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Review on ecosystem restoration

and its effectiveness in Europe

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Recent political decisions including those on “restoration” in a series of targets forces to clarify this concept and to work out how it could be measured and implemented.

At the global level, the 10th meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD), held in Nagoya, Japan, on 18–29 October 2010, adopted decisions including, *inter alia*, a key policy document of high importance, the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets (UNEP 2010). Among the latter, Target No. 15 says that “*By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including* ***restoration*** *of at least 15 % of* ***degraded ecosystems****, thereby contributing to climate change mitigation and adaptation and to combating desertification*.“ In November 2011, the CBD Secretariat was asked by the SBTTA 15 to compile information on relevant including degraded ecosystems and ecosystem restoration including most used definitions of key terms (UNEP 2011). Results should be presented during the next CBD COP 11 in October 2012.

At the EU level, a new Biodiversity Strategy was adopted by the European Commission including an EU Target 2 defined as “*By 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and* ***restoring*** *at least 15% of* ***degraded ecosystems***”.

In this context, the aim of this background document is to gather preliminary elements to help the discussion on restoration of degraded ecosystems:

Definitions and concepts are briefly provided to support the understanding of the document but with no technical details.

Very few European countries provide an overview and assessment of their actions across their projects and programmes; At the EU level, results based on LIFE programme will be available soon by DG ENV B2.

At the global level, restoration projects are mainly focused on **aquatic ecosystems** followed far beyond by grasslands and mountain forests. At the EU level, **forest, grassland and freshwater habitats** are the most targeted by LIFE programme.

Evaluation of ecosystem restoration success needs monitoring scheme, common methodology and indicators. But only a few ecosystem restoration projects have established a reasonable monitoring scheme of restoration success even if some general recommendations and guidelines have been made available.

1.1 Basic definitions and concepts in restoration ecology

1.1.1 What is an ecosystem?

As defined by article 2 of the Convention of Biological Diversity, an ecosystem is a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit (UNITED NATIONS 1992). It is a functional entity or unit formed locally by all the organisms and their physical (abiotic) environment interacting each other (WALLACE 2007). Each ecosystem is characterized by:

- a composition of species and their relative abundances;
- a physical structure: vertical structure of vegetation and soil components;
- a pattern: horizontal arrangement of system components;
- its heterogeneity: a complex variable made up of these 3 first characteristics;
- its functions: performance of basic ecological processes (*i.e.*, energy, water, nutrient transfers);
- the interactions between species interactions: pollination, seed dispersal, *etc.*
- its dynamics and resilience: succession and state-transition processes, recovery from disturbances (adapted from HOBBS 2009).

Ecosystem processes are the interactions (events, reactions and operations) among biotic and abiotic elements of ecosystems that lead to a definite result (WALLACE 2012). In other words, those are changes in the stocks (the amount of a material in a given pool, form or state in an ecosystem) and/or flows (transfer of materials in an ecosystem from stocks and between pools, forms or states) of materials in an ecosystem, resulting from interactions among organisms and with their physical-chemical environment (MACE *et al.* 2012). **Ecosystem functions** are ecosystem processes that control the fluxes of energy, nutrients, organic matter and information through an environment (*e.g.*, primary production, nutrient cycling or decomposition (CARDINALE *et al.* 2012). Ecosystem functions are a subset of ecosystem processes providing ecosystem services to humans (GROOT *et al.* 2010). **Ecosystem services** are most often viewed as the benefits people obtain from ecosystems (MA 2005).

1.1.2 What means ecosystem degradation?

Ecosystem degradation is any process or activity that removes or lessens the viability of ecosystem processes and hence biodiversity (DUNSTER & DUNSTER 1996). But a degraded ecosystem has been understood and consequently recognised more intuitively than based on well-developed criteria applied during any ecosystem assessment (ETC/BD 2011).

1.1.3 What means ecosystem restoration?

Several wordings and expressions are used in the scientific literature and documentation on this subject.

Ecological or ecosystem restoration is the process of actively managing and assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (CLEWELL *et al.* 2004, UNEP 2011). In other words, it is the practice of restoring the species and ecosystems that occupied a site at some point in the past, but were degraded, damaged, or destroyed (PRIMACK 2010).

Ecological or ecosystem restoration is the process of restoring one or more valued processes or attributes of a landscape (DAVIS & SLOBODKIN 2004).

An array of terms has been used to describe population/habitat/ecosystem restoration under various conditions. The most respected terminology was proposed by the Society for Ecological Restoration International.

Rehabilitation emphasizes the reparation of ecosystem processes, productivity and services, whereas the goals of restoration also include the re-establishment of the pre-existing biotic integrity in terms of species composition and community structure. Nonetheless, restoration, as broadly conceived herein, probably encompasses a large majority of project work that has previously been identified as rehabilitation.

The term **reclamation**, as commonly used in the context of mined lands in North America and the U.K., has an even broader application than rehabilitation. The main objectives of reclamation include the stabilization of the terrain, assurance of public safety, aesthetic improvement, and usually a return of the land to what, within the regional context, is considered to be a useful purpose.

Revegetation, which is normally a component of land reclamation, may entail the establishment of only one or few species.

Mitigation is an action that is intended to compensate environmental damage. The term **creation** has enjoyed recent usage, particularly with respect to projects that are conducted as mitigation on terrain that is entirely devoid of vegetation. The alternate term **fabrication** is sometimes employed.

Ecological engineering involves manipulation of natural materials, living organisms and the physical/chemical environment to achieve specific human goals and solve technical problems. It thus differs from civil engineering, which relies on human-made materials such as steel and concrete. Predictability is a primary consideration in all engineering design, whereas restoration recognizes and accepts unpredictable development and addresses goals that reach beyond strict pragmatism and encompass biodiversity and ecosystem integrity and health. When predictability is not at issue, the scope of many ecological engineering projects could be expanded until they qualify as restoration (CLEWELL *et al.* 2004).

1.1.4 Why ecosystem restoration is needed?

Restoration will help ecosystems to recover their resilience and self-sustaining capacities with respect to their structure (species composition, physiognomy) and functional properties (*e.g.*, productivity, energy flow, material cycling) as well as being integrated into the wider land and seascapes and supporting sustainable livelihoods.

This process is an intervention relying on traditional or local knowledge and scientific understanding. It must be justified by a collective decision recognising that previous state of ecosystems is precious and indeed necessary for the good health and survival of many species, including humans.

Ecosystem restoration is complementary to sustainable socio-economic development because restoring and augmenting the natural capital base generates jobs and improves livelihoods and the quality of life of all in the economy. In this respect ecosystem restoration supports conservation and sustainable development efforts worldwide (ARONSON *et al.* 2006, UNEP 2011).

Although restoration can enhance conservation efforts, it is always a poor second to the preservation of original habitats. The fact that ecological restoration can be misused to the detriment of biodiversity conservation should not blind us to its tremendous potential to achieve laudable conservation goals when implemented appropriately (YOUNG 2000). Even more attention has been recently paid to ecosystem restoration in relation to current and expected climate changes (HELLER & ZAVALETA 2009, LAWLER 2009, VERSCHUUREN 2010, HANNAH 2011, HODGSON *et al.* 2011).

1.1.5 How to restore degraded ecosystems?

Restoration of a specific degraded ecosystem is a long process based on restoration of disturbed or degraded sites including this ecosystem.

Different degrees of damage in the target ecosystem require different types of intervention and different restoration objectives require different methods (KAREIVA & MARVIER 2011).

At site level, any project aiming to restore it should include a number of key processes essential for the successful integration of restoration into land management:

1. Identify processes and pressures leading to degradation or decline.
2. Develop methods to reverse or ameliorate the degradation or decline.
3. Determine realistic goals for re-establishing species and functional ecosystems, recognizing both the ecological imitations on restoration and the socioeconomic and cultural barriers to its implementation.
4. Develop easily observable measures of success.
5. Develop practical techniques for implementing these restoration goals at a scale commensurate with the problem.
6. Document and communicate these techniques for broader inclusion in land-use planning and management strategies.
7. Monitor key system variables, assess progress of restoration relative to agreed-upon goals, and adjust procedures if necessary (HOBBS & NORTON 1996).

In addition, decision must be made among three possible ways of restoration (PRACH *et al.* 2001, HILDEBRAND *et al.* 2005, COOPS & VAN GEEST 2007, WALKER *et al.* 2007, PRACH & HOBBS 2008):

<u>Relying completely upon spontaneous succession:</u> This is a useful, low-cost restoration tool with a minimum or no human or technical intervention but which requires an assessment of the level of environmental stress and productivity in a site to be restored.
<u>Adopting exclusively technical measures</u>: Technical recreation is required where environmental stress or productivity is high and where clear abiotic thresholds are apparent (habitat construction, species reintroduction, riverbed reconstruction, *etc.*)
<u>Combining both previous approaches:</u> by manipulating spontaneous succession towards a target.

In practical terms, a choice must be made according to the ecological characteristics of a site, socio-political objectives, level of human and financial means and time frame (BRADSHAW 1990, FALK *et al.* 2006).:

1. No action – restoration is deemed too expensive, previous attempts have failed, or experience has shown that the ecosystem will recover on its own.
2. Rehabilitation – replacing a degraded ecosystem with another productive type, using just a few or many species.
3. Partial restoration – restoring at least some of ecosystem functions and some of the original, dominant species.
4. Complete restoration: restoring the area to its original species composition and structure by an active programme of site modification and reintroduction of original species.

1.2 Knowledge on projects and programmes of restoration in Europe

A preliminary question linked to the EU target on restoration of 15 % of degraded ecosystems is to get an overview of knowledge on ecosystem restoration in Europe. A gap analysis on information about ecosystem restoration including costs based on EU LIFE projects is being under preparation by the European Commission´s DG ENV B2. Here a quick review is done to briefly show what the current knowledge on projects and programmes in Europe is.

At the national level, a lot of activities regarding ecosystem restoration projects/programmes have been carried out in almost all European countries. However, reports providing overview of such particular activities for a whole country are lacking (*cf.* NELLEMANN & CORCORAN 2010). But in Sweden, a national project RESTORE is performed aiming to collect and compile information on ecological restoration projects in the country. In 2014, the resulting database will be analysed to provide an overview of the present situation in Sweden addressing questions about who is performing the projects, who is financing them, what landscapes and habitats are prioritized, and what actors are involved (RESTORE 2012).

At the EU level, a comprehensive source of information on restoration projects in Europe is the **LIFE+ database** and annual assessments and statistics of projects funded under the programme. Projects are mostly implemented at the national level, but some of them are also cross-border as in Belgium and Netherlands, *e.g.*, ZTAR - Zwin Tidal Area Restoration and HELA – restoration of heathland on continental dunes (EUROPEAN COMMUNITIES 2008).

Ecosystem/habitat restoration projects vary greatly in scale ranging from small local restoration to landscape-scale in extensive areas (MILLER & HOBBS 2007). Generally, large-scale projects in European countries are less common. A few examples are listed below.

Examples of large-scale projects

- One of the large-scale grassland restoration projects supported by LIFE+ Nature programme was implemented in the Egyek-Pusztakócs unit (50 km^2) of the Hortobágy National Park, eastern Hungary, in 2005-2008 (LENGYEL *et al.* 2012). The project was exceptional in Europe due to its spatial scale, which covered a total area of 760 ha of arable land. Restoration targeted alkali steppes and loess grasslands by sowing seeds of either two (alkali) or three (loess) foundation grass species.
- The Integrated River Engineering Project on the Danube to the East of Vienna (IREP), a large scale restoration and navigation programme was launched by the Austrian Ministry for Transport, Innovation and Technology and the waterway operating company Via-donau (RECKENDORFER *et al.* 2005). Another project focused on the Danube River was held in Germany called Restoration of riparian areas on the Danube floodplain between Neuburg and Ingolstadt (Germany): it was carried out in a study

area of 2,100 ha consisting of an ancient floodplain forest. Overview of major current, planned and proposed restoration projects for the Danube River and its main tributaries was developed to identify potential restoration sites by the WWF International (SCHWARZ 2010).

- At present, a large-scale restoration project has been in progress for the whole French stretch of the Rhône River. The project aims to increase both the fluvial dynamics, by raising the minimal base flow in the by-passed sections of the river, and the lateral connectivity, through secondary-channel deepening or reconnection with the main river channel (PAILLEX *et al.* 2009).
- In Austria bigger ecosystem restoration projects are almost exclusively funded under the LIFE+ Programme and thus, the information on them is available again in the LIFE+ database. Some of the most important projects during last years were big river restoration projects (*e.g.*, Lebensraum Huchen-Project, the Wachau, Lech, March, Traisen, Enns, Lavant, Drau, Gail rivers), mire restoration projects (the Wenger Moor, Weidmoos, Pürgschachen peat-bog, Hörfeld-Moor, wetland management in Upper Waldviertel) and dry grassland restoration projects (Bisamberg, Pannonische Sanddünen, Pannonian steppes, ELLMAUER *in verb.*).
- The Humber estuary in the U.K. provides a particularly good example of large-scale restoration (EDWARDS 2008), as well as wetlands in the Norfolk and Suffolk Broads where many efforts have been made to restore the lakes from severe eutrophication. The Broads is the Great Britain's largest protected wetland and third largest inland waterway, being the National Park as well as a Natura 2000 site. Regarding large strategic habitat restoration projects there is an effort to develop the Scottish National Ecological Network (SBF 2012). Other large-scale restoration projects have also progressed. Among them, one of the best known is that at Loch Katrine in the Trossachs where the Forestry Commission Scotland is managing the largest landscape-scale habitat and native woodland expansion project in the U.K. (LAMONT 2006).
- The riverine floodplain restoration across the central-eastern Netherlands is an example of the project with institutional dimension, building partnerships with local community and business, cultural and social interests and innovative fund raising (EERTMANN *et al.* 2002).
- The Danish Skjern Aa River restoration project involves the restoration of the lower reaches of a lowland river system that was heavily impacted by canalization and eutrophication. The lower 19 km of the river was restored into a 26 km meandering river in 1999-2002. In total, 22 km^2 of the former 40 km^2 of embanked meadows were rewetted. Additionally, a new permanent shallow lake was created in the lowest part of the river valley (PEDERSEN *et al.* 2007).
- In the last few decades, in Finland almost one thousand lake restoration projects have been carried out in a wide array of different lake types. By 2002, restoration work had been carried out or planned for a total of some 800 lakes or lake waters.
- Along the lower Schelde River, there are also plans for large-scale wetland rehabilitation. In the first stage, four areas have been restored since 2002, namely Ketenissepolder, Paardenschor, Paddenbeek and Heusden. Larger scale projects have

been in initial stage: Kruibeke-Bazel-Rupelmonde (600 ha, under restoration), Durmevallei and Prosperpolder (EERTMANN *et al. l.c.*, ECRR 2008).

- Large-scale approach was also used for evaluation of restoration success, *e.g.* in rewetted peat extraction areas in the north-western part of Germany (SIEG *et al*. 2010). Evaluation was focused on bog restoration activities done during last 30 years and thus several spatially dispersed sites of the different restoration age were compared. Project outputs will help with identification of easily applicable indicators for a successful restoration. The results are meant to enhance the current restoration practices in harvested bogs. They will contribute to a new bog restoration guide for north-western Germany and to establishing an appropriate monitoring programme. Similarly, specific restoration type regarding the use of large wood in stream restoration has been surveyed for 50 projects via questionnaires in Germany and Austria (KAIL *et al.* 2007).
- Future restoration potential focused on "wilderness" is the objective of the Wild Europe Field Programme of the Wild Europe Initiative (a coordinated strategy support by a partnership of several organisations), which announces establishment of five areas, each with a minimum of 100,000 ha where restoration initiatives based on wilderness principles are to be initiated throughout Europe. The pilot areas include: Western Iberia, the Velebit Mts. (Croatia), Danube Delta (Romania), Southern Carpathians (Romania), and Eastern Carpathians in the borderlands of Poland, Slovakia and Ukraine; the latter area alone could extend to some 250,000 ha (WILD EUROPE INITIATIVE 2012).
- In Germany, a restoration of former military training areas in the State of Brandenburg is planned where a target for wilderness on 2% of the territory has been set by 2020 (SNLB 2012). Huge efforts have been paid to restore large post-mining areas in Germany and the Czech Republic (PECHAROVÁ *et al.* 2011, LARONDELLE & HAASE 2012)

1.3 First overview and facts on which types of ecosystems are subject to restoration

In a global perspective, some figures estimated through bibliographic analysis can be used. A first bibliographical investigation on ecosystem restoration made by HENRY *et al.* (2002) summarizes that 521 papers published over 11 years (1987-1997) included various types of ecosystems; among them terrestrial ecosystems represent only 16 % of the total, whereas **aquatic ecosystems** (including rivers and associated wetlands, as well as isolated marshes, artificial gravel pits, and groundwaters) **accounted for 84 % of the total.** Furthermore, rivers, whatever their size and their associated floodplains, and wetlands represent almost half (47 %) of the ecosystem types over the whole period, while lakes and isolated ponds 25 %.

Another analysis mentioned the most studied ecosystems among more 400 articles published from 1993-2003 in Restoration Ecology review are **wetlands** and **grasslands** and **mountain forests**, as referred, *inter* alia, by RUIZ-JAEN & AIDE (2005), although the results could be influenced by higher proportion of studies carried in North America.

In Europe, **rivers** are the common target of restoration activities, *e.g.* the Danube (SCHWAB *et al.* 2008, SCHWARZ *l.c.*), Rhône (HENRY *et al. l.c.*), Scheldt (EERTMANN *et al. l.c.*), *etc.* Whereas river restoration has recently become a widely practiced measure of environmental management in West Europe, **floodplain restoration** has been underdeveloped, being limited largely to a few, small-scale demonstration sites (BUIJSE *et al.* 2002, MOSS 2007).

Interesting review of international wetland restoration projects is reported by COOPS & VAN GEEST (*l.c.*), who gathered the experience in wetland restoration to use them for the implementation of the EU Water Framework Directive.

In terms of measures, **forest**, **grasslands** and **freshwater habitats** were the habitat types most often targeted by LIFE+, and dune, coastal, and rocky habitats the least restored within the programme (EUROPEAN UNION 2010).

Restoration projects are often associated with protected area management and nature conservation measures carried out within them (*e.g.*, Natura 2000 sites, EUROPEAN UNION *l.c.*, VERSCHUUREN *l.c.*, ecological network in Duna Dráva and Kopacki Rit National Parks, ECNC 2012, *etc.*).

1.4 Evaluation of success

While restoration has been attracting huge financial investment in recent times, to date for various reasons, there has been little or no consensus as to what constitutes successful ecological restoration (GILLER 2005). Several possible ones are proposed.

1.4.1 Reasons of successful or unsuccessful projects

Ecosystem restoration **goals** are usually derived from a complex mix of ecological, social, historical, and philosophical viewpoints but, in many cases, are not formulated in such a way as to guide effective restoration. In addition, the reasons ecosystems should be restored are numerous, disparate, generally understated, and commonly underappreciated (CLEWELL & ARONSON 2006, MOREIRA *et al.* 2006, YOUNG *et al.* 2006). Often, the stated goals relate to restoring a system back to some former structure and/or composition based either on historical information or on nearby reference ecosystems. The two most common forms of reference information are historical data from the site to be restored and contemporary data from reference sites, *i.e.* sites chosen as good analogs of the site to be restored (WHITE & WALKER 1997). Setting realistic restoration goals must be predicated on consideration of ecological, financial, and social constraints that are in place (RAMSAR CONVENTION 2003, MILLER & HOBBS *l.c.*). There is unlikely to be a generic set of restoration actions that is applicable everywhere (CLEWELL & ARONSON 2007, HUGHES *et al.* 2011). In all cases the level of success achieved will depend on a careful consideration and clear statement of the project's goals (MILLER & HOBBS *l.c.*, HOBBS & HARRIS 2001). Authors summarize the key set of considerations that need to be taken into account when embarking on a restoration project: target species and/or key habitat elements to be restored, landscape context (including changes in environmental parameters caused by shifts in climate and land-use and by invasive alien species). Generally, there is a lack of knowledge concerning the question which aspects of ecological community/assemblage/guild structure and ecosystem processes are restorable for most ecosystems, yet this information is crucial for achieving successful restoration. Restoring community structure *(e.g.* species composition, diversity and dynamics) and ecosystem process rates are usually listed as two main objectives of restoration and vegetation improvement (HOLL *et al.* 2003, MARTIN *et al.* 2005).

The **emerging policy focus** on ecosystem services represents a significant shift in the objectives of restoration which might result in both conflicts and opportunities, especially if single services are targeted in isolation. The effectiveness of restoration actions in increasing provision of both biodiversity and of ecosystem services has not been evaluated systematically. Furthermore, recovery of biodiversity and ecosystem services can be slow and incomplete (BULLOCK *et al.* 2011).

Institutional dimension of ecosystem restoration is another issue influencing its success (MOSS *l.c.*). Author assessed floodplain restoration where the task of restoring functional floodplains is fraught with institutional complexities, uncertainties and conflicts. He concluded that little is known about the institutional dimensions. Paper was designed as an initial step towards filling this knowledge gap, providing a critical appraisal of the institutional drivers and constrains of floodplain restoration.

1.4.2 Assessment methods

There are numerous scientific papers considering the complexity of ecosystem and habitat, their functional and spatial connectivity, trying to deal with the complexity of recovery issues (EHRENFELD & TOTH 1997, MILLER & HOBBS *l.c.*, *etc.*). Many authors have also tried to deal with a common set of measures used to design restorations and to evaluate their outcomes in practice. Majority of the papers provide general information on how to evaluate ecosystem restoration thereby maintaining the integrity of target species and the ecosystem. A review of concordance of ecosystems ideas and research needs in restoration, using case study that illustrates this concordance was published by EHRENFELD & TOTH (*l.c.*). The review concluded that restoration urgently requires further research on many basic questions in ecosystem ecology.

Although **restoration project monitoring** is extremely important, in order to document achievement of goals and to modify projects in response to unforeseen circumstance, monitoring ahs not been as frequent or thorough as it should be (MCGRAW & THOM 2011).

BLOCK *et al.* (2001) outlined some primary considerations for **designing monitoring studies** that will evaluate effects of restoration on wildlife; the process of testing responses of wildlife to restoration should be a part of monitoring, but the authors stress that monitoring is rarely done, and when it is done, it often suffers from poor design and lack of statistical rigor. They suggest establishing a monitoring framework that results in a logical flow of information. The approach should be standardized to enable broad-based questions to be addressed, yet remain flexible to allow for answers to more local, site specific questions. Once general relationships are established, more project specific studies can be done to understand restoration effects on the selected species such as threatened or endangered species, species of high societal value, or keystone or focal species, or on selected groups of species incl. guilds. Core study designs and field methods for collecting data on a limited set of variables could be standardized to permit pooling data from different projects across large geographic areas for future meta-analyses (*cf.* SCOTT *et al.* 2001).

The criteria of restoration success should be clearly established to evaluate restoration. The Society of Ecological Restoration International (SER) has produced a primer (CLEWELL *et al.* 2005) which includes **nine ecosystem attributes** that should be considered when evaluating restoration success (*cf.* RUIZ-JAEN & AIDE *l.c.*, ERWIN *et al.* 2010).

DILLARD (2004) gives basic outline that covers most of the major elements that should be addressed in a **grassland** restoration plan. Recommendations for measuring the short-term success in grassland restoration are outlined by DÉRI *et al.* (2011). Some recommendations are presented also by MARTIN *et al.* (*l.c.*).

General principles of **river** ecology and restoration are discussed by STANFORD *et al.* (1996). Standards for ecologically successful river restoration, determining five criteria and standards for evaluation for each of the five criteria and examples of suitable indicators are proposed also by PALMER *et al.* (2005, 2007) and IMST (2007). Thematically oriented assessment of European river restoration measures and their effects on hydromorphology and benthic invertebrates was done for 26 central and southern European rivers (JÄHNIG *et al.* 2010). Principles and practical examples of river restoration in Europe are presented by the European Centre for River Restoration (ECRR *l.c.*). Restoration measures used in numerous **wetland** restoration projects in Europe are reviewed by COOPS & VAN GEEST (*l.c.*).

1.4.3 Results

In order to examine how restoration success has been evaluated in restoration projects several authors reviewed articles published in scientific journals. RUIZ-JAEN & AIDE (*l.c.*) reviewed articles published in the journal *Restoration Ecology* (Vols. 1–11) and found out that only 14 % of the analysed studies really evaluated the restoration success. KAIL *et al.* (*l.c.*) concluded that restoration success was monitored only in 58 % of the surveyed projects. Excluding photographs and visual inspection, the proportion of projects monitored even dropped to 44 %. This is in accordance with the results of BASH & RYAN (2002) who reported the lack of monitoring for 47 % of the restoration projects investigated in Washington State, U.S.A. BERNHARDT *et al.* (2005) reported even a lower rate (10 %) for the 37,099 projects investigated in the U.S.A. Moreover, methods and intensity of monitoring activities differed even within the same ecosystem type.

For a meta-analysis of 89 restoration assessment in a wide range of ecosystem types across the globe, REY BENAYAS *et al.* (2009) calculated response ratio of restored ecosystem compared with both the reference and degraded ecosystem for each measure of biodiversity (related to the abundance, species richness, diversity, growth, or biomass of organisms present) and ecosystem services. The results indicate that ecological restoration increased provision of biodiversity by 44% and ecosystem services by 25%. However, values of both remained lower in restored versus intact reference ecosystems. Increases in biodiversity and ecosystem service measures after restoration were positively correlated. Results indicate that restoration actions focused on enhancing biodiversity should support increased provision of ecosystem services, particularly in tropical terrestrial biomes.

JONES & SCHMITZ (2009) tested the prediction of irreparable harm using a synthesis of recovery times compiled from 240 independent studies reported in the scientific literature through measuring multiple response variables. They provided startling evidence that most ecosystems globally can, given human will, recover even from very major perturbations on timescale of decades to half-centuries.

On the other hand, results of a meta-analysis of 621 wetland sites from through the world show that even a century after restoration efforts, biological structure (driven mostly by plant communities/assemblages) and biogeographical functioning (driven primarily by the storages of carbon in wetland soils), remained on average 26 % and 28 % lower, respectively, than in reference sites. For estimating method restoration performance over time, the authors applied 34 variables measured (MORENO-MATEOS *et al.* 2010).

DODDS *et al.* (2008) concluded that within 10 years of restoration, restored ecosystems provide 31 – 93 % of the benefits of native lands.

1.5 Conclusions

This background document proposed some **definitions and concepts** which support the understanding of this first overview. It is clear that **the knowledge on actions of restoration** in Europe is low or scattered. Results from the DG ENV B2 contracts should help to have a better vision at EU level. **Evaluation of ecosystem restoration success** is still a weak part of all these programmes due to complexity of the issues: therefore, it is not easy to develop generally applicable indicators for that purpose.

This preliminary overview should help discussion on the implementation and the measure of the EU target 2 which aims to restore at least 15% of degraded ecosystems.

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http://ec.europa.eu/environment/life/publications/lifepublications/lifefocus/nat.htm#grassland

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Swedish project: http://www.restore-project.org/research

The SER International Primer on Ecological Restoration:

http://www.ser.org/content/ecological_restoration_primer.asp

Guidelines for Developing and Managing Ecological Restoration Projects:

http://www.ser.org/pdf/SER_International_Guidelines.pdf

The 6th European Conference on Ecological Restoration: Towards a sustainable future for European Ecosystems - Providing restoration guidelines for Natura2000 habitats and species – abstracts:

https://www.ser.org/europe/pdf/SER2008_Abstracts.pdf

ECNC:

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Scotland:

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