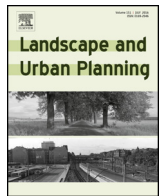




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Tackling wicked environmental problems: The discourse and its influence on praxis in Scotland

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HIGHLIGHTS

- We review strategies to tackle wicked problems in the literature.
- We identify generic approaches present in the wicked problems literature.
- Generic strategies to tackle wicked problems are reflected in current practice in Scotland.
- Strategies to tackle wicked problems are having limited yet promising impacts.

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ABSTRACT

Complex, social-environmental issues can be classified as ‘wicked problems’ because they are incorrigible and hugely challenging for policy makers. Here we re-evaluate what makes problems wicked and assess various theoretical and pragmatic approaches that have been advanced to tackle them. We do so with the aim of contributing new insights to theory through answering the following research questions: What strategies to tackle wicked environmental problems are prominent in the literature?; To what extent do they provide pathways for tackling the defining characteristics of wicked environmental problems?; and, How are these strategies reflected in examples of practice? Our examples look at how emergent strategies have percolated, explicitly or implicitly, in the management of four problems in Scotland: (1) Securing sustainability and resilience of landscape and land-use systems through spatial planning; (2) Addressing population health through livestock disease control; (3) Mitigating climate change through woodland planting; and, (4) Mitigating rural diffuse pollution in freshwater systems. We present a consolidated set of characteristics of wicked problems against which we map strategies to tackle wicked problems proposed by a body of literature identified through a literature review and analysed using a thematic, qualitative approach. We identify fifteen strategies and show that most of these are, within the Scottish context, evident in practice. The extent to which the actual discourse has influenced praxis and how effective it has been is more difficult to determine but we conclude that, within a context of ‘incorrigible’ problems, small steps have been made towards taming an untameable beast.

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1. Introduction

It is widely accepted that resource use is exceeding the planet’s replacement capacity (Melkert & Vos, 2008; WHO, 2013) with anthropogenic, global environmental change problems threaten-

ing human needs. Associated, complex social-environmental issues have, in many cases, been classified as ‘wicked problems’ following Rittel and Webber (1973). This term denotes problems for which it is impossible to define optimal solutions because of both uncertainty about future environmental conditions and intractable differences in social values (Shindler & Cramer, 1999). Environmental, wicked problems are particularly challenging for policy makers. Policy initiatives aiming to address complex social-environmental issues are perennially difficult to implement because of a host of circumstances including when associated knowledge bases are divergent and incomplete, when short-term interests conflict

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with long-term benefits, and when ambiguous boundaries prevent universally agreed problem formulation or assignation of responsibilities for resource allocation (Head, 2014).

This paper re-evaluates what makes problems wicked, reflecting upon the nature of the 'untameable beast' to which wicked problems have been likened (Xiang, 2013, see also Churchman, 1967) and assesses the theoretical and pragmatic approaches that have been advanced to 'tame the beast' through a literature review. We begin by revisiting Rittel and Webber's (1973) despondent analysis in which they set out a series of insoluble conundrums for would-be problem solvers. We see despondency in the superlative negativity of the language repeated throughout the seminal article: wicked problems are not merely difficult to manage but "incorrigible" (Rittel & Webber, 1973). We then move on to critique the discourse that has emerged which promotes more optimistic strategies to tackle wicked problems (for example, ASPC, 2007; Brown, Harris, & Russell, 2010; Termeer, Dewulf, Breeman, & Stiller, 2013) and qualitatively review the presence of corresponding strategic initiatives in actual practices of environmental problem management and the surrounding policy discourse in Scotland. Specifically, we address the following research questions:

What strategies to tackle wicked environmental problems are prominent in the literature and to what extent do they address or provide pathways for tackling the defining characteristics of wicked problems?

How are these strategies, suggested by the literature, reflected in examples of practice in Scotland?

Our analysis seeks out emergent themes in the literature on wicked environmental problems to help us to understand how far both theory and practice have come since the original problem formulation by Rittel and Webber (1973) and how this has percolated, implicitly or explicitly in the policy discourse, using Scottish examples. In Scotland, policy is responding to address wicked environmental problems with a range of instruments including legislation, strategies, programmes and frameworks, and in some cases implementing European directives (e.g. The Water Framework Directive). Encouragement for bottom-up individual or community led approaches and the use of market mechanisms is also present in the Scottish policy discourse. Given this diversity of policy initiatives and with respect to wider interest in all aspects of environmental governance there is a pressing need to leave no stone unturned in exploring the available methods for understanding and responding to wicked environmental problems.

2. Methodology

To address our research questions, the paper conducts a three-step analysis. First, based on Rittel and Webber's (1973) original representation and subsequent formulations (for example, Conklin, 2003; Horn & Weber, 2007; Levin, Cashore, Steven Bernstein, & Auld, 2009), we present a consolidated set of characteristics of wicked problems (see Table 1). Second, we map 'strategies to tackle wicked problems' proposed in the literature onto the particular elements of wicked problems which each strategy claims to tackle, grouping them thematically. Third, we search for evidence that the grouped strategies are reflected in Scottish policy responses to four wicked environmental problems, namely: securing the sustainability and resilience of landscape and land-use systems through spatial planning; addressing population health through the control of livestock diseases; mitigating climate change through woodland planting; and mitigating rural diffuse pollution in freshwater systems.

2.1. Characterizing wicked problems

Table 1 is a novel reformulation of wicked problem characteristics, starting from Rittel and Webber's (1973) article, in which they detailed ten defining characteristics, and developed by collapsing and condensing ten into six descriptive categories. We aim to comprehensively but more concisely capture the original ideas augmented with some of our own insights informed by other literature in the field. Our categories are: 1. *Indefinable*; 2. *Ambiguously bounded*; 3. *Temporally exacting*; 4. *Repercussive*; 5. *Doubly hermeneutic*; and 6. *Morally consequential*. The objective was to develop an instrument that eliminated repetition in the original yet remained true to Rittel and Webber's conceptual construct, and furthermore worked on a pragmatic level within the scope of this paper. In doing so, we acknowledge Conklin (2005) who presents a different, condensed set of defining characteristics.

2.2. Identifying and mapping strategies from the literature

The second step of the analysis maps various proposed strategies to tackle wicked problems onto the six defining categories (Table 1). The objective is to identify the specific characteristic of wickedness purportedly being tackled. Strategies were identified using the ScienceDirect and Google Scholar search engines. The titles of articles and reports identified through keyword searching were reviewed; and articles best matching the search criteria were studied in greater detail. Reference lists from reviewed articles were scanned for other relevant articles. Material was chosen at first for a good match with the 'wicked environmental problem' topic; but later, as strategies began to be repeated with only minor variations; we purposely searched for more novel strategies. We stopped searching the literature following the principle of theoretical saturation; that is; no new concepts were emerging regarding the development of our categorization thereby demonstrating that our overall structure had sufficient variation to enable categorization of all new proposals appearing in the literature; and we had become reasonably confident that relationships among categories were well established and validated; and finally that further discoveries would add little to the model (Glaser & Strauss, 1967). A caveat to the search is however; that while based on an extensive review of the literature, our evaluation is not an inventory of all published papers on the topic of wicked problems but rather the result of a systematic exercise to identify strategies to tackle wicked environmental problems in the literature.

Mapping the strategies to the six defining characteristics was accomplished qualitatively through an 'analytical matrix' in which we plotted how each identified tackling strategy might best correspond to a specific wicked characteristic. This was sometimes straightforward where, as in many cases, there were explicit claims attached to the strategies. At other times the process of drawing linkages was more interpretive. A qualitative, thematic analysis drawing on aspects of Grounded Theory (Corbin & Strauss, 2008; Glaser & Strauss, 1967) was applied revealing a number of common themes. Based on this analysis we identified a set of mitigation approaches taking the most distinct elements from the matrix. Tackling strategies, as proposed by the literature, were consolidated on the basis of having strong similarity or common authorship. Many studies only allowed a partial mapping because all six characteristics (Table 1) were not necessarily tackled thus leaving gaps in the matrix. Furthermore, we recognise that thematically clustering and condensing common ideas inevitably loses some of the nuances in the original papers. However, our review covers a substantial body of literature and what is gained is the degree of generality our research question requires. We also acknowledge applying subjective judgements to the analysis, assigning strategies to categories on the basis of our reading

Table 1
 Six consolidated characteristics of wicked problems.

Short description	Long description
1. Indefinable (and non-generalizable)	The formulation of a wicked problem is the problem. Stakeholder contestation abounds hampering all attempts to reach agreed or definitive problem formulations and making each wicked problem unique and resistant to general strategies of mitigation. This creates an immense problem for both analysts and would-be problem solvers. It undermines all the following definitions (2–6) just as it did for Rittel and Webber whose 10 characteristics were equally caught in this conundrum (of their own devising).
2. Ambiguously bounded	Wicked problems can usually be considered as symptoms of another different problem often at a different scale. The resultant inter and intra-connectedness of issues problematizes the isolation of manageable components. Boundaries are hard to establish and unstable. There are problems within problems and strategies to address one can spawn other single or interlocking problems.
3. Temporally exacting	Time is often running out where wicked problems are concerned. There is generally no stopping rule. There are no ends to the causal chains linking open systems involved. Persistence and longevity confound intervention strategies and mitigation efforts often only cease because of the intervention project's own material limitations. System relationships are frequently nonlinear exhibiting disproportionate and unpredictable changes. Co-evolution occurs both in the overall system and the agents within it.
4. Repercussive	Proposed solutions to wicked problems are entangled with value conflicts and ideological/cultural constraints often with side effects that may themselves be profoundly problematic. They do not have an enumerable or an exhaustively describable set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into any plan. There is no ultimate validity test for solutions. A proposed solution to a wicked problem is often a 'one-shot operation' with the problem resisting a return to square one having often been transformed by attempts to tackle it.
5. Doubly hermeneutic	There is a two-way relationship between analysis and the social world. Understandings of wicked problems cannot be pinned-down but are constantly challenged by active subjects who, unlike rocks or chemicals under the gaze of the natural scientist, can change their practices just as understandings of those practices are developed condemning to failure attempts to solve wicked problems based on a specific understanding of the behaviours involved. The information needed to understand a wicked problem depends upon initial framing which itself is co-dependent on a wide range of contextual factors; human and non-human – adaptive agents react to the system and to each other. System behaviour is emergent from the interaction of the parts, such that the whole is different from the sum of the parts. The problem is not understood until after the formulation of a solution.
6. Morally consequential	Wicked problems demand action while displaying great resistance to change. They exist in social systems where mistakes are unacceptable in contrast to controlled environments. This can create significant moral dilemmas that pose individual risks for would-be problem solvers who may be held to have no right to be wrong yet may be morally obligated to act. Outcomes can always be contested. Those seeking to solve the problem may also be causing it or inadvertently causing another wicked problem.

of the text. This is integral to our methodology. We situate this study within the tradition of qualitative research and hold that the derivation of meaning from text as an interpretive practice is a valid exercise for the social sciences.

2.3. Identifying tackling strategies in four case studies

In the third step we examined four cases of wicked environmental problems found in Scotland in the light of the tackling strategies that we have identified. Our four cases were as follows: (i) securing the sustainability and resilience of landscape and land-use systems through spatial planning; (ii) addressing population health and infectious diseases through livestock disease control; (iii) climate change mitigation with woodland planting; (iv) mitigation of freshwater diffuse pollution. All four cases are high on Scotland's environmental policy agenda and are part of the Scottish Government's Rural Affairs and the Environment Portfolio Strategic Research Programme 2011–2016.

3. Findings from the mapping process

The decades since Rittel and Webber defined wicked problems have seen a wealth of material proposing strategies to tackle wicked environmental problems (for example, Balint, Stewart, Desai, & Walters, 2011; Brown et al., 2010). Post-normal science (Sardar, 2010; Healy, 2011; Ravetz, 2011) and other mixed methods approaches that incorporate adaptive, participatory and transdisciplinary (APT) elements have been proposed and in various cases

applied to wicked problems (O'Connor, 1999; Frame & Brown, 2007; Innes & Booher, 2010). For example, there are claims that scenario planning techniques can open up problem solving possibilities through more creative, inclusive and ongoing engagement processes, such as participatory back-casting, in contrast to normal science-based approaches (Carlsson-Kanyama, Dreborg, Moll, & Padovan, 2008).

Fig. 1 summarizes the results of the analysis and the options identified in the process of mapping the tackling strategies against the six defining characteristics.

3.1. Tackling indefinability

To address the *indefinable* nature of wicked problems, a strand of the literature proposes changing the problem solving paradigm or theoretical framework. For example, Batie (2008) suggests that post-normal science and its epistemic assumptions can generate a more powerful conceptual framework to deal with wicked problems. Berkes (2011) proposes framing problems under the socio-ecological systems paradigm. Other authors go further, advocating methods beyond rationality (Coyne, 2005) and the use of philosophical inputs enlisting environmental philosophers in collaborative reimagining of engineering and technology practices particularly in relation to sustainability problems (Whyte & Thompson, 2012). We label this group of ideas as the *theoretical approach* (strategy 1a, Fig. 1).

Other proposals in the literature are, what can be understood as, *pragmatic* (strategy 1b, Fig. 1). Two *pragmatic* sub themes

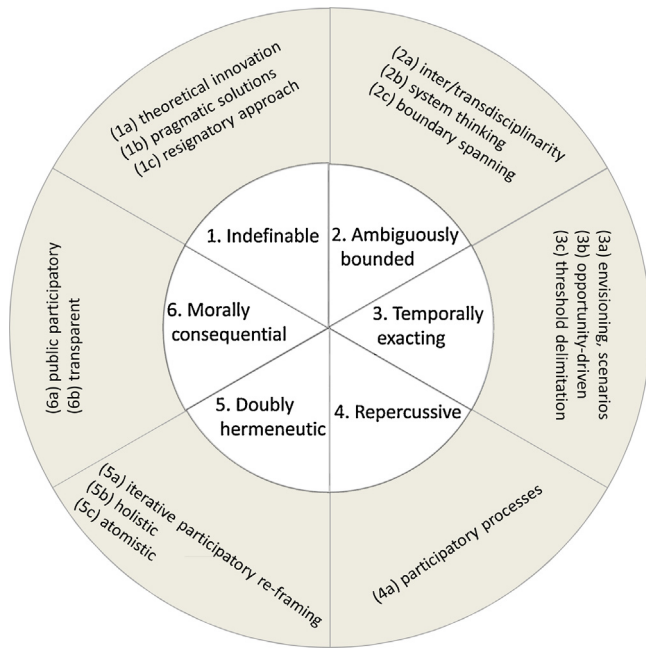


Fig. 1. The wicked wheel: strategies to tackle wicked problems mapped to consolidated characteristics of wickedness proposed in the searched literature.

are identified: firstly, those that advance specific analytical tools or methodological approaches to help cope with uncertainty for example, modelling tools, scenario planning and non-deterministic participatory approaches (see [Batie, 2008](#); [Grootjans in Brown et al., 2010](#)); and secondly, those favouring deconstructing the problem into sub-problems, for example, the translation of complex problems into more recognizable, smaller problems ([Shindler & Cramer, 1999](#)); locking the down the problem definition ([Conklin, 2010](#)) ‘sticking’ to purposes and goals ([Lazarus, 2009](#)) and assessing competences ([Mascarenhas, 2009](#)). These deconstructive approaches are further referred to in our analysis as *atomistic*. In another approach, [Innes and Booher \(2010\)](#) have developed a framework they call ‘collaborative rationality’ that we consider both theoretical and pragmatic. Their approach, explicitly based on Habermas’ ‘Theory of Communicative Rationality’ ([Habermas, 1984](#)), targets reframing the planning process in the complex contexts in which wicked environmental problems arise. These authors balance more abstract theorizing, for example, ‘thinking differently in an age of complexity’ with practical application, for example ‘stories from the field’.

A further theme accepts the *indefinability* of wicked problems offering no way around ([Sharman, 2009](#); [van der Brugge, Rotmans, & Loorbach, 2005](#); [van Latesteijn & Rabbinge, 2012](#); [Palmer, 2012](#)). We denote this as the *resignatory* approach (strategy 1c, [Fig. 1](#)). This neologism is not intended to be a pejorative label but one very much in the spirit of Rittel and Webber’s delineation of the field. They explicitly state that, without severe qualifications there are no solutions and emphasise that wicked problems are “incurable” ([Rittel & Webber’s 1973](#)). To a large extent their seminal paper implies a *resignatory* approach from the outset and this important idea will be revisited in the conclusion.

It is worth noting at this point, that for the defining characteristic of *indefinability*, many studies in our review do not propose any kind of solution, but we make a clear distinction between omissions for which any interpretation would be highly speculative and the *resignatory* approach (strategy 1c, [Fig. 1](#)) which explicitly recognises that little can be done about *indefinability* and the associated non-generalizability beyond informed acceptance.

3.2. Tackling boundary ambiguity

Regarding the *boundary ambiguity* of many wicked problems (2, [Table 1](#)), three strategic options emerged from the analysis; although it should be noted that they are not necessarily mutually exclusive. Some authors propose an explicitly *interdisciplinary* or *transdisciplinary* approach (strategy 2a, [Fig. 1](#)): the distinction being that an *interdisciplinary* approach entails integration across different scientific disciplines whereas *transdisciplinary* entails the incorporation of other strands of knowledge including non-academic knowledge ([Tress, Tress, & Fry, 2004](#)). For example, [Batie \(2008\)](#) uses the example of ecological economics and sustainability sciences as examples of *interdisciplinarity* to address wicked problems, whereas [Conklin \(2010\)](#) and [Palmer \(2012\)](#) advocate *transdisciplinary* approaches in which science is integrated with management. A variation, for [Innes and Booher \(2010\)](#) proposes *transdisciplinarity* with a particular emphasis on the generation of rational knowledge and discussion through permanent collaboration between public and private decision makers, enrolling scientists as informants and facilitators.

Systems thinking (strategy 2b, [Fig. 1](#)) following [van Bertalanffy \(1968\)](#) also features in some approaches such as the one inherent to the socio-ecological framework ([Berkes, 2011](#)) and underpinning the proposals by [Shindler and Cramer \(1999\)](#), [Chapin et al. \(2008\)](#) and [Sharman \(2009\)](#). Beyond *transdisciplinary* planning processes, [Innes and Booher \(2010\)](#) propose a complexity-based approach to tackle wicked problems that also appears to favour looking at wicked problems through the lens of *systems thinking* but using softer tools that recognise different world views and local knowledge (see also [Checkland, 1981, 2000](#)). The ‘collaborative rationality’ proposed by [Innes and Booher \(2010\)](#) draws upon [Habermas \(1984\)](#) and emphasises the importance of leveling power imbalances in order to reach genuine consensus. We distinguish a final approach in response to this defining characteristic, which we call *boundary spanning* (strategy 2c, [Fig. 1](#)). This refers to bridging levels or institutional boundaries within organisations and across functional scales ([van der Brugge et al., 2005](#); [van Latesteijn & Rabbinge, 2012](#); [Whyte & Thompson, 2012](#)).

3.3. Tackling exacting temporality

Several approaches have also been proposed to deal with the *temporally exacting* characteristic evident in many wicked environmental problems. Different forms of scenario building, forecasting and *envisioning* (strategy 3a, [Fig. 1](#)) are advanced for imagining plausible futures and preparing solutions for them (e.g., [Batie, 2008](#); [Whyte & Thompson, 2012](#); [Griffith in Brown et al., 2010](#)). Not mutually exclusive to *envisioning* is the *opportunity-driven approach* (strategy 3b, [Fig. 1](#)), by which several authors propose grasping the opportunity or seizing the moment, to establish dynamic and temporary goals and intermediate solutions ([Lazarus, 2009](#); [van Latesteijn & Rabbinge, 2012](#)). [Mascarenhas \(2009\)](#) expresses this in terms of concentrating on possibility rather than probability. Following their practice based approach to planning and decision-making, [Innes and Booher \(2010\)](#) propose an opportunity-driven approach with (rational) communication taking place amongst different stakeholders as the key tool to adaptive mitigation of wicked problems possessing contingent and ever-changing characteristics. Within the socio-ecological framework, *resilience* (strategy 3c, [Fig. 1](#)) is proposed as the key variable that determines the limits and thresholds that ought not to be passed, thus attempting to determine the point at which the system is destabilized to such an extent that alternative, beneficial courses of action are no longer available ([Berkes, 2011](#)).

3.4. Tackling repercuriveness

The most frequently recurring suggestion addressing the *repercuriveness* characteristic of wicked environmental problems (within the searched literature) is to use different *participatory approaches* (strategy 4a Fig. 1). This is formulated, variously, as effective engagement (Batie, 2008), integration of knowledges, social learning, accommodation of multiple alternatives, group exploration (Mascarenhas, 2009), dialogue mapping and deliberation (Conklin, 2010). Suggestions also include some more concrete frameworks such as adaptive co-management (Berkes, 2011), and collaborative rationality (Innes & Booher, 2010), both of which explicitly prescribe the necessity to go beyond participation and towards active collaboration throughout the whole planning and decision-making process.

3.5. Tackling the double hermeneutic characteristic

The notion of a *double hermeneutic* (5, Fig. 1) draws on Giddens (1987) idea that there is a two-way relationship between reflection upon and participation in the social world. This can be particularly frustrating when tackling wicked environmental problems in which social context and proposed solutions are mutually and constantly reshaping one another. In response, some of the reviewed literature refers to a *participatory re-framing* of the problem through iterative processes (strategy 5a, Fig. 1) that is, sharing views at different stages of the process to reframe the problem. This includes the proposals by van Bueren et al. (2003), Coyne (2005), Batie (2008), Conklin (2010), Palmer (2012), van Latesteijn and Rabbinge (2012) and Schooneveldt (in Brown et al. (2010)). Alternatively, by placing wicked environmental problems in the context of complexity, Innes and Booher suggest going beyond participation through iterative dialogues, and promote instead “a democratic governance for a resilient society” (2010, p. 196). Their idea of resilience envisages public rationality and adaptiveness spontaneously arising from the communicative processes taking place within and between local communities, scientists, planners and politicians. According to these authors, rational processes of communication will allow communities to constantly adapt to any new circumstances, and be empowered to take full responsibility for common, agreed actions and decisions.

A second strand aiming to tackle the *double hermeneutic* problem characteristic can be classified as a *holistic* approach (strategy 5b, Fig. 1) that emphasises connectedness. Mascarenhas (2009) argues for a focus on the relationships between discrete alternatives rather than continuous variables for a better understanding of the systemic nature of wicked problems (see also Sharman (2009)). Waddock (2012) conceives of a holistic shift through which agents of change stand outside the detailed interactions at the operational level and take a bigger-picture view with democratically agreed objectives. According to the APSC (2007) thinking inclusively to tackle wicked problems also belongs to the *holistic* approach.

We also find an *atomistic* (strategy 5c, Fig. 1) proposal in relation to the double hermeneutic in Chapin et al. (2008) who recommend pursuing simple solutions at an appropriate scale (e.g., local or regional), thereby capturing problem definitions at the actor level. This two-way dynamic is treated ambivalently under asymmetric pre-commitment strategy (Lazarus, 2009), an approach which deliberately makes it hard to roll-back laws established to deliver environmental goods, while simultaneously allowing advances that are consistent with the established law's objectives. The pre-commitment rationale recognises that actors, over time, will sometimes subvert less rigid arrangements in the pursuit of self-interest therefore it promotes seizing moments of opportunity to pre-empt this.

3.6. Tackling moral consequentiality

We found a consensus, where the issue arises, that the *morally consequential* nature of wicked problems can be addressed through *public participation* (6a, Fig. 1). Authors refer variously to collective deliberation (Coyne, 2005); citizens at the core of the problems (Sharman, 2009); equal empowerment of everyone (Aslin & Blackstock in Brown et al., 2010); increasing ownership through transparency and participation (Mascarenhas, 2009); comparing different perspectives and incentivizing continuous debate (Whyte & Thompson, 2012); and of going beyond public participation and into rational collaboration (Innes & Booher, 2010). In places this participatory theme evokes a Habermasian view of governance (Habermas, 1984), presupposing that the generation of permanent platforms for discussion and collaboration are the key to overcoming barriers to progressive decision-making (for example, differences in status, power, etc.) and facilitating rational decisions. There are notes of caution however. Participation ought to take proper account of the socio-ecological contingencies of any given moment for Innes and Booher (2010). Head and Alford (2015) agree that collaboration offers one way of recognising the complexity of problems but point to the difficulty of establishing and sustaining robust collaboration particularly in a public-sector context subject to turbulence and strict accountability rules. van Bueren et al. (2003) identify risks involved in over-reliance on citizen engagement citing ethical dilemmas associated with public participation. One example, are the tensions created trying to maintain scientific credibility while engaging in adaptive management (Griffith in Brown et al., 2010). In addition, the APSC (2007) cautions that lack of understanding of the wicked environmental problem can result in different stakeholders being confident that their version of the problem is correct. To the list of logistical challenges Sharman (2009) adds the need to re-think the scale of moral values, with citizens at the core of the process, an idea echoed throughout the literature. Finally, Huxham and Vangen (2005), advise that seeking collaborative advantage is a seriously resource-consuming activity that practitioners and policy makers should not undertake lightly.

4. Case study analysis

There follow four separate case studies undertaken by sector specialists (the four named authors). A personal perspective is presented regarding the influences of the wicked problem discourse within the field of each of these four cases. We were inspired to develop this paper and drawn together through our encounters with the ‘wicked problem’ discourse in the course of our separate programmes of research. These four cases have not been selected necessarily because they feature prominently in the ‘wicked problems’ discourse, although some of them (e.g. the mitigation of diffuse pollution in freshwater systems) have been identified as such (Patterson, Smith, & Bellamy, 2013). For the most part however, they are not exemplars or archetypes long established as wicked problems by scholars. For us ‘wickedness’ is not a fixed academic label but an analytical category and we have selected the four cases to show that they variously share the characteristics of wicked problems as defined in this paper. More importantly, they allow us to present ideas to address or ‘tackle’ wicked problems in the context of real-world environmental challenges that bear the hallmarks of incorrigibility and intractability that first drew the attention of Rittel and Webber (1973). Whether or not wicked problems are either explicitly referred to in the respective policy frames or generally in the measures adopted to manage the challenges is not germane to our analysis and we fully accept that other dis-

courses may have influenced the development of the policies that are in place.

We proceed systematically, case by case, firstly presenting the policy frame, secondly supporting our assertion that the case is a wicked environmental problem. We do so in a narrative way, highlighting elements of the problem that link to the defining characteristics established in this paper. Thirdly, we explore the tackling strategies that we see in evidence and critique them in light of the literature presented above.

4.1. Securing the sustainability and resilience of landscape and land-use systems through spatial planning

4.1.1. What is the policy frame?

Following political devolution from the UK more than a decade ago, the Scottish Government assumed full competence in Spatial Planning. The resulting political and planning framework is fragmented (Campbell et al., 2012; Sugden et al., 2012). It comprises independent regimes for urban, rural and semi-natural land-use systems. This might hamper the achievability of generic political goals for Scotland's land systems, including achieving sustainable multi-functionality and increasing resilience (Scottish Government, 2011a). Relevant examples of regulations and planning tools that concern the built environment include the National Planning Framework 2 (Scottish Government, 2009b), the National Planning Framework 3 (Scottish Government, 2014a), the Scottish Planning Policy (Scottish Government, 2014b) and Local Development Plans for local planning authorities. Meanwhile Scotland's Land Use Strategy (Scottish Government, 2011a), local Forest Indicative Strategies, regional Forest District Strategies, and Rural Development Programmes are all concerned with the planning and regulation of rural areas, whilst the Nature Conservation (Act) Scotland (Scottish Government, 2004) and the Local Biodiversity Action Plans regulate natural resources. Landscape-oriented policies include: National Scenic Areas and National Parks; Local and Regional Landscape Designations; and Landscape Character Assessment and Supplementary Planning Guidelines underpinning local plans and strategies. Additionally, some other regulatory instruments have been recently approved that strongly influence the direction of spatial planning, including; the Land Reform (Scotland) Act 2003 (Scottish Government, 2003), and (Modification) Order 2013 (Scottish Government, 2013), and the Climate Change (Scotland) Act (Scottish Government, 2009a). Clearly therefore, there is a diversity of very specialized regulatory and planning instruments influencing change in land-use (Campbell et al., 2012). This results in a highly fragmented spatial planning framework. Such fragmentation is therefore unfit to address the fact that the diverse components of land-use systems are, in reality, strongly interconnected and mutually dependant, for example, urbanization and its effects on landscape protection, or conflicts amongst forestry and wind-energy expansion.

4.1.2. What is the wicked environmental problem?

Spatial planning is an area of public policy that is defined at diverse levels of public administration, ranging from the National to the Local levels, and across areas of policy that jointly encompass the natural, rural and urban components of land-use systems. It is basically aimed at securing the sustainability and multi-functionality and at increasing the resilience of land-use systems. It is the site of a wicked environmental problem because it operates within cross-cutting socio-political jurisdictions and established institutional, administrative and socio-political structures. Furthermore, it addresses territorial processes that are mutually nested, and hence *ambiguously bounded* (2, Table 1) across spatial-temporal institutional scales (from the national to the local), forming com-

plex patterns, making it both spatially and *temporally exacting* (3, Fig. 1). Ultimately it is subject to huge uncertainty associated with the definition of permanent, concrete targets and objectives (1, Fig. 1). This problem is exacerbated by the lack of stopping rules concerning the definition of targets for change in land-use systems, especially surrounding defining attributes such as resilience and sustainable multi-functionality. Additional complexity arises where outcomes can be determined by the attribution of roles and responsibilities in the decision-making process. This results in the process of spatial planning being characterized by a *double-hermeneutic* nature (5, Fig. 1). Furthermore, even the conceptualisation of spatial planning tools to tackle the wicked problems of resilience and multi-functionality of land-use systems can defy rational formulation (1, Fig. 1), as the domain itself is simultaneously defined as a scientific field of study, an administrative technique and a socio-political praxis (European Regional/Spatial Planning Charter, 1983). Consequently it confounds rules that may be separately applicable to the political, social and scientific spheres of human knowledge and action.

4.1.3. How are the strategies to tackle wicked problems being reflected in practice?

The indefinability that is inherent in the complex nature of land-use systems (Rindfuss et al., 2008; Dearing, Braimoh, Reenberg, Turner, & van der Leeuw, 2010) and the landscapes that are representative of these (Pedroli, Pinto-Correia, & Cornish, 2006; Selman, 2008; Dramstad & Fjellstad, 2011) is currently being tackled in Scotland through the fragmentation of policy and planning frameworks and regimes. This is a *pragmatic* (strategy 1b, Fig. 1) and *atomistic* (strategy 5c, Fig. 1) approach. In order to tackle the *ambiguous boundaries* (2, Table 1) of problems associated with landscapes and land-use systems, the present Scottish planning regime has opted to operate in a *systemic* mode (strategy 2b, Fig. 1). This is clearly reflected in strategic documents such as Scotland's Land Use Strategy (Scottish Government, 2011a) and Scottish Planning Policy (Scottish Government, 2014b) and National Planning Framework 3 (2014a). These documents are reflective of the Scottish Government's intention to embed spatial planning policy in a wider and more holistic understanding of land-use systems, by adopting an ecosystem approach (Scottish Government, 2011b). Regarding the *temporally exacting* (3, Table 1) nature of changes in landscapes and land-use systems, it is clear from major policies and their recent evolution that the approach undertaken by the spatial planning system in Scotland is *opportunity driven* (strategy 3b, Fig. 1). This is well reflected by the recent changes in the definition of targets for issues as important for land-use change as forestry expansion (Scottish Executive, 2006; WEAG, 2012).

In essence, most efforts to cope with the wickedness of land-use systems in the planning and policy framework in Scotland to date have been concentrated through strategic instruments that operate at the national and regional levels. Paradoxically, there is a clear tendency in the Scottish territorial political discourse to favour bottom-up approaches underpinned by the principle of subsidiarity that favour decisions at the local level (Scott & Shannon, 2007), and that are backed by a strong emphasis on promoting public and stakeholder participation in the planning process (strategies 4a and 6a, Fig. 1). Whilst recognising these competing strategies, it is too soon to evaluate their effects on shaping novel planning models that are capable of coping with wicked environmental problems associated with defining targets for planning the sustainable multi-functionality and resilience of land-use systems and associated landscapes. Nevertheless, a joint effort by political authorities, local agents and experts is clearly underway.

4.2. Addressing population health through the control of livestock diseases

4.2.1. What is the policy frame?

Balancing ecological and agricultural objectives under conditions of climate change whilst competing in globalised food and energy markets severely tests collective approaches and encompasses a number of policy areas impacting on the control of livestock disease. The Wildlife and Natural Environment (Scotland) Act 2011 attempts to harmonise policy outcomes with those of the Scottish Rural Development Program (Scottish Government, 2014c) which in turn are subject to the European Rural Development programme. The monolithic Common Agricultural Policy, currently in the midst of profound and politically charged reform, overarches all of these. Environmental management is further subject to European directives (for example the Habitats directive, 1992) and UK law (for example, The Protection of Badgers Act (1992)) as livestock intersects with wild nature. At European Union, UK and devolved Scottish scales there are complex, nested and overlapping constraints on control policies. More widely, Scotland's disease control strategy must co-exist in a minefield of international obligations in a dynamic environment where diseases are both uncertain and emerging, and in which human values are inextricably bound-up. Animal disease is regulated through The World Organization for Animal Health (OIE); trade in livestock through The World Trade Organization; and zoonotic disease through The World Health Organization.

4.2.2. What is the wicked environmental problem?

Few issues attract the polarity of ethical contestation than that of the human, animal interface. Our attitudes to the other sentient creatures that share our planet, with animal rights agendas and animal welfare regimes literally changing the landscape, and our responsibilities to our fellow humans in terms of food security and moral obligations towards the hungry, create incommensurate priorities (Food and Agriculture Organization (FAO), 1996). Controlling livestock disease directly encounters all of these contested areas as evidenced by the furore surrounding the funeral pyres of cattle seen throughout the UK in 2001 (Convery, Bailey, Mort, & Baxter, 2005) or accompanying the ongoing failures to effectively manage bovine tuberculosis (bTB) through culling (or killing) wild badgers (Cassidy, 2012) and during 'mad cow disease' (Murphy-Lawless, 2004) that led to a crisis of confidence in British beef of global proportions. In these recent cases, market pressures, trade arrangements, food safety concerns, food security issues, animal rights and animal welfare agendas, indeed the lives and livelihoods of entire communities, have all been entangled in disputes about science and social justice, constraining proposed interventions. In the case of bTB scientists, farmers, policy makers and non-farming citizens continue to argue amongst and between themselves about the aetiology of the disease and both the efficacy and the ethics of trialled control measures (Cassidy, 2012) making a wicked problem with *indefinability* and *moral consequences* (1 and 6, Table 1) as characteristics.

Livestock disease is, in certain cases, exacerbated by particular modes of production, e.g., intensification, that can constitute new epidemiological risk in terms of diseases associated with livestock production (for example, Arnold, 2013), yet are advanced as a solution to food scarcity. Intensiveness and veterinary interventions create new problems in terms of disease susceptible and drug resistant animals. Highly efficient farms can experience drastic interventions such as mass culling following a disease outbreak that have led to severe social and economic problems, for example, following a Foot and Mouth Disease (FMD) outbreak in 2001. Vaccination strategies are often influenced by trade implications; for example, when a country's disease-free status is compromised

by false-positive test results from vaccinated animals. Conservation measures may produce wildlife disease reservoirs, such as the protection of badgers that farmers associate with increasing bovine TB. These various effects and interrelationships are open to interpretation as *ambiguously bounded* and *repercussive* problem characteristics (2 and 4, Table 1).

Growing global food requirements add further moral and ethical dimensions to already complex issues with ever increasing requirements for highly productive systems, including stock bred for production rather than health. Agricultural pressures on wildlife reservoirs can be intolerant of 'wild nature' seeing in it disease risks including vectors and opportunities such as land resources for additional pasture. Globalisation of trade in animal produce and live animals is ever increasing. The problems are getting worse in various ways as the human population grows and any stopping rule appears unlikely. Zoonotic disease is partly a product of interactions between human and animal systems, and human populations are encroaching on wild spaces evermore (3, Fig. 1). Social impacts of zoonotic pathogens can be significant while the variety of competing economic interests frustrate preparedness initiatives (Miller & Parent, 2012). Drug resistance and disease vulnerable production units may be products of earlier problem framings that sought to address animal welfare or human food requirements thereby revealing both a *doubly hermeneutic* and an *ambiguously bounded* pattern (5 and 2, Table 1). Rational demands for food self-sufficiency post World War II have in part driven intensification for which adverse animal welfare side effects are an unintended consequence; another *repercussive* effect. Culling may be too traumatic to be repeatable in political terms (Convery et al., 2005) with the potential to stigmatise production systems and become politically problematic for would-be decision makers. Outbreaks demand action yet all available actions can be unpalatable. Finally, public responses to livestock disease risk are intersubjective, drawing on earlier experiences, media coverage and other dynamic socio-economic and socio-cultural contingencies (Duckett & Busby, 2013; Busby & Duckett, 2012) making response to outbreaks a highly charged political exercise (6, Table 1).

4.2.3. How are the strategies to tackle wicked problems reflected in practice?

Across the panoply of recent crises besetting the United Kingdom in the area of livestock disease the available toolbox has been extensively and variously called into service. Recent experiences of FMD have, for example, resulted in the formation of *public participatory* exercises (strategy 6a, Fig. 1) considering, for example, issues of access to the countryside during livestock disease outbreaks. Recently, *interdisciplinary* and *participatory* initiatives (strategies 2a and 4a, Fig. 1) have been deployed by Scottish Government through its Centre for Excellence in Livestock Disease Outbreaks (www.epicscotland.org), including *scenario planning* exercises (strategy 3a, Fig. 1) looking at the future of the Scottish cattle sector (EPIC, 2014) and the sheep sector (EPIC, 2015). The work within the centre is *interdisciplinary* and *transdisciplinary* where social scientists, veterinary scientists and other disciplines based across Scotland's major research providers work together to design a *holistic* approach (strategy 5b, Fig. 1) in a one-stop scientific advice centre for policy makers.

The establishment of structures, like EPIC, that are willing to implement a range of strategies broadly in-line with those promoted in the literature on tackling wicked environmental problems, does appear to make Scotland better prepared to meet challenges like those first encountered in 1986 with bovine spongiform encephalopathy (BSE) and in 2001 with foot and mouth disease (FMD). Stakeholders are more engaged; scientists are working in new partnerships, and these developments alone seem

reason for optimism. With diseases however, unlike the other cases under discussion here, progress in tackling outbreaks defines success and it is tempting fate to suggest that novel approaches will deliver significantly better outcomes in the future especially given that traditional responses may have weakened with the reduction in front-line veterinary staff and state veterinary services across the UK including Scotland (Lowe, 2009). It is also worth reflecting that diseases appear as adaptive as any mitigation so far developed which is yet another reason why novel and emerging pathogens are such a wicked adversary.

4.3. Mitigating climate change through woodland planting

4.3.1. What is the policy frame?

Scotland's targets to mitigate greenhouse gas (GHG) emissions were set in the Climate Change (Scotland) Act in 2009 by the Scottish Government. These targets are 80% GHG emission reduction by 2050 and 42% (interim target) reduction by 2020 (Scottish Government, 2009a). This Act presents a stern challenge to the rural land use sector which is expected to mitigate its own GHG emissions and also to offset GHG emissions from other sectors that are not expected to achieve such substantial reductions (for example, transport and industry). One of the Scottish Government policies to achieve the necessary GHG emission reductions is the creation of 10,000 ha of new woodland annually until 2022 (Scottish Government, 2011a). To support woodland creation and management, the Scottish Rural Development Programme 2014–2020 (Scottish Government, 2014c) has made £252 million available through the Forestry Grant Scheme (Forestry Commission Scotland, 2015). Farmers can apply for support under eight categories, two for the creation of woodland and six for management of existing woodland. The most recent discourse points out that apart from climate change mitigation benefits, the Scottish Government also aims at promoting other environmental benefits as well as economic and social benefits, ensuring that new woodlands are created by multiple landowners and across holdings.

4.3.2. What is the wicked environmental problem?

Climate change, perhaps more than any other area, has been conceptualized as a set of wicked environmental problems. It defies resolution due to enormous uncertainties, circularities and conflicting stakeholder interests that become enmeshed in efforts to develop solutions (Lazarus, 2009). Woodland planting has been considered an essential strategy to mitigate GHG emissions due to its capacity to sequester CO₂ from the atmosphere. However, in Scotland, this strategy is difficult to implement due to conflicting food and climate change policy goals (Feliciano, Hunter, Slee, & Smith, 2013; Munoz-Rojas Morenes, Nijnik, Gonzalez-Puente, & Cortines-Garcia, 2015), low acceptability of woodland planting schemes among Scottish farmers (Crabtree, Chalmers, & Eiser, 2001; WEAG, 2012) and volatile stakeholder perceptions about the consequences of climate change (Barnes & Toma, 2012; Feliciano, Slee, Hunter, & Smith, 2014). Therefore, the strategy to mitigate the climate change problem is itself a wicked problem and because of that it engenders slow progress in addressing the main problem. Meanwhile, the rate of GHG emissions is increasing and time seems to be running out for communities and ecosystems both in Scotland and around the world. In short, the problem is *temporally exacting* (3, Table 1). Furthermore, while neither woodland planting nor any single intervention can change such a complex nexus, every individual effort can foster negative repercussions (4, Table 1). For example, reducing available arable land or pasture through woodland planting may promote more intensive farming through demand-side pressure or competing imports from other countries; a development laden with a fur-

ther *ambiguously bounded* set of wicked environmental problems (2, Table 1).

Those seeking to resolve the problem (for example, Scottish Government) are also exacerbating it (5, Table 1). Political discourses are sometimes contradictory in relation to the support of woodland planting to cut GHG emissions since by strengthening food policy discourses, which accept the mantra of increasing food demand, they undermine the aspiration to increase forest cover. Woodland planting is a *morally consequential* problem (6, Table 1) because stakeholders have different perspectives and goals, both specifically in relation to the successful implementation of woodland planting in Scotland, and in relation to climate change in general. A report from the Woodland Expansion Advisory Group (WEAG, 2012) admitted that there is a deep cultural divide between forestry and farming strategy. A glance at the Food and Agriculture Rome declaration (FAO, 1996) highlights the moral imperatives stacked-up on the food side of that divide.

4.3.3. How are the strategies to tackle wicked problems being reflected in practice?

Mitigating climate change through woodland planting requires the Scottish Government to align its own policies, plans and strategies. We focus on the Land Use Strategy for Scotland (Scottish Government, 2011a) and the Scottish Forestry Strategy discourses (Scottish Executive, 2006). Through these instruments the Scottish Government recognises that different individuals have different legitimate interests and priorities for the use of particular areas of land and that the main factors influencing land use can vary considerably from area to area. There is recognition that decisions are generally best made by those closest to the land, namely individuals, land managers, communities and businesses, in order to reflect local needs and circumstances; a recognition partly emerging from and partly creating a need for *participatory processes* (strategy 4a, Fig. 1). The Land Use Strategy for Scotland (Scottish Government, 2011a) proposes a *pragmatic* approach (strategy 1b, Fig. 1) to inform these local processes.

The Scottish Government, working through its Forestry Strategy is cooperating with local authorities and others to expand existing strategies beyond forestry issues. These multi-agency strategies are expected to assist in decisions on grant funding, develop proposals and other decisions relating to land use and land use change, thus embarking upon *boundary spanning* collaborations (strategy 2b, Fig. 1). The APSC (2007) considers that improving the public sector's capacity to work in a distributed way can help to better understand the causes and solutions of a particular wicked problem among the organisations that are supposed to deliver the services.

The Land Use Strategy for Scotland (Scottish Government, 2011a) enshrines values that land use decisions should be informed by an understanding of the opportunities and threats brought about by the changing climate. In addition, it mentions that land should continue to contribute to delivering climate change mitigation objectives in addition to reduced GHG emissions associated to land use change (Scottish Government, 2011a). We interpret this discourse as being an *opportunity driven* approach (strategy 3b, Fig. 1).

Mitigating climate change through woodland planting is entangled with value conflicts, ideological and cultural constraints. The Scottish Government has set out principles to decide how proposals within the Land Use Strategy for Scotland (Scottish Government, 2011a) will be delivered, including a commitment that, "people should have opportunities to contribute to debates and decisions about land use and management decisions which affect their lives and their future" (Scottish Government, 2011a), an explicitly *public participatory* approach (strategy 6a, Fig. 1).

The Land Use Strategy for Scotland (Scottish Government, 2011a) presents a set of ten principles for sustainable land use that

reflect Scottish Government policies on the priorities which should inform national land use choices. These principles tacitly acknowledge the *doubly hermeneutic* characteristics of wicked problem (5, Table 1), whereby contextual factors, human and non-human are an on-going challenge varying in spatial and temporal dimensions. The strategy asserts that it is not an option to look at a narrow range of interests when making decisions about land and it particularly embraces regionalisation. It further recommends an integrated approach and *holistic* action in decision-making about land use to secure tangible benefits in practice (strategy 5b, Fig. 1).

Finally, the Forestry Commission Scotland suggests increasing awareness of the forestry sector's contribution in climate change mitigation with Regional Forestry Forums and assessments of trends in public awareness through public opinion surveys. The Land Use Strategy for Scotland (Scottish Government, 2011a) recognises that people should have opportunities to contribute to debates and decisions about land use and management decisions that affect their lives and their future (strategy 6a, Fig. 1).

In 2012, the Woodland Expansion Advisory Group wrote a report to the cabinet secretary for rural affairs and environment with 24 recommendations to help achieving woodland creation. Given the inclusive approach intended by both the Forestry Strategy and the Land Use Strategy, it is expected that these recommendations will be taken forward for further discussion.

4.4. Mitigating rural diffuse pollution in freshwater systems

4.4.1. What is the policy frame?

The Scotland River Basin Management Plan, developed by the Scottish Environmental Protection Agency (SEPA, 2009), requires programmes and interventions that comply with the Water Framework (WFD) and Nitrates Directives. The WFD (2000) sets the target for European water bodies to reach 'good ecological status', prescribing the use of economic tools and principles and promoting public participation (Martin-Ortega, 2012). The Nitrates Directive (1991) aims to protect water quality across Europe by preventing nitrates from agricultural sources polluting ground and surface waters and by promoting the use of good farming practices. In this context, the Rural Diffuse Pollution Management Strategy for Scotland (SEPA, 2010) aims at improving water quality through a combination of regulation, guidance and voluntary measures.

4.4.2. What is the wicked environmental problem?

We focus on how best to mitigate pollution of freshwater systems at the catchment scale in a cost-effective and socially acceptable way. This is a problem tackled by Scottish Government (SEPA, 2010), and is also recognized as a problem by a range of other stakeholders, however, land managers in Scotland do not always necessarily see or recognise the link between their activities and water quality (Martin-Ortega & Holstead, 2013; Christen, Kjeldsen, Dalgaard, & Martin-Ortega, 2015).

Catchment management in general (von Korff, Daniell, Moellenkamp, Bots, & Bijlsma, 2012) and diffuse pollution in particular have been explicitly recognized to be wicked problems in the literature. Addressing diffuse pollution requires implementation actions involving multiple actors acting at multiple scales and influenced by a range of factors (Patterson et al., 2013; Smith & Porter, 2010), making it *ambiguously bounded* (2, Table 1). It also commonly involves tensions and mismatches between spatial and temporal scales relating to environmental change, human behaviour and institutional processes (Patterson et al., 2013; Smith & Porter, 2010), which are all riddled by uncertainty and affected by *repercusiveness* and the *double hermeneutic* effect (4, 5 Table 1). For example, programmes to improve water quality need to be assessed in terms of their economic efficiency at the catchment scale by the regulator; while each specific intervention requires farmers' action

at the field level. Current hydro-chemical models are limited in their capacity to establish the association and causation between land-management practices and ecological and geomorphological consequences across the catchment and field scales (Slee et al., 2013). There are also heterogeneous perceptions of what constitutes proper land-management and how it affects water quality between different stakeholders (Martin-Ortega & Holstead, 2013; Christen et al., 2015), making the problem *indefinable* (1, Table 1). Moreover, there is evidence that mitigation programmes designed for current conditions might not be 'future-proofed' against climate and land-use change (Jackson-Blake et al., 2013), contributing to a *temporally exacting* dimension (3, Table 1). Finally, the ultimate aim, established by the WFD, to achieve (close to) natural conditions in systems that are essentially anthropogenized, poses a moral dilemma (6, Table 1) as to whether it is acceptable (and ultimately possible) due to the unequal distribution of the costs of measures to improve water quality and the benefits the good ecological status provides (Martin-Ortega et al., 2015).

4.4.3. How are the strategies to tackle wicked problems being reflected in practice?

We focus on the approach followed by The Scottish Environmental Protection Agency, through the analysis of its Rural Diffuse Pollution Plan (SEPA, 2010). The Plan is aimed at ensuring 'that the key stakeholders in Scotland work in a coordinated way to reduce diffuse pollution, tacitly acknowledging the *ambiguously bounded* nature of this wicked environmental problem (2, Table 1). There are some early signs of *interdisciplinarity* (strategy 2a, Fig. 1) and the adopted catchment approach can to some extent be approximated to *systems thinking* (strategy 2b, Fig. 1).

The Scottish Environmental protection Agency acknowledges the fact that "there is no single solution to problems of diffuse pollution and it adopts a *pragmatic* approach (strategy 1b, Fig. 1) by endorsing best management practices, which rely on a range of measures to reduce and alleviate diffuse pollution impacts, and by offering a number of planning tools and in-field measures. Through the creation of a Diffuse Pollution Management Advisory Group (DPMAG) involving a range of stakeholders and aimed at 'helping create robust governance, decision-making and a coordination framework' and "ensuring input from a cross-section of rural, environmental and biodiversity interests", the Scottish Environmental Protection Agency has adopted an explicitly *participatory* approach (strategy 4a, Fig. 1). It is too early to observe whether the advisory group is also an instrument for iterative *participatory re-framing* (strategy 5a, Fig. 1), which could address the double hermeneutic issue. The Diffuse Pollution Management Advisory Group's 'Priority Catchment Strategy' where areas significantly failing water quality standards are prioritized, could be approximated to a certain extent to the *threshold delimitation* approach (strategy 3c, Fig. 1).

The national awareness raising and one-to-one farm visit campaigns, that are at the core of the Rural Diffuse Pollution Plan and by which the Scottish Environmental Protection Agency has moved from a punitive approach to a supportive one, could be interpreted as the regulator's strategy towards tackling the *morally consequential* aspect of diffuse pollution's wickedness (6, Table 1), by increasing *transparency and participation* (strategies 6a and b, Fig. 1). While there has been no formal evaluation of the overall effectiveness of the Rural Diffuse Pollution Plan in mitigating diffuse pollution, the Diffuse Pollution Management Advisory Group is observing positive progress. Compliance with General Binding Rules in six of the priority catchments has risen from 26% to 51%, with 88% compliant or working towards compliance, as evidence by field visits (SEPA, 2015).

5. Discussion

Numerous difficulties remain, some of which we attempt to address below. However first we can say positively that strategies identified in the selected literature are clearly evident in practice in the Scottish cases we have featured. Given that cause and effect between theory and practice is perennially difficult to establish we have at least been able to draw some parallels between environmental management praxis and the ‘tackling wicked environmental problems’ literature, finding clear correspondences in terms of theoretical ideas that have practical counterparts. An exemplar of theoretical ideas resembling elements in current practice is participation. Various participatory processes were evidenced in all four case studies. In this regard, the analytical approach we adopted allows us to offer a partial answer to the question, often raised in this context, regarding whether the wicked problem discourse is any more than a descriptive commentary and is actually grounded in practices, (for example, Xiang, 2013). We have shown that, within the Scottish context at least, socio-ecological challenges are sites where approaches consistent with those advocated in the wicked problem literature are being practiced. In all four of our case studies notable parallels are evident. With regard to securing the sustainability and resilience of landscape and land-use through spatial planning, we have identified in-use tackling strategies, such as the ecosystems approach, (the primary framework for action under the [Convention on Biological Diversity, 1992](#)) that evoke the systemic approaches common in the discourse. Scottish Government have also embraced scenario exercises and appear committed to interdisciplinary science to tackle the thorny issues involved in addressing population health through the control of livestock diseases. When it comes to mitigating climate change through woodland planting, there is further evidence that multi-scale approaches have been deployed in response to the ambiguously bounded nature of the challenges faced. In our fourth case study, mitigating rural diffuse pollution in freshwater systems, it also seems reasonable to argue for the existence of holistic, participatory, interdisciplinary and systemic approaches evoking similar ideas from the literature.

The extent to which the ‘strategies to tackle wicked environmental problems’ discourse has actually influenced these practices is more difficult to determine. All of the options (strategies 1a to 6b) are not only present as strategies to tackle wicked problems but are also aligned to prevailing ideas in wider research beyond any necessary association with wicked problems; examples include quests for transparency and systems thinking. The discourse, in many ways broadly reflects current methodologies, particularly in the social sciences, rather than offering a unique set of approaches tailored for a specifically ‘wicked’ problem. Other examples include the rubric of interdisciplinarity that pervades a great deal of research independently of the discourse of wicked environmental problems. Likewise, participatory approaches are *de rigueur* across social science with the idea of ‘the stakeholder’ a prerequisite for a great many problems that are not ostensibly wicked (for example, Renn, 2003). Similarly both adaptive and holistic approaches within the socio-environmental problem sphere do not appear consistently differentiated in the searched literature from their more general usage.

This degree of generality does not invalidate the utility of any of the aforementioned approaches but does raise questions about the influence of the discourse especially given that it largely operates within an Anglophone diaspora (Xiang, 2013) whereas many of the actual environmental problems and their management approaches appear ubiquitous. The question then arises, regarding whether these approaches are simply generally accepted as valid and useful for tame and wicked problems alike or whether they particularly offer something to wicked environmental problems.

The evidence from our cases is mixed. Participation, for example, is often advanced uncritically as a universal panacea yet has obvious limitations including both potentially greater overheads and more variable outcomes than non-participatory approaches. Other strategies to tackle wicked problems appear overly optimistic, for example overestimating the efficacy of interdisciplinary approaches; a familiar issue for many researchers. Other strategies to tackle wicked environmental problems appear to cherry-pick the least wicked parts of problems. Some of the strategies even appear to go against the foundational definition (*contra-natura*), for example, the atomization approaches. This reductionist strategy, breaking problems up into manageable components, aligns well with traditional ideas about complexity but is singled out for criticism by Rittel and Webber in their original formulation of wickedness. Wicked problems, they insist, are not supposed to be amenable to straightforward simplification. We are therefore keenly aware that wickedness, in its original formulation has a deeply problematic intractability to its nature and is different to complexity. The distinction is starkly evident in the explicitly negative prognosis running through the Rittel and Webber analysis. Those tasked with tackling wicked problems often have to contend with irreconcilable stakeholders, collateral environmental damage caused by previous and current interventions, policy failures, messy situations, conflict, temporary fudges, and paradoxical and morally objectionable outcomes—that’s how wicked problems are defined and where such issues have been avoided or resolved there was probably no wicked problem in the first place.

Complexity, by contrast, has long been ‘tackled’ in many ways in the social sciences, for example through Soft Systems Methodology (SSM) which proposes advanced problem definition techniques, inclusive approaches to different worldviews and participatory exercises with all kinds of stakeholders. This is not to say that SSM or other approaches that have emerged independently are incompatible with tackling wicked environmental problems, rather, that claims for the efficacy or indeed appropriateness of a wicked problems perspective probably needs to be considered on a case by case basis.

One approach that does appear incompatible and worth noting is *precommitment strategy* (see Section 3.5). Its notion of locked-in mitigation appears theoretically ill-equipped to being an effective tackling strategy. In particular, given the general improvement in scientific knowledge over time, privileging current assessments and goals over those that may develop in the future and regarding current opportunities as inherently preferable to those that may arise, seems flawed. Seeking to pin down mitigation when the problem itself cannot be pinned down does not seem to be a sound principle. This is not to say that binding targets, particularly in the sphere of emissions targets, do not have a constructive role.

More broadly, it is far from clear how many of the proposed wicked environmental problem fixes differ from parallel theoretical approaches, beyond belonging to a unique discourse. That said, generality may well be a strength and the postmodern turn that social science has made towards openness of method, inclusivity of stakeholders and rejection of reductionism cannot be excluded from approaches to what may be the severest socio-technical challenges of all. Furthermore, there is a pragmatic and a can-do tenor to most of the literature excluding the original formulation. The idea of ‘tackling wickedness’ has, in the most part, usefully moved away from idealistic notions about ‘solutions’. At the time of publication Rittel and Webber were despondent about a failing planning system in which ‘arrogant systems analysts’ falsely promised continual progress through outdated and failing notions of ‘scientific management’. Most subsequent authors have been at pains to reiterate a version of the wickedness conundrum before proposing their

best-fit approach and most, while determined that efforts must be made, are cautious and conservative in their assessment of efficacy. For example, Head (2014) and Head and Alford (2015), argue that while conclusive solutions are very uncommon, it is possible to frame partial, provisional courses of action against wicked environmental problems. This is not without risk. Addressing only some problem elements can spawn new problems just as the Lernean hydra grew another two heads for each that was cut off. Therefore, it must be stressed that what are considered in this study are explicitly tackling strategies not solutions. The incorrigibility or otherwise of the wickedness bedeviling Scotland's environmental challenges demands our best efforts, however problematic the available options appear.

6. Conclusion

In closing, we believe it is important to reiterate the order of magnitude of the challenge required in making useful progress with wicked environmental problems. Rittel and Webber set us an extraordinary task, already anticipating some of the subsequent proposals and ruling them out as inadequate. For example, they dismiss traditional, objectivist systems approaches unequivocally stating that, “this type of scheme does not work” (Rittel & Webber, 1973). In comparison to the ‘dodekathlon’ of challenges set for Hercules that required only supreme effort, the decathlon of trials Rittel and Webber identified constitute tasks for which even herculean effort is not enough. Unlike the slayer of the Nemean lion, the would-be wicked problem tackler neither knows what the mission is, nor will it necessarily ever be clear whether or not it has been accomplished. Rittel and Webber’s lion is not only “aggressive” but “tricky (like a leprechaun)” and “vicious (like a circle)” (Rittel & Webber, 1973). It is to be expected then, given the scale of the challenges we have investigated in our four cases that any positive impact resulting from strategies to tackle wicked problems, even where it may exist, is extremely difficult to assess. Therefore, it is with some trepidation, within this context of ‘incorrigible’ problems, that we offer this research on small steps that are being taken within Scotland toward taming the untameable beast.

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