



Editorial

Ecological engineering: From concepts to applications

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The international congress “Ecological Engineering: From Concepts to Applications (EECA)” was held from 2 to 4 December 2009, at the Cité Internationale Universitaire de Paris, France. Six keynote presentations and over 60 talks and 40 posters were presented during the 3-day conference. More than 200 participants attended the conference (Fig. 1; Table 1), which was devoted to the exploration of new developments in ecological engineering and thoughts on how to build this field based on sound ecological and conceptual foundations. This conference was organized by the Groupe d'Application de l'Ingénierie des Ecosystèmes (GAIE, Ecological Engineering Applications Group). GAIE promotes the development of ecological engineering and is based in the Ile-de-France. The group is comprised of ca. 125 individuals from many institutions in the region and in France, representing several different disciplines, e.g., ecology, environmental science, management science, engineering and social science. Group activities include organizing conferences, symposia, workshops and working groups, discussion meetings, field trips, research and applied projects.

Conference session topics were extremely varied and aimed at emphasizing broad issues such as the importance of developing ecological engineering while we are still in today's energy-rich society (Mitsch, 2012) so we can use these approaches when we run out of technological solutions, as well as the ethical, relational, intellectual and practical challenges for the future of ecological engineering (Jones, 2012). Several sessions grouped presentations on ‘classical’

ecological engineering topics, e.g. restoration, heavy metal remediation, and/or natural resource management. Other sessions were highly transversal and emphasized the importance of broad classes of processes, such as microbial processes and ecosystem engineering (Jones et al., 1997), which can then be exploited to find solutions for many different problems in all types of ecosystems. Such a variety of presentations and sessions is important because ecological engineering is in its infancy in many countries and requires conceptual development about its place in ecological sub-disciplines and the way it can help in designing sustainable systems.

As many aquatic ecosystems are strongly affected by anthropogenic disturbance, e.g. climate change, acidification of oceans and eutrophication, one congress session was devoted to the management of aquatic ecosystems, and to ways of achieving “good ecological status.” The keynote talk by E. Jeppesen from Aarhus University, Denmark (“Restoration of lakes in different climate zones: from theory to practice”), emphasized the comprehensive knowledge accumulated on the management and restoration of northern temperate aquatic ecosystems and the necessity of ecological engineering approaches for warm waters. Several presentations tackled the aquatic issue in relation to the European Water Framework Directive, along with the problems that arise to implement the directive. An important issue raised was the design of integrated protection and management approaches at the scale of the river basin. In accordance with this objective, one session dealt with the management of watersheds.

Two sessions (“Management of temperate and Mediterranean agro-ecosystems” and “Management of tropical agroecosystems”), with a keynote presentation by C. Dupraz, INRA France (“A challenge for ecology: the engineering of cropping systems with

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Fig. 1. Over 200 participants attended the international conference “Ecological Engineering: From Concepts to Applications (EECA)” held the 2–4 December, 2009 at the Cité Internationale Universitaire in Paris, France.

Table 1
Names of sessions and keynote speakers at the conference “Ecological Engineering: From Concepts to Applications (EECA)” held from 2 to 4 December, 2009, at the Cité Internationale Universitaire in Paris, France.

Keynote presentations and number of talks in each session	Name of talk or session
2 December	
Keynote conference by Pr. Mitsch (USA)	Ecological engineering: its development in an energy-rich society and its Future in an energy-limited one
Session 1 (6 talks)	Conceptual bases of ecological engineering
Keynote presentation by Dr. Dupraz (France)	A challenge for ecology: the ecological engineering of pluri-specific cropping systems
Session 2 (4 talks)	Management of temperate and Mediterranean agro-ecosystems
Session 3 (3 talks)	Bioresources management
Session 4 (3 talks)	Heavy metal remediation
3 December	
Keynote presentation by Pr. Costanza (USA)	Ecosystem health and ecological engineering
Session 5 (5 talks)	Management of tropical agro-ecosystems
Session 6 (5 talks)	Ecological engineering and socio-economic issues
Keynote presentation by Pr. Abbadié & Dr. Weber	From market values to ecological values: ecological engineering at stake
Session 7 (7 talks)	Wetland and watershed management
Session 8 (5 talks)	Microbial processes
Workshop organized by the International Ecological Society	Benefits of ecological engineering practices
4 December	
Keynote presentation by Pr. Jeppesen (Denmark)	Restoration of lakes in different climate zones: from theory to practice
Session 9 (7 talks)	Soil and plant restoration
Session 10 organized by the ONEMA (French National Agency for Water and Aquatic Environments)” (3 talks)	Good ecological status of freshwater environments: progress, limits and scientific opportunities
Session 11 (4 talks)	Management of aquatic systems
Keynote presentation by Dr. C.G. Jones (USA)	Grand challenges for the future of ecological engineering
Session 12 (2 talks)	From ecology to ecological engineering

pluri-specific vegetations”), dealt with crop yield. Modern agriculture means feeding a rapidly increasing human population. It is recognized, however, that current intensive agricultural practices are no longer sustainable because they have too many negative effects on ecosystems and human populations (e.g., emission of greenhouse gases and pollution by pesticides and fertilizers). Intensive modern agriculture has also seriously mined soil fertility, resulting in a decrease in organic matter content and soil

loss through erosion. It is thus necessary to develop alternative and more sustainable agricultural practices such as organic and no-till farming, ecological intensification, agroecology and agro-forestry. These types of agricultural practices are all based on the principle that Society should use more intensively utilize natural processes, and that to design such practices we need to mobilize knowledge from several fields of ecology. Because these practices aim at increasing sustainability and bridging the

gap between basic ecological knowledge and the development of applications, they can indeed be called ecological engineering. Consequently, ecological engineering is not a new name for old practices. It is a new field that integrates ecological knowledge with knowledge of agriculture, forestry and aquaculture, with great potential to lead to new and unforeseen discoveries. One key idea behind ecological engineering is that sustainable practices should benefit both human societies and nature. This aspect was developed in the keynote presentations of R. Costanza (“Ecosystem health and ecological engineering”) and in several communications of the session “Ecological engineering and socio-economical issues.”

The success of the EECA conference is mirrored in the production of two special issues of Elsevier journals: this issue of Ecological Engineering and a special issue of Procedia Environmental Sciences (2011, Volume 9, Pages 1–208) “Ecological Engineering: From Concepts to Applications, Paris 2009” edited by J.-C. Lata, G. Lacroix and S. Barot. A total of 32 papers were published in the special edition of Procedia Environmental Sciences (<http://www.sciencedirect.com/science/journal/18780296/9>).

1. This special issue

The eight papers in this special issue of *Ecological Engineering* cover the broad spectrum of concepts, methods, results and models addressed throughout the conference. Each paper was targeted to specifically identify a given topic or concept discussed. Three papers (Costanza, 2012; Jones, 2012; Mitsch, 2012) were presented as keynote talks and encompass current thoughts and ideologies concerning the theme of ecological engineering, planet-wide.

In the first paper of the special issue, and in his opening keynote presentation at the EECA conference, Mitsch (2012) defines ecological engineering within the context of 30 years of worldwide research and practice. Given that the creation, restoration and maintenance of the ecosystems lies at the heart of ecological engineering, he revisits the six recommendations and concerns about the development of ecological engineering that he presented at the first EcoSummit in Copenhagen in 1996 (Mitsch, 1998), and examines how ecological engineering has developed in light of these recommendations. One of the most important concepts addressed by Mitsch (2012) is how a decrease in energy supply in the future will affect our lives. He calls upon a better understanding of the principles and approaches of ecological engineering, so that they can be applied efficiently in an energy poor society.

In a paper devoted to analyzing developments in ecological engineering over the last 40 years, Barot et al. (2012) analyzed databases, such as the ISI Web of Knowledge and Scopus, to summarize trends in publishing of ecological engineering papers from the 1970s through to 2009, including those in *Ecological Engineering*, founded in 1992. Barot et al. (2012) found that since 1993, there has been a 14% annual increase in the number of articles published in the journal *Ecological Engineering*, and an annual increase of 8 and 14% respectively in the number of articles mentioning the field of ecological engineering in the ISI Web of Knowledge and Scopus, respectively. They also point out a disparity; applied ecology journals, such as *Ecological Applications* (Ecological Society of America) and *The Journal of Applied Ecology* (British Ecological Society), rarely if ever refer to ecological engineering although they frequently refer to subfields such as ecological restoration. Barot et al. (2012) also showed that the field of ecological engineering is currently dominated by study and practice in aquatic systems such as wetlands, lakes, and rivers, and that more than half of the papers published in *Ecological Engineering* are from China or the USA. These authors conclude that the field of

ecological engineering has not been accepted by ecologists, and that, as yet, there has been little integration of applied and fundamental ecology.

The third paper in this special issue underlines how the concept of ‘ecosystem services’ has redefined how politicians, economists and ecologists communicate with each other, particularly since the publication of the seminal paper by R. Costanza et al. (1997) in the journal *Nature*, and the Millennium Ecosystem Assessment (MEA, 2005). In his keynote speech, Costanza described how ecosystem services are the ecological characteristics, functions, or processes that directly or indirectly contribute to human well-being—the benefits people derive from functioning ecosystems. Here, Costanza (2012) reviews ecosystem health and discusses how the four different types of services refer to the relative contribution of natural capital to the production of various human benefits. Natural capital is defined as a stock yielding a flow of services over time, and together with ecosystem services, are concepts that have changed the way we consider and manage different ecosystems.

In an exciting multidisciplinary mixture of ecological and archeological knowhow, the fourth paper of the special issue shows how archeological evidence points to sustainable agricultural techniques used in Mesoamerica and South America over 2000 years ago (Renard et al., 2012). Pre-Columbian farmers used raised field agriculture in seasonally flooded savannahs, resulting in vast agricultural landscapes. Soil was better drained, aerated and had increased fertility. Channels between the raised areas also provided a habitat for fish and turtle farming. Renard et al. (2012) discuss these Pre-Columbian methods in the light of modern agroecological engineering and the need to compensate farmers for ecosystem services provided.

Managing tourism in environmentally fragile sites is a complex problem with which managers and practitioners are familiar. Sawtschuk et al. (2012) discuss how to manage maritime cliff-tops within this context in northern France. Several restoration methods for revegetating degraded cliff-tops are assessed, including turfing, geotextiles and litter treatments. A valuable discussion points out the necessity of taking into account the stress exposure of a restoration site, as this gradient can decrease restoration efficacy. Sawtschuk et al. (2012) also discuss when spontaneous vegetation should be permitted and when ecological engineers (managers and practitioners) should get involved in ecosystem restoration.

With the protection of landslide-prone mountain slopes as a goal, Mao et al. (2012) assess different models currently used to estimate the contribution of vegetation to soil cohesion, or reinforcement against slippage. The use of vegetation to ‘fix’ soil in place is a concept which has existed for several hundred years, but is currently being used more and more worldwide as a cheap and efficient solution for retaining soil and restoring degraded hillsides. Mao et al. (2012) point out the need for improved knowledge of plant root growth and traits over time and space and in natural field conditions.

Ecological engineering in an urban environment is a particularly difficult task, due to the extreme anthropogenic pressure placed upon the environment. Moore et al. (2012) present a new method to assess the ecological health of ecologically designed stormwater systems. These authors based the design of their system on the principles outlined by Odum (1962), in that “ecological engineering refers to those cases where energy supplied by man is small relative to the natural sources but sufficient to produce large effects in the resulting patterns and processes.” Moore et al. (2012) developed stormwater systems in Kansas, USA, based on the tall-grass prairie ecosystem and compared systems of different ages. Ecological health and functionality improved with system age, but maintenance regimes are an important aspect that ecological engineers must consider at the outset of any such system.

In the closing keynote speech of the EECA conference, Jones (2012) philosophized on what he called the three grand challenges for the future of ecological engineering; the ethical, relational and intellectual. The ethical challenge requires discussing how ecological engineering integrates human society with its natural environment for the benefit of both, and what this implies for codes of practice. The relational challenge is strategic: if ecological engineering is to be widely used, it must develop and strengthen its relationships with other scientific disciplines and other segments of society. The intellectual challenge requires those coming from ecological and engineering perspectives to identify and fuse their key principles into a coherent, useful set that is comprehensible and accessible to all. Jones (2012) highlights the key issues and requirements linked to each of these challenges. He invites thinkers of different environmental communities to sit down together and open a discourse in order to allow these three challenges to be met and integrated into practice for a better contribution of ecological engineering to environmental sustainability.

2. Conclusions

In conclusion, this congress and the resulting papers, show how ecological engineering is slowly but steadily becoming a part of research and academic teaching programs worldwide. Notwithstanding the increased academic interest, ecological engineering is starting to be accepted by the engineering community, but has been largely ignored by the ecological community. The acceptance by engineering is slow largely because of a lack of standards and norms, and hesitance over responsibility and liability, especially in cases where the engineered site also performs a protective function, e.g., coastline defenses and mountain protection forests. The lack of acceptance of ecological engineering by ecologists is, perhaps, the apprehension by ecologists that ecosystems can be “engineered” and by the historical, mutual mistrust that the two fields have had for a long time. There is also a fundamental distinction between science and engineering that gets in the way—the former is good at understanding, but not at solving ecological problems; the latter is more adept at “solving” ecological problems even before there is ecological understanding. Ecological engineers need to make the maintenance of ecosystem health and the provision and enhancement of ecological services as their goals, contributing to the proactive sustainability of ecosystems integrating human society with the natural environment, for the benefit of both.

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