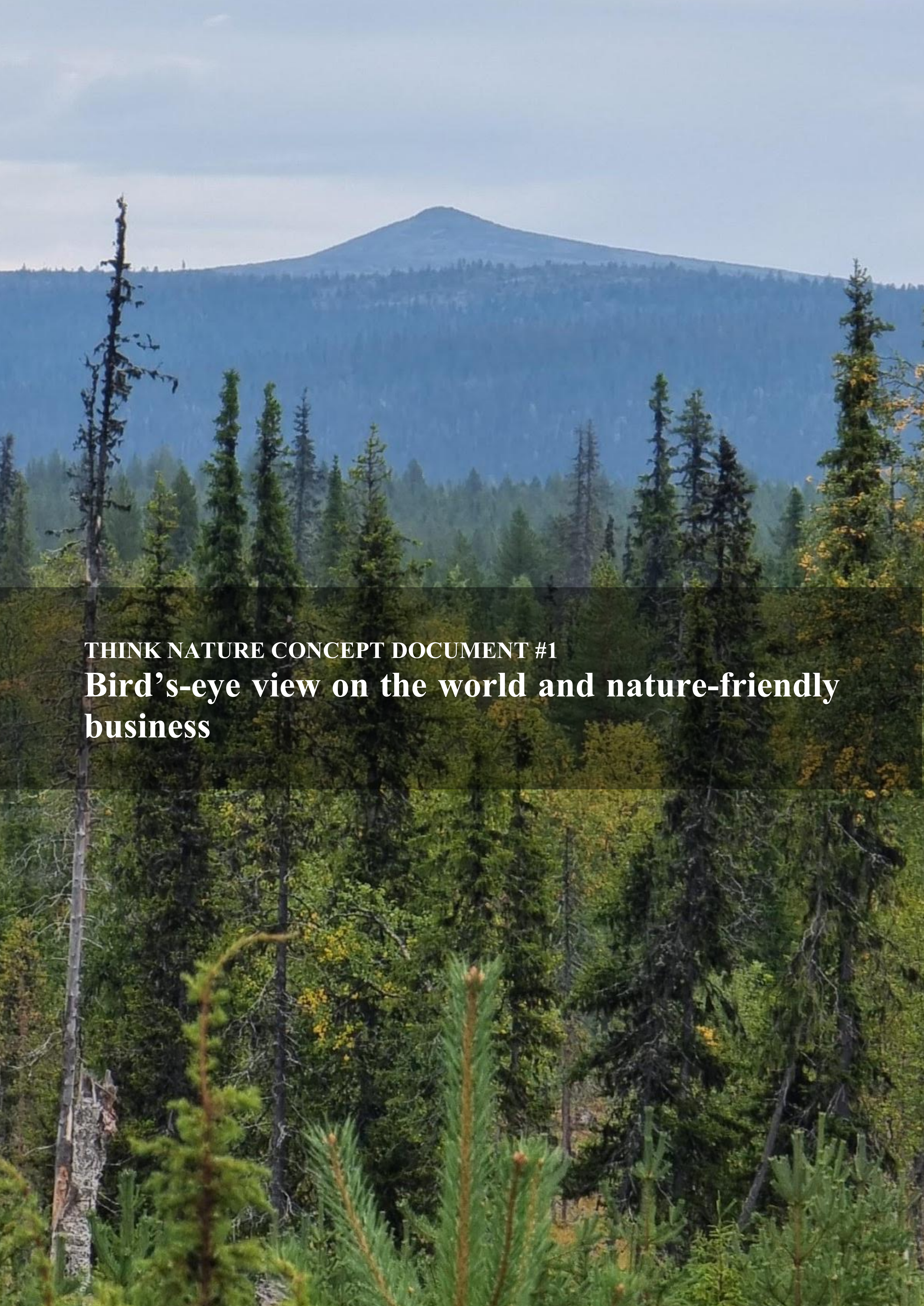

THINK NATURE CONCEPT DOCUMENT #1

Bird’s-eye view on the world and nature-friendly business

Bird's-eye view on the world and nature-friendly business

By Think Nature's science team

Executive summary. Business can interact with the natural world in many ways. Categories of interest include: (i) Operating permits may require analysis and reporting of natural values, possibly complemented with nature-friendly activity to reduce impacts. (ii) Spatial impact avoidance and possibly biodiversity offsets might be desirable for a new construction project. (iii) Environmental impact reduction across value chains might be desirable in procurement. (iv) Production of biodiversity credits might be of interest if a regional or national habitat bank is in operation. (v) Ecological risk assessments might be useful in agriculture, aquaculture, or forestry. (vi) The benefits of biodiversity and green space for recreation and health could be relevant in the design of housing. (vii) A business might adopt a reporting standard around biodiversity and ecosystem services. (viii) Investors and the public at large might be interested about the biodiversity impacts and sustainability of a business. (ix) Societal actors might be interested in spatial biodiversity analysis e.g. in the context of land-use zoning. All these and other tasks require analysis about biodiversity and its interaction with people,

Given the complexity of the natural world and its interaction with people, anticipating and answering such analysis needs is not trivial. This document introduces Think Nature's perspective on the mechanisms of interaction between people and nature (Fig. 1). Topics discussed include in more depth in separate documents include (#2) pressures and threats towards nature, (#3) classification and characteristics of nature-friendly actions used to counteract pressures, (#4) spatial planning and location optimization for spatial impact avoidance and the targeting of nature-friendly actions, (#5) the mitigation hierarchy, biodiversity offsets and biodiversity credits, (#6A) the fundamentals of ecosystems and spatial population biology and (#6B) ecological connectivity, (#7) biodiversity and ecosystem services, and biodiversity and carbon (#8). Other installments to the series might follow later.

This document is #1 in Think Nature's series of Concept Notes provided as a public service for those interested in understanding the interaction of people and biodiversity.

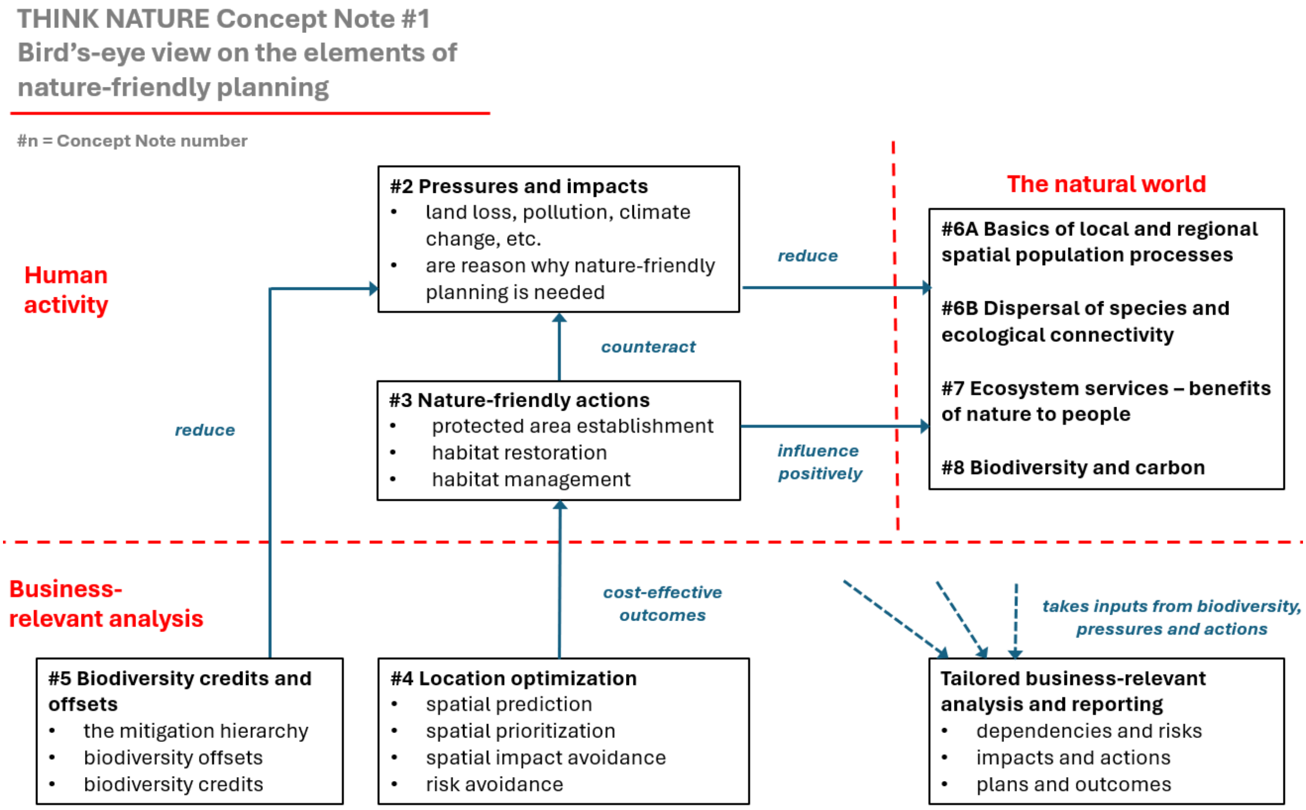

Figure 1. Main linkages between the natural world, human activities, and business. Individual topics are treated in more detail in subsequent documents, marked by a number #n.

1. Human activities and biodiversity

Pressures

Anthropogenic pressures and their impacts on nature are the reason for increasing public concern about the state of our natural world. Pressures, which arise from various human activities, are called by various terms, including threats, stressors, and drivers (Fig. 2). Potential impacts include both direct habitat loss and habitat deterioration from indirect effects that extend over a distance – these are due to noise, pollution, climate change, etc. Pressures may be reduced by *impact avoidance* and they can be counteracted by *nature-friendly actions* (Section 2).

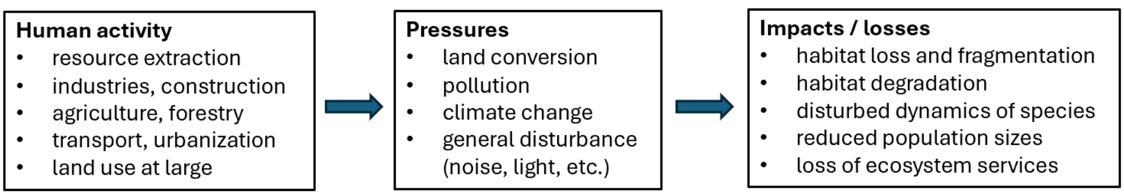

Figure 2. The chain from human activity to pressures to impacts on nature. These are discussed in more detail in TN's Concept Note #2.

There are some concepts around pressures that are useful to be aware of. Whether a pressure is *stoppable*, is important from an operational perspective. Stoppable pressures, such as land conversion, can be cancelled by local decision. *Unstoppable pressures*, such as climate change, cannot be cancelled by local action alone. Some pressures, such as illegal hunting, are *partially stoppable*.

Impacts arise from three components. First there is the *footprint*, the loss of habitat that is left under construction. Second there are *local indirect impacts* that extend outside the immediate area of loss. These are mediated by factors such as pollution, noise, artificial light at night, dust, and increased human presence, which some species may avoid. So-called *scope three external impacts* become distributed via *procurement pathways* and business *value chains*, to other businesses, possibly into other countries. Pressures and impacts are discussed in more detail in Think Nature's Concept Note #2. Competent spatial analysis and technical solutions can be used to reduce impacts from a project (Section 3).

Basics of biodiversity and underlying population processes

Biodiversity is an enormously large topic, as it encompasses all the diversity and complexity of biological life on earth. There are millions of species in the world. Japan alone hosts thousands of *endemic species*, which do not occur elsewhere in the world. There are hundreds of *major ecosystem types* and many thousands of *habitat types*, which all host an *ecological community*, assemblage of species and their interactions, typical to that ecosystem or habitat. Understanding the mechanistic base of spatial population biology helps understand the effects of pressures and nature-friendly actions on species (see Concept Note's #6A and #6B for more). Despite the complexity of detail, there are generalities that allow simplifying the complexity.

Each species requires certain *environmental conditions*, starting from temperature and rainfall, for survival. Additionally, it needs *resources*, the most important ones of which for animals are *food* and *nesting places*. Where a species is found is called its *distribution*. In addition to the climate and resources, the distribution is restricted via competition with other species. A defining fact is that a species will go regionally extinct if the density of resources in a landscape becomes too sparse, which can happen due to human-induced habitat loss and deterioration.

Habitat types are the easiest form of biodiversity that can be mapped. Figure (3) describes a fundamental relationship about how the area size and ecological condition of habitat influences the *carrying capacity* and *connectivity* for a species, and consequently population size and extinction risk as well. Carrying capacity is the number of individuals the region can potentially support and connectivity is related to how easy it is for organisms to move through the landscape.

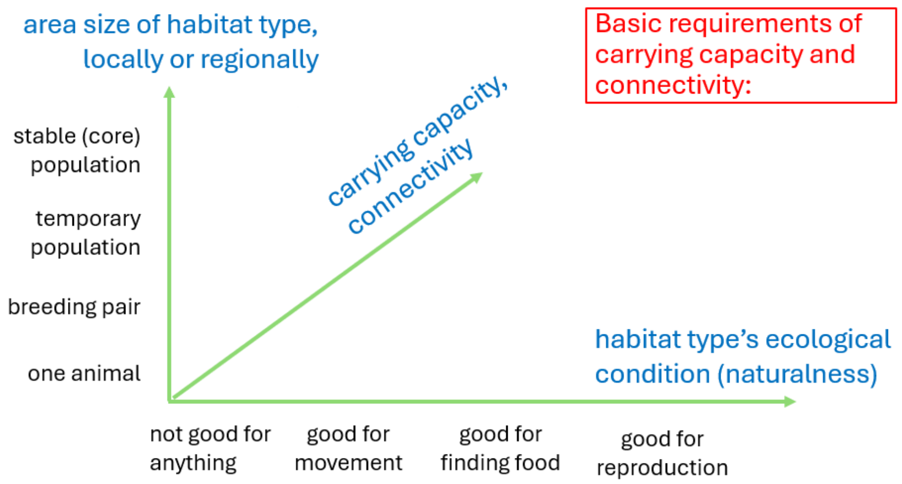

Figure 3. The simple relationship between habitat area size, ecological condition, and carrying capacity + connectivity. The bigger the area is, the more individuals it can support, because resources are larger. The higher the ecological condition, the better suited the area is for reproduction. This is why habitat loss,

deterioration and fragmentation are bad: areas become too small and too poor quality to support viable populations.

A population that inhabits a spatially distinct habitat patch can be called a *local population*. Familiar processes influence the dynamics (growth and decline) of a local population: *births*, *deaths*, *emigration*, and *immigration*. The movement (dispersal) of organisms and thus emigration and immigration are influenced in a species-specific manner by the structure of the landscape, including possible human-made movement barriers. While animals usually move actively, plants disperse passively e.g. via wind dispersal or seeds carried by animals. See Think Nature's Concept Document #6B for more about movement, dispersal and ecological connectivity.

The *scaling* of population processes is highly species-specific, and there are differences between higher taxons (plants, mammals, birds, insects, reptiles and amphibians, fish, etc.). For example, the home-range requirements of large-bodied mammals would be very large compared to most other species. Many insects and plants can have stable local populations in relatively small (sub-hectare) areas, whereas populations of large birds or mammals could require areas of hundreds of square kilometers to support a long-term viable population. With respect to movement, birds would obviously have a dispersal capacity that is higher than that of most other taxons. Many differences like these exist, but the details go beyond the scope of the present text.

Extinction risk is a phrase frequently used in the context of conservation biology. Extinction risk depends very much on both spatial scale (local, regional, national, continental, global) and time frame of interest. It is very difficult to estimate extinction risk numerically accurately. Regional extinction risk is highly influenced by regional *habitat density*, i.e., how dense or thin is the network of suitable habitat patches in a region.

Biodiversity, species, populations, ecological processes, connectivity, etc. are discussed in more detail in Think Nature's concept documents #6A and #6B (Fig. 1).

Ecosystem services

Ecosystem services mean benefits of nature to people (see TN's Concept Note #7). Main categories of ESS include *supporting services* and *regulating services*, which are primarily about the long-term maintenance of *ecosystem processes* and *function*. Examples of these include the nutrient cycle, water cycle, carbon sequestration and pollination. Provisioning services and cultural ESS are primarily about short-term human utilization. Provisioning services include such as food, energy, raw materials, and water. Cultural services include such as recreation, nature-based tourism, and ethical and spiritual values related to nature.

Ecosystem services are closely associated to biodiversity, because their *supply* (*provision*) arises from a well functioning ecosystem. Complicating the operational use of ecosystem services is their other component, which is the volatile *demand* generated by people. Demand is hard to predict. The meeting of ecosystem service provision and demand is often called *flow*. Ecosystem accounting is an activity recently undertaken by countries and organizations.

2. Understanding nature-friendly actions

The main types of nature-friendly actions (a.k.a. interventions) are the establishment of protected areas, habitat restoration, habitat management, and impact avoidance. These have the following main characteristics:

- *Protected area establishment* reduces pressures that impact the area, thereby leading to recovery of habitats and species populations. Protection helps avoid future losses in the area.
- *Habitat restoration* is applied to degraded habitat. Usually, some structural characteristic of the habitat is restored to a more natural state, which allows the recovery of the habitat towards a more natural state.

- *Habitat management* can be applied to a habitat that would be lost due to natural succession. As a common example, it can be applied to traditional agricultural habitats, which quickly become overgrown by shrub unless kept open e.g. by grazing or regular mowing.
- *Impact avoidance* concerns the minimization of ecological / environmental losses via methods of spatial design and technical solutions.

Some types of activities can include characteristics of multiple types of actions. For example, approaches like *regenerative agriculture* or *agroforestry* combine elements of impact avoidance and habitat management to maintain both agricultural production and the sustainability of the ecosystem at large.

The impacts of nature-friendly actions can be understood by examining what components of biodiversity they help and how. One can ask whether the activity only collects information (= *monitoring*) or if it results in *on-the-ground activity*. One can also ask whether the target of action is one species, a group of species or a habitat type at large. Furthermore, it can be examined which components of the spatial population dynamics of a species are influenced by the action. Figure (4) shows a top-level hierarchy of types of nature-friendly activity.

These topics are discussed in more detail in Think Nature's Concept Note #3 (Fig. 1).

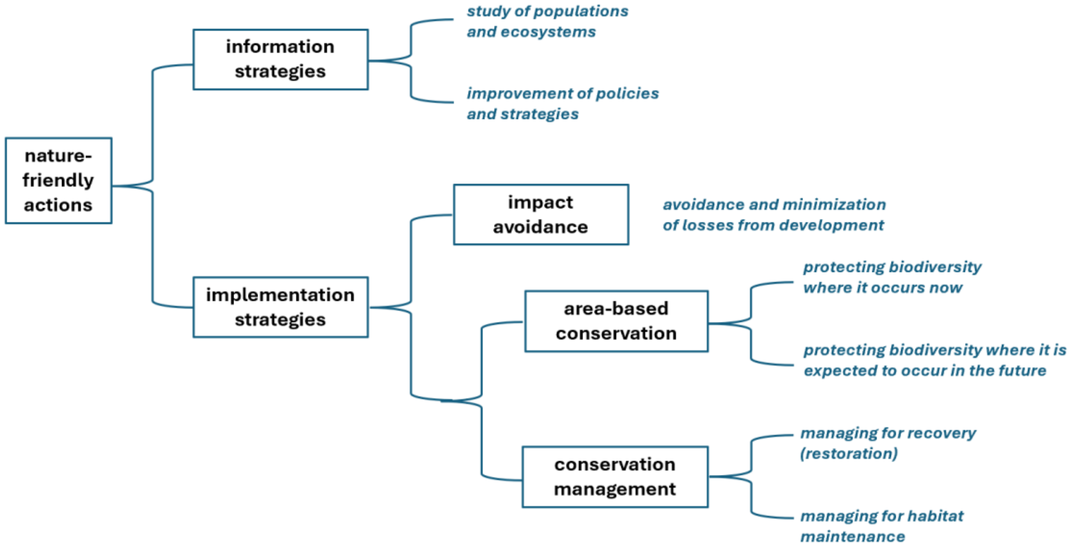

Figure 4. Top-level hierarchy of nature-friendly actions.

3. A note on data

Data is critical for success.

Competent biodiversity analysis requires good data combined with excellent methods. Nevertheless, utilization of large data sets can take major effort.

In some cases specialized data collection is desirable for a local project. If so, good pre-existing background data can help the specification of a statistically robust and cost-effective survey design. Analysis of background data can also help anticipate forthcoming data needs. For example, climate change can induce changes in biodiversity, which may have implications for industries that have dependencies on forestry, agriculture, or aquaculture.

There are many types of relevant data. Data is needed about the effects of actions: for example, different habitat restoration actions can have widely variable feasibility, costs, ecological response through time, and effectiveness. Spatial analysis is a specific case. It benefits from distribution data for many species, habitat types, and pressures, and possibly information about land ownership and cost. If the question is about spatial design for a development project, analysis resolution should be high – hectare or sub hectare – so that analysis corresponds to the typical resolution of land use decisions. This means that e.g. national-scale data sets become rather large in dimension, requiring powerful analysis methods and software, such as Zonation used by Think Nature (see Think Nature's Concept Note #4).

Common issues with data include lack of data for the species or habitats of interest. Data may also be low-quality, low-resolution, out of date, or its format may be impractical requiring much processing before use. Also, user rights might be unclear. While data availability has been improving, there is much about the natural world that we do not know.

Not all data collection is automatically good. If the need for new survey data is unclear, limited resources can sometimes be better spent in just doing more of the nature-friendly on-the-ground actions.

In response to data issues, Think Nature utilizes proprietary, custom-built data sets. For example, TN has statistically modelled species distribution estimates for 160 000 species globally and high-resolution models for thousands of species across Japan.

4. Business-relevant analysis types

Dependencies, Impacts, Risks, and Reporting

Dependencies on biological processes and associated risks can be important for businesses such as agriculture, aquaculture, and forestry. *Ecosystem processes* underlie *biological productivity* and *ecosystem services*. These may be harmed by pressures and impacts. From the perspective of a business, dependence on *natural capital* is a source of risk. Impacts, through reputation, may also become a risk to a company. Consequently, biodiversity forecasts and risk assessment may be important and valuable for a company dependent on natural resources. The context-dependent characteristics of each business need to be accounted for in risk assessment. *Optimal spatial design*, *spatial impact avoidance*, and *biodiversity offsets* – discussed below – can be used part as ecological *risk avoidance* and *mitigation*.

Biodiversity-related reporting is dependent on the availability of data. Field surveys may be conducted around a project site to understand the biodiversity there. Past aerial photos or satellite images may be utilized to understand what was in an area previously. *Statistical distribution models* may be used to understand the global, national, or regional distribution of a species now or in the future. Such analyses are relevant for disclosures under standards such as TNFD, CSRD, and EURD. Conducting reporting in line with the principles mentioned above ensures that communication with investors and the public remains honest.

Tailored analysis for individual species of interest

Generally one should be concerned about biodiversity as a whole, but sometimes there are questions around individual species of relevance. The many applied uses of single-species spatial modelling include those for adaptive population control and harvesting, risk analysis, predictions for invasive species and diseases, and predictions for endangered species of interest. Questions of relevance include the following: how might climate change influence the suitability of areas for crops? Where might an invasive species or pest become a concern? Where might a rare or endangered species occur? Please see Think Nature's Concept Notes #4, #6A and #6B for more information about statistical species distribution models and dynamic population models.

Location optimization and optimal spatial design

Many biodiversity-relevant decisions are spatial in nature and can be answered with techniques of spatial prioritization, as done by Think Nature. It is a way of doing ecologically well-informed land use planning: where to develop, where to not develop, where to allocate nature-friendly actions? Spatial prioritization can integrate high-resolution spatial data for many species, habitats, ecosystem services, threats, costs etc. The specific construction of analysis will depend on analysis goals and data available (See Think Nature's Concept Note #4 for more). For example, data demands and analysis structure are different between protected area design and allocation of habitat restoration.

An important feature of spatial prioritization is that it provides a relative regional perspective. If only local data and analysis is available, there is no understanding about the relative importance of the location at the regional or national scale.

Typical prioritization tasks include identification of high-priority biodiversity areas: these can for example be protected or habitat restoration might be targeted to their neighborhood. Optimal allocation of habitat restoration is a relatively difficult problem, which combines aspects of what would be best for biodiversity and local people in the future.

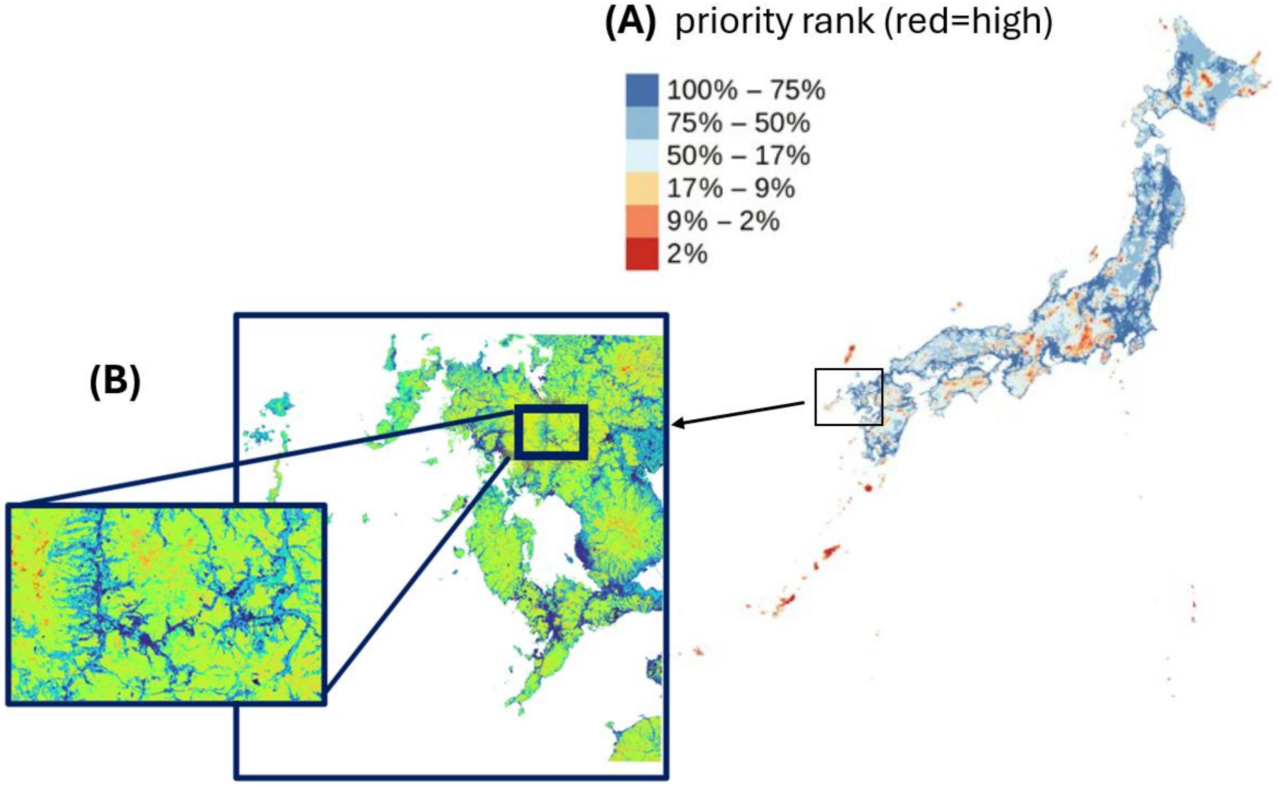

Figure 5. First balanced biodiversity priority rank map of Japan, calculated using modelled species distribution maps for 6325 species, from Lehtomäki J., Kusumoto B., et. al. (2017) in Diversity and Distributions – many present members of Think Nature were involved in this work. Panels (B) show regional enlargements of recent higher-resolution versions of the same analysis utilized by Think Nature. TN's *Concept Note #4* discusses location selection and spatial prioritization in more detail.

Avoidance and minimization of impacts

A concept called the *mitigation hierarchy* appears regularly in global policy documents and regulation. The basic version of the mitigation hierarchy states that ecological losses must be (i) avoided, (ii) minimized, (iii) restored locally, and (iv) offset elsewhere (TN's Concept Note #5). The first two steps include *spatial impact* *avoidance* in development as a critical component. It is desirable to avoid the proximity of locations with protected areas, areas with high species richness and rarity, ecologically high-condition areas of important habitats, and areas of generally high naturalness (wilderness areas). Spatial data collated by Think Nature supports spatial impact avoidance (TN's Concept Note #5).

Biodiversity offsetting can be applied in the context of construction and land use. It aims to replace lost ecological values by restoring and protecting similar values elsewhere. The goal of biodiversity offsetting is so-called *no net loss*, which means that net losses must be fully compensated by corresponding net gains. (The calculation of net gain is a somewhat involved task.) Also of interest is *net positive impact*, which can at simplest be achieved by doing more than what is needed for no net loss.

It turns out that both biodiversity offsets and *biodiversity credits* rely on the same fundamental piece of information: the effectiveness of the nature-friendly action through time, which can be summarized by a *response function*. A response function describes how ecological gains grow through time after the action has been done. The average of the response over a chosen time interval gives an estimate of the per-area-unit gains achieved by doing said action. Replacement of losses by gains is closely related to biodiversity credits: the same methods of producing gains can be used, the difference being that credits are stored for later use rather than used immediately. Think Nature's Concept Note #5 discusses impact avoidance, offsets, and biodiversity credits in more detail.

Irrespective of analysis type, it is important that nature-friendly actions are *cost-effective* in a world of limited budgets. While *reliability*, *feasibility* and *credibility* are the responsible starting point of nature-friendly design, also *costs* and *opportunity costs* should be accounted for when developing alternative action plans. Understanding the mechanism of action is the starting point for credibility. Experience and good data are the starting point for feasibility, reliability, and cost-effectiveness. Well-informed simplification can be key to successful planning in the face of high complexity.

To conclude, we summarize Think Nature's philosophy.

5. Think Nature's way

This white paper concept note has described high-level considerations that are at the core of nature-friendly planning. The purpose of this text is to facilitate understanding of biodiversity and ecology in business. Much more detailed overviews of individual topics are provided by Concept Notes #2 - #8, which also includes references to literature.

Think Nature holds a standard of honest, balanced, top-down planning of nature-friendly activity. Competent methods must make both ecological and mathematical sense, and it must be possible to link analyses to credible data. On-the-ground solutions should be cost-effective.

Importantly, intelligence provided by TN is not based on science alone, but also on the understanding of the limits of science. Many scientific studies are based on long-term, locally collected, highly detailed data and complicated analysis: such cannot be extrapolated elsewhere without enormous effort and expense.

Consequently, understanding methods, data, and well-informed simplification are key to success.

Think Nature strives to follow the Japanese principle of three sides of benefit:

Think Nature

Good for the environment,

good for the customer,

good for the company,

and good for the society.