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Environmental Stewardship and Ecological Solidarity: Rethinking Social-Ecological Interdependency and Responsibility

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Abstract

This paper explores and discusses the various meanings of the stewardship concept in the field of sustainability science. We highlight the increasing differences between alternative approaches to stewardship and propose a typology to enable scientists and practitioners to more precisely identify the basis and objectives of the concept of stewardship. We first present the two dimensions we used to map the diversity of stances concerning stewardship. Second, we analyze these positions in relation to the limits of the systemic approach, ideological manipulation, responsibility, and solidarity. In the final section we explain how the concept of ecological solidarity, a core principal in recent French law on biodiversity conservation and national park governance can contribute to the underpinning of a specific form of socialecological stewardship.

Keywords Environmental ethics, Solidarity, Biodiversity conservation, Socioecosytem, Sustainability

Introduction

The effects of human impacts on natural ecosystems around the World and the functioning of global climatic drivers has stimulated thought on how we now live in a new geological era, the Anthropocene. What this means

is that human societies have begun to depend more and more on many features of Planet Earth that in turn depend more and more on us (Mathevet 2012). This basic observation puts the focus on how human impacts occur on a global scale and the growing importance of feedback loops in our concern for nature and the future of humanity (Rozzi et al. 2015; Young et al. 2016). The idea that we are in the Anthropocene era questions the opposition between anthropocentrism and non-anthropocentrism because of the catastrophic nature of the processes that now threaten bio- diversity and humanity (Corlett 2015; Callicott 2013). Because of the local and global consequences of their actions, humans even though they may not intend to do so, have become directly or indirectly the managers of nature, and are thus accountable for their actions (Mathevet 2012). This situation strongly invites us not only to make better use of nature but also to pay attention and even take care of nature (Larrère and Larrère 2009, 2015). In response to global change we still need to develop a new conceptual framework for public actions grounded in the real world of interdependence between humanity and the biosphere (Folke et al. 2011).

During the last four decades, the concept of "environmental stewardship" has emerged as a key tool with which to define the environmental ethics of various organizations (i.e. governments, NGOs) at different decision levels (Passmore 1974; Berry 2006; Rozzi et al. 2015). Stewardship has both religious and secular interpretations (Passmore 1974; Attfield 2001; Wunderlich 2004; Plieninger et al. 2015). From a traditional perspective, stewardship is a form of guardianship in a long-standing association with land-holdings, i.e. an on-going relationship between stewards, land and the humans and non-humans in their care (Welchman 2012). Stewardship also comprises a set of moral virtues such as loyalty, temperance, solidarity, diligence, justice, integrity, practical rationality and wise use. However, contemporary environmental stewardship is marked by the absence of both an appointment by some form of supra (religious) authority, and any mon- etary compensation. Some authors (Palmer 2006; Plumwood 1999; Beavis 1994) have argued that this concept is not in line with nature or with biodiversity con- servation because stewardship originates in traditional social systems based on patriarchal, elitist, sexist, speciesist and anthropocentric or inegalitarian relationships and a narrow Judeo-Christian religious position (White 1967; Welchman 2012). In her analysis of these objections, Jennifer Welchman (2012) showed that policy-makers, practitioners and NGOs have altered and expanded the concept in new ways, aiming to replace old notions of human/nature relationships such as ownership and conquest (i.e. where humans are "masters and owners/possessors of nature", Descartes 1962).

From the early to mid-20th century, the American Country Life Association contributed to defining and promoting a consensus on what rural life in the USA actually was (Merwin 1977). Based on criticisms of Judeo-Christian ethics and on the growing concerns of ecologists about the environment after the Second World War, this association progressively promoted a man-in-nature perspective where humans represent caring stewards of non-humans for which they are responsible (Wunderlich 2004). This stewardship also has its roots in the *land ethic* developed by the North American naturalist and thinker, Aldo Leopold (Leopold 1949) who promoted the integration of human relationships into the communities in which they exist (Callicott 2013).

In the 1990s, the development of various stewardship programs to support bio- diversity conservation efforts were initiated first by conservation NGOs, as well as by private landowners and natural resource managers and then by local and national governmental services, especially in North America, English-speaking countries in general (Callicott et al. 1999; Chapin et al. 2011) and Western Europe (Ode Sang and Tveit 2013; Raymond et al. 2015). Environmental stewardship is defined as a form of responsible management of human activities according to their impacts on the natural environment in order to ensure the conservation of biodiversity, natural resources and their values in terms of use and non-use for future generations of humans and non-humans (Mathevet et al. 2018). Interest in the concept of steward- ship is growing in the literature of sustainability sciences and conservation, especially with regards to the use of natural resources and in relation to agri-environmental programs (Raymond et al. 2016; Hejnowicz et al. 2016) and protected area management (Mathevet et al. 2016; Jepson et al. 2017).

Stewardship adds an important dimension to the human preference for land- scape conservation. In the context of social-ecological systems (SES), the steward- ship approach aims to enhance ecological resilience and to support the provision of ecosystem services for human wellbeing. In urban environments, the stewardship approach engages networks of community-based urban land management to provide green infrastructures and establish ecosystem services in cities (Beavis 1994; Fisher et al. 2015). Stewardship is also a factor in incentive policies that encourage sustain- able farming, logging or fishing or the protection of privately-owned land (Mathevet et al. 2018). There is thus a plurality in the understanding of stewardship linked to various sets of

norms, values and land management actions. Calls to serve the public interest, for instance in the preservation of locally threatened species or to rein- force the interests of future generations, combined with an invitation to individuals to appoint themselves as stewards are the main features of stewardship (Welchman 2012). In a voluntary-based approach, anyone can be involved in a stewardship programs, be they sponsored or not by governments, and can be engaged in the reduction or mitigation of the negative environmental impacts of their own activity as developed in the Forest or Marine Stewardship Councils during the 1990 s, despite some critical limits (Christian et al. 2013).

The extensive use of the stewardship concept by practitioners and academics involves a variety of stances that have key differences in terms of analyzing and understanding change and the definition of human/nature relationships. The objective of this paper is to explore and discuss the various stances on stewardship development in the fields of sustainability sciences and biodiversity conservation. Moral and ethical dimensions and the understanding of social-ecological change underpin modern stewardship policies and their efficiency. In this context our aim is to highlight the increasing differences between the various stewardship stances and to identify citizen participation and the systemic approach as principles to help conservationists to put the stewardship concept into practice. This work does not aim to be an exhaustive review or to provide quantitative analysis but rather to expose the state of the debate on the stewardship concept and also to highlight the concept of ecological solidarity that is a central concept of recent French policy for national parks (2006) and an umbrella concept of the new biodiversity law (2016). Because ecological solidarity promotes a vision in which human beings are part of the social- ecological community and have a responsibility, a moral duty, to understand and develop actions according to their impacts on the components of that community (Jonas 1979; Thompson et al. 2011; Mathevet et al. 2016), we argue that ecological solidarity provides guidelines for what we called "socialecological stewardship". We first present the two dimensions that are used to map the diversity of stewardship approaches. Second, we discuss these dimensions in terms of the limits of the systemic approach, ideological manipulation, responsibility, and solidarity. In the final section, we examine the concept of ecological solidarity and its contribution to specific social-ecological stewardship.

Moulding a Typology of Stewardship Stances

The ethical aspects of stewardship provide rational and moral support for human/ nature relationships (Callicott 2013; Norton 2005). The values assigned to nature by human beings are not always human-centred and the stewards' values assigned to natural entities are not always instrumental values but may also be spiritual, aesthetic, scientific, or cultural (Norton 2005). The preservation of these values is a moral duty, which means that stewards should have equitable concern for all instrumental, non-instrumental, anthropocentric, and non-anthropocentric sets of values (McShane 2007). Thus, the implementation of environmental stewardship is based on a process that deals with the plurality of values and interests in order to accommodate divergent views (Norton 2005; Barrett and Grizzle 1999). Trade-offs need to be made among community members (Worrell and Appleby 2000).

The Citizen Participation Dimension

The stewardship concept is based on social engagement for sustainable development and biodiversity conservation, and thus should be positioned in the context of citizen participation. Stewardship cannot simply take citizen involvement for granted, but should question what it means. Citizen participation can refer to elementary information and consultation or partnership and citizen empowerment (Arnstein 1969; Pretty 1995), and this distinction forms one dimension for categorizing environmental stewardship stances. A basic and simplified gradient of participation may help to analyze this dimension. At the bottom level of this gradient we observed processes based on expert knowledge where power holders (i.e. elite, top-level decision-makers, scientists) educate, inform or consult citizens or participants (e.g. within the management of French National Park before the law of 2006). Further up the gradient, citizens are integrated in a partnership and cooperative process that enables them to engage in negotiations on potential trade-offs with power holders, such as international corporations, scientists or state services (e.g. French regional natural parks following their creation in 1967 are based on an agreement between local authorities and the national government in order to protect the natural and cultural heritage of a specific area and to promote sustainable development activities). At the top of the gradient, citizens are fully engaged in the decision-making process and control its management and design (e.g. the Pastoral pact of the "Causses Aigual Cevennes" in the south of France is based on negotiated rights among stakeholders such as elected representatives, landowners, conservationists and livestock breeders, mixing local customary laws with national and supranational laws, Barrière and Bes 2017). The issue here is to characterize the interactive political relationships of the stewardship process that mixes competition and cooperation, partnership encompassing government and a vision of complex interconnections between people and nature. This questions the kind of participatory process that is developed (information, consultation, cooperation), what cultural relationships relate people to decision making and collective work and how the process allows for the exploration and integration of the plurality of values and interests.

In order to pinpoint more precisely the various postures related to this first dimension we suggest that anyone involved in a stewardship approach can consider their actions in relation to the stewardship in three ways. First, in terms of their *relation- ship to nature* one can ask whether nature is subordinate to human problem solving and control, or whether people are subordinate to nature or state, economic growth or environmental protection. It is interesting here to ask whether people consider they are part of a nested network of social and ecological systems where they can act individually and collectively. Second, stewardship *governance* may be based on a polycentric, centralized or decentralized model potentially driven by scientists and experts, by conservation NGOs and citizens or by elites and top-level decision makers. A major question here concerns whether we have the capacity to modify rules and the decision-making system and to change norms and principles of rule-making and implementation, and to transform the governance and human agency in creating a more just society. Third, there are questions concerning who may be the *decision agents* in control of the stewardship process and its reform? The answer could be State services, scientists, stakeholders, NGOs, corporations, inhabitants or entrepreneurs, or a mix of several or all of these actors.

The System Thinking Dimension

A second dimension would take note of the fact that the understanding and study of the relationships between ecological and human systems and organizations can be based on either an engineering approach or a complexity approach (Mathevet and Bousquet 2014). In the engineering approach the system is an object, an engine, and the objective is to discover how it is organized and how it functions. With the work of automation engineers as foundation, electronics engineers (Wiener 1948; Shannon 1949; McCulloch 1988; Forrester 1991) looked at the models, principles and laws applying to generalized systems or their subsystems. This domain has been conceptually fertile, producing the notions of feedback, delays, information flow, command and control, viability and many others. In this approach, the behavior of any system depends essentially on flow and state variables that link ecological and economic components in an integrated model. Subsystem dynamics are controlled by stock of capital. The theoretical assumptions and the tools used by this approach aim at studying properties of the system: how does the system escape undesirable attractors? What is the trajectory of the system when thresholds are crossed? Can we observe regime shifts?

In contrast, the complexity approach focuses on the behavior and interactions among entities and the objective is to identify the different patterns that may emerge from these interactions and in turn influence those interactions. The general state of a set of interacting entities may converge toward attractors, may be disordered, or may exhibit patterns of organization that change from one to another in unpredictable ways (Wolfram 1984; Langton 1992). To study these systems, the observations focus on the connectivity of the entities, their interactions and their organization across various scales. Furthermore, some entities of the system are conscious of being part of a system and may decide to change its organization in terms of their own behavior and their connections with other entities. The theoretical assumptions of this approach, and the tools used, aim at studying the patterns that emerge from heterogeneous behavior and interactions: which configuration of entities react and make decisions when perturbation occurs?

Four Different Postures

Based on these two dimensions—citizen participation level in environmental conflict resolution and system thinking—our analysis of sustainability science and biological conservation works reveals four different postures (Table 1).

The first posture, or "global stance" posits that nature consists of complex, adaptive and dynamic ecosystems.

Their states reflect their resilience to changes usually induced by human activities. Humankind appears here primarily as a user or as a destructive force of the environment. Protecting ecosystems is thus a moral choice, fuelled mainly by the life sciences—biology and ecology—but also by a management approach similar to an entrepreneurial form, and gives a central place to policymakers and experts. This design is anchored in the theories of management of the Earth-system and the characterization of planetary boundaries (Rockström et al. 2009). Science tries to be predictive and to co-pilot the Earth as a spaceship. This approach does not fundamentally call into question the development model, even if it is open to uncertainties and to criticism from social sciences. Here we find the techno-scientific approaches that provide geo-technocratic solutions to global problems such as blocking sunlight to cool Earth or carbon dioxide removal through ocean fertilization (Morton 2016; Preston 2016). Of course, different framings of climate geoengineering exist and behind the term "geoengineering" strategic and political issues are high and competing, as are their implications in terms of govern- ance and public engagement (Cairns and Stirling 2014). This "global stance" based on techno-scientific approaches is often perceived as likely to be a major threat to democratic governance (Macnaghten and Szerzynski 2013).

Table 1. A typology of postures (italic) and stewardships (bold) according to citizen participation level and systemic approach.

		System thinking approach	
		Engineering approach	Complexity approach
Citizen participation level (from non-participation to citizen control)	Information Consultation	<i>Global</i> Planetary Stewardship (i)control, (ii)central, (iii) elites and scientists	
	Consultation Partnership	Plural Ecosystem Stewardship (i)problem solving, (ii)decentralized, (iii)experts and managers	Pluralist Landscape Stewardship (i)plurality, (ii)polycentric, (iii)conservationists and managers
	Partnership Citizen control		Solidarity Social-Ecological Stewardship (i)partnership, (ii)polycentric, (iii) local citizens and scientists

Parameters are: (i) relationship to nature; (ii) governance; (iii) decision agents. Empty boxes mean that the posture is theoretically possible but not observed in the literature, probably due to unsolved operational antagonisms between parameters

The second posture, or "**plural stance**" attempts to reconcile the stakes of con- servation and those of development and emphasizes the integration of the social and ecological spheres. It focuses on the management of natural resources and the envi- ronment and seeks to develop a human society more concerned with and involved in environmental issues (Chapin et al. 2009). This posture is also embedded in an engineering approach, counting on both an administrative regulation and a mar- ket-based approach. It supports the idea that the market economy can benefit from this posture: nature—in all its forms—can then appear as capital to be developed through ecosystem services. For instance, biodiversity conservationists who believe that positive outcomes in which people benefit from biodiversity conservation can be achieved by promoting economic growth and private corporations' partnerships or integrated conservation and development projects, share this stance (Kareiva and Marvier 2012; Noss et al. 2013).

The third posture, or "**pluralistic stance**", is built on the descriptive and analytical capacity of the first two approaches, but integrates a plurality of perspectives and value systems: those of stakeholders. The decision-

making process is more open — the system is based on less institutionalized expertise. On the other hand, if humans are part of nature, the relationship is not designed in mechanistic terms (force to control or economic calculation) as in the first two positions. Moreover, the approach is more interdisciplinary and collaborative. It incorporates the expression of different points of view, but without really questioning the meaning of interactions between social groups or their inclusion in a broader, but equally decisive, set of links. Here we find the literature on the management of landscape or natural resources based on local communities (Berkes and Folke 2000; McGinnis 2005; Bieling and Plieninger 2017).

In a fourth posture, or "**social-ecological stance**", the issue of resilience relies more on knowledge of ecological and social interdependencies organized within net- works of interactions. Stakeholders' value systems are studied in order to understand the social connections and processes they share. Beyond the relationship between people and nature, this approach emphasizes the relationship between people and nature, including its emotional and cultural dimensions (CENLR 2014). The question is one of "living together" within a wider community enlarged to include non- humans: the social-ecological community. Here we find the works on adaptive co- management, collective actions and participatory modelling (Armitage et al. 2017; Mathevet et al. 2018). Drawing on the assessment of the adaptive co-management of various social-ecological systems such as marine protected areas and fisheries, numerous authors have shown how this approach can be seen as successful as it supports, on the one hand multiple understandings of knowledge and environmental issues at both the local and regional level and, on the other, explicit attention to the learning and collaboration functions (Armitage et al. 2009, 2017; Gutiérrez et al. 2011).

The first two positions can be observed in the *planetary stewardship and ecosystem stewardship* approaches (Table 1), the third in *landscape stewardship*. In the fourth position (*social-ecological stewardship*), what dominates here is, in contrast, the logic of linkage, the interdependencies between natural and human spheres.

Highlight on Four Key Points

Each type of stewardship is carried out at different spatial levels (from ecosystem or landscape levels to earth level), organizational levels (from local management agency to United Nation Agencies) and is built on various kinds of knowledge (science and lay knowledge), all claiming complex system dynamics analysis, multilevel and multiscale dynamics and also interdisciplinary approaches to environmental issues. Here, we address the limits of the systemic approach, actual or projected ideologies, responsibility, and the solidarity that underpins stewardship.

Stewardship and the Systemic Approach

The use of the systemic approach has generated much debate. One objection challenges the very existence and purpose of the system. A conception of the system as a whole would erase the diversity of points of view, the complexity of ecological and social processes, and power relations between different positions. The advocates of the systemic approach tend to respond by stressing the importance of the difference between two uses of the concept of system (Ison 2010). There is, on the one hand, an approach that actually thinks that the system does exist (ontological approach), it may be considered as a super-organism, and on the other hand, an approach which says that the system is a useful intellectual construction to help thinking (epistemological approach). The extension of this systemic approach to the social system, generally by ecologists, supposes an analogy between nature and society; this has generated strong reactions from social scientists (Foster and Clark 2008; Cote and Nightingale 2012). It is necessary, as well, to be vigilant regarding the effective con-sideration of the multiplicity of social processes and the diversity of views or positions. We note here that the engineering systemic is a form of "closed holism" that promotes the community of destiny (e.g. the planet as spatial vessel within planetary stewardship, Table 1), while in the open holism (or systems thinking) we may find solidarity. The community of destiny reminds us that we have no choice and could thus be understood as an "is/ought" fallacy, while ecological solidarity via social- ecological stewardship considers a diversity of choices and opportunities. Another way to address the systemic dimension of stewardship can be based on its invitation, given or not, to go beyond dualism, both from the ontological and moral points of view (i.e. with the expansion of the moral concern to include nonhumans, Callicott 2013).

The second objection to the systemic approach arises from the need to clarify the limits of the system. What is part of the system and what does not belong to it? How are the limits to be defined and who defines them: the stewardship of what by whom? Who are the stewards? The answers to these questions will determine the relevance of the delimitation of the spatial, temporal and social system. The geographical boundaries are often crucial. But in an increasingly connected world, where people, information and capital move easily and where ecological processes are linked and dependent on global climate change, defining the spatial boundaries of a system is more and more difficult. The social context must also be defined: adaptation to change cannot be explained by the technological, ecological or eco- nomic characteristics of the system only; we must also consider the social context that can greatly constrain the stewardship process.

The third objection is that the systems approach tends to neglect relationships between individuals, the role of power and structural arrangements (Cote and Nightingale 2012), in favor of a more functional design based on consensus. The stewardship processes often propose an analysis of institutions or arrangements between actors that is too simplistic or too much influenced by the epistemic baseline of ecologists; it does not sufficiently integrate the question of power (Hornborg 2009). Stewardship approaches based on ecological management projects are not neutral from a socio-economic and political perspective just as socio-economic projects are not from an ecological perspective. It seems essential in any stewardship process to explicitly integrate the political dimensions of knowledge production: when an agent of the landscape enhances the stewardship of a social-ecological system this also promotes a set of socio-ecological relationships that characterize the functioning of the desired system (Mathevet and Bousquet 2014).

Stewardship and Ideology

The concept of stewardship is not protected from political and ideological manipulations. This concept is used by those who are critical of the current development model and who attempt to identify new models on a basis of coordination, regulation and solidarity, but also by those who see the individual and the entrepreneur as a source of innovation for change.

The degradation of social-ecological systems has its origin in the non-rational industrial extraction of natural resources and the development of the agro-industrial capitalism. In the central areas of the world-system, money and technology accumulate at the expense of natural resources, environment and the health of peripheral areas, the latter being emptied then filled with wastes and pollutants (Hornborg 2009; Castree 2000). The exploitation of people and nature are two sides of the same coin. The concept of stewardship in its dominant forms (i.e. planetary and ecosystem stewardships, Table 1) is criticized because it primarily suggests that local adaptations bear the consequences of the dominant development model, instead of the global economic model at the root of many environ- mental problems being changed. Adaptive co-management projects would lead to small successes very circumscribed in time and space (i.e. in some protected areas or during a short-term project that focuses on the management plan of natural resource, Brandon and Wells 1992), and sometimes to conventional management dressed in new words. In a world system dominated by resource exploitation, it would not be sufficient to correct the global capitalist model by preserving what this model has made vulnerable. Trust and consensus could not compensate for major asymmetries of power and interests.

The concept of stewardship is used in numerous scientific communities, among major donors and development, humanitarian or nature conservation agencies. Stewardship is then sometimes manipulated to justify local action and responsibility at the expense of the planned action and centralized or shared responsibility. The latter is redistributed from government to ordinary citizens, who become the entrepreneurs of their lives and the stewards of their system. Local social groups and individuals are encouraged to take responsibility and to develop their stewardship engagement.

Such an interpretation does not question the social and political system, geopolitical dimensions of ecological disasters or resource scarcity; it focuses on the questioning of collective action, humanitarian aid, development assistance or solidarity; it promotes the neoliberal policies imposed under the pretext of adaptation, steward-ship development, social deregulation and individual responsibility according to the recipes of business management. The promotion of innovation, leadership and entrepreneurship could lead, if we are not careful, to further opportunistic commodification of goods and services by international operators already in place (Spash 2015). We must learn to remain critical of those who promulgate the crisis as well as of those who promote the system stewardship—often a strong or potentially powerful actor within the social system (Brockington and Duffy 2011). Therefore, social and environmental justice must be present in all stages of the analysis of the stewardship process,

for those who drive it as well as for those involved in its implementation.

Stewardship and Responsibility

The capacity of actors to develop a sound-stewardship approach is based on their position in the flow of resources and power networks of the world-system. As many environmental problems or biodiversity conservation issues are longitudinal to collective action problems (Sandler 2010), they may arise from the cumulative unintended effects of numerous individual decisions and actions from people who are unaware of their interdependence with other people or places. Because changing ways to do things or changing lifestyles may be costly, the problem of "unconsequentialism" arises. For instance, we cannot assign responsibility for human-induced climate change to individuals (Jamieson 2014) with climate change being the con- sequence of many intentional and unintentional—but also direct and indirect—individual acts that have transboundary effects in various spatial and time scales. The narrative of global change thus undermines responsibility assignment at the individual level; moralizing individual action takes time (Clayton 2012) and placing our hopes on shifting individual actions by claiming respect for nature is also uncertain in terms of efficiency in the short-run.

In this context, the issue at stake is also to make responsibility collective, the real moral obligation is to push governments to do something to curtail the negative effects of global change (Gardiner 2011). If no one is responsible for something, the responsibility must be shared, making the matter a political issue (Gardiner 2011). This contrasts with attempts to assign responsibility to individuals, that stem from *new management* practices linked to neo-liberal philosophy. However, institutional economy shows that national or international, private or public, institutional levels of action are not enough (Ostrom 2009). Individual involvement and collective commitment are key to changing lifestyles and behaviours (Clayton 2012). Thus, some authors have argued that virtue-oriented ethics might be more efficient (Sandler 2010). For instance, Di Paola (2015) argued that a virtuous stewardship such as gardening is useful in considering the direct and indirect outcomes of our actions. The acknowledgement of a "sense of place" in a wider network of interdependencies helps to affirm cheerfulness, freedom and dignity and promotes local success in tasks that are never-ending. Other authors have distinguished relational responsibility from substantial responsibility: to make people liable or accountable, the issue at stake is mostly to emphasize that we are in networks, and that we have to fight against indifference; in the era of the internet we cannot say we did not know.

In this perspective, Young (2006) developed the "social connection model" of responsibility postulating that all agents who are aware that they contribute by their actions to structural processes that produce social and environmental injustice have the responsibility to work to remedy these injustices. Even if some authors have argued that local successful experiences rarely spread, for instance in integrated conservation and development projects (ICDP), and are not adequate to change processes that harm people and nature (Brandon et al. 1998), we may consider that the stewardship approach may well result in emergent global collective action. Indeed, contrary to the "invisible hand" of Providence theory of Smith (i.e. individual actions guided only by each individual's personal interests can contribute to the wealth and well- being of the whole society) where the Scottish Enlightenment conception of unintended outcomes leads to naturalizing economics (Larrère and Larrère 2015), Sartre (1960) and his "practico-inert" concept (i.e. anything that is produced by human praxis and freezes into the inertia of matter and which serves nobody's interest), underlined the negative unintended consequences ("counter- finalities") and allowed for thinking of the historical causality that helps to identify human responsibilities (Young 2006). *Mutatis mutandis*, the practico-inert, the cumulative effects as the invisible hand is an emergent property of social-ecological community dynamics.

Indeed, there are two differences to be considered apart from the one already mentioned (i.e. the invisible hand leads to a naturalization of phenomena, whereas the practico-inert helps to identify those phenomena's connections to human responsibility). First, the practico-inert implies the accumulation over a long period of similar actions whereas the invisible hand balances (dissimilar) actions over a relatively short time period. Second, the invisible hand produces goods only if there is no intentional intervention exceeding the interested and rational actions of individuals. In so doing, the invisible hand emphasizes the perverse effects of any willingness to change the spontaneous order of market practices. By underlining the perverse, or even in the long run disastrous, impacts of the routine the practico-inert does not exclude intentional actions. On the contrary, it even calls for measures preventing the accumulation of similar practices over time and their transformation that, in a com- mon destiny, could be harmful to all, humans and non-humans. Thus we can argue that despite the scale and complexity of anthropogenic impacts on Earth ecosystems, the non-linear causation and the fragmentation of

responsibility in the Anthropocene, the increase of stewardship experiments within the social-ecological network of interdependencies may connect individuals aware of how they are embedded in the same social-ecological processes, and as an emergent property, how they have to change the structures that are leading to unjust and undesirable outcomes and to a lack of solidarity.

Stewardship and Solidarity

The term solidarity comes from the Latin *solidus* meaning literally "solid", "whole", "consistent". Regarding abstract entities, living things or not, solidarity is a relation- ship of causality, a dependence, a relationship of interdependence (Mathevet et al. 2010). More generally, solidarity is the feeling of responsibility and mutual dependence within a group of people. The term "Ecological solidarity" was used in two French national laws for national parks policy in 2006 and biodiversity conservation in 2016 and has recently been cited in the sixth session of the intergovernmental science-policy platform on biodiversity and ecosystem services in March 2018 (i.e. a summary for policymakers of the thematic assessment of land degradation and restoration, IPBES 2018, p. 16) to emphasize that humans and ecosystems not only interact but are interdependent.

The reform of national parks introduces (Law 2006-436 of 14 April 2006) the new concept of Ecological solidarity into French environmental law and uses it to establish the membership area. The law specifies that a national park "is composed of one or more core areas, defined as the terrestrial and maritime areas to be protected, as well as an area of membership, defined as all or part of the territory of the communes (i.e. the French lowest administrative unit) which, having the vocation to be part of the national park because of their geographical continuity or their ecological solidarity with the core area, have decided to accede to the charter of the national park and to voluntarily contribute to this protection". Thus, this notion of ecological solidarity operates in two steps: during the elaboration of the park project, the concept must guide the identification of the zoning and especially the optimal area of membership; and when the national park is created, Ecological Solidarity is "implemented" through the commitments made by the communes that accede to the Charter to protect the core area of the park, and those made by the state in the core area to ensure the maintenance of economic activities within the membership area. This area, in the sense of the concept of Ecological Solidarity, is no longer a basic buffer zone, but an area that contributes to the protection of the heart of the park and that is benefiting from these protection efforts. On another level, the Ecological Solidarity is one of the "fundamental principles" of the environmental law voted in 2016. The Article L. 110-1 of the Environment Code states that Ecological Solidarity "requires taking into account, in any public decision having a significant impact on the environment of the concerned territories, the interactions of ecosystems, living beings and natural or built environments".

Thus, the Ecological Solidarity concept is based on two main dimensions: (1) on Ecology (i.e. biophysical and functional interactions), and (2) on the solidarity among people with a shared goal and a sense of community (Mathevet et al. 2010; Thompson et al. 2011). This highlights the biophysical roots of the concept. Following the well-known Russian biogeochemist Vladimir Vernadsky, the biosphere can be defined as all living things (including humans) and the dynamic relationships and interdependence between them and the non-living components of the planet. This means that biodiversity conservation issues go well beyond the perimeters of any protected areas (Janzen 1983). It is therefore necessary to be able to understand, explain and manage the links that exist between the spatial organization of natural habitats on the landscape scale (patterns) and the ecological systems (Turner 1989; Theobald et al. 2000). It is important to recognize the reciprocity of these interactions: nature, in a national park for instance, depends for its efficient functioning of the surrounding areas (Hansen and DeFries 2007), the human activities outside the protected area can influence the biodiversity within the PA itself (DeFries et al. 2007). This is where ecological solidarity takes on its full meaning.

Hence, the transition from the concept of ecological interdependence to the concept of "ecological solidarity" highlights the common destiny humans share, their societies and the rest of nature, as well as the importance of being aware of interdependences when choosing a development trajectory. Ecological solidarity is then defined as the set of interdependencies among living organisms, and the fact that they evolve with their environment. It therefore includes issues related to environmental interdependencies and to the functioning of socio-ecological systems and is based on the need to adopt natural resource management and biodiversity policies that are both responsible to and respectful of their members (i.e. humans and non-humans).

In our view Ecological Solidarity is not synonymous with ecological and/or social interdependence: solidarity is chosen, interdependence is often not, and this is the main difference. Ecological solidarity is the moral and positive attitude derived from acknowledging objective social and ecological interdependencies. It actually leads to affirming the plurality of interdependencies, and therefore to thinking of the diversity of the valuation methods and values associated with them. Beyond taking note of interdependencies, we have to question how we take individual and collective responsibility for the social and environmental consequences of these interdependencies. Insofar as a human community develops a respectful approach to knowledge and to the sharing of socio-ecological interdependencies—showing the invisible, exploring what holds humans and non-humans together, by querying the value of the components of biodiversity and the links between them in a world held in common—it strengthens its adaptability and resilience to crises (Mathevet and Bousquet 2014).

Ecological Solidarity is anchored in the political will or in the political representation of non-humans, and is rooted in material forms, enshrined in landscapes. It considers the double human and natural heritage of the environment. The studies of the management of common-pool resources (Ostrom 2009) showed that, unlike the dominant modern western model of land property ownership, traditional collective institutions of natural resource management such as water, are part of a form of stewardship in which human beings are obligated at the same time towards the environment that pre-exist to them (and of which they are parts) but also places them in a "chain of actions and choices" made by successive generations over time. Ecological solidarity then contributes to the process of taking into account the materiality of landscapes and territories and all the natural and human-related processes that have shaped and still produce the environment today.

Ecological solidarity thus provides a valuable basis for the stewardship approach (see Mathevet et al. 2010, 2016; Thompson et al. 2011 for some examples of Ecological Solidarity applications). Paying attention to biodiversity, protecting spontaneous nature and taking care of human-made nature and natural resources could be the leitmotifs of a new social and ecological stewardship. To avoid the pitfalls of universalism, of pluralism or of moral relativism, and to collectively forge territories capable of reconciling human activities and biodiversity, we have to consider that humans are always linked with other living beings, their identity being first and foremost ecological, as they are always in relation with nature (Plumwood 2002; Mathevet et al. 2016). In other words, adopting a social-ecological stewardship stance means dealing with ecological solidarity that stands for reconnecting facts, values, valuations, decisions and actions. We thus have to fill a double deficit: one concerning a lack of recognition of nature, rather than merging with it, and the other concerning a deficit of recognition that we live in a fragile and vulnerable socio-ecological community in which the ecological consequences of our own actions can be detected (Nussbaum 2006).

Concluding Remarks: Towards Social-Ecological Stewardship

The stewardship concept engages science, ethics and praxis to shape decisions and actions (DeWitt 2006). We have shown that there are several ways to envision stewardship in theory and practice. Our results, highlighting knowledge of different citizen participation levels and ways of dealing with the systemic approach that support these different stewardship stances, may help in developing a clearer vision of what stewardship is and who the stewards of the social- ecological systems are. Stewardship still needs to integrate the core mission of public bodies and research needs to develop more consideration for rights, power and social issues related to land access and land management. Without a social community there is no social-ecological community, thus the design of steward- ship should aim to explore relationships between ecological processes, value systems and valuation methods, decision-making process, individual and collective actions, economic system and public policy. By placing the relationship to the biosphere at the centre of reflection, ecological solidarity revives the traditions of many non-Western cultures. It appears therefore as the cornerstone of a socio- ecological stewardship. Our "interactions" with nature are also functional "inter- dependencies", and are as well "interrelationships" that we create with nature and other humans. Our "co-existence" with wildlife is also "interexistence". In this context, new levers would be complementary to the previous ones, but are still not being used: the need for social recognition, the social demand for joint responsibility. Respect and care (Merchant 1996, 2004) for nature are the means to set both our duties and the limits of our action on nature (Serre 1995; Nussbaum 2006). Socio-ecological stewardship considers, pragmatically, that we can increase the resilience of a system by using science and social knowledge. Participatory exploration through modelling experiments of social-ecological system dynamics can give social, economic and symbolic dimensions to interdependencies (ComMod 2003, Etienne 2011). Such a participatory approach can be useful to integrate the plurality of perspectives and for considering collectively the social-ecological community made by humans and non-humans and their evolution. It facilitates the identification of adaptations or transformations necessary to ensure the continuity of the desired state and functioning of the system. Like the social connection model of Young (2006), ecological solidarity leads to an analysis of the social-ecological system that can identify its morally unacceptable effects. Consequently, exploring ecological and social interdependencies leads to understanding the consequences of human actions and to making the choice of solidarity. The choice of solidarity leads to transforming the structural processes that produce social damage and threaten nature. While collective responsibility used to be delegated to the government, ecological solidarity nurtures social- ecological stewardship and implies the sharing of the responsibility of promoting both the individual and collective commitment to changing things and leads to collective efforts to develop direct political actions.

The social-ecological stewardship we have presented and promoted here is based on a problem-oriented attitude, that is, pragmatism, and it encourages the empowerment of stakeholders based on social learning from experience in an adaptive management and companion-modelling framework (Norton 2005; Mathevet et al. 2016). This type of stewardship relies on the belief that through the concept of ecological solidarity we can revisit the relationships between technologies, development and environmental changes using means that are capable of accommodating the diversity and pluralism of social groups, and also to deal with the political challenges of global change. In this respect, ecological solidarity is more than a new French normative concept. Based on both science and engagement with social transformation, it provides an inspiring call to act.

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References

- Armitage, D., Charles, A., & Berkes, F. (2017). Governing the coastal commons: Communities, resilience and transformation. New York: Routledge.
- Armitage, D. R., Plummer, R., Berkes, F., et al. (2009). Adaptive co-management for social-ecological complexity. *Frontiers in Ecology and the Environment*, 7(2), 95–102.
- Arnstein, S. R. (1969). A ladder of citizen participation. *Journal of the American Planning Association*, 35(4), 216–224.
- Attfield, R. (2001). Christianity. In D. Jamieson (Ed.), A companion to environmental philosophy. Blackwell companions to philosophy (pp. 96–110). Oxford: Blackwell Publishers.
- Barrett, C. B., & Grizzle, R. E. (1999). A holistic approach to sustainability based on pluralistic stewardship. *Environmental Ethics*, 21(1), 23–42.
- Barrière, O., & Bes, C. (2017). Droit foncier et pastoralisme, entre propriété et territoire. VertigO—la revue électronique en sciences de l'environnement, 17(1).
- Beavis, M. A. (1994). *Environmental stewardship: History, theory and practice workshop proceedings.* Occasional paper 32, Institute Of Urban Studies, University of Winnipeg.
- Berkes, F., & Folke, C. (2000). Linking social and ecological systems: Management practices and social mechanisms for building resilience. Cambridge: Cambridge University Press.
- Berry, R. J. (2006). Environmental stewardship: Critical perspectives, past and present. London: T&T Clark.
- Bieling, C., & Plieninger, T. (2017). *The science and practice of landscape stewardship*. Cambridge: Cambridge University Press.
- Brandon, K., Redford, K., & Sanderson, S. (1998). *Parks in Peril: People, politics and protected areas.* Washington, DC: Island Press.
- Brandon, K., & Wells, M. (1992). Planning for people and parks: Design delemmas. *World Development*, 20(4), 557–570.
- Brockington, D., & Duffy, R. (2011). Capitalism and conservation. Chichester: Wiley-Blackwell.
- Cairns, R., & Stirling, A. (2014). Maintaining 'planetary systems' or 'concentrating global power?' High stakes in contending framings of climate geoengineering'. *Global Environmental Change*, 28, 25–38.
- Callicott, J. B. (2013). Thinking like a planet, the land ethic and the earth ethic. Oxford: Oxford University Press.
- Callicott, J. B., Crowder, L. B., & Mumford, K. (1999). Current normative concepts in conservation. *Conservation Biology*, 13(1), 22–35.
- Castree, N. (2000). Marxism and the production of nature. Capital and Class, 24(3), 5-36.
- CENLR. (2014). L'intendance écologique des territoires. Montpellier, FR: Conservatoire des Espaces Naturels.
- Chapin, F. S., III, Kofinas, G. P., & Folke, C. (2009). Principles of ecosystem stewardship. Resilience-based natural resource management in a changing world. New York: Springer.
- Chapin, F. S., III, Power, M. E., Pickett, S. T. A., et al. (2011). Earth Stewardship: Science for action to sustain the human-earth system. *Ecosphere*, 2, art89.
- Christian, C., Ainley, D., Bailey, M., et al. (2013). A review of formal objections to Marine Stewardship Council fisheries certifications. *Biological Conservation*, *161*, 10–17.
- Clayton, S. (Ed.). (2012). *Handbook of environmental and conservation psychology*. New York: Oxford University Press.
- ComMod. (2003). Our companion modelling approach. *Journal of Artificial Societies and Social Simula- tion*, 6(2).
- Corlett, R. T. (2015). The Anthropocene concept in ecology and conservation. *Trends in Ecology & Evo-lution*, 30(1), 36–41.
- Cote, M., & Nightingale, A. J. (2012). Resilience thinking meets social theory: Situating social change in socioecological systems research. *Progress in Human Geography*, *36*(4), 475–489.
- DeFries, R., Hansen, A., Turner, B. L., Reid, R., & Liu, J. (2007). Land use change around protected areas: Management to balance human needs and ecological function. *Ecological Applications*, 17, 1031–1038.
- Descartes, R. (1962). Discours de la méthode, texte et commentaire, E. Gilson, Paris: J. Vrin.
- DeWitt, C. B. (2006). Stewardship: Responding dynamically to the consequence of human action in the world. In R. J. Berry (Ed.), *Environmental stewardship: Critical perspectives, past and present* (pp. 145–158). London: T&T Clark.
- Di Paola, M. (2015). Virtues for the Anthropocene: Taking action in the garden. *Environmental Values*, 24, 183–207.
- Etienne, M. (Ed.). (2011). Companion modelling. A participatory approach to support sustainable devel- opment. Versailles: Quae & Springer.
- Fisher, D. R., Svendsen, E. S., & Connolly, J. J. T. (2015). Urban environmental stewardship and civic engagement: How planting trees strengthens the roots of democracy. New York: Routledge.

Folke, C., Jansson, Å., Rockström, J., et al. (2011). Reconnecting to the Biosphere. Ambio, 40, 719–738.

- Forrester, J. W. (1991). System dynamics and the lessons of 35 years. In K. B. De Greene (Ed.), *The systemic basis of policy making in the 1990s*. Sloan School of Management Massachusetts Institute of Technology.
- Foster, J. B., & Clark, B. (2008). The sociology of ecology: Ecological organicism versus ecosystem ecology in the social construction of ecological science, 1926–1935. *Organization & Environment*, 21(3), 311–352.
- Gardiner, S. M. (2011). Is no one responsible for global environmental tragedy? Climate change as a challenge to our ethical concepts. In D. G. Arnold (Ed.), *The ethics of global climate change* (pp. 38–59). Cambridge: Cambridge University Press.
- Gutiérrez, N. L., Hilborn, R., & Defeo, O. (2011). Leadership, social capital and incentives promote successful fisheries. *Nature*, 470(7334), 386–389.
- Hansen, A., & DeFries, R. (2007). Ecological mechanisms linking protected areas to surrounding lands. *Ecological Applications*, 17, 974–988.
- Hejnowicz, A. P., Rudd, M. A., & White, P. C. L. (2016). A survey exploring private farm advisor perspectives of agri-environment schemes: The case of England's environmental stewardship programme. *Land Use Policy*, 55, 240–256.
- Hornborg, A. (2009). Zero-sum world: Challenges in conceptualizing environmental local displacement and ecologically unequal exchange in the world system. *International Journal of Comparative Soci- ology*, 50(3– 4), 237–262.
- Ison, R. (2010). Systems practice: How to act in a climate-change world. London: Springer.
- Jamieson, D. (2014). *Reason in a dark time, why the struggle against climate change failed—and what it means for our future.* New York: Oxford University Press.
- Janzen, D. H. (1983). No park is an island. Oikos, 41, 402–410.
- Jepson, P. R., Caldecott, B., Schmitt, S. F., et al. (2017). Protected area asset stewardship. *Biological Conservation*, 212, 183–190.
- Jonas, H. (1979). *The imperative of responsibility. In search for an ethics for the technological age.* Chicago: The University of Chicago Press.
- Kareiva, P., & Marvier, M. (2012). What is conservation science? BioScience, 62(11), 962-969.
- Langton, C. G. (1992). Life at the edge of chaos. In C. G. Langton, C. Taylor, J. D. Farmer, & S. Rasmussen (Eds.), *Artificial life II* (pp. 42–91). Reading, MA: Addison Wesley.
- Larrère, C., & Larrère, R. (2009). Du bon usage de la nature. Pour une philosophie de l'environnement. Paris, FR: Flammarion.
- Larrère, C., & Larrère, R. (2015). Penser et agir avec la nature: Une enquête philosophique. Paris, FR: La Découverte.
- Leopold, A. (1949). A Sand County Almanac and sketches here and there. New York: Oxford University Press.
- Macnaghten, P., & Szerzynski, B. (2013). Living the global social experiment: An analysis of public discourse on solar radiation management and its implications for governance. *Global Environmental Change, 23,* 465–474.
 Mathevet, R. (2012). *La solidarité écologique, Ce lien qui nous oblige.* Arles, FR: Actes Sud.
- Mathevet, R., & Bousquet, F. (2014). *Résilience & environnement, penser les changements socio-écologiques.* Paris, FR: Buchet-Chastel.
- Mathevet, R., Bousquet, F., & Raymond, C. M. (2018). The stewardship concept in sustainability science and conservation biology. *Biological Conservation*, 217, 363–370.
- Mathevet, R., Thompson, J., Delanoë, O., Cheylan, M., & Bonnin, M. (2010). La solidarité écologique: Un nouveau concept pour la gestion intégrée des parcs nationaux et des territoires. *Natures Sciences Sociétés*, 18(4), 424–433.
- Mathevet, R., Thompson, J., Folke, C., & Chapin, F. S., III. (2016). Protected areas and their sur-rounding territory: Social-ecological systems in the context of ecological solidarity. *Ecological Applications*, 26(1), 5–16.
- McCulloch, W. (1988). Embodiments of the mind. Cambridge, MA: MIT Press.
- McGinnis, V. (2005). Bioregionalism. New York: Taylor and Francis.
- McShane, K. (2007). Why environmental ethics shouldn't give up on intrinsic value. *Environmental Ethics*, 29, 43–61.
- Merchant, C. (1996). Earthcare, women and the environment. New York: Routledge.
- Merchant, C. (2004). Reinventing Eden. The fate of nature in western culture. London: Routledge.
- Merwin, S. (1977). The "Country Life Movement" and the American Churches. *Church History*, 46, 358–359.
- Morton, O. (2016). *The planet remade. How geoengineering could change the world.* Princeton: Princeton University Press.
- Norton, B. (2005). Sustainability: A philosophy of adaptive ecosystem management. Chicago: University of Chicago Press.

- Noss, R., Nash, R., Paquet, P., & Soulé, M. (2013). Humanity's domination of nature is part of the problem: A response to Kareiva and Marvier. *BioScience*, 63(4), 241–242.
- Nussbaum, M. C. (2006). Frontiers of justice: Disability, nationality, species membership. Cam- bridge, MA: Harvard University Press.
- Ode Sang, Å., & Tveit, M. S. (2013). Perceptions of stewardship in Norwegian agricultural landscapes. *Land Use Policy*, 31, 557–564.
- Ostrom, E. (2009). A general framework for analysing sustainability of social-ecological systems. *Science*, *325*, 419–422.
- Palmer, C. (2006). Stewardship: A case study in environmental ethics. In R. J. Berry (Ed.), *Environmental stewardship: Critical perspectives, past and present* (pp. 63–75). London: T&T Clark.
- Passmore, J. (1974). Man's responsability for nature: Ecological problems and western tradition. New York: Scribner's Sons.
- Plieninger, T., Kizos, T., Bieling, C., et al. (2015). Exploring ecosystem-change and society through a landscape lens: Recent progress in European landscape research. *Ecology and Society*, 20, 5.
- Plumwood, V. (1999). Paths beyond human-centeredness: lessons from liberation struggles. In A. Weston (Ed.), *An invitation to environmental philosophy* (pp. 69–106). New York: Oxford University Press.
- Plumwood, V. (2002). Environmental culture: The ecological crisis of reason. New York: Routledge.
- Preston, C. J. (2016). *Climate justice and geoengineering: Ethics and policy in the atmospheric anthropocene*. Lanham, Maryland: Rowman & Littlefield International.
- Pretty, J. (1995). Participatory learning for sustainable agriculture. World Development, 23(8), 1247–1263.
- Raymond, C. M., Bieling, C., Fagerholm, N., et al. (2015). The farmer as a landscape steward: Com- paring local understandings of landscape stewardship, landscape values, and land management actions. *Ambio*, 45, 173–184.
- Raymond, C. M., Reed, M. S., Bieling, C., et al. (2016). Integrating different understandings of landscape stewardship into the design of agri-environmental schemes. *Environmental Conservation*, 43(4), 350–358.
- Rockström, J., Steffen, W., Noone, K., et al. (2009). A safe operating space for humanity. Nature, 461, 472-475.
- Rozzi, R., Pickett, S. T. A., Palmer, C., et al. (2015). *Linking ecology and ethics for a changing world. Values, philosophy, and action.* New York: Springer.
- Sandler, R. (2010). Ethical theory and the problem of inconsequentialism: Why environmental ethicists should be virtue-oriented ethicists. *Journal of Agriculture and Environmental Ethics*, 23(1–2), 167–183.
- Sartre, J. P. (1960). Critique de la raison dialectique. Paris, FR: Galllimard.
- Serre, M. (1995). The natural contract. Ann Arbor: University of Michigan Press.
- Shannon, C. E. (1949). Communication theory of secrecy systems. *Bell System Technical Journal*, 28, 656–715.
- Spash, C. L. (2015). Bulldozing biodiversity: The economics of offsets and trading-in Nature. *Biological Conservation*, 192, 541–551.
- Theobald, D. M., Hobbs, N. T., Bearly, T., Zack, J. A., Shenk, T., & Riebsame, W. E. (2000). Incorporating biological information in local land use decision making for conservation planning. *Landscape Ecology*, 15, 35–45.
- Thompson, J., Mathevet, R., Delanoë, O., Cheylan, M., & Bonnin, M. (2011). Ecological solidarity as a conceptual tool for rethinking ecological and social interdependence in conservation policy for protected areas and their surrounding landscape. *Comptes Rendus de l'Académie des Sciences, 334,* 412–419.
- Turner, M. G. (1989). Landscape ecology: The effect of pattern on process. *Annual Reviews of Ecology and Systematics*, 20, 171–197.
- Welchman, J. (2012). A defence of environmental stewardship. *Environmental Values, 21, 297–316.* White, L. (1967). The historical roots of our ecologic crisis. *Science, 155,* 1203–1207.
- Wiener, N. (1948). *Cybernetics or control and communication in the animal and the machine*. Cambridge: The Technology Press.
- Wolfram, S. (1984). Cellular automata as models of complexity. Nature, 311, 419-424.
- Worrell, R., & Appleby, M. C. (2000). Stewardship of natural resources: Definition, ethical and practical aspects. *Journal of Agriculture and Environmental Ethics*, *12*, 263–277.
- Wunderlich, G. (2004). Evolution of the stewardship idea in American country life. *Journal of Agricul- tural* and Environmental Ethics, 17(1), 77–93.
- Young, I. M. (2006). Responsibility for justice. New York: Oxford University Press.
- Young, H. S., McCauley, D. J., Galetti, M., & Dirzo, R. (2016). Patterns, causes, and consequences of Anthropocene defaunation. *Annual Review of Ecology Evolution and Systematics*, 47, 333–358.