Ecological Economics 108 (2014) 269–273

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Commentary

Environmental protection goals, policy & publics in the European regulation of GMOs

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ARTICLE INFO

Article history:
Received 11 October 2013
Received in revised form 18 September 2014
Accepted 21 September 2014
Available online 8 October 2014

Keywords:
GMOs
Risk
Environmental protection goals
Regulation
Ecosystem services
Cultural services

ABSTRACT

One of the most divisive debates in modern agriculture concerns the use of genetically modified organisms (GMOs). In Europe, the policy debate over GMOs has been met with a persistent attempt to retreat into "sound science" as a potential unifying force. However, environmental risk assessment as an aid to regulatory decision-making is inherently entangled with questions of environmental ethics. This is particularly manifested in the setting of environmental protection goals. For the risk assessment of GMOs, the European Food Safety Authority has presented an inconsistent position on environmental protection goals. There is, however, an emerging trend for biodiversity conservation to be enfolded within an ecosystem services frame, and for ecosystem services to be reduced to biological terms. How environmental protection goals are understood, articulated and used to define risk assessment and shape regulatory decision-making is a significant factor in the entrenched debate over the regulation of GMOs in Europe. In negotiating this territory, I suggest that the attempt to enforce a strict divide between nature and culture or social and ecological systems in Europe's risk assessment of GMOs is emphatically counter-productive, for both robust science and considered ethical action.

1. Introduction

The regulation of genetically modified organisms (GMOs) in European agriculture has been a deeply controversial issue for decades. In recent years, however, the sense of crisis that this has generated for the European Union has intensified as several of the larger and more powerful member states (e.g. Germany, France, Austria and Italy), have declared national prohibitions on the cultivation of particular genetically modified crops despite safety approvals from the European Commission and the European Food Safety Authority (EFSA) (see GMO-free Europe 2010). According to Directive 2001/18, 'temporary' prohibitions by member states are legally permitted under the safeguard clause (Article 23) if made on the basis of a potential risk to human health or the environment that is supported by new scientific knowledge. EFSA has, however, evaluated each prohibition on GM crop cultivation to date and deemed all of them lacking in sufficient scientific support. The national bans have therefore effectively been declared illegal. Despite this, the bans remain in place and this has created a deep and reverberating political impasse that scientific method and process have not been able to resolve, despite several years of intense effort (Wickson and Wynne, 2012a).

Despite the traditional view that risk assessment is an objective process conducted by neutral scientific experts (Kuntz 2012), values precede and pervade scientific risk assessment (Wickson and Wynne, 2012b). For environmental risk assessment, this is most clearly apparent in the setting of environmental protection goals. Before any environmental risk assessment can be conducted, it must first be established what it is we care about, what we value, and why.

One of the key faultlines of debate in environmental ethics (the field of philosophy directly concerned about what we value in nature and why) is that between intrinsic and instrumental values. In other words, the question of whether nature only has value in so far as it aids human endeavors or whether it possesses value beyond its usefulness to us. Despite lively philosophical debate across this divide, the notion of intrinsic value is often accused of being little use for environmental policy, since it seems to provide no guidance for action (particularly in agricultural settings where organisms necessarily die for us to survive). While intrinsic value is typically awarded to individual organisms or systems, a close reading of the philosophy of deep ecology, usually cited as arguing for nature's intrinsic value, actually suggests that it is the flourishing of life that has 'intrinsic value' (see Næss and Rothenberg, 1989). According to this interpretation, intrinsic value is actually widely recognized in environmental policy.

Biodiversity (i.e. flourishing life) is an internationally recognized protection goal, including for the assessment and governance of biotechnologies (Cartagena Protocol 2000). In recent years, however, the discourse of biodiversity conservation has increasingly become dominated by the concept of 'ecosystem services'. This is seeing a shift away from commitment to the intrinsic value of flourishing life on earth, towards a more restricted emphasis on the instrumental value

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http://dx.doi.org/10.1016/j.ecolecon.2014.09.025
0921-8009/

of biodiversity for delivering ecosystem services. It is worth noting, however, that instrumental value can be either anthropocentric or non-anthropocentric; e.g. we can value biodiversity for the resilience it provides ecosystems in the face of future change motivated by a desire to see them provide ongoing services for humanity, or motivated by a desire to see ecosystems persist for their own sake. As a concept, ecosystem services can also be restricted to a biophysical conceptualisation or it can more broadly encompass socio-cultural services, such as the value ecosystems have for education, recreation, inspiration and/or spiritual connection.

In this commentary I will demonstrate the existence of a tension between instrumental and intrinsic value positions in the articulation of environmental protection goals both within and across two EFSA panels responsible for aspects of GMO risk assessment. I will also highlight the strong trend towards emphasizing an ecosystem services frame, as well as demonstrate how within the GMO panel of EFSA, ecosystem services are consistently reduced to biological services, ignoring the significance of socio-cultural dimensions. Through this work I will argue that the current attempt to enforce a strict divide between nature and culture or social and ecological systems in Europe's risk assessment of GMOs is emphatically counter-productive, for both robust science and considered ethical action. I will then conclude by suggesting that recognizing the porosity of this boundary and working to move from a concept of environmental protection goals to socio-ecological promotion aims may offer a unique and important opportunity to break through the current European deadlock over the risk assessment and use of GMOs in agriculture.

2. Material and Methods

The arguments presented in this paper are the result of a detailed comparative textual analysis performed on the three key documents articulating EFSA's environmental protection goals in relation to the risk assessment of GMOs. These documents were produced by two different EFSA panels: the Panel on Plant Protection Products and their Residues (PPR Panel), and the Panel on Genetically Modified Organisms (GMO Panel). The EFSA panel on Plant Protection Products and their Residues (PPR panel) has a mandate to provide scientific advice on the risks to human health and the environment from the chemicals often tightly coupled to GM crops (e.g. herbicides GM plants are modified to tolerate). The GMO panel has a mandate to evaluate the safety of all GMOs (including GM food and feed) for which approval is being sought in Europe and their risk assessments form the basis for decisions taken by the Commission. The EFSA website provides detailed information on the members of each panel (see http://www.efsa.europa.eu/en/pesticides/pprmembers.htm and http://www.efsa.europa.eu/en/gmo/gmomembers.htm).

The documents analyzed in this case were: 1) the Scientific Opinion on the development of specific protection goal options for environmental risk assessment of pesticides, in particular in relation to the revision of the Guidance Documents on Aquatic and Terrestrial Ecotoxicology (PPR Panel, 2010); 2) the Guidance on the environmental risk assessment of genetically modified plants (GMO Panel, 2010a) and 3) the Scientific Opinion on the assessment of potential impacts of genetically modified plants on non-target organisms (GMO panel, 2010b). To perform the analysis, each document was coded for keywords, statements and positions relating to environmental protection goals and values. These codes were then compared for their content, frequency and location within and across the documents. The initial results of the analysis were presented at the third annual Meeting of the European Advisory Committees on Biosafety (MEACB) in Paris in December 2012, in which a number of members of the EFSA GMO panel were present in addition to GMO regulators and risk assessors from a range of member states. While these participants came from diverse backgrounds, all played a significant role in risk assessment and/or management of GMOs at a national or European level. Feedback, insights and corrections to the analysis from this meeting were then incorporated into a new presentation on the topic that was invited and given at the EFSA Network for Risk Assessment of GMO Meeting in Parma in May 2013. Present at this meeting were several members of the GMO panel, select members of the PPR panel, employees of EFSA's GMO unit (providing administrative support to the panel) and various national representatives engaged in GMO risk assessment and/or management. Feedback presented at this meeting has been incorporated into the final analysis presented here.

3. Results

Deciding that the guidance in existing legislation was too general to be practically applicable, the PPR panel developed a specific Scientific Opinion on environmental protection goals (PPR, 2010). In this document they present two main axes for defining environmental protection goals: biodiversity and ecosystem services. For environmental risk assessment (ERA) they state that although European legislation implies a goal of protecting all species in all habitats, in agricultural landscapes "not all biodiversity can be protected in every location all the time" (pg. 20). They follow this with an argument that for practical purposes they need a conceptual framework that can identify and protect different "key drivers" and therefore explicitly adopt ecosystem services to structure their work.

In contrast, the GMO panel has not developed a specific opinion on environmental protection goals. Instead, statements on them are embedded within other documents, including the Guidance on the ERA of GM plants (GMO Panel, 2010a) and the Scientific Opinion on the assessment of the potential impacts on non-target organisms (NTOs) (GMO Panel, 2010b). In their Guidance on ERA, the GMO panel also identifies biodiversity conservation and ecological function as the two key protection goals expressed in relevant legislation. In their Opinion on NTOs, however, these are extended to include sustainable land use and integrated pest management. Unlike the PPR panel, the GMO panel does not explicitly choose ecosystem services as a more operable protection goal. In practice, however, the meaning of biodiversity changes throughout their documents until its value is ultimately situated within an ecosystem services frame. For example, early in the Scientific Opinion on NTO assessment (GMO Panel, 2010b) it is stated that biodiversity is broadly interpreted to refer to both species richness ("wider biodiversity") and the role that this plays in the provision of ecosystem services ("functional biodiversity"). Later in the same document, however, and seeming to contradict "wider biodiversity" as a protection goal, it is stated that: "Logically, an 'acceptable' level of biodiversity needs to be defined in terms of a 'minimum' biodiversity level for the efficient and sustainable functioning of the particular agro-ecosystem (i.e. providing essential 'ecosystem services')". The idea that biodiversity generally has a kind of intrinsic value worthy of protection is therefore reduced to a position that only the minimum level of biodiversity necessary for the provision of instrumental ecosystem services needs to be protected.

When biodiversity conservation gets enfolded into an ecosystem services frame, questions arise concerning the relationship between the two. Here we encounter a basic divide in the philosophy of ecology, which is also differentially approached across the EFSA panels. According to the 'rivet hypothesis' (Ehrlich and Ehrlich, 1981) ecological communities are integrated units of specialized species wherein changing the abundance of one species can affect others and the loss of each species may have an increasingly critical effect (e.g. like popping rivets in an airplane wing). In contrast, the 'redundancy hypothesis' (Walker, 1992) suggests that ecological communities are loosely associated species operating largely independently and if one species is lost, another may arise to take its place, creating a degree of functional redundancy in natural systems.

The PPR panel acknowledges the existence of both of these views and suggests that there is ongoing scientific debate as to which is correct

or which predominates in particular systems of interest (PPR Panel, 2010). In contrast, the GMO panel adopts the redundancy hypothesis without explicitly mentioning the scientific debate or engaging its potential limitations, simply stating: "the decline of a certain population might be compensated by another species within the same guild without adversely affecting functionality" (GMO Panel, 2010b). For the GMO panel then, it appears that the slide from conservation of a "wider biodiversity" down to a "functional biodiversity" is supported by a belief in redundancy in ecological systems.

3.1. EFSA & the Socio-Cultural Dimension of Ecosystem Services

While in practice both panels arguably employ an ecosystem services framing of environmental protection goals, this approach can be more or less inclusive of socio-cultural dimensions. Both PPR and GMO panels initially define ecosystem services by citing the Millennium Ecosystem Assessment (MEA), which uses categories of provisioning, regulatory, supporting and cultural services (MEA, 2005). Despite this, the GMO panel consistently limits its later descriptions of ecosystem services to biological terms, e.g. referring to them as "including biological control of pests and diseases, nutrient fixing and cycling, decomposing plant materials, maintenance of soil quality and fertility and structural stability" (GMO Panel, 2010b). By referring only to provisioning, regulatory and supporting services in their clarifications of what is meant by the term, the GMO panel effectively neglects the important ways in which ecosystems (and arguably agroecosystems in particular) are also valued for their cultural services (e.g. aesthetic, educational, inspirational, recreational, spiritual).

As an illustration, consider the following example: if honeybees were deemed functionally redundant because other insects, humans or technologies could perform pollination equally well and honey could be synthetically manufactured, could honeybees disappear without any loss of value? If we only acknowledge their biological services, this certainly appears possible. However, if we recognize that they also perform cultural services (e.g. their complex social structures and unique abilities provide us with inspiration and educational opportunities), we will not agree to such an argument. Indeed the question of whether there can be functional redundancy at all in cultural services seems ripe for further exploration.

Note that here I am not arguing for an assessment of the socio-economic impacts of GMOs (although this is an additionally important argument to be made), rather my point here is that the assessment of environmental risk a) is inherently dependent on what we value in the environment, and b) that in addition to our biological needs, this will be defined by our socio-cultural relations with the land, or in other terms, the cultural services agroecosystems provide. This means that if the EFSA GMO panel chooses to assess risks to the environment in terms of risks to ecosystem services, they cannot just ignore or sideline the subset of services labeled cultural.

One place where the GMO panel does explicitly acknowledge cultural services is in reference to the selection of non-target organisms for the assessment: "In the categorization of relevant NTO species, additional species of economic, aesthetic or cultural value, or species of conservational importance considered as threatened or endangered may also need to be included" (GMO Panel, 2010b). However, while this document dedicates significant attention to describing how test organisms should be identified based on their biological functions, no guidance is provided for how species of socio-economic or cultural value are to be identified. This is despite the vast literature within the social sciences on methods for identifying cultural values (Daniel et al., 2012) and on public engagement and participatory approaches for doing this (Rowe and Frewer, 2005). Despite the lack of guidance, the above statement seems to indicate at least a superficial recognition that environmental protection goals and risk assessment can be legitimately shaped by the cultural services of agroecosystems and organisms.

The significance of cultural factors for environmental risk assessment also appears to be at least superficially acknowledged in the setting of 'limits of concern' (i.e. the threshold used to identify when a protection goal is threatened). Here the GMO panel states: "The required level of biodiversity in a particular agricultural ecosystem is often subjective and a cultural response in a human-managed habitat, rather than a basic and definitive biological measure ….They will therefore vary from region to region, Member State to Member State …" (GMO Panel, 2010b). This appearance of sensitivity to cultural diversity does not, however, translate into the following paragraph in which the process for identifying limits of concern is described: "The applicants shall select assessment endpoints and define limits of concern" and "The information in problem formulation (in which environmental protection goals and limits of concern are chosen) can take many forms, including published scientific literature, scientific and expert opinion, and/or research data" (GMO Panel, 2010b). Confusingly therefore, despite apparently recognizing the subjectivity such choices involve, the GMO panel does not indicate any need for public engagement on the questions at stake. In contrast, the PPR panel claims that it "considers it necessary to derive specific protection goal options that can be agreed with risk managers and other stakeholders via a consultation process" (PPR Panel, 2010). These clearly represent remarkably different positions on what constitutes a legitimate process for such decisions.

Why the GMO panel superficially acknowledges cultural services but consistently marginalizes their importance and impact in practice is surely connected to the broader political context. If we recognize that ecosystems provide cultural services and acknowledge that Europe contains a diverse mix of cultures, different European nations could clearly value different types of agroecosystems. This, however, would challenge the legitimacy of the persistent assertion that scientific assessments of risk can be generated with Europe-wide validity (Wickson and Wynne, 2012a) and would open for the legitimacy of using socio-cultural grounds for taking decisions on GMOs. However, by not consistently embracing and developing cultural services as a component of the ecosystem services frame, the GMO panel fails to account for the enormous cultural significance of agroecosystems, as well as the full range of potentially relevant environmental protection goals for their risk assessments. Actively embracing cultural services would provide the panel with an opportunity to hold to their mandate to assess environmental risks, while also allowing for the development of an integrated understanding in which the value of ecosystems, and agroecosystems in particular, could be recognized as containing both cultural and biological dimensions. In the risk assessment of GMOs, however, there appears to be an emerging threat that the articulation of environmental protection goals will proceed through an instrumental and reductive vision of ecosystem services (limited to biological services), where the issue is framed not as one of environmental ethics, but rather one of environmental science, and thereby firmly placed in the domain of scientific expertise, negating opportunities for public engagement.

4. Discussion

One way to improve consistency within EFSA would arguably be for the GMO panel to follow the PPR panel and explicitly and consistently use an ecosystem services approach. If this were done, however, it would certainly need to more fully embrace the role of cultural services than is currently the case and give it a more sophisticated treatment (see Chan et al., 2012; Daniel et al., 2012). While this could open useful new avenues for greater flexibility and diversity in the definition of relevant protection goals and therefore risk assessment of GMOs in Europe, it is important to realize that adopting the ecosystem services approach also raises concerns. Although historically developed to popularize the importance of nature conservation, the ecosystem services concept has largely gained currency through its uptake in economic

theory (Gómez-Baggethun et al., 2010). Here it has been used to assign value (and particularly monetary value) to natural systems (Costanza et al., 1997). While its use in an economic valuation of nature can be critiqued on a number of grounds (e.g. Vatn, 2000; Sagoff, 2011; Spangenberg and Settele, 2010), the concept has also been critiqued as a way of approaching conservation. It has, for example, been referred to as a reductive and distorting prism, which through employing metaphors of engineering and economy, blinds us to ecological complexity and fails to cultivate the virtues and attitudes ultimately required for conservation (e.g. wonder, humility, reverence, respect) (Norgaard, 2010; Sharman, 2010). Philosophically, the instrumentalism of the concept can be interpreted as rejecting any responsibility for the planet beyond protecting what is useful for our own well-being, thereby permitting as morally acceptable the human-induced loss of biodiversity not essential to the provision of services we require. From a scientific basis, the concept has also been critiqued for its practicability, i.e. in terms of our ability to understand, predict and manage behavior in complex ecological systems so as to successfully maintain desired services (Chee, 2004).

Given these limitations, it may be desirable to explore conceptual alternatives. The need for new terminology seems particularly important because of the problems associated with both the term 'the environment' and the idea of it needing 'protection'. The term 'the environment' implies something that surrounds us but which in a fundamental sense is separate and distinct from us (Næss, 1973), while the idea of 'protection' appears to convey a desire for something to remain the same. In talking about environmental protection goals then, we seem to be engaging in a conversation about the things in the world around us that we want to try and preserve in a particular static form. This is despite widespread recognition that environments are dynamic entities that change over time, and that especially in agricultural settings, this change is deeply interconnected with human activity. In contrast, reference to socio-ecological systems (as opposed to 'the environment') specifically emphasizes the interactive and co-constitutive relationship between human organisms and their surroundings, while the idea of a promotion aim could be used to describe the kind of relationship we wish to actively encourage and develop. Rather than an environmental protection goal then, a socio-ecological promotion aim may be concerned with how we wish to cultivate our ecological selves (Næss, 1988) or our socio-ecological communities, with this recognized as an ongoing, iterative and dynamic process of co-creation.

The GMO panel arguably has a good basis for pursuing this alternative because in addition to biodiversity conservation and ecological function, it also identifies sustainable agriculture and integrated pest management (IPM) as important protection goals (GMO Panel, 2010b). Since our currently dominant modes of agricultural production are neither sustainable nor widely adopting IPM practices, it is not a question of whether GMOs protect sustainability and IPM, but rather a question of whether they promote it. Reformulated as socio-ecological promotion aims, IPM and sustainability could be used more seriously to frame assessment processes (as is indeed already the case for sustainability under the Norwegian Gene Technology Act). Significantly, such a reorientation would also open up the question of what is deemed a relevant comparator for risk assessment. Rather than a backward-looking comparison considering only whether the use of a GMO will create more environmental harm than practices already recognized as unsustainable, the use of promotion goals would enable us to look forward and consider new agricultural developments and technologies in light of what we want for our future. This means that rather than just assessing the acceptability of their risks against an already questionable baseline, GM crops would actually have to demonstrate their positive socio-ecological function for European economies. Furthermore, when operating within the frame of protection goals, we are often forced to use the default (chemically intensive agriculture) as our point of comparison for acceptability. By shifting towards promotion aims, however, even this default position can be legitimately brought under scrutiny. While it is beyond the scope of this commentary to elaborate a detailed plan for how to operationalize the proposed notion of socio-ecological promotion aims, a first step could involve a task aligned with the emerging articulation of "sustainable development goals" (provided these integrate social, economic and biological dimensions (Griggs et al., 2013)), to articulate such aims at national and regional levels, utilizing broadly participatory approaches and potentially focused on particular sectors.

Using such a concept, the core question for deliberative public debate would not necessarily be what level of risk is acceptable, nor what entities we want to protect, but rather, what kind of relationship we wish to build with the community of life on earth and whether particular technologies and practices help us cultivate this in our agroecosystems. To engage in a meaningful discussion about the virtues we wish to promote in our ecological relations, or indeed how to advance the intrinsic value of flourishing life, or even the instrumental cultural services provided by agroecosystems, would, however, all require that we relinquish the idea that environmental risk assessment is a scientific process divorced from questions of environmental ethics and that our agricultural systems serve only biological needs. Overcoming the misguided search for nature/culture purity therefore represents the real challenge for the European regulation of GMOs — a challenge that also arguably offers the most hopes for the development of a socially robust alternative capable of breaking the current deadlock.

5. Conclusion

This commentary has drawn attention to the way in which the European Food Safety Authority presents an inconsistent position on the environmental protection goals it uses to define and shape the process of assessing the environmental risks posed by GMOs. Despite this inconsistency, the commentary has argued that there is an increasing trend for biodiversity conservation to be approached from within an ecosystem services frame and that this sidelines the view of biodiversity having intrinsic value. Furthermore, the commentary has shown how within the GMO panel of EFSA, ecosystem services are consistently narrowed to exclude cultural services and has shown how this fails to recognize the particular cultural significance of agroecosystems and works to marginalize public participation in decision-making. Arguing that all of these factors are only working to amplify rather than resolve the entrenched debate in Europe over the cultivation of GMOs, the commentary concluded by suggesting that there is a need to overcome the perceived boundary between nature and culture in the regulation of GMOs. Finally it was suggested that this could in the first instance be advanced through a shift in language and orientation away from environmental protection goals towards socio-ecological promotion aims and the operationalization of these by EFSA through, for example, their existing commitments to furthering integrated pest management and sustainability in agricultural systems. Unless the interaction between social and ecological factors can be recognized and directly addressed in the regulation of GMOs, either through embracing and further articulating the cultural services dimension of the ecosystem services frame more clearly or recognizing its limits and developing an alternative frame more able to embrace non-instrumental values, it seems likely that unproductive stalemates in Europe's GMO debate will continue.

Financial Disclosure

This work was funded by the Norwegian Research Council (Project Nos. 203288 and 231146). The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Acknowledgments

The author would like to thank participants at the Meeting of the European Advisory Committees on Biosafety (MEACB) in Paris in December 2012 and participants at the EFSA Network for Risk Assessment

of GMOs Meeting in Parma in May 2013 for useful feedback on the ideas presented in this paper.

References

Cartagena Protocol, 2000. The Cartagena Protocol on Biosafety to the Convention on Biological Diversity. http://bch.cbd.int/protocol/text/ (last accessed 23.09.14).

Chan, K.M.A., Satterfield, T., Goldstein, J., 2012. Rethinking ecosystem services to better address and navigate cultural values. Ecol. Econ. 74, 8–18.

Chee, Y.E., 2004. An ecological perspective on the valuation of ecosystem services. Biol. Conserv. 120, 549–565.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., et al., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260.

Daniel, T.C., Muhar, A., Arnberger, A., Aznar, O., Boyd, J.W., 2012. Contributions of cultural services to the ecosystem services agenda. PNAS 109 (23), 8812–8819.

EFSA Panel on Genetically Modified Organisms (GMO Panel), 2010a. Guidance on the environmental risk assessment of genetically modified plants. EFSA J. 8 (11), 1–10.

EFSA Panel on Genetically Modified Organisms (GMO Panel), 2010b. Scientific opinion on the assessment of potential impacts of genetically modified plants on non-target organisms. EFSA J. 8 (11), 1–72.

EFSA Panel on Plant Protection Products and their Residues (PPR Panel), 2010. Scientific opinion on the development of specific protection goal options for environmental risk assessment of pesticides, in particular in relation to the revision of the guidance documents on aquatic and terrestrial ecotoxicology (SANCO/3268/2001 and SANCO/10329/2002). EFSA J. 8 (10), 1–55.

Ehrlich, P.R., Ehrlich, A.H., 1981. Extinction: the causes and consequences of the disappearance of species. Random House, New York (305 pp.).

Gómez-Baggethun, E., de Groot, R., Lomas, P.L., Montes, C., 2010. The history of ecosystem services in economic theory and practice: from early notions to markets and payments schemes. Ecol. Econ. 69, 1209–1218.

GMO-free Europe, 2010. GE cultivation bans in Europe. http://www.gmo-free-regions.org/gmo-free-regions/bans.html (last accessed 23.09.14).

Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M.C., et al., 2013. Sustainable development goals for people and planet. Nature 495, 305–307.

Kuntz, M., 2012. The postmodern assault on science. EMBO Reports 13 (10), 885–889.

Millennium Ecosystem Assessment (MEA), 2005. Ecosystems and human well-being. Island Press, Washington DC (160 pp.).

Næss, A., 1973. The shallow and the deep, long range ecology movement: a summary. Inquiry 1, 95–100.

Næss, A., 1988. Self realization: an ecological approach to being in the world. In: Seed, J., Macy, J., Fleming, P., Næss, A. (Eds.), Thinking Like a Mountain: Towards a Council of All Beings. New Society Publisher, Gabriola Island.

Næss, A., Rothenberg, D., 1989. Ecology, Community & Lifestyle. Cambridge University Press, Cambridge (223 pp.).

Norgaard, R.B., 2010. Ecosystem services: from eye-opening metaphor to complexity blinder. Ecol. Econ. 69, 1219–1227.

Rowe, G., Frewer, L., 2005. A topology of pubic engagement mechanisms. Sci. Technol. Hum. Values 30 (2), 251–290.

Sagoff, M., 2011. The quantification and valuation of ecosystem services. Ecol. Econ. 70, 497–502.

Sharman M (2010) Ecosystem Services: paradigm, prism, pablum or placebo? Brussels: Unpublished manuscript.

Spangenberg, J.H., Settele, J., 2010. Precisely incorrect? Monetising the value of ecosystem services. Ecol. Complex. 7 (3), 327–337.

Vatn, A., 2000. The environment as a commodity. Environ. Values 9, 493–509.

Walker, B.H., 1992. Biodiversity and ecological redundancy. Conserv. Biol. 6, 18–23.

Wickson, F., Wynne, B., 2012a. The anglerfish deception: the light of proposed reform in the regulation of GM crops hides underlying problems in EU science and governance. EMBO Rep. 13 (2), 100–105.

Wickson, F., Wynne, B., 2012b. Ethics of science for policy in the environmental governance of biotechnology: MON810 Maize in Europe. Ethics Policy Environ. 15 (3), 321–340.