Towards the integration of urban planning and biodiversity conservation through collaboration

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Abstract

Despite aspirations to halt biodiversity loss by 2020 under the Aichi Biodiversity Targets, urban development continues to negatively impact UK wildlife and habitats. Reasons behind continued biodiversity decline are examined through the use of semi-structured interviews with ecologists, statutory regulators and land developers.. It is found that despite strict legislation and best practice, for both planning and ecology, there is still much room for subjectivity regarding the protection of specific ecological features and the implementation of the mitigation hierarchy. Interviews also revealed that such subjectivity often facilitates the prioritisation of commercial over ecological benefits during site design. Furthermore, many felt an over reliance on the protection of individual animals, as opposed to maintaining functional connectivity for conservation of wider populations was detrimental to both the development industry and ecology. Our findings support the case for further research into the development of innovative geographical information systems to allow spatial deliberation, and collaborative decision-making between the three stakeholder groups.

Keywords

Collaborative GIS; Commercial ecology; Ecological legislation; Development site; Planning; Biodiversity

1. Introduction

The Millennium Ecosystem Assessment [1] concluded that anthropogenic drivers were causing adverse effects on ecosystems, and that these effects look poised to intensify as human population grows alongside our ecological footprint. At the time of publication, over half of the ecosystem services identified and assessed were reported to be in serious decline. Half a decade later, the United Nations' Global Biodiversity Outlook 3 [2] report demonstrated continuing losses of biodiversity. The report concluded that attempts to meet the Convention on Biological Diversity's targets "to halt the loss of biodiversity by 2010" had failed. Today a renewed effort is underway to finally halt trends in biodiversity loss under the Aichi Biodiversity Targets for 2020 [3]. Although there are many avenues along which improvements can be made, including better nature reserve design [4], tighter control of invasive alien species [5] and better agricultural practices [6], we focus here on protected species and habitats legislation. Much of the literature concerned with protected species and habitats legislation suggest that improvements to the legislation itself may serve as a catalyst for improvement [e.g. 7, 8-10]. However, weaknesses in the ways that existing ecological legislation is applied are seldom examined.

We use the context of ecological legislative impacts on UK urban planning and development as a framework for our study. The ecological impacts of landuse change to accommodate new residential, commercial and industrial buildings, and associated infrastructure (such as roads and utility lines) have been widely reported [11-13] . Impacts include habitat fragmentation, degradation and homogenisation as well as direct impacts upon individual animals such as the destruction of shelters and disturbance [14]. In order to combat such impingements, legislation has been derived requiring developers to avoid, mitigate and compensate for impacts on certain species and habitats during new developments under the mitigation hierarchy [15].

UK ecological legislation however, is currently under review in a bid to cut the 'red tape' perceived to inhibit the planning and development industry [16]. Such a review seems to be a response to criticisms of current ecological practices, made not only by developers [17] and economically driven governments, but by ecological scholars too [8]. Whilst the criticisms made by developers and government seem to be centred upon the economic implications of conservation, scholars argue that conservation practices are too simplistic, paying little attention to concepts such as population connectivity [8]. As such, emphasis is placed on the conservation of isolated individuals or sub-populations within a development site, which can facilitate fragmentation and ultimately, species population declines. Edgar and Griffiths [18] for example, looked at development sites on which great crested newt *Triturus cristatus* mitigation had been implemented; only 56% of the sites showed signs of newt breeding activity a year after the development was completed. Such examples coupled with the general decline in biodiversity reported in the United Nations' Global Biodiversity Outlook 3 [2], signify the need for more robust conservation measures.

The coordinators of the development project will usually employ the services of an ecological consultancy to provide advice on how best to adhere to the legislation, and to provide ecological evidence to support the planning application. Where impacts are unavoidable, the ecologist will devise mitigation and compensation plans which must be approved by relevant authority (Natural England, Scottish Natural Heritage or Natural Resources Wales), who will issue a licence for the works to go ahead. This process is outlined in detail in Figure 1. In practice however, the recommendations made by commercial ecologists are but one consideration of development planners who are attempting to balance many competing social, economic, environmental, engineering and geotechnical demands [19, 20]. Achieving a balance between these demands, when designing the final site layout and programme of works, is a problem of spatial optimisation. However, solving spatial optimisation problems in this context can be categorised as a 'wicked problem' [21], with no clear solution, as what may be deemed optimal by one individual or stakeholder group may be considered otherwise by another. Moreover, an optimal solution for a single stakeholder group may be achieved through a number of different development scenarios and pathways. Therefore solutions to problems of spatial optimisation derived by the developer (which is usually the case) may well result in layouts that favour commercial over ecological benefits. Examples of this may include prioritising housing units over retained habitat and increasing human access to retained habitat which can raise land values but also increases the potential for wildlife disturbance [22, 23]. An obvious answer to this issue is to give ecological considerations higher precedence within layout design and to integrate them into layout planning at an earlier stage. Less obvious however, is the mechanism through which this can be achieved.

Figure 1. – Relationships between stakeholders in the commercial ecology process

We use semi-structured interviews with commercial ecologists, developers and competent authorities to investigate various influences in ecological decision making, identify commonalities and conflicts and highlight under-represented points of view. We then use this analysis to suggest an innovative solution to spatial decision making for development site layouts, which utilises a collaborative spatial decision support system (C-SDSS) to achieve more mutually beneficial outcomes in terms of conservation and development efficiency. Before the benefits of implementing C-SDSS in commercial ecology applications can be ascertained however, it is first necessary to review their common features and instances of their usage.

2. Collaborative Spatial Decision Support Systems (C-SDSS)

Densham [24] defines a SDSS as "a framework for integrating database management systems with analytical models, graphical display and tabular reporting capabilities, and the expert knowledge of decision makers". SDSS are often implemented as an extension to geographical information systems (GIS) [e.g. 24, 25-29], since GIS packages provide a spatial database management system, graphical display and a user interface. Early SDSSs were subject to similar problems of demographic marginalisation reported by early GIS critics such as Lake [30] and Sheppard [31]. Their arguments stemmed from the idea that digital representations of geographical objects reflect the particular view point of the data creator and can therefore act to prioritise one view point over another. This bias can often be a manifestation of the decision maker's underlying principles and specialisations, rather than a deliberate intention [28]. The emergence of the Web 2.0 paradigm [32] over the last decade however, has elevated ubiquity of data in the GIS research agenda. Consequently, a wealth of literature has now been published promoting collaborative and participatory GIS as tools to empower previously marginalised groups and individuals when creating spatial knowledge [28, 33, 34].

Mirrored by progressions in GIS research toward ubiquity, SDSSs have also benefited from movement into the collaborative domain. Multi-criteria decision analysis (MCDA) has long been a popular form of SDSS, utilised to balance competing demands during spatial decision making [29, 35-38]. The methodology involves gathering multi-stakeholder view-points by asking individuals to apply subjective interpretations of importance, known as weights, to each criterion encapsulated within the study. These weights can then be quantitatively combined using a variety of techniques [see 36] to reveal a collective interpretation of importance and priority for each criterion, which in turn can be utilised to achieve planning solutions that balance competing objectives. Scholars such as Ramsey [28] however, suggest that MCDA only facilitates collaboration at the final stages of decision making, and that the problem definition and criteria to be evaluated are still selected by a single individual, thus are still reflective of a single view-point. C-SDSS software has now emerged as an alternative, supporting not only a multi-stakeholder perspective on problem solutions, but a multi-stakeholder viewpoint on the problem itself.

Applications of C-SDSS have been prominent in the domain of land use planning; nonetheless the research focus seems to be centred on public participation to achieve a balance between social requirements [e.g. 38, 39, 40]. We advocate here that C-SDSS be used to promote the agenda of ecologists within planning for the built environment, thus helping to ensure that Aichi Biodiversity Targets are achieved for 2020. Although collaborative governance has been advocated elsewhere [41, 42], Uran and Janssen [43] note that SDSS software is rarely implemented beyond an academic context. They go on to conclude that a closer link between SDSS programmers and stakeholders involved in the decision making process may improve SDSS adoption. This paper attempts fulfil this requirement by gathering the views of different stakeholders on the practical problems faced when implementing ecological legislation.

3. Methodology

In order to gain a deeper understanding of the challenges faced by different stakeholders within the development process, semi-structured interviews were held with a sample of commercial ecologists, developers and competent authorities. Interviews were designed to reveal stakeholder opinions on commercial ecology practices to identify both positive and negative attributes of current ecological practices as perceived by each stakeholder group.

3.1 Stakeholder Groups

We adopt the same classification of stakeholders involved in ecological legislation implementation as Drayson and Thompson [44] i.e. ecological consultants, developers and competent authorities (though for simplicity, we refer to them as regulators). Ecological consultants are employed by the developer to undertake ecological surveys on site, report on the current status of the wildlife, identify potential impacts caused by development and propose solutions to these. Developers, for the purpose of this study, encompass a wide range of actors who influence site layouts including landscape architects, builders, planning consultancies and brownfield decommissioning engineers. Regulators are responsible for ensuring that development works are compliant with ecological legislation. Their role differs from that of ecological consultants in that they rarely conduct site visits. Instead, local authority ecologists ensure that the findings and recommendations of the commercial ecologist are supported by robust evidence, whilst public bodies such as Natural England or Scottish Natural Heritage grant the developer licences to disturb protected species. Disturbance to wildlife can only occur if the development serves an "overriding public interest" [45], such as addressing a housing shortage for the locality, and if the proposed mitigation is deemed adequate.

3.2 Study Design and Sampling

A sample of two ecologists, six developers and one regulator involved in a large-scale redevelopment project were identified and invited to interview. Snowball sampling techniques were then utilised to expand the number of participants to five ecologists, seven developers and five regulators (three of whom represented local authorities, two of which represented different national conservation agencies). These additional participants were not associated with the redevelopment project, nevertheless, their views were considered useful in the context of proposed C-SDSS solutions.

Semi-structured interviews were utilised to explore a number of themes with the interviewees. The benefit of semi-structured interviews is that similar themes can be explored across the sample group, even though questions can be phrased in a way that is specific to the interviewee [46]. Given that this study covers an interdisciplinary spectrum of stakeholders, it was felt that this technique would be the most effective means of generating qualitative data. Themes that were explored with interviewees included: problems with the current legislation and its implementation, issues surrounding the representation of complex ecological processes, uncertainties in ecological knowledge within GIS and relationships between other stakeholders in the planning process. Interviews were conducted face to face at the work place in all cases, tended to last 30-60 minutes and were audio recorded before being transcribed verbatim. Transcripts were subsequently analysed for common themes and interviewees were given pseudonyms to preserve anonymity. Follow up emails were also sent in some instances in order to explore certain topics in more detail, or to give earlier respondents a chance to comment on topics raised by later interviewees.

4. Results

4.1 Interpretation of Guidance and Legislation

4.1.1 Approach to Protection

Both European and UK legislation clearly identifies lists of species for protection and prohibits anthropogenic disturbance to individuals of those species, and intentional or reckless damage to their shelters and resting places. All of the interviewed ecologists reported that in practice, this approach to prohibition caused them difficulties since the animals themselves, their associated field signs (such as faeces and prints), shelters and resting places could be elusive, with surveys designed to determine their presence susceptible to false negative conclusions. The majority went on to state that they thought this had caused instances where development had unknowingly impacted in some way upon a protected species population. However, no ecologist was prepared to quantify how often this might occur, or the extent to which severe impacts were experienced.

Possible solutions to either limit such uncertainty in ecological knowledge or to incorporate it into decision making were explored with all participants. An overwhelming majority across developer and ecologist groups favoured a move toward species conservation on the probability of occurrence, whereby presence is assumed in suitable habitat, rather than tested for through survey. Some of the reasons given for such a movement are highlighted in Table 1. Despite their generally positive comments on mitigation based on probability of occurrence, one regulator did express concerns that the approach promoted standardised compensation measures, rather than measures bespoke to individual situations. The regulator also pointed out that such an approach failed to generate any further spatial data for protected species locations such as that held by local records centres and the NBN gateway.

> *Probability in some ways would be more useful because you're saying, 'Right, okay. I've assessed this building as low potential, I've done a bat survey, there's no roost there'. That's not to say something won't move in."*
> **Ecologist 3.**

It is important to realise that a developer is under no legal obligation to assume the presence of protected species on their site, nor are regulators required to accept mitigation proposals based upon such an assumption. In fact, regulators generally favoured the conventional approach, but said that they would support an alternative probabilistic approach if it would alleviate a significant amount of development pressure. Dialogue between the developer and the regulator is therefore essential in agreeing a mitigation strategy since there would be no prescribed course of action applicable to all development scenarios.

> *" [There's] a danger if a developer wanted to challenge this approach, to say 'hang on, you're making me do something for newts, you're making me put aside a third of my development site for habitat creation for this species when this species isn't even there'."* **Regulator 5.**

Table 1 – Positive reasons given in interviews for a move toward conservation based on the probability of species occurrence rather than confirmed presence.

Group	Reasons
Ecologists	• Reduces the risk of false negative survey results • Particularly useful for species such as water voles where presence/absence for a given locality is temporally dynamic
Developers	• Negates the need to wait for optimal survey seasons thereby reducing development delay • Dovetails well with cost/risk analysis developers already undertake, allowing them to make more informed decisions
Regulators	• Would secure biodiversity for the future, rather than just concentrating on the current situation

4.1.2 The mitigation hierarchy

Once the presence of a protected species is detected onsite, or the developer and regulator agree to proceed under the 'protect the potential' principle, ecologists, regulators and developers must then agree on development procedures that follow the mitigation hierarchy. The hierarchy is set out by the Chartered Institute of Ecology and Environmental Management [15] and requires developers to first avoid impacts, then mitigate any unavoidable impacts and finally compensate for residual impact. The interviews however revealed considerable inconsistencies in the stringency with which the hierarchy is applied between sites.

> *"Yes, that's in the habitats regulations, 'is there any alternative?' But I think that tends to be taken as, 'does the developer have another barn that he can convert… which isn't really how an ecologist would read that"* **Regulator 1.**

Ecologists stated that the main reason for this inconsistency was the time elapsed between the beginning of the project and the involvement of the commercial ecology company. In instances where ecologists were involved at an early stage, there was a higher proportion of impacts avoided since ecological constraints could be mapped before the development layout was designed. Conversely, ecologists and regulators reported cases where the development layout had already been devised before the advice of the ecologist had been sought. In this latter instance, ecologists were simply asked to mitigate and compensate for the design. Room for subjectivity in the boundaries between the levels of the mitigation hierarchy is therefore clearly demonstrated. Furthermore, ecologists tended to express frustration at a lack of means to better negotiate layout design after it has already been devised in the first instance.

Ecologists did, however, convey that having a detailed knowledge of developer’s layout plans enabled them to create more specific mitigation and compensation advice. The precise location and orientation of a bat box attached to a building for example, can be given only if the shape, orientation and height of that building is known. It can therefore be concluded that designing layouts to optimise dual usage efficiency for humans and wildlife is an iterative process whereby ecologists feed into each stage of the planning.

4.2 Stewards of Ecology

Where differences of opinion arise regarding what should be protected, and the actions that protection should necessitate or prohibit, decisions are largely influenced by the decision makers underlying principles. Whilst assumptions that developers prioritise profit and that regulators prioritise legislative adherence (although see below) were generally confirmed, the assumption the ecologists prioritise conservation was not. Regulators frequently voiced concerns that ecologists did not advocate positive development choices for wildlife. When asked what they thought was the reason behind this bias, they all pointed to the fact that in commercial ecology as with any business, customer satisfaction is paramount in order to gain repeat business. In practice, this means that it is in the interest of the ecologist to place the minimum constraints upon development, which may not be the best promotion of conservation practice. In other words, the ecologist is discouraged from asking the developer for anything above and beyond the bare minimum for biodiversity protection. This suspicion was confirmed by three ecologists who admitted to “interpreting” the regulations to favour developer’s requirements, and by developers who said that they actively seek “development-savvy” ecological consultancies. Coupled with the perception that there are relatively few legislative repercussions for those who deliberately break ecological laws, one held by nearly all interviewees, there seems to be little incentive to maximise ecological benefit from developments.

> *“Ecologists all have a slightly different view on what their role is and some of them are approaching it as trying to get the applicant planning*

permission without necessarily providing them with the correct advice"
Regulator 1.

"So we'd never advocate them [developers] breaking the law … but from our knowledge and experience there are lots of practical things you can do and ways in which you can interpret the regulations to make it more effective."
Ecologist 4.

"*You want to have an ecologist who is development savvy"* **Developer 4.**

Developers also tended to argue that enhancements for biodiversity were not cost effective. Whilst they agreed that community woodland and ponds could boost the value of nearby properties for example, they were quick to point out that the conditions conducive to ecological prosperity were rarely in line with what prospective residents would want. Many developers, for example drew attention to the concept of public access, highlighting that ecologists often advocate keeping people away from ecologically sensitive areas to protect wildlife, thereby reducing the capacity with which they can enjoy the area. Furthermore, developers suggested that ecologists paid little attention to how proposed mitigation measures might affect current or planned land use. One developer spoke of an example where an ecologist had proposed a wetland with the potential to "harbour a breeding ground for mosquitoes" next to a proposed high wealth restaurant with outside seating. It therefore seems that a lack of integration between developers and ecologists when planning their respective land uses may be leading to tensions between these stakeholder groups.

4.3 Regionally Strategic Mitigation and Compensation

A lack of integration was also echoed by regulators, albeit at a wider scale. They reported a number of issues related to ecological mitigation being implemented on a site by site basis, with little consideration given to how each site fits ecologically within its wider spatial context. One of the main examples offered was that a disproportionate amount of mitigation and compensation was often prescribed through planning conditions for a small population of protected animals or a population that had become isolated through habitat fragmentation. Interviewees commented that if less effort was spent on conservation of these less significant populations, more could be spent on conservation of pivotal populations and forming linkages through green corridors. Many interviewees attributed such a lack of strategy in mitigation efforts to a "tick box exercise in ecology" where regulators have an overly prescriptive set of guidelines that they must ensure are followed, without the flexibility, resources, time and (in some cases) experience to tailor requirements to species sites needs on a case by case basis.

> *"Lose the individual, save the population… we need to get away from individual animal conservation and individual animal welfare, we need to get away from that, we need to focus on conservation of populations and metapopulations"* **Regulator 3.**

One regulator reported success utilising region wide habitat niche modelling for great crested newts, to inform more strategic impact mitigation at two different levels. Firstly, modelling results are used to influence the scale of survey required to detect presence or absence. Where there is a high likelihood of presence or absence, a reduced number of surveys are required. Additionally, where there is a high probability of occurrence, less work is required to establish the environmental context. Secondly, modelling is utilised to support a case for offsite mitigation where great crested newts populations are small, isolated, and in habitat that is only marginally suitable to support the population. Conversely, modelling is also utilised to support greater impact avoidance and more meticulous mitigation in highly suitable habitat, supporting greater numbers.

Such an approach seems to be the exception rather than the rule among regulators. Although other regulators saw the merit in such a paradigm, many pointed to a lack of resources, unwillingness of various stakeholders to share spatial data and a lack of training in GIS and modelling software as barriers to wider adoption. Nearly all interviewees stated that they use GIS in their daily work but this use rarely extended beyond simple mapping tasks. Even when ecologists and regulators are tasked with identifying impacts on protected species neighbouring the development site, they all reported that population connectivity and potential impact pathways were all discerned by eye.

Such a poor level of sophistication in ecological impact analysis may well be reflected in developer's general distrust in ecological prediction capabilities. In some cases this distrust was so prominent that the developer would not be prepared to use any ecological modelling to help plan works, but would only use spatial data representative of the current temporal snapshot. The developers were aware that they ran the risk of encountering unforeseen issues with protected species as development progressed, but expressed that this was favourable to planning for a situation that often never came to fruition.

> *"Well, I think prediction's dangerous, with ecology it's particularly dangerous… I don't believe anything an ecologist tells me anymore"* **Developer 3**

4.4 Resolution of Differences in Opinion

Tension can arise when there is a disagreement between the commercial ecologist and the regulator. Planning applications are submitted based on the commercial ecologist's interpretation of the ecological characteristics of the site. However, as previously discussed, there is much uncertainty and subjectivity in discerning these characteristics, leaving the door open to differences of opinion. If such a difference of opinion should occur between the regulator and the commercial ecologist, significant delay to the development can ensue. Regulators tended to attribute such disagreements to ecologists, either through a lack of detail or unsubstantiated conclusions in their reports. Whilst all ecologists admitted to the occasional and unintentional omission of details in their reports to regulators, they tended to claim that the main cause of differing opinions was the inflexible regulatory approach highlighted in section 4.3. Many ecologists elaborated that because each site has a unique set of ecological characteristics, environmental conditions and an individual landscape context, the "tick box" approach undertaken by regulators is too simplistic and generalised. Responses given by developers corroborated the ecologist's perception, stating that regulators often asked for too much or irrelevant ecological information. Although no developer speculated on the reasons for such demands, their remarks highlight that a reliance on generalised working methodologies generates requirements that are contrary to common sense. When discussed with regulators, a lack of funding was the sole reason given for such an approach.

> *"There just needs to be some more kind of human interaction and a little bit more of human determination in things rather than a tick box exercise"*
> **Ecologist 1**

> *"…what you find is that councils ask for way too much information... On validation, some councils will tell you what is required, we will submit it, and then they will add on a few things, which is so frustrating"* **Developer 4**

5. Discussion

Despite the fairly disparate issues reported throughout the stakeholder interviews, they appear to be unified through the common thread that ecological uncertainties leave room for subjectivity in the application ecological legislation. Ecological uncertainties reported within this study seem to cohobate those illustrated elsewhere within the literature, including the presence or absence of protected species [47]; spatio-temporal positions of animals, their shelters resting places and travelling routes [14] and how the site fits into the wider ecological context [48]. It seems that attempts to robustly include these uncertainties into decision making are not common practice, largely because of decision maker's (usually the developer's) preference for simplicity of data over accuracy and precision, and a lack of time, resources and spatial modelling skills across all groups.

Coupled with the widely held perception reported throughout this study and elsewhere [e.g. 17] that ecological legislation equates to little more than bureaucracy, it is unsurprising that biodiversity targets are not being met [2].

Moreover, because of the complexities, competing agendas and multifaceted issues involved in the development layout design, any attempt to combat continued biodiversity degradation must not rely upon legislative measures alone. Although legislation has proved to be a positive stimulus for wildlife protection during development, the uncertainties associated with ecological study and mitigation procedures at the site scale act to introduce stakeholder subjectivity. As demonstrated throughout this study, subjectivity can arise when determining what impacts are avoidable, the level of conservation effort required and the form it should take, when implementing the mitigation hierarchy [15]. The issues faced by commercial ecologists are therefore analogous to Rittel and Webber's [21] "wicked problems". Decision making within such a subjective decision space is consequently, at least in part, a reflection of the decision makers' knowledge, values and attitudes, which are unlikely to be altered by legislative changes.

A solution is therefore clearly needed that satisfies a number of criteria. Firstly, ecological knowledge and uncertainties need to be better represented in decision making at the site and landscape scales. Secondly, ecologists and developers need to enhance knowledge sharing to promote better integration of ecological demands into development design. Thirdly, regulators need access to this data to be able to dispense bespoke advice and governance to each specific situation, and to be able to pool data from different ecologists and developers to make better decisions at the regional scale. Lastly, a means to deliberate solutions is required, where competing demands needs to be balanced and each stakeholder group is given equal footing in discussions.

These requirements seem to support our initial hypothesis that C-SDSS could offer considerable advantages to both development and wildlife if more widely adopted throughout commercial ecology and its regulation. Whilst the merit of collaborative solutions to wicked problems in neighbourhood design has hitherto been demonstrated [49-51], the emphasis seems to be on public participation. We envision C-SDSS operating as a tool for spatial deliberation between the members of the stakeholder groups, enabling negotiation not only over courses of action to avoid and mitigate impacts, but even over what features should be protected. This is in line with Ramsey's [28] assertion that collaboration can help achieve both mutual solutions to problems and mutual problem definitions. Negotiation and deliberation through C-SDSS may also introduce flexibility into commercial ecology regulation, which in turn may reduce ecologist's and developer's perceptions of bureaucracy and "tick box exercises". Ultimately, it is hoped that the introduction of flexibility and more human interaction (albeit though a GIS) may act to remove the feelings of sympathy ecologists and regulators sometimes hold for developers which can currently cause them to prioritise development over ecology. Furthermore, a GIS based approach would pave the way for the integration of spatio-temporal modelling of ecology in development decision making, which may well promote more strategic mitigation and compensation measures with dual benefits for development companies and wildlife. Finally, by providing ecologists and regulators with a means to deliberate where courses of action are unclear, both parties are enabled to better express their viewpoints and draw attention to supporting spatial data where required.

Despite the theoretical benefits to the implementation of a C-SDSS toolset to support ecological report writing, a lack of GIS skill reported throughout the stakeholder interviews acts as a potential barrier in practice. Whilst GIS was not completely absent from the majority of interviewees' skillsets, their general lack of advanced GIS modelling capabilities warrants further research into designing user friendly GIS interfaces to automate much of the complex analysis and digital representation. Through this lens we view a C-SDSS solution more of a communicative and deliberation aid as opposed to a tool set for enabling complex spatio-temporal modelling. That is not to say however that this type of analysis cannot be undertaken by more skilled GIS users and shared among stakeholders as and when required.

6. Conclusion

This paper set out to identify areas where differing opinions, regarding the implementation of commercial ecology, may be acting to the detriment of wildlife conservation and the construction industry. We found that opinions differed between developers, commercial ecologists and regulators regarding suitable levels of ecological mitigation, the actions that mitigation necessitate and even what ecological features require mitigation. It emerged that these differing opinions can cause costly delays and needless expense to developers, as there is little opportunity for negotiation around design problems with no obvious optimal solution. Additionally, results indicate that a lack of integration between stakeholders involved in development design, with ecologists becoming involved in the development design at too late a stage and the perception of ecology equating to little more than bureaucracy facilitate suboptimal conservation.

By comparing these issues to the benefits of collaborative planning demonstrated in the literature, we suggest that development and adoption of C-SDSS software for commercial ecology applications may well act to reduce such issues. A C-SDSS solution would quicken the negotiations between stakeholders by allowing them to manipulate digital site layout designs until a common spatial solution is achieved. Where differing opinions regarding development design persist, each stakeholder is given equal footing in arguing their case can draw on a wealth of spatial and non-spatial information loaded into the C-SDSS including links to reports, graphics, videos and modelling outcomes and expert opinion.

C-SDSS can therefore be seen as an innovative solution to many of the various challenges faced by the current commercial ecological industry. It is hoped that the results of this research will act to promote collaborative planning on the ecological research agenda. Ideally, collaborative planning will act in tandem with advancements made in spatial ecological modelling to facilitate more strategic, joined up and mutually beneficial landscape management. This would represent a significant step towards achieving the biodiversity goals for 2020.

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