Operationalization of a Functioning Ecological Infrastructure

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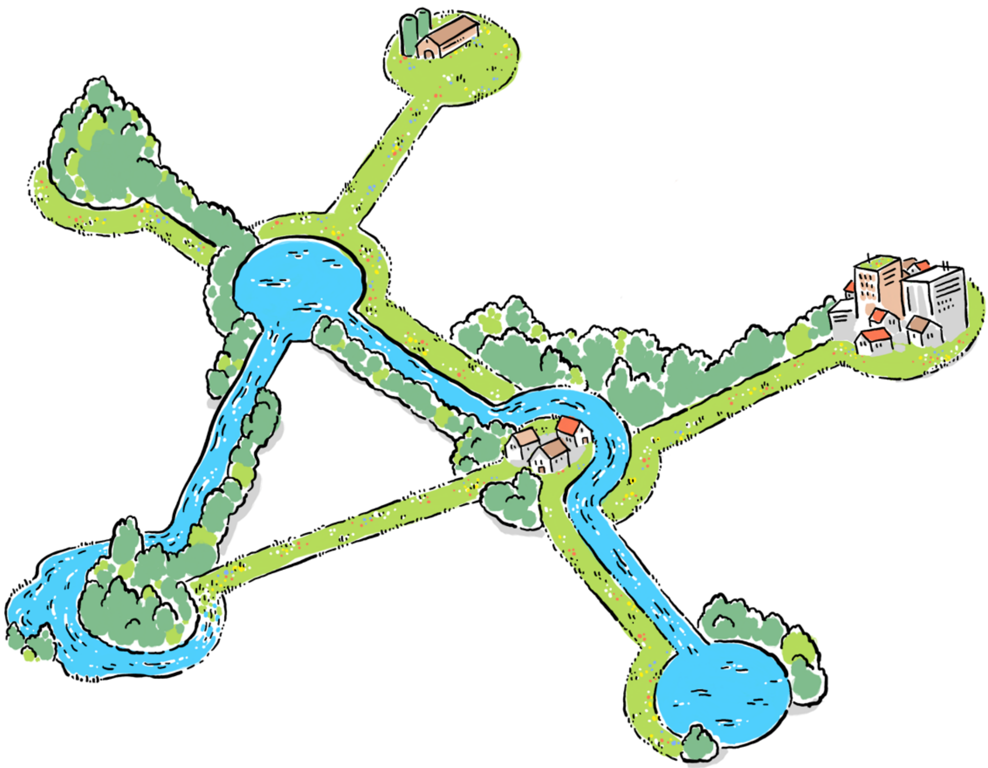

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Participation

The following people contributed to the working paper:

Adrienne Grêt-Regamey (ETHZ): lead author, drafting the first version, editing all versions.
Sven-Erik Rabe (ETHZ): draft of the first version, commenting on all versions.
Roger Keller (UZH): conceptualization of the first version, commenting/editing of all versions.
Marina Cracco (UNIL): conceptualization of the first version, commenting on all versions.
Jodok Guntern (FOEN Support Group, Biodiversity Forum): detailed commenting/editing of two versions.
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Abstract

Ecological infrastructure (EI) is essential for the conservation and promotion of biodiversity and provides vital services for humans. EI is based on natural and semi-natural habitats. The development and protection of EI have been identified as key steps for the success of the Swiss Biodiversity Strategy (SBS). Concepts such as "Green Infrastructure" or "Nature-based Solutions", which refer to EI, have become increasingly established in recent decades. However, their partly different perspectives make application in practice difficult.

This working paper is a literature-based overview and presents different approaches to the operationalization of a "functioning" EI. For the ValPar.CH project, this working paper is an important basis for arriving at a common understanding of the term within the project team. The research team will assess the functioning of an EI based on ecological aspects (Module A), as well as based on the societal and economic benefits of the EI (Module B) and its long-term safeguarding through different "policy" mechanisms (Module D). Based on this, the team will develop recommendations for ensuring a functioning EI.

Content

1 Ecological Infrastructure and related concepts

Terms such as "Green", "Blue", "Natural", "Ecological Infrastructure" and "Nature-based Solutions" are rather new, but the underlying concepts are old. They are rooted in the spatial planning and conservation efforts of the conservation movement, which began about 150 years ago. They are embedded in the context of habitat creation and restoration (Perrow and Davy, 2002) and ecological networks (Lindenmayer and Fischer, 2006). These concepts follow a paradigm shift in conservation, from a focus on protecting nature to Nature's Contributions to People (NCP; Diaz et al., 2018). Accordingly, they emphasize the shift in human roles from passive beneficiary to active protector, steward, and designer of nature and its habitats. By using the term "infrastructure", politicians, scientists and conservationists emphasize the economic importance of ecosystems. However, the use of the term "infrastructure" also aims to establish nature as a long-term service provider for society - analogous to technical infrastructure systems such as "transport", "communication", "water supply" or "waste water".

The term "**Ecological Infrastructure**" (EI) was first used in 1984 as part of a technical meeting of the Man and the Biosphere program on urban planning (UNESCO, 1984). At that time, the concept focused on ecological networks and conservation corridors for landscape-level protected area planning (Ahern, 1995). More recently, with the goal of emphasizing the importance of ecological networks in safeguarding ecosystem services, the concept has been expanded. This idea is reflected in the **FOEN definition** of EI (see Box 1), which is based on the requirements of the Strategic Plan of the Convention on Biological Diversity, the European Emerald Network of the Bern Convention, and the Ramsar Convention. It emphasizes the role of core and connected areas in supporting functional and regenerative habitats as the foundation for biodiversity and ecosystem services (BAFU, 2021). Similarly, the **IPBES definition** of EI emphasizes the importance of natural or semi-natural structural elements of ecosystems and landscapes (IPBES, 2020). However, it does not focus on safeguarding biodiversity, but rather on providing ecosystem services.

Box 1: **Definitions of "Ecological Infrastructure"**

FOEN definition: *"Ecological Infrastructure provides nature with a network of natural and semi-natural habitats of high quality and functionality. It consists of core and interconnected areas, which are distributed in space in sufficient quality, quantity and suitable arrangement, as well as interconnected with each other and with the valuable areas of the neighboring countries. This natural network takes into account the development and mobility requirements of species in their distribution areas, even under changing conditions such as climate change. Ecological Infrastructure secures habitats that are capable of functioning and regenerating over the long term. It complements the careful use of natural resources across the country, ensuring the basis for a rich biodiversity that is responsive to change. In this way, the Ecological Infrastructure, as "Switzerland's web of life", also makes a significant contribution to safeguarding the central services of nature for society and the economy"* (BAFU, 2021: 8).

IPBES definition: "*Ecological Infrastructure refers to the natural or semi-natural structural elements of ecosystems and landscapes that are important for the provision of ecosystem services"* (IPBES, 2020).

The concept of "**Green Infrastructure**" (GI), introduced by a commission of nongovernmental, practice-oriented and scientific organizations (Florida Greenway Commission) in the United States in 1994, goes a step further and proposes the planning of multifunctional green networks, especially in urban areas (Benedict and McMahon, 2006; Koc et al., 2017). It aims to protect ecosystem health and biodiversity, enhance ecosystem functioning, promote ecosystem services, societal well-being and health, and support the development of a green economy and sustainable land and water management (European Commission, 2012). While the concept is rooted in ecological network thinking, it focuses heavily on the societal benefits of ecosystem services (Box 2).

Box 2: **Definition of "Green Infrastructure"**

EU definition: "*Green Infrastructure can be broadly defined as a strategically planned network of high quality natural as well as semi-natural spaces with other environmental elements, designed and managed to ensure a wide range of ecosystem services and protect biodiversity in both rural and urban areas. More specifically, Green Infrastructure aims to enhance the capacity of nature to provide the wide range of valuable ecosystem goods and services such as clean air or clean water*" (European Commission, 2013).

The FOEN and IPBES definitions of EI are thus embedded in the broader European definition of GI used internationally. The latter includes diverse infrastructures of green spaces and structures that are planned and designed to support multiple ecosystem services (European Commission, 2013). In this respect, this definition emphasizes the role of GI in providing a wide range of ecosystem services and protecting biodiversity in both rural and urban areas. Figure 1 illustrates the positions of FOEN's definition of EI and the EU's definition of GI. The concepts partly overlap, with the concept of GI being complementary to that of EI. Both concepts emphasize the importance of functional and regenerative habitats as the basis for biodiversity and ecosystem services. However, GI focuses more on expected ecosystem services/NCP, while EI focuses more on natural and semi-natural habitats to protect and promote biodiversity as the basis for ecosystem service/NCP delivery.

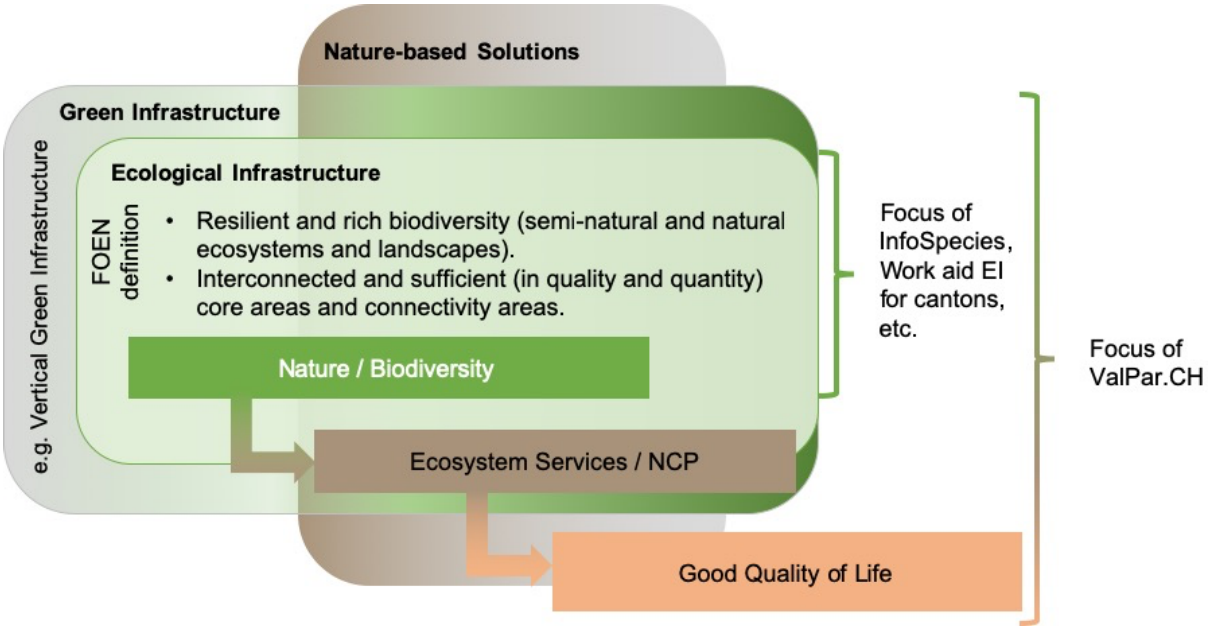

Figure 1: Concepts related to Ecological Infrastructure and examples of their relationships to Nature's Contribution to People (NCP). Gray: human-created habitats (Vertical Green Infrastructure represents, for example, green facades and other vertical greening); green: semi-natural and natural habitats. The square brackets indicate the focus of individual projects.

Both the concept of EI and GI contribute to Nature-based Solutions (NbS; Box 3), as proposed by the International Union for Conservation of Nature (IUCN) (Nature Editorial, 2017). NbS are grounded in the ecosystem approach, which views the conservation of biodiversity and human wellbeing as dependent on functioning and resilient natural ecosystems (CBD, 2004). However, the internationally recognized umbrella term of NbS is more explicit than the two infrastructure approaches in terms of social and economic ambitions and emphasizes the positive impacts of nature for society ("solutions"). It also emphasizes a wide range of activities - from planning to the green economy - that support human well-being and biodiversity (Cohen-Shacham et al., 2016 and 2019). While the EI concept explicitly commits to biodiversity conservation and protection, in NbS not every conservation action necessarily qualifies as a NbS. In general, NbS seem to focus on the management and provision of a variety of ecosystem services at an average human use intensity, rather than measures focused exclusively on biodiversity conservation. Compared to the concepts of "weak and strong sustainability"[1], NbS also support the substitutability of different forms of capital (weak sustainability) in line with Switzerland's "weak sustainability plus" position (SDC/FOSD, 2004). EI, on the other hand, presents natural capital as not fully substitutable (Nesshöver et al., 2017). NbS thus emphasize total benefits.

Box 3: **Nature-based Solutions**

Nature-based solutions are defined as measures to protect, sustainably manage, and restore natural or modified ecosystems that effectively and adaptively address societal challenges while benefiting human well-being and biodiversity (Cohen-Shacham et al., 2016).

2 Interim summary

While the terms and concepts of EI, GI, or NbS are open to different interpretations depending on the stakeholder group, they are robust enough to enable two-way communication (Garmendia et al., 2016). All three concepts provide a reliable bridge between scientists and practitioners. They foster the ability to translate knowledge into actions that lead to a more sustainable future (Childers et al., 2015; Pickett et al., 2016). The broader definitions of GI and NbS, which integrate both human-made and natural infrastructures, emphasize both the connection between nature and people and the potential for people to restore or create ecological networks. These broader concepts are sometimes accused of undermining the existential view through their anthropocentric, benefit-oriented perspectives (Pauleit et al., 2011). However, their advantage is that they crucially promote the co-development of sustainable solutions in designed and managed landscapes, helping them to become resilient landscapes (Childers et al., 2019).

3 Operationalization of a "functioning" EI

While "functioning" is an important concept in ecology, in terms of its operationalization it poses significant problems in practice (Jax, 2005). The semantics of the word are nuanced, ranging from a mechanistic understanding of a single process to the functioning of a complex system. Several authors have attempted to disentangle the word "functioning" by identifying the key determinants of a **functioning EI (**Angelstam et al., 2017). These include *structural elements* such as the quantity and arrangement of land use areas, which include (a) quality, (b) size, and (c) number of areas or their spatial configuration (e.g., Fahrig, 2001, 2002, 2003), but also *functional elements* that are assessed in terms of connectivity. Functional assessments describe, for example, the extent to which patches are interconnected and how the network of patches affects a particular species or ecosystem process (Saura et al., 2011). The determinants of a functioning EI also include *governance elements* such as the inclusion or participation of public, private, and civil sector actors at different levels (Elbakidze et al., 2018). When talking about a **functioning GI**, the concept of "functioning" of an ecological system is expanded to include the concept of "services" provided by the system to various species including humans. This extension makes it necessary to examine the interrelationships between the social and ecological systems, defining functioning for what and whom.

[1] Weak sustainability is a relatively "tolerant" demand for sustainability. It assumes, at least partially, the substitutability of different resources or capitals. In contrast to weak sustainability, the paradigm of strong sustainability calls for the value of natural capital to remain constant. It emphasizes the importance of an intact stock of natural capital.

4 "Functioning" EI in the ValPar.CH project

The research team will first assess the functionality of EI using plant and animal species models (Module A) by evaluating *structural* and *functional elements* as described above (McGill et al., 2010; Balvanera et al., 2014). However, achieving a functioning EI also requires that the various stakeholders perceive, understand, and are prepared to act on the issues (Bennett, 2016). The research team is therefore investigating, on the one hand, what "functioning" means to the various stakeholders (Module C), but also what is needed from a socioeconomic perspective (Module B) and from a policy-making perspective (Module D) to make the EI work - for example, participation, legislation, enforcement, etc. - and how or with what indicators a functioning EI can be measured. Ecosystem services/NCP help demonstrate the value of a functioning EI according to the functional and structural elements described above (Modules A). Work package C.1 of the ValPar.CH project therefore proposes to capture a "functioning" EI based on the analysis of structural and functional elements defined above (**ecological approach**). Furthermore, we investigate whether ecological objectives can be achieved in the same way or more easily if ecosystem management is based on the provision of NCP (**NCP approach**). In the ecological approach, we are guided by existing targets, such as the protection of 30 percent of Switzerland's total land area by 2020 (Guntern et al, 2013). However, it should be noted here that it is not only about area, but also about the ecological quality of the landscape. The lower the ecological quality of the landscape, the higher the area requirement for high-quality, well-connected and spatially defined areas. Thus, the role of EI varies depending on the type of landscape and the initial situation. For example, in many alpine regions of Switzerland, ecological permeability is still little impaired; therefore, EI can focus in particular on safeguarding and enhancing existing species hotspots as well as large-scale connectivity. In an intensively used midland landscape, on the other hand, only residual areas with a certain ecological value still exist; here, the EI should restore a minimum amount of area and quality and strengthen important habitat corridors. In the NCP approach, we envision primarily a participatory determination of reference conditions. In doing so, we take three approaches: (1) formulating shared visions of a functioning EI with actors in the parks, (2) clarifying trade-offs and synergies between individual NCP based on the societal values of Module B, and (3) taking into account normative goals set in charters, in legislation in general, and specifically in parks policy. In addition, the target values defined in the ecological approach and the reference states described above are explicitly linked to the governance opportunities formulated in Module D. This serves to ensure that the development paths of the EI lead to the defined targets.

ValPar.CH thus has a broader analytical focus than only the "functioning" of ecological systems. We show the added value and benefits of a functioning EI for ecology, society and the economy. This is particularly relevant for Switzerland, because here many areas serve different uses at the same time.

5 Conclusions for the ValPar.CH project

Embedded in the Action Plan of the Swiss Biodiversity Strategy (AP SBS), the ValPar.CH project builds on the FOEN definition of EI. Based on the concepts of GI and NbS, the research team will focus not only on ecological aspects, but also on the societal and economic benefits of EI and their long-term safeguarding through various "policy" mechanisms. It will operationalize functionality based on ecological aspects as well as incorporate additional aspects in a participatory manner through a holistic NCP view. Based on the frameworks developed by da Silva and Wheeler (2017), Nesshöver et al. (2017) and IUCN (2020), the team will develop recommendations to (1) capture a functioning EI using indicators and evaluate EI functioning, (2) secure and manage EI in an integrated and adaptive manner, (3) ensure its multifunctionality, (4) promote its resilience, (5) develop, secure, and manage its inherent nonmonetary value and biodiversity, (6) develop decision-making processes that demonstrate how to secure and manage a functioning EI, and (7) deal with uncertainty, complexity, ambiguity, and conflict so that equitable tradeoffs can be reached and synergies can be exploited.

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