Results from the Swedish University of Agricultural Sciences Nr 5 2017

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Knowledge production and learning for functional green infrastructure

– *multiple landscapes as a research platform*

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Green (or blue) infrastructure policy stresses the need to sustain functional networks of representative terrestrial and aquatic ecosystems for **the sustainable provision of multiple ecosystem services**. Implementing this means that the complexity of interactions between social and ecological systems at multiple spatial scales and levels of governance needs to be understood.

Place-based knowledge production through integration of different research perspectives in collaboration with stakeholders is a key feature. We applied a stepwise approach to produce knowledge and encourage learning towards a functional green infrastructure, using a suite of landscapes as a transdisciplinary research platform in Europe's West and East.

As an example of diagnosis of ecosystems, we found that t**he functionality for wood production and biodiversity conservation was inversely related** in the gradient from long to short histories of forestry in the Baltic Sea Region. In Sweden more protected areas, several management methods, and restoration are required, while in Europe's East, forestry need to become more intensive.

Examples of diagnosis of social systems included **evaluation of strategic spatial planning in Sweden, outcomes for biodiversity conservation of forest certification in Lithuania, and learning from successful environmental managers in Sweden.** Our case studies show that the main challenge for securing functional green infrastructure is poor cross-sectoral integration.

Treatment of social-ecological systems requires evidence-based cross-sectoral collaboration. The diversity of landscape histories and governance legacies in the Baltic Sea Region offers grand opportunities for both knowledge production about performance targets for green infrastructure functionality, and learning to adapt governance and management to regional conditions.

Integrating project funding from different sources for both researchers and stakeholders is a necessary strategy to fill the transdisciplinary research agenda. However, formal and informal **disciplinary and administrative barriers can limit team building** in spite of self-reflection and experience.

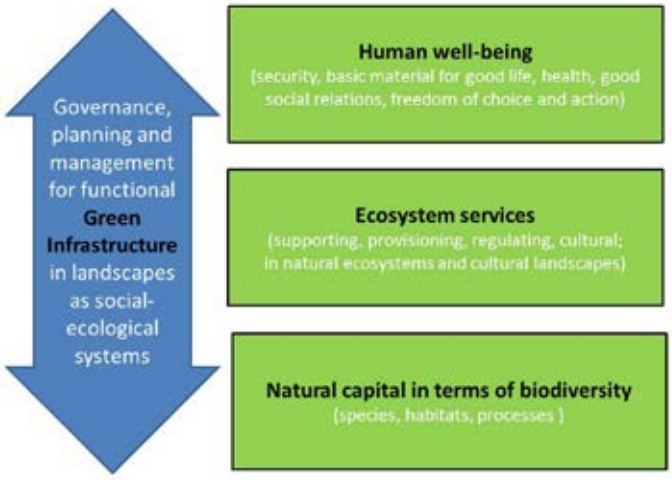

Figure 1. The policy term "green infrastructure" conceptualizes the need to maintain sufficient amounts of representative ecosystems as functional networks by spatial planning. Green infrastructure is a tool towards delivering ecosystem services that support human well-being.

Natural capital, in terms of species, habitats and ecosystem processes, is the ultimate base for human well-being (Figure 1). To tackle the increasing loss and fragmentation of habitats for both wild species and humans in rural and urban landscapes there is a need to maintain many types of functional networks as a green infrastructure. Examples include different kinds of forests, streams, wooded grasslands, cultural wetlands and urban green space.

Today, the demand on what landscapes are expected to deliver is increasing. How does society take care of landscapes so that biodiversity conservation and ecosystem services for human well-being are delivered in the long-term? Working with green infrastructure means integration of protected area development, sustainable use and landscape restoration. This requires an integrated approach for governance and management of landscapes as coupled social-ecological systems.

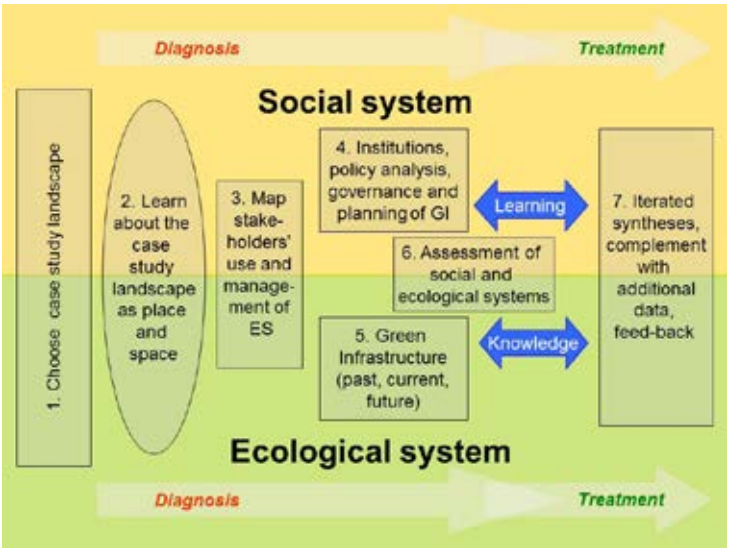

Figure 2. To compare landscapes with different land use histories and governance arrangements, knowledge production and learning towards functional green infrastructure require a systematic approach. For each landscape case study both diagnoses and treatment are needed. First, diagnoses of both the ecological system and the social system are needed to understand barriers and bridges for a functional green infrastructure (steps 1–6). Second, treatment is provided in the form of knowledge production and social learning through analyses and visualization tools as a basis for integrated spatial planning by actors from different levels and sectors of society (steps 6–7).

Transdisciplinary research

To support knowledge production and learning towards functional habitat networks as green infrastructure in landscapes requires integration of academic and non-academic actors. This means that researchers representing human and natural sciences, as well as stakeholders in landscapes, co-produce the knowledge needed to protect, manage and restore functional habitat networks. Viewing landscapes as individuals, we use a systematic approach to "diagnose" green infrastructures as well as societal steering processes, and to identify "treatments" to maintain functional green infrastructures (Figure 2) in a suite of case study landscapes (Figure 3).

State of the green infrastructure

Traditionally, forestry aims to maximise economic revenue from forest resources such as timber, pulpwood and bio-energy. However, emerging societal values and policy changes since the early 1990s require a transition from sustained yield forestry to sustainable forest management, which targets also the maintenance of biodiversity in terms of species, habitats and processes, and human well-being, such as having a place to live and a job. We used a macroecological approach along the steep West-East gradient within the Baltic Sea Region to assess regional profiles of economic vs. ecological benefits delivered by forest landscapes. We found an inverse relationship between the opportunities for economic benefits based on intensive wood and biomass production on the one hand, and biodiversity conservation on the other (Figure 4). It is crucial to produce knowledge about thresholds for how much habitat that is needed to maintain species. The same applies to ecological processes such as herbivory and predation, as well as types and intensities of land use.

Governance and strategic spatial planning

Spatial planning is an important tool for integration of economic, ecological, social and cultural policy agendas. Municipalities' comprehensive planning aim to steer territorial development and help to solve conflicts among different interests. However, in the Swedish Bergslagen region they experience difficulties to integrate different topics and engage stakeholders in long-term spatial planning.

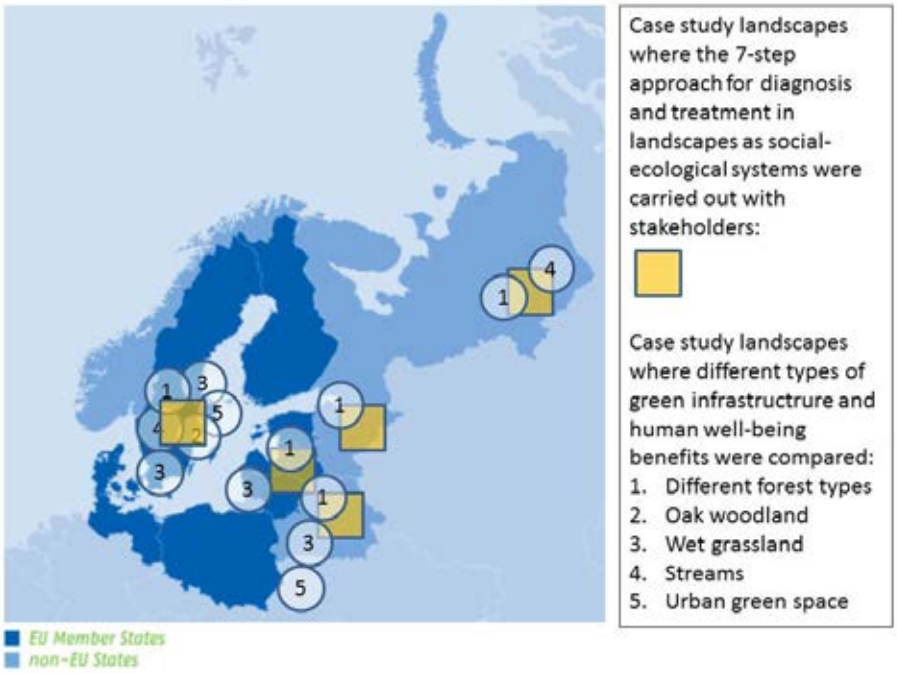

Figure 3. The Baltic Sea Region in northern Europe hosts a steep gradient of landscape histories ranging from long to short, and with different approaches to governance and planning. Map from Interreg Baltic Sea Region (interreg-baltic.eu).

A study on FSC certification outcomes for biodiversity conservation in Lithuania shows that there is a clear mismatch between criteria and indicators related to biodiversity in the FSC standard and evidence-based knowledge. A key gap in the current standard in Lithuania is the lack of any requirement to maintain connectivity of habitats. Formally protected areas were more important for green infrastructure than voluntary set-asides within forest certification.

Due to a long history of intensive land and water use, habitat networks for biodiversity conservation are degraded in Sweden. Landscape restoration is important to maintain functional green infrastructures. We analysed the causal structures underlying governance and management of landscape restoration in Sweden. Key solutions were to secure institutional flexibility, timely availability of sufficient funds, and effective learning and knowledge production processes.

”Today, the demand on what landscapes are expected to deliver is increasing.”

Collaborative learning as treatment

Implementing policy about green infrastructure requires evidence-based cross-sectoral collaboration and regional adaptation. This means that social innovations need to be encouraged in landscapes as social-ecological systems. The diversity of landscape histories and governance

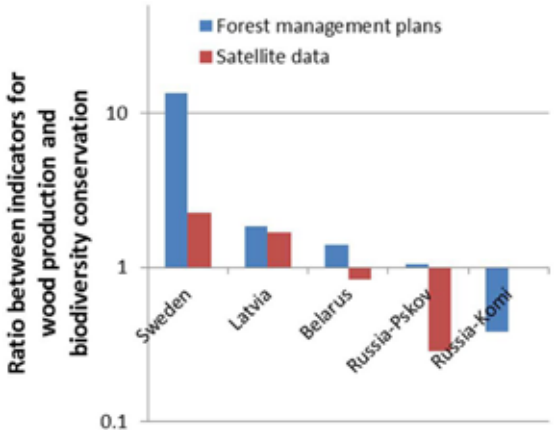

Figure 4. Spatial data based on open access remote sensing and forest management plans showed that green infrastructures for wood production and biodiversity conservation, using for example resident birds as indicators, are inversely related among the the case study regions. Therefore, while restoration for biodiversity conservation is needed in the West, intensified use of wood and biomass is possible in the East. However, a cautious approach should be applied because intensification of wood production threatens biodiversity.

Figure 5. Knowledge-based stakeholder participation in planning through deliberation and collaborative learning is a way forward for better strategic comprehensive planning. Collaborative learning among representatives from a county administrative board, a forest company, and a NGO, an archaeologist and researchers working together to remove a fish migration obstacle can build capacity for evidence-based landscape restoration. Photo: Johan Törnblom.

legacies among regions in both Sweden, and countries the Baltic Sea Region, offers grand opportunities for both knowledge production about thresholds for green infrastructure functionality, and learning to adapt to regional contexts regarding different ecosystems, landscape histories and legacies of governance and land ownership (Figure 4) ■

Figure 6. Northern Sweden and NW Russia are both dominated by boreal forests. However, their landscapes deliver different portfolios of ecosystem services, and have different planning and management systems. Securing long-term funding for multiple landscapes as a transdisciplinary research infrastructure would be a valuable investment for collaborative learning towards functional green infrastructure. Photos of streams in Swedish Bergslagen (Hedströmmen) and Russia's Komi Republic (Lokchim) by Mikael Angelstam and Per Angelstam.

Keywords
Ecosystem services, community planning, collaboration, transdisciplinary, knowledge production, learning.

Read more:

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FOREST FACTS – Results from the Swedish University of Agricultural Sciences
ISSN: 1400-7789. **Production:** SLU, Faculty of Forest Sciences 2017.
Responsible editor: Goran.Stahl@slu.se.
Editor: Goran.Sjoberg@slu.se.
Illustrator: Fredrik Saarkoppel, Kobolt Media AB. **Print:** TMG Tabergs. **Subscription:** www.slu.se/faktaskog