**Box 1: Glossary**

**Biodiversity**: variety of life. We use the concept to include people in the living earth system; biodiversity is measured at many scales and in many ways, from genetic diversity to functional diversity to behavioral or cultural diversity.

**Feedback:** modification or control of a process by the results or effects of the same process.

**Ecosystems**: joint biotic/abiotic systems of life, characterized by dynamic stocks and fluxes of energy, materials and information and their feedbacks.

**Biodiversity**-**ecosystem function (BEF) relationship**: refers to the relationship between diversity *per se* and the magnitude and stability of an ecosystem function. BEF refers to the role diversity plays in an ecosystem function that is over and above the importance of total abundance, biomass or composition of the biological assemblage (Loreau et al 2001).

**Ecosystem functions**: the processes of energy flow (e.g., primary production), material cycling (e.g., carbon cycling) and information processing (e.g., evolution) carried out by living systems. Functions are understood to reflect interaction networks involving multiple genetic and functional elements of biodiversity, and include stocks and pools of biomass, elements and energy forms.

**Ecosystem services**: nature’s contribution to people (Diaz et al, 2019), including economic values to cultural values, in intrinsic, instrumental or relational systems (Chan et al. 2016).

**OR, this:**

**- Ecosystem services**: the value of ecosystem functions to people (MA), and originally, defined as ecosystem-based goods and services for human well-being (Braat 2018, Ecosystem Services). Although different opinions exist as they could be viewed as "rights-based approaches to biodiversity conservation and sustainable use" (Diaz et al. 2018), it is important to emphasize that the value can be assessed in a variety of ways, from economic values to cultural values, in intrinsic, instrumental or relational systems (Chan et al. 2016; Braat 2018).

**- Natures contributions to people**: another pluralistic view for the value of ecosystems and ecosystem functions to people (Pascual et al. 2017). Peterson et al. (2018) expect the view to encourage a recognition of pluralism and the need for a richer process of articulation, translation, and discussion among many different perspectives on people’s relationship with nature.

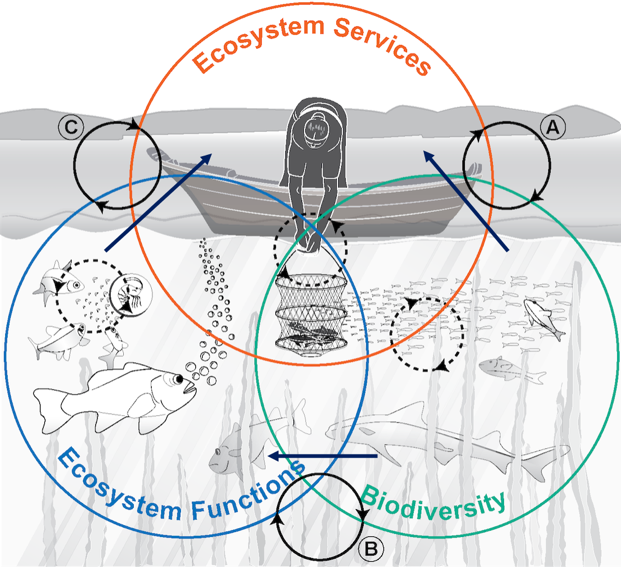
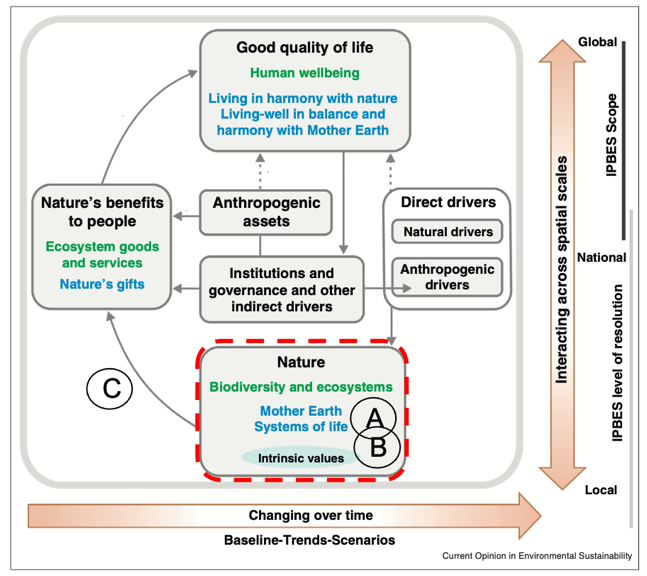
**Table 1. Feedbacks between biodiversity, ecosystem function and human well-being.**

|  |  |  |  |
| --- | --- | --- | --- |
| Context | Feedback |  | Description |
| Biodiversity-Ecosystem Function |  | | Negative feedback between plant density and of species-specific soil pathogens stabilize plant species richness (Schnitzer et al 2011). |
| Social-ecological |  | | Grassland plant and small animal diversity maintains microclimate and habitat; grazing on such habitat provides a service, but overgrazing reduces diversity which in turn leads to desertification when the feedback is disrupted (Odorico et al, Chillo et al 2017). |
| Social-Ecological | (figure copied from Cumming and von Cramon-Taubadel, 2018) | | Negative feedbacks between the dependence of GDP on ecosystem services and economic development have been invoked to explain stability of countries on trajectories of greater or lesser sustainability (Cumming and von Cramon-Taubadel, 2018) |
| Social-Ecological |  | FIGURE COMING FROM LAURA DEE | When biodiversity is an input to services, decisions about biodiversity protection alter current levels of ecosystem services and feedback to affect future biodiversity and thus ES. (Dee et al., 2017) |

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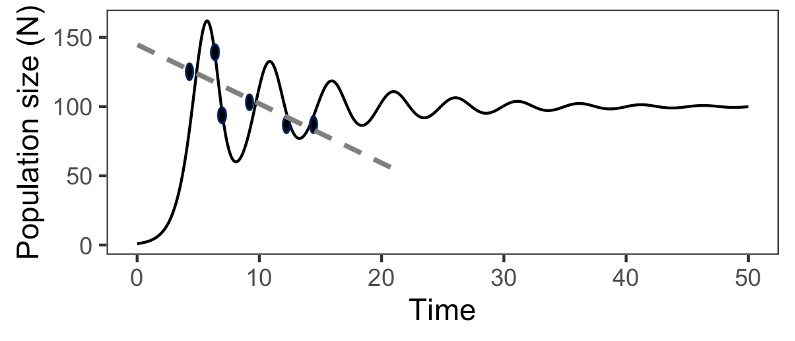
**Figure 1. Concepts of biodiversity, ecosystem functioning and ecosystem services join different aspects of a single biosphere. A)** One example of a more local feedback between biodiversity, ecosystem functioning and ecosystem services occurs in some aquatic systems in which invertebrate and vertebrate diversity enhance biomass production and thereby elevate ecosystem functions food webs; this may be harvested for food and livelihood by people, and harvesting may maintain some fish at high population growth rates by reducing population densities thereby maintaining biodiversity. Within each element (biodiversity, ecosystem functions and humans) feedbacks occur (dashed arrows) that can stabilize or destabilize systems (see Figure 2), and feedbacks across these elements (solid arrows) can also stabilize or destabilize the system at a larger scale. Direct one-way effects are most often the focus of experiments and policy syntheses and these are indicated by straight arrows. **B)** The conceptual framework for the IPBES framework (2015) (Díaz et al., 2015) emphasizes feedbacks between humans and nature, but by including a single box for nature under-emphasizes the feedbacks within nature such as those emphasized in Figure 2.

A) B)  

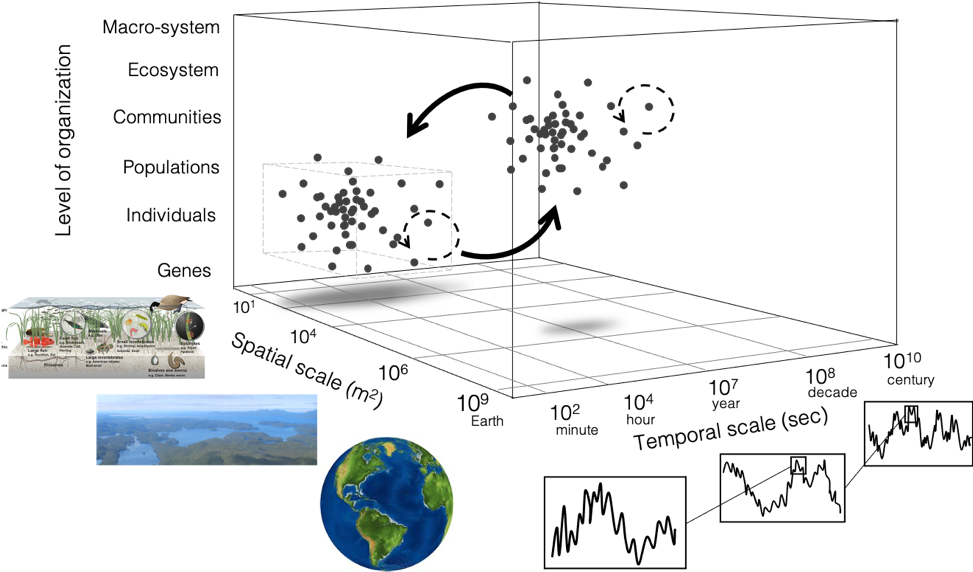
C this is a draft – Sylvia is working on a pollinator figure comparable to what we have in figure 1a for seafood



**Figure 3. Illustrations of knowledge gaps associated with feedbacks. A)** Often we observe populations or species assemblages in nature in regular surveys. Points in this panel illustrate hypothetical observations that might be made once every few years in a population whose temporal trajectory is defined by density dependent feedbacks (Box 2). If researchers simply fit a regression to the observed population sizes over time, without considering the population dynamics, a forecast might be made of severe population decline (dashed line). In contrast, if population modeling suggested feedbacks were at play, managers might consider the population to be stable. *If anyone is inspired to contribute a figure for additional knowledge gaps, I welcome it!*

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**Figure 4.** To address the challenges we face understanding feedbacks between biodiversity, function and human systems across scales, we must use models, experiments and observation systems that explicitly address feedbacks and scales of space, time and biological organization. A) Current observation or experimental programs tend to focus in one part of this space – for example, generating data within the dashed box – and we argue that we need to develop approaches for understanding feedbacks that would relate observations at scales within the focal system (the box) and at other scales (the upper right hand cloud)(modified from Gonzalez et al 2020). B) When possible, the knowledge we generate via observations, theory, models and experiments must involve the biodiversity, ecosystem function and human components at each level. The data in panel A are shown here, illustrating that we should strive for observations and understanding of how biodiversity, human activities and ecosystem functions change at the same levels of spatial and temporal resolution, in the context of other spatial and temporal processes (panel A).



B)

