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Biodiversity and Green Infrastructure in Europe: Boundary object or ecological trap?

The concept of green infrastructure is widely used in environmental planning, but so far it has no standard definition. Planners, conservationists and scientists tend to welcome the term because it can serve as a boundary object, providing links among policy makers, developers and different academic disciplines. However, the concept of green infrastructure creates risks for biodiversity conservation in its adoption. It can be used to water down biodiversity conservation aims and objectives as easily as it can be used to further them because of the different ideas associated with it and the multiple interests pursued. In this paper, we address such risks by looking, among others, at the European Union's Green Infrastructure Strategy and we suggest how planners and conservationists might deal with its growing importance in environmental policy and planning to enhance its value for biodiversity conservation

Keywords: Biodiversity Conservation Planning Ecological connectivity Ecosystem services Natural capital Green economy

1. Introduction

Green Infrastructure (hereafter GI) has become increasingly animportant concept in environmental planning (UNEP, 2014), forexample in Europe, (e.g. in France, Grenelle Environment, 2010,and the UK, DCLG, 2012), and the USA (EPA, 2014). Most recently,the European Union's (EU) Green Infrastructure Strategy has beenlaunched, where GI is defined as 'a strategically planned networkof natural and semi-natural areas with other environmental fea-tures designed and managed to deliver a wide range of ecosystemservices' (EC, 2013, p. 3). Such ecosystem services (ESs) includeprovision of new habitats, flood protection, cleaner air and water.Furthermore, at least four key actions of the EU Biodiversity Strat-egy appear to us as relevant to GI, including: (i) the provision ofbaselines against which nature's benefits to society can be valuedand GI investments can be measured (action 5); (ii) the establish-ment of a restoration prioritization framework (action 6a); (iii) the mainstreaming of biodiversity in key EU funds (action 7a); and(iv) the establishment of links between GI implementation and no-net-loss policies (action 7b), through, for example compensation oroffsetting schemes (EC, 2013). Hence, the way GI has been framed,interpreted and implemented in practice can significantly influencethe way the wider biodiversity conservation agenda is understoodand promoted in Europe.

The concept of GI can act as a 'boundary object', as does the con-cept of ecosystem services (Abson et al., 2014). 'Boundary objects'may be concrete or abstract (e.g. an idea), and are plastic enough tobe interpreted differently among communities or interest groups,yet are robust enough to enable cross-communication (Star andGriesemer, 1989). In this case, the term 'green infrastructure' has the potential to link planners, conservationists and academicstogether in a common task, namely the provision of areas of habitator undeveloped open space in human-dominated (predominantlyurban) landscapes.

The idea of GI builds on the long history of the creation of pub-lic parks and open spaces in industrialized regions for amenityand ecological purposes (Walmsley, 2006). Academic interest inGI cuts across several disciplines, although it draws in particular onlandscape and urban planning (Benedict and McMahon, 2002) and landscape ecology (e.g. Jongman and Pungetti, 2004). In ecology andbiodiversity conservation, the idea of GI (particularly in the contextof urban planning and regeneration projects) is framed in the con-text of habitat creation and restoration (Perrow and Davy, 2002),ecological networks (Lindenmayer and Fischer, 2006), urban bio-diversity (Muller et al., 2010) and increasingly ESs (Schindler et al.,2014). GI projects also show a great diversity of scale, from greenroofs (Williams et al., 2014) through local storm water manage-ment projects (Ahern, 2010) to large national ecological networks(Weber and Allen, 2010).

GI is considered important in biodiversity conservation for threemain reasons. First, it focuses attention on the creation or mainte-nance of areas of wildlife-rich natural or semi-natural habitat inheavily developed, developing or urbanised landscapes. Second, itinvolves the creation of ecological connections between differentareas of habitat, potentially allowing species movements amongotherwise isolated habitat blocks. Third, it translates ideas aboutthe importance of areas of wildlife habitat in a language that can beunderstood by planners and private businesses that control deci-sions about land development and urbanisation. In the EU, GI is seenas having an important role in conserving biodiversity (Kettunenet al., 2014). In particular, GI has been considered the main instru-ment for the implementation of Target 2 of the EU 2020 BiodiversityStrategy, which aims by 2020 to maintain and enhance ecosystemsand their services by establishing green infrastructure and restoringat least 15% of degraded ecosystems (EC, 2011).

However, there are risks in the adoption of the GI concept. Inthis paper, we analyze these, focusing on its current deploymentin Europe as this is illustrated in the EU Strategy for Green Infras-tructure (EC, 2013). We consider first the biodiversity value of GIlandscapes and second the implications of the role of GI as naturalcapital. Finally, we provide a series of recommendations to enhanceGI's value for biodiversity conservation. These recommendationsare not limited to the European case, but extend globally whereverGI is implemented in a similar manner.

2. Biodiversity value of GI landscapes

A range of factors determines the value of GI landscape features for biodiversity. Here we identify three.

First, multi-functional planning is central to the conception of GI, seeking to provide 'win–win' solutions by enhancing multiple benefits simultaneously (Benedict and McMahon, 2002). Thus the stated benefits of GI in the new EU strategy (EC, 2013) include bio-diversity conservation; climate change adaptation and mitigation; disaster risk management; reduced energy use; water regulation; cooling; food provision; economic growth; recreation, health and well-being; increased land and property values; and the enhancement of territorial cohesion, among even more. Planning to meet multiple goals of this kind inevitably involves trade-offs (Maeset al., 2012), and the provision of habitat for biodiversity can easily become buried in an agenda of broadly defined 'green' projects(see also EPA, 2014; UNEP, 2014). Indeed, GI is widely considered as a means to create 'appealing places to live and work in' (EC,2013, p. 3), a goal that can be interpreted in many different ways and which does not necessarily include biodiversity conservationas one of its objectives. The issue of potential conflicts between GI functions is not simply a technical issue (Wright, 2011). On the contrary, achieving biodiversity conservation goals in the face of competing demands on land and investment involves hard politi-cal choices where win–win outcomes may not be possible (Hirschet al., 2011). Hence, planning for multi-functionality involves inclu-sions and exclusions, has winners and losers and can exacerbateenvironmental and socio-spatial injustices for certain social groups(Hansen and Pauleit, 2014) while also creating conflicts that cannegatively impact on biodiversity (Redpath et al., 2013).

Second, the definition of GI is so broad as to include urbanplazas, sports pitches, cycle-paths, landscaped gardens, road vergesor landfill sites (EEA, 2011). In practice, GI often tends to be con-founded with generic 'green space', meaning land that is not builtupon. The value of a piece of land for biodiversity depends ona species-and-place-specific balance between habitat area, qual-ity and connectivity. The quality of such land for biodiversity isoften low and rarely corresponds to breeding habitat for mostspecies (Hodgson et al., 2009). Indeed, despite the contributionof urban ecosystems to specific taxonomic groups (Muller et al.,2010) and diverse ESs (Gómez-Baggethun and Barton 2013), recentreviews and meta-analyses show that flagship GI elements suchas corridors (Shwartz et al., 2014; Snäll et al., 2016), urban gar-dens (Cameron et al., 2012), green roofs (Williams et al., 2014) andbrownfields (Bonthoux et al., 2014) are not as valuable for biodi-versity as often portrayed. To the above, we should add the possibleeffects of disturbance and maladaptive habitat selection. Examplesinclude Cooper's hawks (Accipiter cooperii) in urban contexts (Boaland Mannan, 1999), the desert lizard Acanthodactylus beershebensisand afforestation (Hawlena et al., 2010), wetland restoration andthe Lycaena xanthoides butterfly (Severns, 2011), and road trafficdisturbance and meadow birds (Reijnen et al., 1997).

Third, while the enhancement of connectivity between areasof wildlife-rich habitat is identified as an important contributionof GI to biodiversity conservation (Benedict and McMahon, 2002),the value of these connections is highly variable and often speciesand species-group specific (Henle et al., 2004). The EU strategyobserves that GI has the potential to reduce ecosystem fragmen-tation and increase the connectivity between Natura 2000 sites(an EU-wide network of nature protection areas established underthe 1992 Habitats Directive), connecting 'national parks, natureparks, biosphere reserves, trans-boundary protected areas andnon-protected areas along or across borders' (EC, 2013, p. 10). How-ever, understanding the multiplicity of factors that contribute tolandscape connectivity remains challenging and the scientific evi-dence of the value of corridors is still inconclusive (Moilanen, 2011;Snäll et al., 2016). In addition, the connectivity relevant to biodiver-sity may not be at a spatial scale relevant to planning (Rudnick et al.,2012): ecosystem elements visible to humans, e.g. hedges or linearparks, may only be relevant to a subset of species e.g. birds. Hence,the quality of habitat in corridors is likely to be more importantthan their layout, and corridors developed within GI projects forother purposes than biodiversity (e.g. a footpath to link housingareas to open spaces, or the visual effect of a line of roadside trees,Jongman and Pungetti, 2004) may be of limited ecological value.Synergies between these objectives and biodiversity will dependon visual character and ecological character coinciding, and humanand wildlife movements being enhanced by the same features.Moreover, in a context of increasing urban and development pres-sures, connectivity or wildlife corridors, can be used to legitimisehabitat destruction allowing planners to 'ring-fence the best andtrade-off the rest' (Selman, 2002, p. 284), permitting developmentof all land except a minimalist network of defined 'corridors'.

To investigate if our concerns reflect the reality of GI practice,we conducted a desk study of the GI strategies developed for Eng-land, arguably the European country where 'explicit' GI policieshave been most developed. We surveyed all GI strategies and plansthat we could locate online using the search term "green infrastruc-ture UK"(59, from 2005 to

2015). Their treatment of connectivityincluded cycle paths, footpaths, road verges and planning-stylecorridors—even in some cases with connectivity of 'habitats andlandscapes, businesses and communities at a range of scales' (UEAssociates, 2010, p. 6). While all of them analysed maps within a GISsystem: (a) 94% (56) only used map overlays within a GIS system to assign potential GI areas (see Snäll et al., 2016 for the limitations ofthis approach); (b) only 6.7% (4) used or incorporated a systematic,scientific method for 'drawing' corridors that takes into accountecology; and (c) none of them considered trade-offs between GIand biodiversity conservation.

3. GI and natural capital

The connections between GI, ESs and natural capital were notexplicit when the GI concept first emerged in the US. But, as thewhole field of environmental – and not just biodiversity – conser-vation and restoration gradually moved to a more utilitarian andneoliberal framing of nature (Gómez-Baggethun et al., 2010), so didGI. The idea of nature as a provider of 'services' that can producefinancial gains along with biodiversity conservation is also reflectedin the EU GI strategy (Green Infrastructure—Enhancing Europe's Nat-ural Capital, EC, 2013) and the EU Biodiversity Strategy (Our lifeinsurance, our natural capital: an EU biodiversity strategy to 2020, EC,2011). In line with this new thinking, the EU GI strategy does nothave a separate section on 'biodiversity conservation' and the con-cept is explicitly framed in terms of 'natural capital' (as one formof capital alongside built, financial and human capital). By anal-ogy with hard infrastructure, this framing suggests that nature andgreen spaces must be actively managed and measured as economicassets (Thomas and Littlewood, 2010; Wright, 2011).

A key aspect of the influence of the idea of GI as natural capital isthe way its value is expressed in terms of its capacity to deliver ESsthat are valuable for the economy (EEA, 2011). The emphasis on ESsand the parallel underestimation of an explicit reference to biodi-versity conservation in the EU GI strategy implies that biodiversityand ESs are one and the same. However, although managementinterventions to enhance biodiversity conservation and ESs, espe-cially in semi-natural or human dominated landscapes, can bemutually beneficial under specific circumstances (Schneiders et al.,2012), the interplay between ESs and biodiversity is complex andcontext dependent (Bullock et al., 2011), so improving one does notnecessarily imply benefits for the other (Adams, 2014). Moreover,while GI has the potential to enhance diverse urban ESs (Gómez-Baggethun and Barton, 2013), an economically driven focus onthose 'services' that are valuable to the current economic systemand profitable to investors may restrict GI projects to those thatmatch the needs of the market and not biodiversity conservation(Vira and Adams, 2009). Especially regarding large-scale GI projectsthat would require significant funding, available funds through theEU cohesion policy programmes or the European Investment Bankrequire that projects contribute not only to environmental targetsbut also to economic growth and job creation (Maes et al., 2015).In this context it is important to note that although GI is the mainEU policy instrument to maintain or enhance ecosystem services(Target 2 of the EU Biodiversity Strategy), no dedicated funding toachieve this target is available.

The framing of GI in terms of natural capital by the EU locatesit as part of a 'green economy' agenda that belies trade-offsbetween environmental protection and economic growth (Gómez-Baggethun and Naredo, 2015). Indeed, the EU strategy emphasizesthe role of GI in enabling economic growth and investment (EC,2013). GI is expected to contribute to the 'recovery of Europe's econ-omy by fostering innovative approaches and creating new greenbusinesses'1; as the Roadmap to a Resource Efficient Europe reiter-ates calling for proposals to 'foster investments in natural capital,to seize the full growth and innovation potential of GI and the restoration economy'.2 Thus the role of GI in supporting biodiver-sity becomes secondary to the broader needs of economic growth. Many GI projects are designed to address infrastructure cost, dura-bility, safety, or aesthetics (Foster et al., 2011) and biodiversity conservation features only as a mere desirable side effect or co-benefit. For instance, among the 1824 green roof projects reviewed by Williams et al. (2014) only 8% cited biodiversity conservation or related benefits.

Furthermore, in a green economy, the enhancement of GI becomes an economic opportunity to promote develop-ment and growth by attracting investment and actors pursuing entrepreneurialism and place competitiveness agendas (Thomas and Littlewood, 2010). Such growth may have negative broader impacts on biodiversity that are not educed or offset by any GI created, for the reasons discussed above. Current initiatives to enhance GI in the EU, the US and globally (e.g. UNEP, 2014) prioritize support for economic growth over the need to conserve biodiver-sity and natural ecosystems. In Europe, industry and the business sector are considered as increasingly important by the EC to the funding of GI (EC, 2012) while in the USA, new partnerships (e.g. 'NatLab') among private companies and conservation agencies are being promoted to attract private capital in GI, e.g. through credit trading programmes, offsite mitigation, private-public partner-ships and transformation of vacant lands.3 To corporations, hybrid approaches combining green and grey infrastructure are seen to provide an optimum solution to 'improve business resilience' through new investment opportunities but the precise impacts of GI on biodiversity remain largely unaddressed (Williams et al., 2014). GI projects still lack rigorous evaluation in terms of baseline measures or agreed indicators over time (EC, 2012) despite recent efforts to bridge this gap (Bonthoux et al., 2014).

4. Enhancing GI's value for biodiversity conservation

While in principle various forms of GI can lead to the enhance-ment of biodiversity and habitat restoration, planners, scientists and civil society actors need to be realistic about GI's potential and limitations in this regard. There is a risk that biodiversity loss will be legitimized under this banner, and this loss hidden behind a generic rhetoric of 'green planning'. We identify four areas that need to be explicitly addressed to ensure the contribution of GI projects to biodiversity conservation.

First, the level of uncertainty involved in assuming that 'green spaces' will necessarily support significant biodiversity needs to be recognized. The assumptions made about the ecological value of linear or visual 'corridors' in species dispersal or movement need to be addressed explicitly in project planning. Where appropriate research should be carried out to determine the relative value of dif-ferent kinds of GI landscape elements, for example 'connectivity' versus habitat extent and quality as variables in explaining pop-ulation persistence. Approaches that integrate information about organisms' life histories, habitat quality, and other key deter-minants of connectivity are available for bridging this gap and reducing the uncertainty of connectivity models (e.g. Moilanen and Hanski 1998; Ovaskainen et al., 2008; Rudnick et al., 2012). Never-theless, further research is needed to improve our understanding of not only the structural connectivity created by GI projects (the physical characteristics of the landscape), but also the functional connectivity (how well genes, individuals, or populations would be able to move through the new landscapes).

Second, biodiversity proofing of projects appears in the Com-mission's agenda (see for instance action 7a, b on not net loss inthe EU's Biodiversity Strategy, EC, 2011). However, currently, thebenefits of such strategies for biodiversity conservation are subjectto great uncertainty and the focus of strong debate (e.g. Moreno-Mateos et al., 2015; Apostolopoulou and Adams, 2016). Hence, theenvironmental impacts of GI projects need to be carefully assessedin project design, for example through improved EnvironmentalImpact Assessments, and appropriate mechanisms need to be inte-grated to ensure the protection of biodiversity as projects develop.Depending on the complexity of the target landscape and the scopeof the intervention, this will require the adoption of the precaution-ary approach as well as flexibility and anticipation in GI projects.Among other issues, to avoid irreversible damage, careful assess-ment will be needed, to adapt GI projects to the emerging propertiesof new landscapes and to ensure appropriate resources (human,economic, technological and legal) to handle the unintended conse-quences such as the spread of invasive species and disease throughconnected landscapes.

Third, measures to safeguard those ecosystems and species ofcritical importance for biodiversity conservation need to be madecentral in planning GI programmes. Lessons on biodiversity safe-guards from other conservation interventions (Phelps et al., 2012)should be incorporated to GI projects. Safeguards should be bindingand monitored against previously defined indicators for assessingbiodiversity outcomes. This will require improved knowledge ofspecies' requirements, habitat and ecosystem processes to ensurefunctional green infrastructures for biodiversity.

Fourth, attention needs to be paid to the synergies and trade-offs between biodiversity and ESs. Assumptions that conflate ESsand biodiversity in GI projects needs to be recognized and ques-tioned, and the synergies demonstrated. While there is increasingevidence on the ways in which specific elements of biodiversityunderpin the provision of ESs (Isbell et al., 2015; Maes et al., 2015),lessons from ecological restoration show that both opportunitiesand conflicts for biodiversity conservation emerge from interven-tions to enhance ESs (Bullock et al., 2011). Plans to enhance ESshave often failed in their attempt to achieve biodiversity conser-vation (Macfadyen et al., 2012). Important drawbacks also arisefrom the lack of spatial concordance between some ESs and speciesrichness measures (Naidoo et al., 2008). Hence, attention needs tobe paid to the trade-offs and synergies between biodiversity con-servation and other objectives of GI projects like the provision ofESs. Systematic conservation planning has recently been proposedas a way to include these trade-offs and synergies at the planningstage (Snäll et al., 2016), although such an approach has rarely beenpromoted (Snäll et al., 2016) or used in practice. Likewise novelspatial approaches have emerged promising to reconcile conserva-tion targets with ES based GI approaches (Schneiders et al., 2012).However, due to the small scale of the majority of GI projects, theknowledge-practice gap, and the time and funding problems facedby many local and regional authorities in Europe, such approachesare unlikely to gain mass use.

5. Conclusion

The increasing calls for 'smart' conservation (e.g. EEA, 2011)identify the need for conservationists to engage with spatial plan-ning and the economic engine that drive it. GI works powerfullyas a boundary object to enable that engagement (c.f. Abson et al.,2014). However, the idea of GI, as currently configured, poses chal-lenges as well as opportunities for biodiversity conservation. Todraw an analogy from ecology, there is a risk GI could act as a con-ceptual 'ecological trap' (Battin, 2004; Robertson and Hutto, 2006)− an idea that attracts funding and effort from specific conservation measures that could deliver better biodiversity conservation outcomes.

In an era when the pursuit of economic growth is considered aparamount policy goal to deal with the effects of the economic cri-sis, calls to de-regulate and weaken state support for environmentalprotection have grown both in the US (McCarthy, 2012) and Europe(Apostolopoulou and Adams, 2015).4In this policy context, it isnot surprising that GI initiatives are increasingly linked to businessinterests. However, GI projects that are attractive for the marketor cost-effective for investors will not necessarily be beneficial tobiodiversity conservation.

GI has an important complementary role in the implementa-tion of the EU biodiversity strategy, and is influential in shaping thewider policy context of biodiversity conservation in Europe. How-ever, if the GI strategy is implemented without specific measuresfor biodiversity, GI could divert funding and effort from specificconservation measures, with negative net effects on biodiversity.Clarity about the goals of GI projects, and the incorporation ofbiodiversity conservation needs from the earliest stage of projectplanning through implementation and maintenance, are essentialif this trap is to be avoided.

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