Ecosystem Services and Resilience

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Introduction and 'State-of-the-art'

For many decades, diverse fields have used the concept of r*esilience* in both their research and practice; including engineering, psychology, organisational management, economics, international development, and environmental sciences. Interest in resilience has grown significantly in recent years, as society seeks long-term strategies for addressing ongoing global and inter-related social, economic and environmental crises. The ecological dimensions of resilience are now incorporated into wider research frameworks and societal initiatives, with ecosystem services (ES) and natural capital (NC) often seen as core aspects of resilience in social-ecological systems, and an important part of "resilience thinking" (e.g. Plummer and Armitage, 2007). Within the context of operationalizing ES and NC, resilience describes the capacity of a social-ecological system to cope with assorted forms of variability: including abrupt changes resulting from hazardous events, longer-term trends, or other forms of disturbance. This synthesis paper discusses the development of the resilience concept across disciplines, and how we can integrate the ES and NC concepts into resilience thinking.

In his seminal paper on resilience in 1973, Holling defined resilience in ecosystems as "a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling 1973, p.14). Holling and others (e.g. Levin, 1998; Walker et al., 2006) considered this ecological resilience the result of the evolutionary processes that act on ecosystems and generate the interactions between species, communities and the physical environment. Similarly, social resilience is the ability of communities to recover from external shocks to their social infrastructure (Adger 2000). Social resilience frequently depends on the resilience of local ecosystems, and activities that reduce ecological resilience generally reduce sustainability of both formal and informal social institutions through loss of ES. While resilience is often considered in terms how well systems respond to adverse events, it is worth noting that this is not merely about response to change that is either semi-permanent or a directional transition from one state to another—but rather about responses to "variability". Adverse events tend to be more of a "pulse" than a "press". For example, it is arguable that under climate change the increased frequency of extreme events is a greater challenge to social-ecological resilience than gradual warming. In a world of increasing social, cultural, economic and environmental variability, framing resilience as a response to variability makes a strong case for its importance to the four challenges.

Several initiatives have highlighted the importance of ecological resilience to business and industry, particularly for sectors that have direct dependence on ES and NC (MA, 2005; Hanson et al., 2012). Ensuring operational resilience and security in the face of environmental and economic variability and shocks—and similarly ensuring that business activity does not negatively impact wider societal resilience—requires addressing corporate dependence and impact upon ES (Hanson et al., 2012). Bristow (2010) argued that economic competitiveness strategies framed in a place-based context, accounting for regional environmental and social dimensions, are important to ensure regional resilience: "Resilience is defined as the region's ability to experience positive economic success that is socially inclusive, works within environmental limits, and which can ride global economic punches" (Bristow, 2010, p. 153).

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Resilience has become particularly important in light of the measured existing and anticipated future impacts of climate change, with increased human security risks associated with extreme weather events, related natural disasters, and the subsequent social and economic consequences including migration and economic shocks. The Intergovernmental Panel on Climate Change (IPCC, 2014) has described resilience as "the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure while also maintaining the capacity for adaptation, learning and transformation" (IPCC, 2014; p.40). The UN International Strategy for Disaster Reduction adds, "The resilience of a community in respect to potential hazard events is determined by the degree to which the community has the necessary resources and is capable of organising itself both prior to and during times of need"[3]. The creation of disaster-resilient societies is both tied to and dependent upon resilience in ecosystems, and sustainability and security in the flow and delivery of essential ecosystem services—not only those directly associated with resilience to immediate disaster impacts, but also those that normally support communities and wider society.

Climate change and recent crises in global food security have also placed resilience at the heart of global food and nutrition strategies, with an increasing recognition of the role of agroecosystems and related ES. The UN Food and Agriculture Organisation states that conservation and management of agrobiodiversity—including crop genetic resources, crop wild relatives and traditional seed varieties—can be important aspects of disaster risk reduction and of post-disaster recovery and relief efforts. Recent experience in communities affected by conflict, famine and drought has demonstrated the value of native seed stocks in maintaining food system resilience and in supporting recovery efforts. The resilience of seed systems is therefore a key element in promoting food and nutrition security amongst vulnerable populations (McGuire and Sperling, 2011). We can also link ecological resilience to community and institutional capacity to address increasing health challenges and other social, environmental and economic pressures. Communities affected by loss of ES and NC are likely to be significantly more vulnerable to disaster impacts than communities with a lower level of environmental disturbance and ecosystem degradation (CBD & WHO, 2015).

While many now promote resilience as a requirement for sustainability (e.g., resilience is a core element of the UN post-2015 Sustainable Development Goals[4]), we still see concern that resilience is simply an inadequately defined buzzword that could detract from efforts sustainable development efforts (e.g., Hussain, 2013). It is often unclear how to implement or measure resilience in a policy context, or what this ambiguity means for broader sustainable development goals (Grünewald and Warner, 2012). However, while Brand and Jax (2007) contend that that resilience's vagueness could limit its potential utility in fields of environmental management, they also posit that the same ambiguity positions resilience as a useful boundary concept for transcending disciplines. Bhamra et al. (2011) underscore resilience's transdisciplinary utility by writing that, across all its uses, resilience simply deals with "the capability and ability of an element to return to a stable state after a disruption" (Bhamra et al., 2011; p. 5376).

Actually quantifying resilience remains elusive. Holling suggested possible approaches to measuring resilience in ecological communities, but felt that "such measures require an immense amount of knowledge of a system and it is unlikely that we will often have all that is necessary" (Holling 1973, 20). Decades later, many commentators still highlight the difficulties of both developing standardised metrics for resilience and defining it in a way that clearly identifies the source and target of risk (e.g. Carpenter et al. 2001; Haines-Young & Potschin, 2010). Folke et al. (2004) propose four key attributes for ecological resilience: 1) *latitude*, or the maximum amount a system can change before recovery is not possible; 2) *resistance*, or the degree to which a system is unaffected by pressures; 3) *precariousness*, or the current trends in a system's attributes and its proximity to thresholds; and 4) *cross-scale interaction*, describing the states and dynamics of multiple scales affect the above three attributes. The UN FAO propose a similar framework for calculating resilience in food systems that incorporates local incomes, access to basic needs

[3] See http://www.unisdr.org/we/inform/terminology. Accessed 13th July 2015.

[4] See https://sustainabledevelopment.un.org/focussdgs.html. Accessed 13th July 2015.

including food and water, land/ livestock assets, access to social safety nets (e.g., food assistance and social security), access to healthcare and energy, households' adaptive capacity (linked to education and diversity of income), and the stability of these factors over time (UN FAO, 2012).

Successfully refining and implementing such approaches for specific local or regional contexts requires accounting for multiple stakeholders' needs and perspectives—integrating various forms of knowledge including those related to local biodiversity, ES and NC (e.g. Folke et al., 2010; Weichselgartner and Kelman, 2015). Biggs et al. (2015) proposed a set of principles for implementing a resilience approach to sustainable development that are both based on human dependency on ecosystem services and account for local knowledge and institutional practices. These principles include (1) Maintaining diversity and redundancy, (2) Managing connectivity, (3) Managing slow variables and feedbacks, (4) Fostering complex adaptive systems thinking, (5) Encouraging learning, (6) Broadening participation, and (7) Promoting polycentric governance systems. This may provide a useful starting point for identifying potential indicators and assessment approaches for OpenNESS, particularly through scenario building, and mapping and modelling methods.

Issues to be discussed

1. Resilience is an important aspect for human well-being and competitiveness across social, environmental and economic spheres. How should resilience be quantified at local or regional scales? What are the most appropriate local / regional indicators of resilience, and how do they relate to local biodiversity (BD) and ES / NC concepts?
2. Resilience may relate to both the supply side and demand side of ES supply bundles (see Berry et al., 2016). Where in the cascade (see Potschin and Haines-Young, 2016) is it best to address resilience? Does resilience in ecosystems—and thereby any support for resilience in human communities—depend ultimately upon human action?
3. How can sustainable ecosystem management increase or sustain resilience in ecological and human communities?
4. Can resilience be incorporated into non-monetary valuation of ES (see Kelemen et al., 2016), and natural capital accounting? If so, how, and what are the most useful metrics?
5. What aspects of resilience are being addressed (directly or indirectly) through the project? Do any of the case studies outputs help to identify vulnerable groups, communities or infrastructure that can be made more resilient through operationalisation of ES and NC (perhaps linking to issues of mitigation & preparedness)?

Significance to OpenNESS and specific Work Packages[5]

WP1 (Key challenges and conceptual frameworks): Conceptual frameworks for the delivery, use and valuation of ES / NC can factor in issues of social, economic and environmental resilience, and whether it is appropriate to develop a core set of resilience indicators that relate to BD / ES / NC. Whilst resilience can overlap to varying degrees with measures of well-being (including health and social justice etc.), framing these issues explicitly in a resilience context may be useful. Notions of resilience have been factored into WP1 guidelines for testing draft conceptual frameworks (D1.3). These and other WP1 outputs can help to identify where and how to highlight resilience issues in the decision-making process, and consider whether focus on resilience aspects can facilitate operationalisation of ES / NC concepts, including for non-environment sectors (e.g. linking ES with climate change and health, or with social change and poverty, etc.).

WP2 (Regulatory frameworks and drivers of change): WP2 policy analysis has determined that the outcomes of some EU policies can include sustaining or enhancing resilience in social-ecological systems (see D2.1) Assessing drivers of social or ecological change can help to identify key policies and strategies that can affect the resilience not only of ES, but also of communities and economies.

[5] For a brief description of the OpenNESS Work Packages see: http://openness-project.eu/about/work-packages

Scenarios can help to account for how future demands for and losses of ES can affect human resilience or affect demand for other forms of capital (e.g. social, economic). This may include identifying the aspects of biodiversity, NC and ES that are likely to be (or not be) resilient under future conditions.

WP3 **(Biophysical control of ecosystem services):** Changes in ecosystem resilience may affect the resilience of associated communities or other end users of ES. Mapping and modelling methods that combine assessment of critical NC/ ES or ES bundles, combined with mapping of beneficiaries and key drivers of change, are a vital tool for resilience planning and related management strategies. Models can also seek to identify areas at risk of becoming less resilient through erosion of critical ES/ NC.

WP4 **(Valuation of the demand for ecosystem services):** Considering sustainable levels of use and exploitation can factor in the dimensions of resilience, and consider how changes in levels of exploitation or demand can affect the ability of ecosystems, communities or economies to cope with or adapt to change. WP4 has highlighted how ecosystems have "insurance value" in sustaining resilience to social and ecological change (D4.1 and 4.2). Further work can identify opportunities for utilising measures of resilience for non-monetary valuation methods.

WP5 **(Place-based exploration of ES and NC concepts):** Stakeholder engagement may be particularly important for gauging the degree to which different sectors, communities or groups within communities are dependent upon particular aspects of BD/ ES/ NC, and can help to gain insight into risks or opportunities associated with resilience to future environmental, social or economic changes.

WP6 **(Integration: Synthesis and Menu of Multiscale Solutions):** Existing policy frameworks are already moving towards resilience issues in connection with climate change adaptation and economic stability. Building on institutional analysis under WP2, WP6 can help to identify where concepts of ES/ NC/ SEM can strengthen adaptation policies or offer novel avenues for effective, equitable approaches to governance that can help to build resilience to emerging challenges across society.

Relationship to four challenges[6]

Human well-being: Resilience (taken as the ability of individual, communities, or institutions to adapt to a challenge) can be considered an important determinant of well-being; e.g., it has been argued that resilience is a key aspect of human health, and it is increasingly important in policies for protecting vulnerable populations from impacts of climate change.	**Sustainable Ecosystem Management (SEM):** Resilience is a key aspect of ecosystem health. Long term ecosystem sustainability requires resilience in the face of social, economic, environmental and demographic changes, and should be a key aim of management planning and practices.
Governance: Resilience may be considered an important cross-cutting issue for mainstreaming BD / ES / NC across government sectors and for ensuring coherence between various policies.	**Competiveness:** Resilience is a core component of economic competitiveness for enterprise and for cities, regions, countries etc. It is also an important element of social competitiveness, related to long-term cohesion, stability and well-being within communities. It also links to environmental competitiveness – the sustainability of natural capital and heritage assets which support societies and economies.

Recommendations

[6] There are certainly more societal challenges; the reduced number presented here is due to the four major challenges mentioned in the work programme of FP7 to which OpenNESS responded.

To incorporate the various perspectives on resilience and its wide usage across relevant sectors, we propose the following definition for resilience (based on IPCC, 2014) as an update to the term used in the OpenNESS Glossary:

"Resilience refers to the capacity of a social-ecological system to cope with variability, including hazardous events or trends or disturbances, responding or reorganizing in ways that maintain its essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation."

Three 'Must Read' Papers

Biggs, R. et al. (Eds.) (2015): *Principles for Building Resilience: Sustaining Ecosystem Services in Social-Ecological Systems*. Cambridge University Press. (Summary available on Extranet as: Simonsen, S. H.et al. (2014). *Applying resilience thinking: seven principles for building resilience in social-ecological systems*. Stockholm University, Stockholm.)

Folke, C. et al. (2010): Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and Society* **15(4)**: 20.

Weichselgartner, J. and I. Kelman (2015): Geographies of resilience Challenges and opportunities of a descriptive concept. *Progress in Human Geography* **39(3)**: 249–267.

Further Literature or cited References

Adger, W. N. (2000): Social and ecological resilience: are they related?. Progress in human geography, 24(3), 347-364.

Berry, P., et al. (2016): Ecosystem Services Bundles. In: Potschin, M. and K. Jax (eds): *OpenNESS Ecosystem Services Reference Book.* EC FP7 Grant Agreement no. 308428. Available via: www.openness-project.eu/library/reference-book

Bhamra, R., et al. (2011): Resilience: the concept, a literature review and future directions. International *Journal of Production Research* **49(18)**: 5375-5393.

Brand, F. S. and K. Jax. (2007): Focusing the meaning(s) of resilience: resilience as a descriptive concept and a boundary object. *Ecology and Society* **12(1)**: 23.

Bristow, G. (2010): Resilient regions: re-'place'ing regional competitiveness. *Cambridge Journal of Regions, Economy and Society* **3(1)**: 153-167.

Carpenter, S. et al. (2001): From metaphor to measurement: resilience of what to what? *Ecosystems* **4(8)**: 765-781.

CBD & WHO (2015): Connecting Global Priorities – Biodiversity and Human Health, a State of Knowledge Review. WHO, Geneva.

EU FP7 OpenNESS Project Deliverable 1.3, Potschin, M.; R. Haines-Young.; K. Jax, C. Görg, U. Heink, E. Kelemen, C. Kretsch, and C. Schleyer (2015): *Preliminary Guidelines for testing the draft conceptual frameworks in case study areas using methods and data resources developed in WPs 2, 3 and 4*. European Commission FP7

EU FP7 OpenNESS Project Deliverable 2.1, Schleyer C., I. M. Bouwma, E. Primmer, G. Bela, P. Berry, A. Smith, J. Hauck, K.J. Winkler, C. Deerenberg, J. young, E. Carmen, P. Bezák, J. Ŝpulerová, Z. Barankova, H.-L. Kangas, E. Preda, A. Vadineanu, and C. Görg (2015) *Paper on the policy analysis*. European Commission FP7.

EU FP7 OpenNESS Project Deliverable 4.1., Gómez-Baggethun, E., B. Martín-López, D. Barton, L. Braat, H. Saarikoski, Kelemen, M. García-Llorente, E., J. van den Bergh, P. Arias, P. Berry, L., M. Potschin, H. Keene, R. Dunford, C. Schröter-Schlaack, P. Harrison (2014). *State-of-the-art report on integrated valuation of ecosystem services*. European Commission FP7, 2014.

EU FP7 OpenNESS Project Deliverable 4.2., Braat, L.C. , E. Gómez-Baggethun, B. Martín-López, D. N. Barton, M. García-Llorente, E. Kelemen, H. Saarikoski.(2014) *Framework for integration of valuation methods to assess ecosystem service policies*. European Commission FP7.

Folke, C. et al. (2004): Regime shifts, resilience, and biodiversity in ecosystem management. *Annual Review of Ecology, Evolution, and Systematics* **35**: 557-581.

Griggs, D. et al. (2013): Policy: Sustainable development goals for people and planet. *Nature* **495**: 305-307.

Grünewald, F. and J. Warner (2012): *Resilience: buzz word or critical strategic concept?* Humanitarian Aid on the Move; No. 10. Groupe URD, Plaisians.

Haines-Young, R. and M. Potschin (2010): The resilience of ecosystems to environmental change (RECCE). Overview report, 27pp. DEFRA project code: NR0134. Available at: http://www.nottingham.ac.uk/cem/research.htm

Hanson, C. et al. (2012): *The Corporate Ecosystem Services Review: Guidelines for Identifying Business Risks and Opportunities Arising from Ecosystem Change*. Version 2.0. WRI, Washington DC.

Holling, C. S. (1973): Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* **4**: 1-23.

Hussain M. (2013): Resilience: meaningless jargon or development solution? Guardian Online, Published Tuesday 5th March 2013. Available at http://www.theguardian.com/global-development-professionals-network/2013/mar/05/resilience-development-buzzwords Access 6th July 2015.

IPCC (Intergovernmental Panel on Climate Change) (2014): *Climate Change 2014: Impacts, Adaptation and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the 5th Assessment Report of the IPCC*. Cambridge: Cambridge University Press

Kelemen, E.; et al. (2016): Non-monetary techniques for the valuation of ecosystem service. In: Potschin, M. and K. Jax (eds): *OpenNESS Ecosystem Services Reference Book*. EC FP7 Grant Agreement no. 308428. Available via: www.openness-project.eu/library/reference-book

Levin, S. A. (1998): Ecosystems and the biosphere as complex adaptive systems. *Ecosystems* **1(5)**: 431-436.

Manyena, S. B. and S. Gordon (2015): Bridging the concepts of resilience, fragility and stabilisation. *Disaster Prevention and Management* **24(1)**: 38-52

McGuire, S. and Sperling, L. (2011): The links between food security and seed security: facts and fiction that guide response. *Development in Practice* **21(4-5)**: 493-508.

MA (Millennium Ecosystem Assessment (2005): *Ecosystems and Human Well–being: Opportunities and Challenges for Business and Industry*. World Resources Institute, Washington DC.

Perrings, C. (2006): Resilience and sustainable development. *Environment & Development Economics* **11(04)**: 417-427.

Plummer, R. and D. Armitage (2007): A resilience-based framework for evaluating adaptive co-management: linking ecology, economics and society in a complex world. *Ecological Economics* **61(1)**: 62-74.

Potschin, M and R. Haines-Young (2016): Conceptual Frameworks and the Cascade Model. In: Potschin, M. and K. Jax (eds): *OpenNESS Ecosystem Services Reference Book*. EC FP7 Grant Agreement no. 308428

Sheffi, Y. (2007): *The Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage*. Cambridge, MA: MIT Press.

UN FAO (United Nations Food and Agriculture Organisation) (2012): *Measuring Resilience: A Concept Note on the Resilience Tool*. FAO, Rome.

Walker, B. et al. (2006): A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecology and Society* **11(1)**: 13.

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