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SPECIAL FEATURE: ORIGINAL ARTICLE

Operationalizing the Nature Futures Framework to Catalyze the Development of Nature-Future Scenarios

Operationalizing the Nature Futures Framework for ecological infrastructure

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Abstract
Scenarios are useful for considering development pathways under different future conditions. To manage a functioning ecological infrastructure (EI) as a network of natural and semi-natural habitats that can promote biodiversity and provide nature's contributions to people (NCPs), one needs to understand future biophysical and socio-economic influences on its development. However, scenarios often do not incorporate the reciprocity of biophysical and societal changes. This has prompted new proposals from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) on the importance of creating nature-centered multiscale scenarios that include a normative dimension accounting for diverse human–nature relationships. In this contribution, we operationalize the Nature Futures Framework (NFF), developed under IPBES, into integrated normative and exploratory scenarios framing the development of a functioning EI in Switzerland until 2060. We follow a two-stage participatory approach methodologically aligned with the IPBES development. First, we elaborated positive visions for future EI with stakeholders in four regions of Switzerland. We then collaborated with experts to create integrated normative and exploratory scenarios through a process comprising literature research, workshops and a survey. By positioning status quo and future scenarios within the Nature Futures Framework, we demonstrate the diversity of nature values in a specific context of EI in Switzerland, thus contributing to the global set of Nature Futures scenarios. Integrating both plausible and desirable developments, these scenarios will serve as a valuable tool in the planning of long-term measures to ensure a functioning EI in Switzerland.

Keywords Ecological infrastructure · Participatory scenario development · Visioning · ValPar.CH · Nature Futures Framework

Introduction

Ongoing human-induced biodiversity crisis severely threatens good quality of life and ultimately human existence (Hoffmann et al. 2010; IPBES 2019; Maxwell et al. 2016). Land use change, climate change, invasive alien species, overexploitation and pollution drive biodiversity loss and many essential nature's contributions to people (NCPs) (Díaz et al. 2019; IPBES 2019). Improving the prospects for life on earth by effectively steering biodiversity management requires a drastic rethinking of existing strategies across diverse sectors (Ten Brink et al. 2010; Tilman et al. 2017). The concept of ecological infrastructure (EI) refers to the design and management of networks encompassing high-quality natural and semi-natural elements to protect biodiversity and to provide NCPs (Cumming et al. 2017; IPBES 2022a; Reynard et al. 2021). Effectively planning and managing a functioning EI across temporal and spatial scales necessitates a projection of today's policy decisions on future biodiversity trends (Bai et al. 2016; Díaz et al. 2019; Leclère et al. 2020; Visconti et al. 2016) under consideration of global megatrends (Retief et al. 2016).

Scenarios have proven useful for policy-oriented research, especially when the development of the considered systems

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is highly uncertain (Parson 2008; Wright et al. 2020). Based on assessments of current conditions, driving forces, and potential consequences of actions, scenarios provide coherent, internally consistent, and plausible descriptions of future developments (Rotmans et al. 2000). Scenarios can be mainly separated into predictive (foresighted: *what will happen*?), exploratory (descriptive*: what can happen?*) and normative types (target-seeking: *what is desired to happen?*) (Börjeson et al. 2006; Höjer et al. 2008; IPBES 2016). Exploratory scenarios should explore different plausible pathways with corresponding future endpoints assuming different trends in driving factors (Börjeson et al. 2006). Normative or target-seeking scenarios work in reverse, establishing a plausible desired endpoint in the future and then evaluating pathways to that endpoint (Robinson 2003). This requires envisioning a normative future first, and then looking back to identify how this desirable future could be achieved. Scenario development integrates qualitative and quantitative data, often accompanied by participatory methods with stakeholders and experts (van Notten et al. 2003). Thereby, both the process and the product of the scenario work allow for integrating knowledge and examining the future in an organized way (Swart et al. 2004). A combination of exploratory and normative elements in scenario development can be useful for informing policy design (van Vliet and Kok 2015). This latter approach requires including the formulation of desired future endpoints for a particular issue (normative element) as well as an assessment of the impacts of different developments of external factors (exploratory element) on that issue (Milestad et al. 2014).

While the most prominent existing scenarios assess the trajectories of climate forcing (Nakicenovic et al. 2000), global scenarios have also been developed that assess human impacts on biodiversity and associated NCPs (Carpenter et al. 2006; Millennium Ecosystem Assessment 2005). Combining scenarios and models can provide powerful tools for evaluating impacts of drivers on biodiversity, exploring social–ecological development pathways and for conservation target setting (IPBES 2016; Kok et al. 2017; Nicholson et al. 2019; Pereira et al. 2010). However, existing scenarios rarely account for social–ecological feedbacks and are only limited in their consideration of multiscale processes (Rosa et al. 2017). Furthermore, existing approaches to scenario development are criticized for lacking the integration of different value perspectives, indigenous and local knowledge due to insufficient stakeholder participation (Obermeister 2019; de Vries and Petersen 2009). In particular, existing global scenarios are poorly suited to outlining positive futures, as they often emphasize negative trends and their dire consequences, rather than desirable futures for nature and people (Bennett et al. 2016). Focusing on 'seeds of a good Anthropocene' (Bennett et al. 2016), applying creative processes of scenario co-creating (Pereira et al. 2019) and storytelling (Veland et al. 2018) may encourage transformative developments towards desirable futures. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) task force on scenarios and models is developing a guidance to develop positive multiscale scenarios of global Nature Futures that account for different human–nature relationships (Pereira et al. 2020). To this end, positive visions for global Nature Futures have been developed during expert workshops, resulting in the creation of the Nature Futures Framework (NFF). In the NFF, different human–nature relationships can be mapped in a space spanned by three axes representing three main value perspectives on nature: nature can be valued according to its intrinsic values, to its instrumental values, and to its relational values within these three extremes reflecting the reality of diverse combinations (Pereira et al. 2020). This allows scenarios to be differentiated by value perspectives on nature and differs from common methods such as the scenario-axes technique, which frames scenario narratives according to extreme manifestations of the most influential drivers (Rhydderch 2017; van't Klooster and van Asselt 2006). Currently, the IPBES strongly encourages the scientific community and other relevant stakeholders, especially indigenous peoples and local communities, to operationalize the NFF for scenario and model development in regional case studies and to discuss and test its possibilities and limitations (Lundquist et al. 2021). Studies already exist that apply the NFF in a variety of settings, such as participatory approaches to developing visions for a future national park (Kuiper et al. 2022), creating scenarios for urban development (Lembi et al. 2020; Mansur et al. 2022), or exploring trade-offs between values and management options for adaptive decision making (Palacios-Abrantes et al. 2022). However, there is a great need for more literature on the process of developing bottom-up scenarios at the national level or beyond for informing policy decisions toward desirable futures.

In this paper, we present how normative and explorative methods can be combined to develop scenarios framing the development pathways of a functioning EI. By operationalizing the NFF to the particular context of EI, we demonstrate how considering different value perspectives on nature can open up discussions about how to steer regional landscape management in desirable directions. One of the strategic goals of the Swiss Biodiversity Strategy, which is addressed in the respective action plan, is to secure a functioning EI in 2060 in Switzerland (FOEN 2012, 2017a). To date, the concept of a functioning EI has not been clearly defined, especially when it comes to the impact of future climatic and socio-economic changes on biodiversity (Grêt-Regamey et al. 2021), resulting in its implementation lagging behind on the political agenda. Swiss cantons are mandated to map and plan future EI within their borders, and the Swiss

Federal Office for the Environment (FOEN) has commissioned the interdisciplinary ValPar.CH research project to provide scenarios to support decision making for this task (Reynard et al. 2021). The scenarios will help identify strategies and management actions to secure a functioning EI in 2060 in Switzerland. Further, the scenarios will be used as input to a modeling pipeline for simulating future land use, biodiversity, and NCPs in Switzerland in 2060 under various scenarios, which may assist in prioritizing areas for planning EI.

Methods

For the development of scenarios for the development of EI in Switzerland, we integrated several steps of participatory processes. Figure 1 shows the process of integrating normative and exploratory elements towards the final scenario products. The normative elements comprised visioning exercises in several workshops in four case study regions in Switzerland to assess stakeholders' desired future for EI in 2060. The explorative process encompassed a desktop analysis of relevant drivers influencing the Swiss EI based on available global scenarios, including the representative concentration pathways (RCPs) (van Vuuren et al. 2011) and the shared socio-economic pathways (SSPs) (Kriegler et al. 2014), as well as an expert process to complement and weight the drivers. Normative and exploratory scenario elements were integrated in a process alternating desk research and expert validations resulting in five final scenarios.

Switzerland and its ecological infrastructure

Switzerland is characterized by an extensive topographic gradient, covering an area of about 4.1 million ha, with altitudes ranging from 193 to 4634 m a.s.l. and encompassing six biogeographical regions, i.e., the Jura, Central Plateau, Northern Alps, Western Central Alps, and Eastern Central Alps as well as the Southern Alps (FOEN 2022b). Its growing settlements and transport systems, spatial fragmentation, intensive agriculture, as well as the spread of invasive alien species drive habitat degradation and loss (FOEN 2017b) and threaten biodiversity (Brunner and Grêt-Regamey 2016). Protected areas of national, regional and local importance currently account for 9.9% of the country's land area, while another 3.7% is dedicated to biodiversity by other means, making a total of about 13.4% of the country's land area designated as areas for protecting biodiversity (FOEN 2021). Hence, Switzerland still lacks protected areas to reach the national proportion of 17% land area that it has committed to under the Convention on Biological Diversity (CBD) for achieving

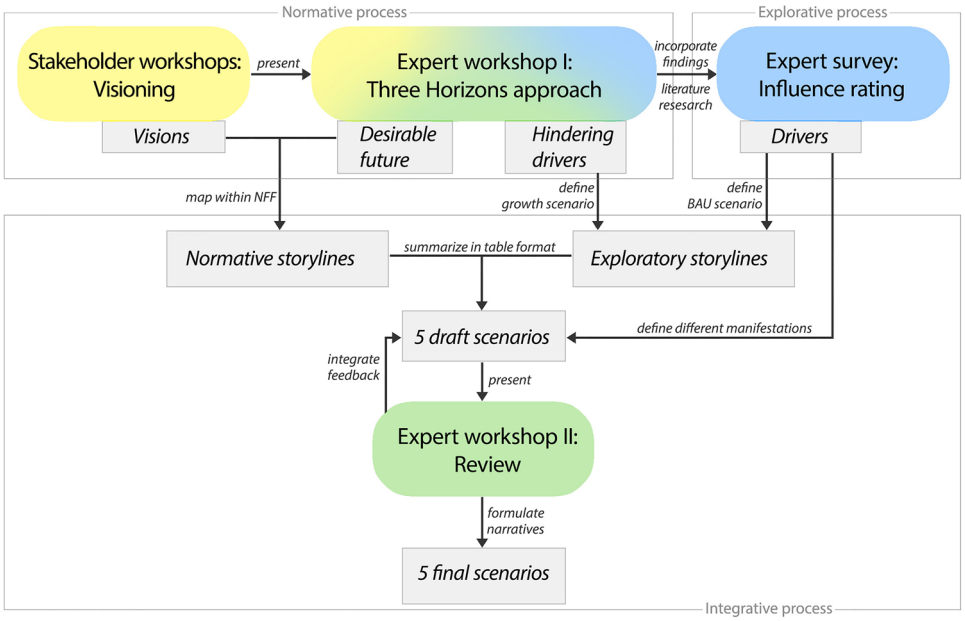

Fig. 1 Scenario development process. Round boxes indicate participatory processes representing exploratory (blue), normative (yellow), and integrative (green) approaches. Grey rectangles represent outcomes from participatory processes, and arrows indicate intermediate steps taken by the research group. Visioning workshops with stakeholders served as the basis for conceptualizing desired futures of Swiss Ecological Infrastructure (EI). Expert Workshop I was designed to deepen the discussion of desirable futures but also served as basis for exploring factors influencing EI, which was complemented by a literature review and finalized in an expert survey. Expert workshop II served to review the integrated normative and exploratory scenario drafts for completeness, plausibility and internal consistency

the Aichi Biodiversity Target 11 by 2020 (CBD 2014). EI is defined by the FOEN as a network of areas that preserve, enhance, restore and connect the valuable natural and semi-natural habitats in Switzerland. Core areas of EI should be specifically designated for species and habitat protection and need appropriate protection status for this purpose (FOEN 2022a).

The interdisciplinary project ValPar.CH aims to investigate the benefits and added value of EI both at the level of Swiss parks and nationwide, and provided the framework for our studies at two tiers: in order to derive place-based but national scenarios, we collaborated with four regional nature parks allowing to capture the contextualized views of stakeholders and a set of experts at the national level, allowing to upscale the local knowledge (Reynard et al. 2021). In Switzerland, the regional nature parks function as model regions for sustainable development reconciling environmental, social and economic interests (Swiss Parks Network 2022). Despite geographical and ecological differences, these parks pursue similar goals such as preserving and enhancing the cultural and natural landscape, promoting a sustainable regional economy, and providing environmental education and awareness (Network Parks Switzerland 2022), making them suitable prototypes for future EIs. We focused on four parks including the *Jurapark Aargau,* the *Naturpark Beverin,* the *Naturpark Pfyn-Finges,* and the *Parc naturel régional Gruyère Pays-d'Enhaut*, spanning the heterogeneous geographic (Swiss biogeographic and linguistic regions) and ecological conditions (coverage of the main habitat types of Switzerland) in Switzerland (Fig. 2).

Normative process

As a first step in 2021, we held eleven 2-h visioning workshops with a total of 57 participants (see supplementary material 1 for details) from the respective parks, covering different fields of interest and activities, namely park management, nature conservation (administration and NGO), regional economy, agriculture, education, hunting, forestry and administration (municipality and canton). In the workshops, participants were motivated to create their own narratives about desirable futures of EI in their respective regions through guided discussions. To this end, they specified which biophysical, socio-economic, cultural and political–administrative aspects a functioning, desirable EI in 2060 would contain. Discussions were recorded graphically in the form of live illustrations (see supplementary material 2). This was partly for documentation purposes, but in particular to promote imagination of participants and to stimulate the discussions (Pereira et al. 2019). Subsequently, the workshop conversations, which had been recorded as video files, were transcribed and paraphrased according to Mayring (2010). In the second step, the paraphrased transcript was further summarized by deleting paraphrases with the same content and omitting paraphrases irrelevant to the topic. Codes were then inductively developed from the data material. In this process, coding was done entirely by one person, while another person reviewed both the transcription and the coding. Building on this coding, we conducted a content analysis of the key elements of a desired EI and the commonalities

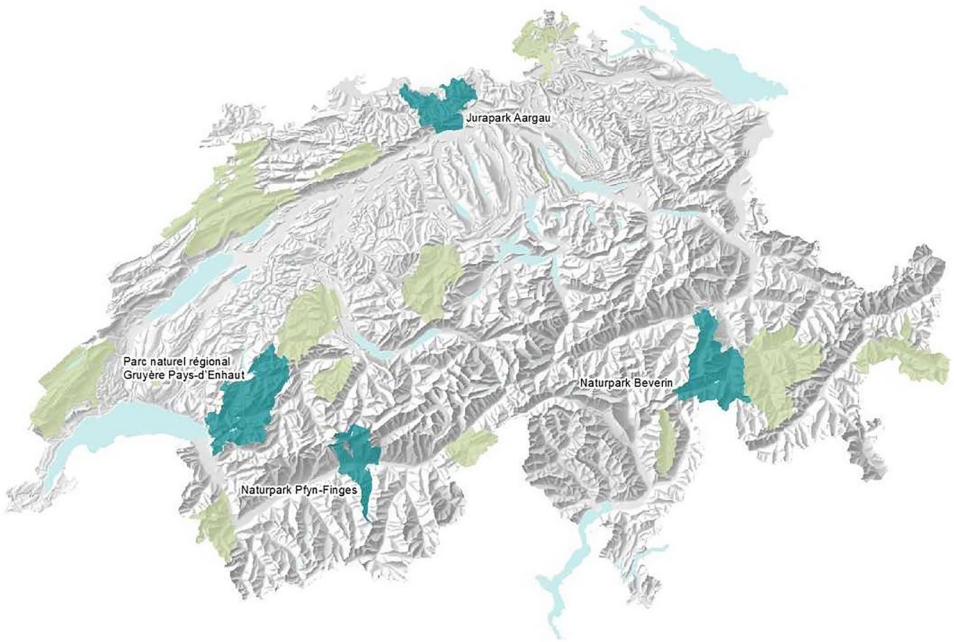

Fig. 2 Switzerland and its parks of national importance. All areas marked in green are part of the Swiss Parks network. The darker green areas are the four selected case areas of regional nature parks (source: ValPar.CH)

and differences between the visions. In particular, we analyzed which topics were discussed and with what intensity, as well as which actors or sectors were associated with certain topics.

In the next step, we worked with eleven experts, six of whom are intensively involved in the development of the concept of EI in Switzerland, and others with different backgrounds (climate, regional economics, forest, biodiversity, and social change) to construct plausible desired states and frameworks for the EI in 2060 by applying the Three-Horizon approach (Sharpe et al. 2016). Horizon 1 (H1) describes the current situation of prevailing states and drivers, Horizon 3 (H3) the desired future situations, whereas Horizon 2 (H2) explores pathways to achieve those visions. After discussing the current situation of EI (H1), we presented the visions from park stakeholders and encouraged experts to expand these with their own visions (H3). After identifying "seeds", initiatives that exist, at least as prototypes, but are not currently dominant or prominent (Bennett et al. 2016) as well as drivers that hinder positive visions of EI, experts discussed potential ways to achieve the desired future of EI (H2). We encouraged them to consider current climatic, economic, and societal developments at the global level when reflecting on the potentially desirable pathways for EI development of Switzerland. A highly interactive environment was created by alternating brainstorming in small groups (two to three people) on elements of each horizon and plenary discussions where participants could present the elements found by their group by positioning post-its on a whiteboard (see supplementary material 3). The results were digitized and served as a starting point for further scenario development.

Explorative process

The explorative process consisted of assessing driving factors on EI development (Börjeson et al. 2006). In the first step, we summarized current drivers influencing EI development identified by experts during the Three-Horizon workshop as well as drivers of land use change, identified based on literature research. The latter part also included the identification of important future climate drivers from the RCPs, describing global atmospheric radiative forcing linked to varying levels of greenhouse gas emissions and concentrations (van Vuuren et al. 2011), and the SSPs, portraying future global socio-economic conditions (Kriegler et al. 2014).

We then organized the drivers into biophysical, socio-economic, cultural, and political–administrative domains, and asked the expert group to rank these according to their influence on EI development. To this end, we created a hierarchically structured online questionnaire that was designed to review, add to, and nuance the list, or remove negligible drivers. Experts first had to indicate the importance of each driver for the development of EI by hierarchical direct weighting and could then modify the generated weighted ranking. Based on eleven responses to the questionnaire, we compiled an averaged ranking list of drivers (see supplementary material 4).

Integrative process

The combination of the normative and exploratory elements was done in an iterative process between the same group of experts and us, fed by the information collected in the normative and the explorative process. Information collected in the previous workshops and the expert survey provided the backbone for the first formulation of the scenario storylines. These storylines were informed by descriptions of driver developments. Finally, draft scenarios were validated in a workshop and then elaborated into final scenarios. In the following, these three stages are described in more details.

In the first stage, the information obtained in the stakeholder vision workshops, the Three-Horizon workshop and the expert survey was used to differentiate and flesh out the content of the *scenario storylines*. We aimed to develop five scenarios, with three of them containing normative elements from the stakeholders' and experts' visions and two exploratory scenarios. In the first step, we differentiated three preliminary scenario storylines by emphasizing three different value perspectives on EI based on the NFF. Using the NFF in the background without introducing it to the participants, we intended to organize their ideas without steering them in any particular direction during the visioning exercises. We distinguished individual aspects of stakeholders' and experts' visions according to whether they considered EI in terms of intrinsic biodiversity values (EI for nature), instrumental values for providing all kinds of NCPs (EI for society), or relational values especially for providing non-material NCPs (EI as culture). To this end, we examined the coded discussions of the eleven stakeholder visioning workshops (see supplementary material 2) and the expert ideas from Horizon 3 (see supplementary material 3) by tabulating their elements to one or more of the three dimensions: EI for nature included all elements that consider the importance of protecting biodiversity for its own sake, without a direct link to societal benefits (e.g., restricting human access to protected areas). EI for society comprised all elements associated with societal benefits (e.g., promoting recreational use of landscapes). EI as culture focused on elements that are primarily important to society's relational values (e.g., involving communities in local land management). We also made sure to incorporate elements that overlap with two or more of these perspectives (e.g., educating society about the state of biodiversity) into multiple scenario storylines.

In the second step, we grouped the drivers that were identified during the explorative process as the most influential

for EI development into themes. Now, we could further differentiate the three scenario storylines "EI for nature", "EI for society" and "EI as culture" by assuming different manifestations of the themes for each of them. In parallel, we developed two additional exploratory scenario storylines based on the discussions of the Three-Horizon workshop. One assumes business-as-usual trends of influential drivers, and the other assumes growth trends of drivers currently hindering EI development.

In the second stage, we produced *draft scenarios* by assigning the corresponding manifestations of all biophysical, socio-economic, cultural and political drivers influencing EI development to each of the five scenario storylines. For future climate trends, we combined the RCPs and the SSPs, which proved useful for projecting future impacts on biodiversity and ecosystem services (Kim et al. 2018; Nunez et al. 2020; Su et al. 2021). Global SSPs were attributed to match the respective storyline at the Swiss level, and RCPs were assigned according to existing SSP–RCP combination matrices (O'Neill et al. 2016; O'Neill et al. 2020). In addition, we integrated existing scenarios for the population development of Switzerland until 2050 (BFS 2020). For all other drivers, we compiled short textual descriptions and qualitative comparisons with the actual state, fitting the respective storylines. Finally, we summarized various characteristics of single drivers in a table covering all five draft scenarios.

In the final stage, we asked the expert group to review and if necessary, adapt this table to reach consensus on five final scenarios. First, the experts were able to explore and comment individually on all five draft scenarios in an online spreadsheet using the Miro whiteboard (Miro 2022). In the following workshop, we asked them if they agreed with the general spectrum of scenario storylines. We began by telling the scenario stories, each with a brief glimpse of Switzerland in 2060, to engage participants in imagining that future. Then, we invited them to review the draft scenarios for completeness, plausibility and internal consistency. For this purpose, small groups worked on revising one draft scenario each and then discussed their proposals in the plenary session. The review process was facilitated by providing printed posters of the individual draft scenarios in table format. In the process, the experts examined whether the manifestations of the individual drivers matched each other, added and removed drivers, and made detailed corrections to individual descriptions. Finally, small groups were asked to brainstorm what might specifically happen between now and 2060 that could lead to the respective situations of the scenarios. After this workshop, we adjusted the scenarios according to the participants' comments, graphed all of them in the NFF triangle, formulated narratives, and designed pictograms for each scenario.

Results

Visions for ecological infrastructure in Switzerland

In the first phase of the normative process, stakeholders from the four different Swiss regional nature parks co-created positive visions of future EI (Fig. 3, see supplementary material 2 for detailed designs). The visions developed in the workshops are characterized by different focal points and details.

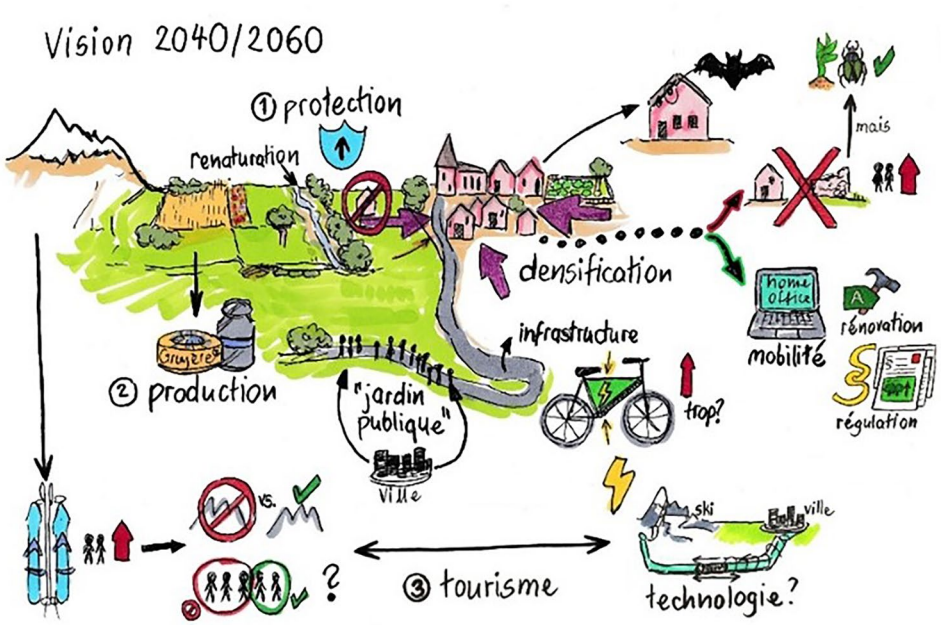

Fig. 3 Cutout from a vision developed in a workshop with stakeholders in the Parc naturel régional Gruyère Pays-d'Enhaut

At the same time, similar argumentation patterns and comparable descriptions of key elements of the desired futures were observed repeatedly, which we present in the following.

Seven aspects were highlighted in all visions of the four parks. *Quality of life* formed an essential component of the elaborated visions. EI should contribute to quality of life, which in turn, as a location factor, would be a prerequisite for *economic development*. Stakeholders associate the EI of the future with typical regional forms of production linked to specific landscapes and cultural values, and the promotion of *regional market chains*. In all parks, a *functioning knowledge transfer* is desired and considered key. To this end, ecosystem processes and social–ecological interrelationships should be addressed in school education. The future society would be aware of the effects of individual and societal actions on ecosystems and know about the requirements of land management for a functioning EI. Stakeholders pointed out that EI entails diverse land uses and actor responsibilities that need to be named and specifically managed. In the future, various actors should be jointly involved in the creation and management of EI. However, *cross-sectoral collaboration* is not automatically a result of the cross-sectoral issue but would have to be specifically designed and organized. Societal and climatic changes would require the EI to be *adaptable* in order to react flexibly to changing societal requirements and necessities of conservation. Stakeholders wish agricultural and forestry use to correspond to the respective possibilities and potentials of a site. In addition, diversified and regionally coordinated land use should strengthen the multifunctionality of the EI. The visions explicitly highlight *multifunctional settlements* as part of the EI. These should be oriented inward with respect to their growth and characterized by an active provision of habitats and connectivity elements. Stakeholders further wish settlement development to integrate climate adaptation strategies and identity-forming landscape elements.

Scenarios framing the development of future ecological infrastructure in Switzerland

All five Swiss-wide scenarios integrate existing scenarios for future trends in climate and population development. They further describe features related to the economy, urbanization, spatial planning and land management, social values, policies in the agriculture, forestry, energy, and tourism sectors. The scenarios "EI for nature", "EI for society", and "EI as culture" highlight different elements of local stakeholder visions and nationwide expert visions. All three assume that EI is given high priority in Swiss politics, that planning and implementation takes place across sectors and cantons, and that EI becomes a mainstream issue in Swiss society. In contrast, the two exploratory scenarios "Business as usual" and "Growth and Extinction" do not include any vision-based elements. They assume that EI remains more of a scientific concept and has little or no relevance on the political agenda and for practical implementation. Figure 4 illustrates the scenarios mapped within the NFF, Table 1 summarizes information on main scenario characteristics, whereas supplementary material 5 contains detailed information on all drivers of EI development.

EI for nature emphasizes the protection and promotion of biodiversity. This scenario characterizes that in

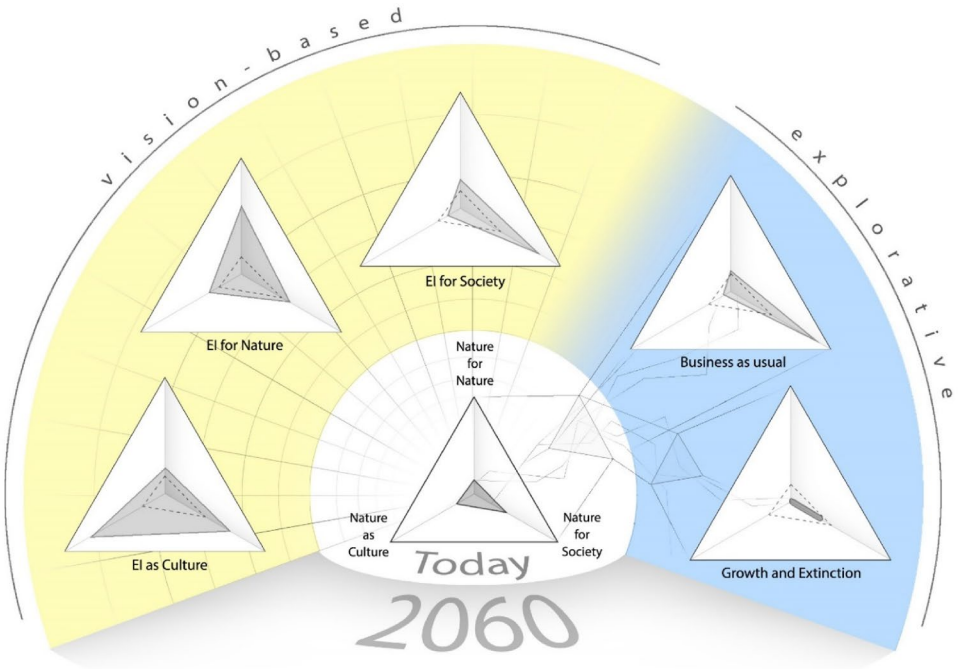

Fig. 4 Using the Nature Futures Framework (NFF) to map the status quo and future scenarios framing Swiss Ecological Infrastructure (EI) along axes of nature values (nature for nature, nature for society, and nature as culture) with three vision-based scenario storylines intentionally emphasizing the three different value perspectives on EI, as well as two exploratory storylines with a business as usual and a growth scenario

Table 1 Summary of key characteristics for the five scenarios

Scenario	EI for nature	EI as culture	EI for society	Business as usual	Growth and extinction
Driver					
Prevailing values on biodiversity	High value placed on biodiversity for its intrinsic value	High value placed on biodiversity mainly for its links to the provision of tangible and intangible NCPs	High value placed on biodiversity for its benefits to human society	Medium value placed on biodiversity for its benefits to human society	Low value placed on biodiversity
Political prioritization of EI	High priority (*focus biodiversity*)	High priority (*focus regional promotion of biodiversity and nonmaterial NCPs*)	High priority (*focus efficient use of NCPs*)	Low priority	Low priority
Agricultural policy	Biodiversity-oriented	Production and biodiversity-oriented	Production-oriented	Production-oriented with integrated measures for biodiversity promotion	Production-oriented
Spatial planning and land management	Multifunctional land management with strong limitation of settlement growth and land fragmentation, and land set aside for biodiversity only	Multifunctional land management with moderate settlement growth	Functional zoning of the landscape (residential, agricultural production, biodiversity protection, recreation, and energy production are spatially separated)	Multifunctional land management with moderate settlement growth	Land management for the provision of food and employment through commercial activities with strong settlement growth
Policy for protected areas (PAs)	Existing protected areas are expanded and additional sites established (30% of Swiss land area protected by 2060)	Existing protected areas are expanded and additional sites established (25% of Swiss land area protected by 2060)	Existing protected areas are expanded and additional sites established (22% of Swiss land area protected by 2060)	Existing protected areas are expanded and additional sites established (17% of Swiss land area protected by 2060)	Protected areas are downsized (10% of Swiss land area protected by 2060)
Population[a]	"Low" scenario (2060: 9.5 Mio.)	"Low" scenario (2060: 9.5 Mio.)	"Reference" scenario (2060: 10.5 Mio.)	"Reference" scenario (2060: 10.5 Mio.)	"High" scenario (2060: 11.5 Mio.)
Urbanization	Medium growth, no urban sprawl	Slight growth, no urban sprawl	Strong growth, no urban sprawl	Medium growth, continuing urban sprawl	Medium growth, strong urban sprawl
Economy	Shift beyond economic growth through increasing sufficiency in production and consumption	Shift beyond economic growth through a regionalized model of production and consumption with short supply chains	Green growth through increasing efficiency of technological solutions	Green growth through increasing efficiency of technological solutions	Growth in production and consumption
Climate[b]	RCP2.6–SSP1	RCP2.6–SSP1	RCP 4.5–SSP2	RCP4.5–SSP2	RCP7–SSP3

[a]Based on population scenarios by the Swiss Federal Office (BFS 2020)

[b]Scenario combinations of representative concentration pathways (RCPs) and shared socio-economic pathways (SSPs) (O'Neill et al. 2020)

certain areas for biodiversity promotion, humans are denied access. There is a societal consensus that biodiversity needs its space to thrive, as people value nature for its intrinsic values. This scenario assumes that human society globally follows sustainable pathways (SSP1) and climate action is effective (RCP2.6). Switzerland aims for an economy beyond growth and expands protected areas to 30% of the Swiss land area until 2060.

EI as culture sets the priority on integrating communities into land management. It assumes a multifunctional land management with strong focus on community engagement and regional development. Biodiversity and NCPs are highly respected, and the development of a regional EI is ingrained in human culture. This scenario assumes that humankind follows sustainable pathways (SSP1 and RCP2.6) and the Swiss economy shifts to a regionalized model beyond growth with short market chains. EI has high priority on the political agenda and is coordinated among sectors to provide a diversity of NCPs.

EI for society focuses on the sustainable supply of NCPs to the Swiss population. It assumes a strong division of the landscape: housing, agricultural production, biodiversity protection, recreation, and energy production are spatially separated. This has implications for the planning of rural and urban areas, with most people living in large, green cities. Society highly values NCPs for their instrumental values—provision of material (e.g., timber and crops), regulatory (e.g., flood control), and immaterial (e.g., recreation) assets. A global development of RCP4.5 and SSP2 and a Swiss economy characterized by green growth form the underlying assumptions of this scenario.

Business as usual assumes the continuing trends of the last decades: EI has a low priority on the political agenda and Switzerland follows a general trend of green growth. The broader society continues to have a distorted view of the biodiversity crisis lacking comprehension of its reality in Switzerland. Since EI is not an issue in Swiss society, people follow their current value patterns by valuing nature for providing NCPs but without understanding the underlying social–ecological feedbacks. The scenario assumes the world to follow RCP4.5 and SSP2 developments.

Growth and extinction follow trends of drivers identified during the Three-Horizon workshop as hindering for EI development: there is a general mentality of disinterest in the biodiversity crisis and a lack of cross-sectoral and cross-cantonal cooperation, while at the same time, agricultural practices that are detrimental to biodiversity are increasing and urban sprawl is growing. In the face of global crises, Switzerland is striving for domestic agricultural production to ensure food security for the population. Globally, SSP3 and RCP7 are assumed, leading to significantly warmer conditions and more frequent extreme events in Switzerland than in any of the other four scenarios.

Discussion

For a new generation of multiscale scenarios for Nature Futures (Pereira et al. 2020; Rosa et al. 2017), we believe it is key to integrate normative and exploratory elements to envisage desired regional futures embedded in possible global trajectories. Storytelling is fundamental to humanity (Harari 2018), and shaping new narratives could inspire pathways towards more just and sustainable futures on Earth (Jepson 2019; Moore and Milkoreit 2020; Wyborn et al. 2020). The challenge, however, is to develop narratives that depict a desirable future against a backdrop of uncertain driving forces (Van der Voorn et al. 2012). We show how combining a normative and exploratory scenario development process and involving both stakeholders and experts in storytelling opens up space for positive EI development pathways in Switzerland that support high biodiversity and NCPs.

From visioning towards integrated multiscale scenarios

The selection of participants involved in collaborative development of scenario narratives is critical for procedural equity and the quality of the outcomes (Bonaccorsi et al. 2020). Engaging with stakeholders in Swiss parks was a valuable starting point to capture local knowledge and aspirations (Obermeister 2019) in regions spread across Switzerland that can act as pilot areas for Switzerland's sustainable development. For participants, in turn, visioning processes can be inspiring and even motivating for the desired change (van der Helm 2009; Wiek and Iwaniec 2014). The participants of the visioning workshops expressed this on several occasions in their feedback, and we hope that this process will encourage the participants to implement measures to achieve the visioned states. Although the four case study areas selected for the regional visioning are representatively distributed throughout Switzerland, the nationwide scenarios encompass developments in a much wider variety of contexts in Switzerland. In the context of this study, visioning could only be conducted with actors in rather rural Swiss parks, but we ideally recommend for other studies to extend this crucial process of visioning to more diverse contexts, including urban and peri-urban regions. The expert-based approach then allowed to scale the perspective on EI as a nationwide network and to stimulate cross-sector thinking

about current and potential social–ecological feedbacks. Experts were encouraged to embrace a transformative future consciousness as they reflected on the seeds for desirable futures, impeding factors in the present, and ways to achieve those positive futures during the Three-Horizon approach (Sharpe 2020; Sharpe et al. 2016). Such a highly interactive, creative co-development process resulted in the values of stakeholders, experts and of ourselves, flowing into the final scenarios (Morgan 2014), and enabling transformative thinking about the future (Bennett et al. 2016; Merrie et al. 2018; Pereira et al. 2022).

Linking the normative elements from the regionally oriented stakeholder visioning and the federally oriented Three-Horizon workshop with the definitions on driver developments in the exploratory process proved not always straightforward. While we could easily link the development of drivers that are primarily anchored in the political–administrative context of Switzerland, such as the orientation of agricultural policy or the achievement of area-based targets for protected areas currently under discussion in Swiss politics, with normative vision aspects (e.g., "promoting biodiversity in agriculture" and "ensuring sufficient area for the conservation of existing species"), linking such normative elements to predictions of highly uncertain global socio-economic and climatic developments was challenging. Furthermore, contextualizing existing global scenarios comes with important constraints (Kok et al. 2006). In particular, no degrowth SSP scenario currently exists (see Otero et al. 2020 for discussion), which led us to assign SSP1 to the "EI as culture" and "EI for nature" scenarios. This may be plausible, as Switzerland could deviate from the global path in its economic development. However, we strongly advocate for the development of global degrowth scenarios that can be used and scaled down by both climate and biodiversity research communities to develop internally consistent scenarios for desirable Nature Futures.

Exploring desirable versus non-desirable Nature Futures

Our approach diverges in part from the IPBES call for positive scenarios for Nature Futures to promote transformative change (IPBES 2022b; Pereira et al. 2019): we contrasted three desirable, vision-based with two non-desirable, exploratory scenarios, arguing that human motivation for behavior change is grounded in the mental juxtaposition of desirable futures and resistant realities (Oettingen 2012). In contrast to other studies developing only desirable scenarios based on the NFF (e.g., Mansur et al. 2022; Pereira et al. 2022), we found it critical to further depict both business-as-usual trends and growth scenarios that may impede desirable futures to identify salient management options for steering alternative, desirable pathways. In this regard, we have found the NFF useful in two ways. First, it served as a tool to distinguish the three vision-based scenario storylines along value axes. Second, the NFF allowed us to get a sense of possible future value perspectives of the two exploratory scenarios after they had been developed based on driver assumptions. In this way, we were able to depict in a very simplified way nature values that could emerge in the absence of pro-active steps toward a desirable, functioning EI. Simplified frameworks such as the NFF are vital, not to target the extremes of one of the value perspectives, but to actually address nature values and incorporate them into models, policy decisions, and ultimately action.

A window of opportunity for steering Swiss Ecological Infrastructure towards desirable futures

With the new global biodiversity framework setting out global actions to conserve nature and its essential services to humans by 2030 (CBD 2021) and the established Swiss biodiversity strategy (FOEN 2017a), the pressure on Swiss planning and implementation of EI is high. Nevertheless, the future development of EI is currently mainly discussed as a concept among experts. During the workshop discussions, it became clear that even for experts, the boundaries between drivers of and EI itself are blurring. Although EI itself could readily be understood as a network of functioning protected areas (FOEN 2022a), the presented scenarios are intended to span space for innovative ideas beyond the current understanding of protected areas. In the presented scenarios, for example, area-based targets and site prioritization of protected areas are considered drivers rather than components of EI. Building scenario storylines around different value perspectives based on the NFF allowed overcoming the challenge of fuzzy definitions and rather exploring potential EI futures along gradients of management intensity, instrumental values, and cultural significance of nature. Looking at Switzerland's business as usual future, a strongly instrumental view of nature seems to prevail, while biodiversity continues to decline without the broader society being aware of it (Lindemann-Matthies and Bose 2008). Opportunities exist to blend synergies between biodiversity promotion and human quality of life, such as the featured Swiss parks or the European rewilding movement, which combine species reintroduction and landscape restoration with community engagement and nature-based business models (Jepson et al. 2018; Rewilding Europe 2022). We, therefore, encourage leveraging EI as an opportunity beyond the protection of a network of habitats to build societal understanding and support for the promotion of biodiversity. However, the broader value perspective on nature opened up by the scenarios can only enter the mainstream if this value shift flows into EI

planning. To this end, the scenarios need to be operationalized into quantitative, spatially explicit land use models so that cantonal administrations can explore and plan for regional elements of a desirable EI in Switzerland.

Conclusion and outlook

There is no blueprint and many unanswered questions about how to create an equitable and functioning EI promoting biodiversity and NCP provision under uncertain climate change, societal shifts, shocks, and crises. We recognize that the presented scenarios are the first step toward further discussion and cross-sector decision making, both Swiss wide and in detail for different regions. Engaging stakeholders in many other areas beyond Swiss parks, including cities, tourism hotspots, and areas with intensive agriculture, to name a few, will be critical for further EI planning processes. The NFF helped us identify desirable, vision-based scenarios framing EI development that emphasize nature values, and contrast these with non-desirable, exploratory scenarios. We believe that our scenarios can strengthen communication about the state of biodiversity and the opportunities of a functioning EI for society and nature if shared with a broader society in an engaging way.

In order to become operational, the current narratives will need to be translated into spatially explicit datasets to explore policy and management options towards desirable Nature futures. With the described approach, we aim to encourage to elaborate on similar approaches to integrated scenario development with the combination of normative and exploratory elements. We believe it is highly valuable to focus on desirable futures of human–nature relationships to (1) gather insights into ways to connect them to spatially explicit models and (2) discover the transformative potential of such scenario development processes and products.

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Declarations

Conflict of interest The authors have no competing interests to declare that are relevant to the content of this article.

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