[NTNU_IBI] [Case number 1]

Institution: Norwegian University of Science and Technology (NTNU)
Administrative unit: Department of Biology (IBI)
Title of case study: **Quantitative criteria for assessment of environmental risks to biological diversity**
Period when the underpinning research was undertaken: 2011-2021
Period when staff involved in the underpinning research were employed by the submitting institution: 2011-2021
Period when the impact occurred: 2011-2021

1. Summary of the impact (indicative maximum 100 words) An outcome of the research in the unit has been the development of quantitative methods for analysing dynamical processes in nature. These approaches have been included in development of criteria for risk assessment of alien species in Norway operated by Norwegian Biodiversity Information Centre. These criteria have been used to develop different levels of blacklisting of species, which can serve as objective tools for prioritizing funds for management actions. Such a list of black-listed species is now regularly produced every 5- 6 years based on evaluation by several expert panels. Our models have also been used to develop strategies for reducing the impact of Chronic Wasting Disease on the wild reindeer population at Hardangervidda. CBD has also been involved by the Norwegian Environment Agency to develop criteria for assessing the vulnerability of environmental changes on ecosystems.
2. Underpinning research (indicative maximum 500 words) A central aim of the research of the unit has been the development of a theoretical framework for analysing ecological and genetical dynamics in natural populations. A characteristics of these models is the focus of on stochastic processes, which facilitate risk analyses. These models have been developed during 2011-2021 by Steinar Engen, Russell Lande and Bernt-Erik Sæther. During the period 2011-2013 this approach was used to develop a quantitative risk classification system of alien species in Norway. This system was based on two dimensions: categories for the risk for colonization and establishment of new species along one axis and an assessment of the potential ecological and genetical impact of the species on Norwegian ecosystems on the other axis. The practical implementation of this system was done during 2012-2014 by researcher Hanno Sandvik and Bernt-Erik Sæther and is summarized in Sandvik , H., B. E. Saether, T. Holmern, J. Tufto, S. Engen, and H. E. Roy. 2013. Biodiversity and Conservation **22**:37-62. Two national lists of black-listed species are now produced by expert panels using these criteria to assess different alien species. An important aspect of this approach is that it also enables assessment of which species to prioriterize for making management interventions, see Sandvik, H., et al. 2020. Ecological Solutions and Evidence 1 and Sandvik et al. 2019.. Biological Invasions **21**:2803-2810. Another application of the modelling framework developed at the unit has been developing proposal for harvsting the wild reindeer population at Hardangervidda to maintain genetic diversity but at the same time changing the structure and size of the population in a way that prevents further spread of the Chronic Wasting Disease to other Norwegian reindeer populations. Researcher Thomas Kvalnes and professor Bernt-Erik Sæther developed models for how different harvesting regime to reduce the prevalence of ChorniC Wasting Disease will affect the random genetic drift. These caculations strongly affected the choice of management strategies by the Norwegian authorities. These analyses were based on methods developed in Engen, S., B. -E. Sæther, T. Kvalnes, and H. Jensen. 2012. Journal

of Evolutionary Biology **25**:1487-1499 and were published in Flagstad, Ø., Kvalnes, T., Røed, K. H. Våge, J., Strand O., & Sæther B.-E. 2022. NINA Rapport 2176.
An important challenge in the management of biological diversity is that the number of species in area is diffucult to asses because of low detection proababilities. Based on community models using lognormal species abundance distribution (Sæther and Engen 2013 Journal of Animal Ecology (2013) , professor Sæther proprosed to Norwegian Environment Agency a new set of rules to evaluate the impact of environmental changes on species diversity (see CBD Reports) and through provide quantitive criteria for assessing the vulerability of ecosystem to global changes.

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3. References to the research (indicative maximum of six references)

Engen, S., Saether, B.E., Kvalnes, T. & Jensen, H. Estimating fluctuating selection in age-structured populations (2012). *Journal of Evolutionary Biology,* **25,** 1487-1499. https://doi.org/10.1111/j.1420-9101.2012.02530.x

Flagstad, Ø., Kvalnes, T., Røed, K.H., Våge, J., Strand, O. & Sæther, B.-E. Genetisk levedyktig villreinbestand på Hardangervidda (2022). *NINA Rapport,* **2176**.

Sandvik, H., Hilmo, O., Finstad, A.G., Hegre, H., Moen, T.L., Rafoss, T.,..., Gederaas, L. Generic ecological impact assessment of alien species (GEIAA): the third generation of assessments in Norway. (2019) *Biological Invasions,* **21,** 2803-2810. https://doi.org/10.1007/s10530-019-02033-6

Sandvik, H., Hilmo, O., Henriksen, S., Elven, R., Asen, P.A., Hegre, H.,..., Gederaas, L. Alien species in Norway: Results from quantitative ecological impact assessments (2020). *Ecological Solutions and Evidence,* **1**. https://doi.org/10.1002/2688-8319.12006

Sandvik, H., Saether, B.E., Holmern, T., Tufto, J., Engen, S. & Roy, H.E. Generic ecological impact assessments of alien species in Norway: a semi-quantitative set of criteria (2013). *Biodiversity and Conservation,* **22,** 37-62. https://doi.org/10.1007/s10531-012-0394-z

Sæther, B.-E. Prediksjonsmodellering av arter og samfunn i forvaltning av biologisk mangfold: utfordringer og muligheter (2021). *CBD Report*, pp. 1-84.

Sæther, B.-E., Engen, S. & Grøtan, V. Species diversity and community similarity in fluctuating environments: parametric approaches using species abundance distributions (2013). *Journal of Animal Ecology,* **82,** 721-738.

Sæther, B.-E., Herfindal, I., Solbu, E.B. & Norberg, A. Prediksjonsmodellering av samfunn i et endret miljø: praktiske eksemple (2022)r. *CBD Report*. Trondheim.

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4. Details of the impact (indicative maximum 750 words)

Quantitative approaches have a long tradition in the management of vulnerable and threatened, for which Red Lists strongly influence management practices of vulnerable species all over the world. The risk categories involved in the classification of species are often based on different levels of the probability of extinction within a given period. For alien species no such quantitative scheme for classification was available even some of these alien species could have large economic and ecological impact in Norway. Beginning in 2011 we developed a new set of criteria which in principle were based on the reverse principle of those involved in risk classification of vulnerable species. Instead of extinction as overall measure, we proposed that the probability of establishment should form as the key classification parameter. We further indicated a set of characteristics as indicator of such an ability for a species to colonize and establish itself. In addition, we suggested that the potential for affecting important aspects of ecosystem structure and functioning also should form as an assessment criterium. This two-dimensional risk classification scheme provides a fundament for grouping different alien and

doorstep-species into different risk categories. This approach has been used two times by the Norwegian Bioinformation Center to assess by means of expert panels the risk categorization of different alien species in Norway. These lists of black-listed species have received huge public attention and resulted in several management actions to reduce the invasion of harmful alien species into Norway.

Wild reindeer is a species which Norway takes particular responsibility for ("ansvarsart). In one of the Norwegian populations Chroniic Wasting Disease was found, which led to a governmental decision to exterminate the whole population to prevent spread to other wild reindeer populations and semi-domesticated reindeer herds owned by the Sami people. Unfortunately, the disease was then recently found to be present in the largest reindeer population in Norway, located at Hardangervidda. In this area the reindeer hunt is of great cultural and economic importance, and extermination of the herd would be extremely controversial. CBD was involved, starting in 2021, on behalf of Norwegian central authorities to develop harvest strategies that reduce the rate of disease transmission while at same time reduces the impact on the rate of loss of genetical diversity. These analyses have probably influenced decisions made by Norwegian government of the choice of harvest practices of this population.

Norway is rapidly losing biological diversity, mainly due to loss and fragmentation of important habitat types. CBD has since 2020 been involved in developing for the Norwegian Environment Agency criteria for assessing the vulnerability of communities to environmental change. Furthermore, based on analyses of species distribution models researcher at CBD have evaluated how well remote sensing data can be used to predict the occurrence of rare and vulnerable bird species. Such information is crucial when imposing on restrictions on land use.

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5. Sources to corroborate the impact (indicative maximum of ten references)

Artsdatabanken 2018
https://www.artsdatabanken.no/Pages/239659/Risikokategorier_og_kriterier)

Grøtan, V. and Engen, S. poilog: Poisson lognormal and bivariate lognormal distribution. – R package ver. 0.4, http:// cran.r-project.org/web/packages/poilog/

Ims, RA, N.G.. Yoccoz, B.-E. Sæther and NC. Steinseth (2020) Naturovervåkningen i Norge må trappes kraftig opp. Aftenposten 20.3.2020

Ovaskainen, O. & Abrego, N. (2020) *Joint Species Distribution Modeling with Applications in R*.Cambridge: Cambridge University Press.

Salguero-Gómez, R. & Gamelon, M. (2021) *Demographic Methods across the Tree of Life*. Oxford: Oxford University Press.

Sæther, Bernt-Erik. (2021) Jul uten multekrem. NRK Ytring .29.12. 2021

Sæther, B.-E., Herfindal, I., Solbu, E.B. & Norberg, A. Prediksjonsmodellering av samfunn i et endret miljø: praktiske eksemple (2022)r. *CBD Report*. Trondheim.