jyväskylä, Finland.

Kareksela, S. 2018. Using the current prioritization analyses to determine and identify cost-effective resource allocation within the N2000 network and for the surrounding green infrastructure. EU-Finland Priority Action Framework -workshop. The Ministry of the Environment, Helsinki, Finland.

Kareksela, S. 2018. Prioritizing conservation areas and measures using Zonation Identifying cost-effective improvement and irreplaceability within a protected area network. Invited speaker. Finland-Estonia working group for nature conservation -meeting. Tikkurila, Vantaa, Finland.

Kareksela, S. 2018. Prioritization of conservation areas Spatial prioritization approach to identify irreplaceability and cost-effective improvement opportunities in a protected area network. The Arctic Biodiversity Congress (CAFF/the Arctic Council).

Kareksela, S. 2018. Current prioritization approaches – how well can we identify different priorities and the related challenges. The Arctic Biodiversity Congress (CAFF/the Arctic Council).

Kareksela, S. 2018. Prioritization of conservation areas - Identifying cost-effective improvement and irreplaceability within a protected area network. EU-Finland bilateral meeting. Nuuksio, Espoo, Finland.

Kareksela, S. 2016. Where to improve - Ranking protected Natura 2000 areas in Finland. Mötesplats skyddad natur -seminar, Stockholm, Sweden.

Kareksela, S. 2016. Restoration prioritization for Finnish Natura 2000 areas using the Zonation analysis. Natura 2000 Biogeographic Process Boreal Region -meeting, Vilnus, Lithuania.

Kareksela, S. & Kuusela, S., 2018. Integrated solutions for increased planetary wellbeing by restoring degraded habitats. Presentation in the European Congress for Conservation Biology (ECCB), Jyväskylä, Finland.

Mikkonen, N. 2018. Case Zonation and forest biodiversity. European Congress for Conservation Biology (ECCB), Jyväskylä, Finland.

Mikkonen, N., Leikola, N. Lahtinen, A., Lehtomäki, J., Haapalehto, T., Hokkanen, M., Lilja-Rothsten, S., Syrjänen, K. & Wallenius, T. 2018. Spatial conservation prioritization of Finnish forests for more sustainable land use planning. Poster in the European Congress for Conservation Biology (ECCB), Jyväskylä, Finland.

Mikkonen, N. & Moilanen, A. 2015. Identification and assessment of top priority areas for conservation management using Natura 2000 data. Poster and presentation in EUROCITE / Barcelona, Spain.

Moilanen, A. 2018. The twelve (or so) operationally important decisions in biodiversity offsetting. Plenary presentation in European Congress for Conservation Biology (ECCB), Jyväskylä, Finland.

Moilanen, A. 2018. Society for Conservation Biology awarded Moilanen a Distinguished Service Award "For extraordinary contributions to ecologically based, computational methods to support conservation solutions that successfully tradeoff biodiversity values, costs and alternative land uses and conservation resource allocation".

Moilanen, A. 2018. Ecological decisions – or not – in a declining World. Univ. Helsinki, Finland.

Moilanen, A. 2018. Ecologically based spatial prioritization to support land use planning. Univ. Geneven, Switzerland.

Moilanen, A. 2019. Biodiversity offsets: 15 factors. Univ. Münich, Germany.

Nieminen, E., Kotiaho, J. S., Kareksela, S. & Halme P. 2018. The potential biodiversity effects of voluntary peatland conservation in Finland: Poster in the European Congress for Conservation Biology (ECCB), Jyväskylä, Finland.

Appendix: about Zonation

A note about Zonation has been added to the English version of this report. Below is a quote from a recently published open access publication (Virtanen et al. 2018). Please see this paper for representative case study and further references, many of which are open access. Please see also Kujala et al. (2018b) for a description of the general structure of spatial conservation prioritization.

Straight quote from Virtanen et al. (2018): "Zonation is an approach and software for ecologically based spatial prioritization, for the purposes of conservation planning, zoning, spatial impact avoidance, and other similar applications (Moilanen et al., 2005; Lehtomaki and Moilanen, 2013; Di Minin et al., 2014). It is capable of high-resolution, large extent, ecologically informed planning, with up to tens of thousands of layers of biodiversity distribution information used in analysis (Kremen et al., 2008; Pouzols et al., 2014). In addition to distribution information for biodiversity features, Zonation can account for factors such as connectivity, ecosystem services, costs, threats, etc., of course conditional on the availability of appropriate input data layers (Kareksela et al., 2013, 2018; Di Minin et al., 2017).".

The MetZo II -project has applied ecological decision analysis to support societal decisions about nature conservation and land use. Spatial prioritization analyses implemented within the project using the Zonation approach have been utilized, e.g., in the South Finland Forest Biodiversity Program (METSO), in the targeting of habitat restoration for Natura 2000 areas, and in land use zoning. Additionally, design principles have been developed for biodiversity offsets, which are currently under active consideration in Finland. Background work by MetZo II has created opportunities for other projects targeting to protect biodiversity.

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