Policy windows for the environment: Tips for improving the uptake of scientific knowledge

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ABSTRACT

Scientific knowledge is considered to be an important factor (alongside others) in environmental policy-making. However, the opportunity for environmentalists to influence policy can often occur within short, discrete time windows. Therefore, a piece of research may have a negligible or transformative policy influence depending on when it is presented. These 'policy windows' are sometimes predictable, such as those dealing with conventions or legislation with a defined renewal period, but are often hard to anticipate. We describe four ways that environmentalists can respond to policy windows and increase the likelihood of knowledge uptake: 1) *foresee (and create)* emergent windows, 2) *respond* quickly to opening windows, 3) *frame* research in line with appropriate windows, and 4) *persevere* in closed windows. These categories are closely linked; efforts to enhance the incorporation of scientific knowledge into policy need to harness mechanisms within each. We illustrate the main points with reference to nature conservation, but the principles apply widely.

1. Introduction

Describing and understanding the ways in which scientific knowledge is, or should be, used in policy-making is a challenging endeavour. Critics of a linear relationship between science and policy point to the manifold roles individuals can play in evidence-informed policy-making, and highlight the need to understand the interrelations between science and policy as complex processes (e.g. Owens, 2015; Rose, 2014a). This is particularly true in areas, such as biodiversity conservation and sustainability, where different forms of knowledge compete for legitimacy and authority within and beyond institutionalised "science-policy interfaces" (e.g. Cook et al., 2013; Rose et al., 2016; Vadrot, 2014a, 2014b; Young et al., 2014). Existing studies have illustrated that lack of knowledge is rarely the limiting factor preventing evidence-informed policy-making (Rose et al., 2014b). Instead, competing and conflicting values, worldviews and interests are often important, further challenging the implementation and practicality of conservation policies (Rose, 2014b). However, given that scientific knowledge is considered to be an important part of policy-making (OECD, 2015), particularly in areas related to environmental issues

characterised by a high degree of complexity, more emphasis should be placed on the conditions for integrating scientific knowledge into formal policy-making processes and institutions.

A number of studies have offered advice for increasing the efficiency and effectiveness of environmental science-policy interfaces. These typically note that science and policy are very different, sometimes even contrary, co-evolving activities (e.g. Cook et al., 2013; Cvitanovic et al., 2015; Young et al., 2014). They suggest strategies for overcoming related complexities and communication gaps. The strategies include (i) training scientists and policy-makers via joint research projects (Bainbridge et al., 2011), (ii) making better use of knowledge brokerage systems including boundary organisations e.g. the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and individuals (Brooke, 2008; Neßhöver et al., 2016; Young et al., 2014), and (iii) telling appropriate policy-relevant narratives (e.g. Cook et al., 2013; Rose, 2015; Sarkki et al., 2014).

There has however been limited constructive engagement with temporal aspects of institutionalised policy-making and how these affect the likeliness of scientific knowledge being taken into account at different stages of agenda-setting. Moreover, the timing of a scientific

publication can influence whether it is used in policy, a scenario that is already widely discussed (e.g. Reed et al., 2014). Whilst noting that the relationship between science and policy is rarely linear, it is the case that specific moments exist in which the ground is fertile for the uptake of scientific knowledge into policy.

To develop this idea further, this paper focuses on the concept of 'policy windows' (Kingdon, 2003). When policy windows are discussed in environmental science, they are usually recognised as a serendipitous problem, rather than something that can be harnessed for the benefit of evidence-informed policy (e.g. Reed et al., 2014). However, a practical and applied understanding of policy windows may provide opportunities for the uptake of scientific knowledge, a process that may otherwise fail or take longer outside these windows.

In this paper, we focus on formal politics and decision making at a "stage in the political process during which actors, operating under set institutional constraints, choose binding outcomes or identify preferred options", and focus less on informal arenas, characterised by informal rules, restricted participation and unofficially drawn boundaries (Reh et al., 2013, 1115). Even though a separation between formal and informal decision making is not always clear cut, particularly with regard to the role of science-policy interfaces, we prefer – for the purpose of this article – to exclude from our study informal ways by which scientific knowledge can contribute to agenda setting more broadly (e.g. through protest, social movements, (social) media, clientelism etc.).

We begin with a brief explanation of policy windows. This is followed by insights into how policy windows can influence the uptake of scientific knowledge and a discussion of the existing literature on techniques for approaching policy windows. Finally, we present a fourfold conceptual framework that can be used by environmentalists[1] (e.g. scientists, NGO staff, individuals in conservation policy roles) to respond to policy windows in a more differentiated and appropriate way. The framework points to four capacities: foresee (even create), respond, frame, and persevere. It is based on case studies and success stories that we use as reference points for demonstrating how policy windows have been used in the past to increase the likelihood that knowledge is used in policy making. Examples are from the field of conservation science, but the principles apply to other areas of environmental science, and more widely. We conclude that more awareness of the four capacities we have identified could improve the likelihood of scientific knowledge uptake at environmental science-policy interfaces.

2. Methods

Rose et al. (2016) investigated why the scientific knowledge contained in one scientific report (on conservation) had such an immediate impact on a government White Paper[2] in the UK. The authors conducted 38 interviews of senior policy-makers and conservation scientists, and undertook documentary analysis of key policy documents, in order to elucidate the possible reasons for the immediate impact. The opening of a policy window was found to be a key determinant of science uptake.

The project described here set out to provide a simple, but wide-ranging framework to provide advice about how to best engage with policy windows. As part of the University of Cambridge Conservation Research Institute, (a multi-disciplinary research group interested in

conservation), a multi-disciplinary team of researchers was formed. This team covered several different disciplines and contained people with specialist knowledge of working at environmental science-policy interfaces (see Appendix 1).

To develop the conceptual framework, we first conducted a structured literature review of papers relevant to conservation and the environment, which also cited Kingdon's work on policy windows (see Appendices 2, 3 and 4). We supplemented these papers with other literature suggested by reviewers and experts in the field. From this literature, we drew out key messages about how to engage constructively with policy windows, and used these to inform a simple, wide-ranging framework. Finally, we collated examples to illustrate how each 'tip' in the framework had led to knowledge uptake. The latter point was important since tangible success stories provide useful guidance for those seeking to learn how to follow the framework. From the literature review, it was clear that, while there are several existing pieces of constructive advice for environmentalists seeking to engage better with policy windows, such advice tends to be piecemeal and not joined into a wide-ranging framework.

3. Policy windows

Kingdon (2003) describes how windows of opportunity for policy change periodically create situations for the sudden uptake of knowledge, even when it has been previously ignored. These windows can open as a result of several converging 'process streams', often in combination: a *problem* may become impossible to ignore, a *policy* solution may appear that is practical to adopt, or *political* events may lead to sudden changes in a government's agenda (Fig. 1). Windows of opportunity are usually short-lived and open only occasionally (Gulbrandsson and Fossum, 2009; Solecki and Shelley, 1996).

The concept of agenda-setting, first explored by McCombs and Shaw (1972), is linked to policy windows. These authors investigated the agenda-setting power of mass media, which could raise the prominence of specific issues in the public consciousness by giving them more airtime. Thus, the media had agency to shape prominent issues on the public agenda. This concept has also been applied in the policy sphere. Downs (1972) suggests the concept of the 'issue-attention cycle' suggesting that issues rise and fall regularly from a government's agenda. Agenda-setting is often perceived to be the first stage in policy-making process, which leads us to Kingdons' question of why certain problems get more attention within formal politics and institutions than others. The question of which issue rises to the top of a policy-maker's agenda can be serendipitous, but it can also be predictable, and groups can play a role in influencing the agenda. Some windows are relatively easy to predict, such as those linked to the next round of Common Agricultural Policy reform; requests for expertise by assessment producing bodies such as IPBES; or the next Conference of the Parties to the Convention on Biological Diversity (CBD). However, others may open unexpectedly with little warning (e.g. the recent Zika virus outbreak).

3.1. How do policy windows affect knowledge uptake?

Kingdon (2003) developed his ideas in the USA in the 1980s, but his work has inspired scholars to use the idea of policy windows to explain decision-making in a variety of contexts. Kingdon identified three streams (problem stream, policy stream, and politics stream), anticipating the emergence of a policy-window when these streams joined at critical moments. Most studies drawing on Kingdon's work note that the opening of a policy window occurs as a result of interactions between process streams (e.g. Anderson and MacLean, 2015; Butler et al., 2015; Keskitalo et al., 2012; Lober, 1997), such as a pressing problem coinciding with a change in government. From our assessment of both environmental and non-environmental research that has used the idea of policy windows, two of the process streams seem particularly significant: first, the influence of crisis events (problem stream), and

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[1] We note that environmentalists may wish to use other forms of knowledge in addition to scientific knowledge when seeking to influence policy. However, for the purposes of this perspective, we focus on how environmentalists can improve the uptake of scientific knowledge. We do not focus on decision-making by other stakeholders, including business, professional organisations, or consumers.

[2] Rose et al. (2016) show how prominent the 'Lawton Review' was in the subsequent Natural Environment White Paper, which presented a firm policy position to support landscape-scale conservation (which the Lawton Review had proposed). The report was cited regularly in the White Paper and was listed as an important source in the text (see also Lawton and Rudd, 2016).
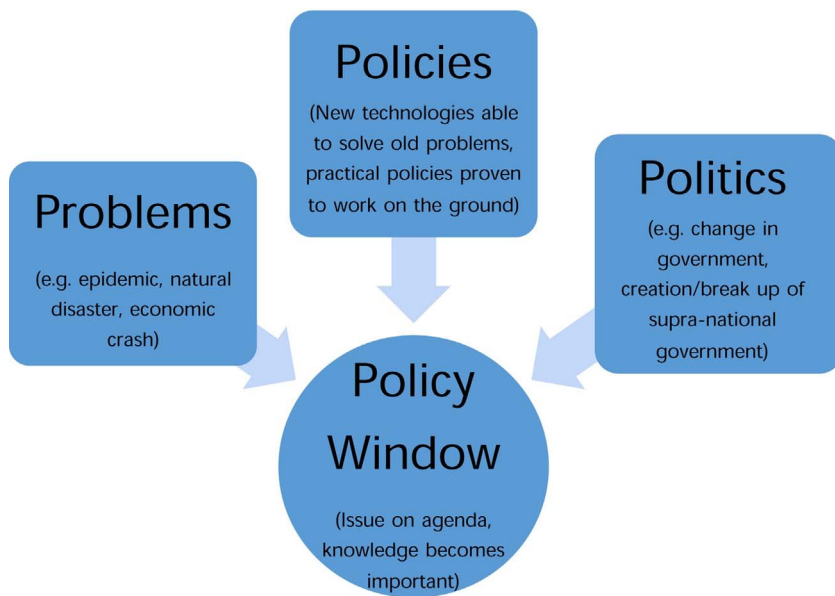
Fig. 1. Events that can open a policy window via convergence of three 'process streams' (modified from Kingdon, 2003).

Policies
(New technologies able to solve old problems, practical policies proven to work on the ground)

Problems
(e.g. epidemic, natural disaster, economic crash)

Politics
(e.g. change in government, creation/break up of supra-national government)

Policy Window
(Issue on agenda, knowledge becomes important)

second, a change in the politics stream, perhaps caused by a change in administration.

Policy windows as a concept has been used widely to explain the policy shifts associated with crisis events. For example, Österblom and Sumaila (2011) investigated the evolution of strategies designed to deal with the problem of illegal, unregulated and unreported fishing in the Southern Ocean. They discovered that the appetite for policy change, and for supporting evidence, was largest in the immediate aftermath of crisis events. These included global fisheries crises and other focusing events that brought increased attention to the problem of low fish stocks, and of the protection of state territories.

Policy windows influenced by a shift in political administration is a popular topic in studies that have used Kingdon's work. For example, the fortunes of pro-environmental legislation, including the uptake of supporting evidence, have been improved by the rise to power of favourable political administrations (e.g. Dudley, 2013; Weber and Driessen, 2010). For instance, Simon and Alm (1995) investigated why the USA Clean Air Act was passed in 1990 following a relatively long period of discussion. Using Kingdon's framework, they conclude that two factors were influential: first, the change in presidency from Reagan to Bush Snr., since the latter had pledged to be an 'environmental president'; second, congressional leadership also became more pro-environmental. Both occurrences helped to create a policy window for the Clean Air Act to be passed. A similar pattern was noted by Solecki and Shelley (1996) in their analysis of why concerns about environmental pollution grew in 1950s America.

In the context of nature conservation, shifts in the political landscape have been identified as a factor in the uptake of scientific knowledge. For example, Dicks et al. (2015) describe how the uptake of science into a new UK Pollinator Strategy was stimulated by the appetite of the Department for Environment, Food and Rural Affairs [Defra] (and Natural England) to develop an agri-environment scheme with a focus on pollinators. As a result of deciding that pollinators should be a key part of Defra's agenda, policy-makers were actively looking for scientific knowledge on which strategies to develop in the new scheme. Furthermore, Haeuber (1998) presents two different examples of where the presence (or absence) of a favourable policy window affected the fortunes of policies: targeting desertification in California and the quality of wilderness areas in the Northern Rockies. In the former case, Haeuber describes how the newly-elected and pro-environmental Clinton administration in 1993, combined with a strong individual in the California Senate delegation, pushed through the California Desert Protection Act. Conversely, a proposal to secure greater protection for wilderness areas in the Northern Rocky Mountains continued to be blocked by consistent political opposition from the region's Congressional delegations.

Similarly, Garrelts et al. (2005) conducted a comparative analysis of the designation of Protected Areas in East Germany and Guatemala, finding that conservation in both countries had benefited from a change of political regimes. These shifts helped make research conducted under previous administrations more pertinent (Garrelts et al., 2005). Finally, Rose et al. (2016) illustrate why the scientific knowledge contained within a particular scientific report (Lawton et al., 2010) made such a significant and immediate impact on Government policy. One of the most important reasons was the opening of a policy window, created by the election of a government that promised to be the 'greenest ever'. As such, the government was looking to improve their environmental record, and the timing of the report's publication coincided with an appetite to do something pro-environmental.

3.2. Tips for seizing upon windows of opportunity

In the context of environmental conservation on the Great Barrier Reef, Moon et al. (2014) note that policy change rarely occurs without an opportunity for evidence uptake, further noting that such opportunities 'materialize and vaporize very quickly' (p. 149). Research across different disciplines, including medicine and public health (Ashford et al., 2006; Gulbrandsson and Fossum, 2009), development (Court and Young, 2003), and nature conservation (Cook et al., 2014), note that the uptake of scientific knowledge could be increased if policy windows could be predicted and thus seized upon more effectively. A number of different tips have been identified for experts seeking to seize upon windows of opportunity for the uptake of knowledge – these include (1) responding quickly, (2) establishing credibility, (3) building coalitions, (4) planning ahead and collating existing solutions, (5) following political debate, and (6) framing research effectively. The work of Moon et al. (2014) illustrates that techniques are most useful when they are combined.

Taking these six points in turn, since windows of opportunity are rarely open for long, Court and Young (2003) suggest that policy engagers should be ready to capitalise on them quickly. As Larsson and Grandstedt (2010 citing Kingdon, 1984) suggest, there is a need 'to strike while the iron is hot'. A quick response can be facilitated if environmentalists have strategic foresight (Cook et al., 2014); to achieve this various methods, such as undertaking horizon scans, can be used to identify upcoming opportunities. In order to be in a credible position

(point two) to offer salient knowledge to policy-makers in a policy window, individuals should build networks with decision-makers and other groups (e.g. NGOs, business), and scientists in particular should establish the credibility of their work within them (Court and Young, 2003). Building coalitions of expertise (point three), for example by working with of environmental NGOs, can enable environmentalists to harness a range of trans-disciplinary skills in order to present knowledge effectively (Brooke, 2008). Establishing rapport with key stakeholder groups can also build support for scientific knowledge (or at least limit opposition), which can be mobilised in windows of opportunity (Rose et al., 2016).

Fourthly, the ability to respond quickly, but also effectively, is enhanced if solutions can be prepared ahead of time, and can be packaged as 'ready-to-go' (McCarthy et al., 2014). Olsson et al. (2004) also report on the success of an idea for a new adaptive co-management system for wetland conservation in Sweden. The authors argue that proponents of the idea were able to seize upon a policy window by publishing a compilation of knowledge.

The latter two points suggest that it is important to follow political debate in order to identify salient themes, then to frame knowledge accordingly (Rose et al., 2016). As Stefes (2010) argues, it is not inevitable that fertile ground for a piece of knowledge causes uptake; rather, the opportunity must be seized upon. For example, Owens (2015) illustrates that policy engagers need to seize upon them effectively by framing knowledge saliently.[3] Exploring the influence of the Ninth Report by the UK Royal Commission on Environmental Pollution on the use of lead in petrol, Owens argues that the independent advisory group seized a policy window and were able to bring about change. The Commission's report avoided the controversy over the link between lead and health (which had not been sufficiently proven) and instead argued that lead-free petrol could be promoted without unacceptable costs to industry or consumers (Owens, 2015). Therefore, maintaining lead in petrol was a risk that did not have to be taken. This frame was politically salient and timely, and helped the report to influence policy quickly: less than an hour after publication, the government used it in the House of Commons, and the recommendations to remove lead from petrol were acted upon within a few months.

In light of the suggestions made in previous literature (tips 1–6 outlined above), including in environmental research, we argue that a better understanding of policy windows presents opportunities to influence policy. In contrast to much of the existing literature, which focuses on specific tips for approaching policy windows, we seek to provide a simple, wide-ranging framework for environmentalists to follow, supported by case studies and examples of success.

We argue that there are several ways of predicting, and reacting to, windows of opportunity, and for working in periods of closed windows. If we accept that policy windows occur at fixed points in time, it follows that environmentalists could prepare for an upcoming opportunity and even influence agendas, respond quickly when a window arises, and frame research saliently to take advantage of it. In addition, it is clear that policy windows are often closed, and therefore we suggest methods to enhance policy relevance in such periods. Overall, we describe four logical categories of actions: the capacity to foresee (and create), respond, frame, and persevere (Fig. 2). As these actions are not mutually exclusive, the discussion later brings these categories together to discuss how they may be used to improve the uptake of scientific knowledge into policy. The framework has relevance across the environmental sciences and may be used by individuals from the science, NGO,

or policy communities to identify opportunities for the uptake of scientific knowledge. We acknowledge that some activities may not be suitable for a particular group (e.g. pressuring or activism by scientists), but as a wider coalition these suggestions may have relevance.

4. Four-point framework

4.1. Capacity to foresee

The ability to foresee emergent windows helps to prepare environmentalists for a period in which the ground is fertile for their specific topic. Policy relevant outputs can be prepared in advance, so that if a predicted policy window opens, then scientific evidence is readily available when the time comes. Employing strategic foresight (Cook et al., 2014) can therefore reduce response times when policy-makers suddenly demand knowledge about a particular issue. It is also worth noting that identifying future problems of environmental importance may help to set the agenda for policy-makers, and therefore may even create policy windows in addition to predicting their emergence.

4.1.1. Horizon scanning for emergent environmental problems and legislation

Horizon scanning is a key tool for identifying potential issues that might impact conservation in the future (Sutherland et al., 2011). Unlike most policy actions that are reactive to events, horizon scanning is pro-active in policy preparedness. For example, in one exercise, each year a team of global experts identifies a list of 15 issues likely to be of future conservation concern (Sutherland et al., 2017) through a rigorous process based on the modified Delphi technique (Mukherjee et al., 2015). A horizon scan by Roy et al. (2014) identified a list of invasive species likely to become established, and problematic, in the UK.

A similar process can generate a list of upcoming legislative issues at a nation-state or supra-national level. This allows the *political* element of decision-making to be tentatively predicted. For example, Sutherland et al. (2016) have undertaken annual legislative horizon scans to highlight issues that are likely to feature on policy agendas with probable consequences for the environment. These scans address forthcoming issues at the global, EU, and national scale.

4.1.2. Engagement with policy organisations

Governmental or other external organisations may also have some sense of where environmental policy is being driven in the short to medium-term future, and how they are anticipating adapting to this. Contact and informal discussions with such organisations can give insight into where research can be most informative. For example, engagement with the Parliamentary Office of Science and Technology (POST) in the UK, or the Congressional Research Service in the U.S., might offer opportunities to foresee upcoming policy windows for bridging science and policy. POST publishes proactive 'POSTnotes' which synthesize evidence for policy-makers before an issue rises to prominence. At the international level, the recently established Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) offers opportunities for identifying future directions of conservation science, as does EKLIPSE. Linking with such organisations is dependent on good networking and on responding to various open calls asking individuals to engage with a particular process. Engaging with key knowledge brokers, such as learned societies and green alliances (e.g. Wildlife and Countryside Link in the UK), can also be a good way of spotting opportunities.

4.2. Capacity to respond

Policy-makers face severe time constraints, and since policy windows are usually open for a short time (Court and Young, 2003), their

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[3] There were many other examples in the review of the need for policy engagers, or policy entrepreneurs, to seize effectively upon a policy window. Lehrer (2010) reports on how policy entrepreneurs were able to seize upon a policy window to influence the passage of the EU's biofuels policy by framing their ideas in line with salient topics, such as national security and energy security. Johnson (2008) describes how individuals were able to take advantage of a change in leadership in China to push forward renewable energy policies.

- Horizon scanning
- Policy engagement

- Headstarting to enable rapid reaction
- Understand policy environment

Foresee (even create)

Respond

Persevere

Frame

- Persevere with arguments
- Argue for incremental change
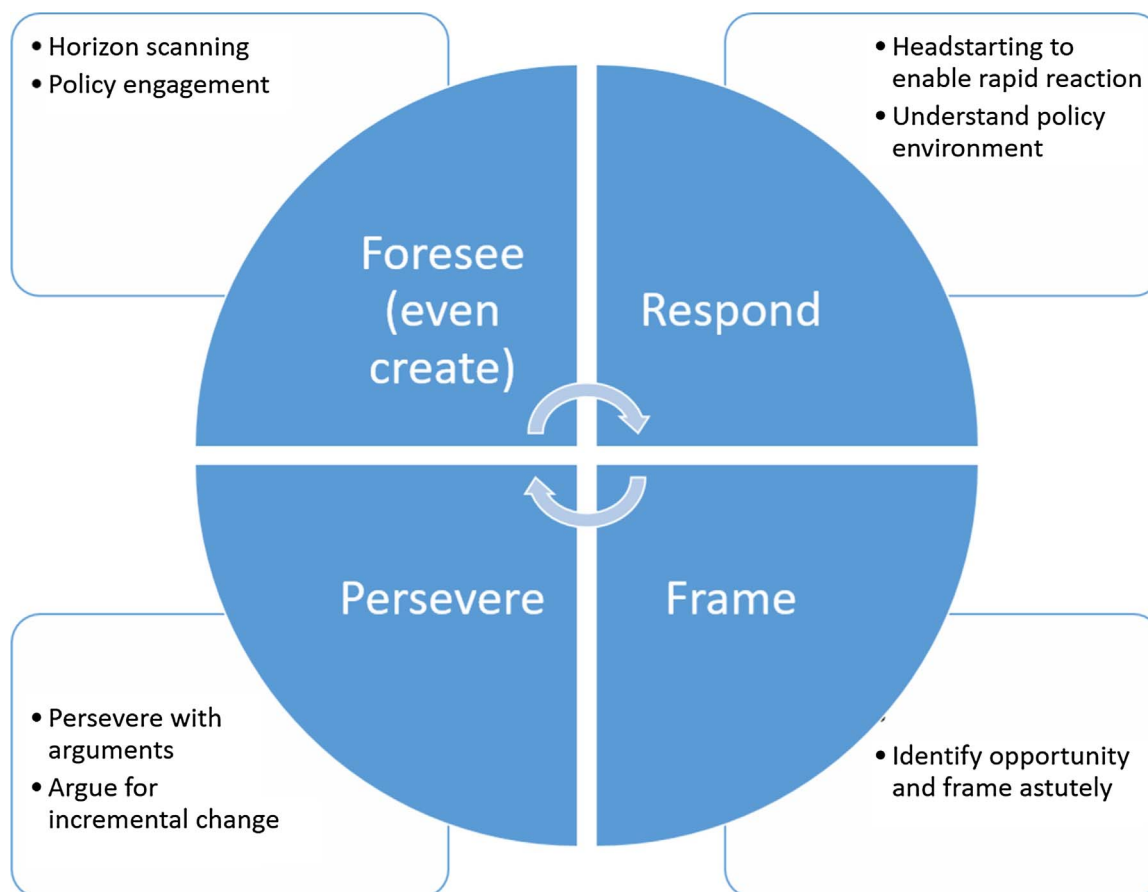
- Identify opportunity and frame astutely

Fig. 2. The four suggested interconnecting tips for responding to policy windows.

attention must be captured quickly. Therefore, the capacity to respond quickly to salient windows is important, ensuring that scientific knowledge can be deployed to reach decision-makers in a timely manner.

4.2.1. Headstarting to enable a rapid reaction

Decision-making in conservation is often based on intuition rather than rigorous evidence of management effectiveness (Sutherland et al., 2004). One of the commonly cited reasons for this problem is the inaccessibility of scientific evidence: decision-makers may not have access to peer-reviewed literature, or may lack the time or skills necessary to navigate through scientific terminology. This can lead to slow response times to a problem, which can limit the chances for knowledge use. Although improving response times does not guarantee the use of scientific knowledge in policy, the chances of influence are improved if knowledge reaches decision-makers in a timely way. One way to address this is if environmental scientists (with NGO and policy support) collate, synthesize, and present evidence in a comprehensive form that is available immediately and freely. While systematic reviews and synopses are useful tools for the collation of scientific evidence, they take a significant amount of time to compile, and thus an opportunity may be missed.

Two initiatives aim to use systematic review methodologies to collate evidence proactively in advance, even if the saliency of the evidence might not be significant at the time of collation. Conservation Evidence (Sutherland, 2004) provides a freely accessible, online, global database of conservation interventions across a range of taxa and habitats, which also measures effectiveness (Sutherland et al., 2010), while the Collaboration for Environmental Evidence (CEE, 2008) is a network of scientists and managers who synthesize evidence of greatest concern to policy-makers and practitioners. Such techniques provide a

critical headstart, allowing the quick deployment of scientific evidence to policy-makers.

4.2.2. Understand and facilitate policy environment to lower barriers

If an opportunity for impact presents itself, there is a need to ensure that scientific knowledge reaches decision-makers. Reed et al. (2014) illustrate that individuals who understand how policy is made, and crucially how it differs from methods used in science, are most effective at science-policy interfaces. There are several ways of building knowledge about policy-making. In the education of environmentalists, there is a need to foster greater interest in learning about policy, perhaps by encouraging shadowing schemes and training in how to write policy briefs (Blickley et al., 2013). A number of such schemes exist (such as the POST scheme in UK), but mostly in the UK and USA, and usually offer the greatest policy engagement at an early career stage. Although already practised in many cases, universities can play a leading role here in recognising the value of an inter-disciplinary graduate degree, requiring students to engage in diverse training.

Astute political networking by environmentalists may also help to lower existing barriers in communicating to policy-makers. Owens' (2015) investigation of the practices of the Royal Commission on Environmental Pollution demonstrates the value of well-networked scientists. Here, many experts on the Commission were also embedded in influential policy rooms. For example, some were members of the House of Lords, who could refer to newly published reports from the Commission in Parliamentary debates. While it is seldom possible for environmentalists to serve in Parliament directly, Owens' (2015) work nevertheless presents the important overarching message of good networking; for example, environmentalists could have meetings with elected representatives, including in their own constituency, and grasp opportunities to advise policy-makers on expert committees.

Universities (as well as government and funders through research guidelines) can also play a role in encouraging researchers to engage in networking, including serving on expert committees at larger scales (e.g. IPBES). Building professional working relationships and structures for knowledge exchange helps to lower the barriers for the uptake of scientific knowledge (e.g. Natural Environment Research Council knowledge exchange scheme in the UK).

4.3. Capacity to frame

Framing issues persuasively is an integral part of responding to policy windows. The first task for successful framing involves the identification of a salient idea for which a window is open, such as a pressing problem on a government's agenda. Once an environmentalist becomes aware of such an issue, the second task is to examine whether there are synergies with their research. If there are useful overlaps, then knowledge can be presented persuasively in line with the salient frame. Much research in conservation suggests that astute framing improves knowledge uptake (see e.g. Rose, 2015).

4.3.1. Identify opportunity and frame conservation issues astutely

The RSPB's campaign to convince the EU to ban the trade in wild birds is a clear example of finding a salient way to promote nature conservation (see Avery, 2012; Rose, 2015). A long-term campaign on conservation grounds had not been sufficiently persuasive. However, when avian flu emerged as a threat to human health, the RSPB reframed their knowledge rapidly in line with measures to protect human health. As the policy window was open for research relating to this health epidemic, policy-makers were much more receptive to research on the potential of bird trading in exacerbating the problem.

Framing issues in anthropogenic terms (intentionally or unintentionally) has similarly enabled pollination ecologists to influence policy. Pollinator declines constitute a policy window that has received substantial attention from decision-makers at the national and international scale. For example, the first major report by IPBES was a 'Thematic Assessment of Pollinators, Pollination and Food Production' (IPBES, 2016) and, in 2014, the UK launched a ten-year National Pollinator Strategy (Defra, 2014). While not ignoring the role of pollinators in maintaining wild plant diversity, these reports are united in their focus on the importance of pollinators for crops and human health. This has resulted in the uptake of scientific studies that address these areas, such as Smith et al. (2015), who use a modelling approach to quantify the global nutritional and health impacts of reduced intake of pollinator-dependent foods. The art of framing research in line with societal, as well as conservation needs, is clearly an effective technique that could be utilised more by environmentalists.

4.4. Capacity to persevere

When no policy window is open for a specific conservation issue, stand-alone knowledge may have a limited impact. In such a closed window situation, environmentalists have two options: first, to persevere while waiting for a better opportunity to present their research, and then re-frame accordingly (see *capacity to frame*); or secondly, to bring about change incrementally.

4.4.1. Persevere with arguments

Although a lack of fertile ground for knowledge uptake can be detrimental, this need not be an unbreakable barrier. Referencing the work of Likens (2010), who argued that perseverance was a key attribute for effective science input into river conservation, Dahm et al. (2013) explore knowledge uptake in the management of the Californian Bay-delta. Here they argue that "repeated, positive, non-confrontational exposure to relevant science" (p. 323) is necessary: for example, the Delta Lead Scientist makes regular presentations of science to policy-makers at monthly Delta Stewardship Council meetings. This suggests

that environmentalists should not be disheartened at immediate low uptake, but instead carry on making clear arguments about why scientific knowledge matters (until a better opportunity presents itself). Perseverance can also involve applying pressure, but such pressuring activities might be best done in coalitions with the wider environmental community. Individual scientists may prefer to act as honest brokers, rather than as advocates of knowledge[4] (Pielke, 2007; Rose et al., 2016), so pressure from environmental NGOs is often preferable.

4.4.2. Argue for incremental change

In a closed window, policy-makers may not be receptive to any substantial changes. However, there may be an opportunity to influence relatively small changes to policy, which can provide the focal point for future efforts. In this sense, the agenda can be subtly influenced over time through the actions of environmentalists. Useful small changes could involve establishing a working group or review that could play a role in influencing minor shifts in legislation, such as a requirement to take due regard to an issue in future decisions. It is noted that incremental change is sometimes difficult, as in the case of adding newly threatened species to the Annexes of the EU Birds Directive, but there are cases where gradual change has been successful.

For example, Warren (2013) describes the evolution of the Site of Special Scientific Interest (SSSI) designation in the UK, from relatively humble beginnings through to their status as the cornerstone of conservation policy. In the original National Parks Act of 1949, the designation of SSSI was little more than a factual statement that a piece of land was of a certain scientific quality. Warren (2013) describes how policy-makers saw the idea as uncontroversial because there was no duty on the local planning authority to respond to evidence showing the scientific importance of a site. Since then, however, SSSIs have been strengthened by a series of incremental legal changes and it is now an offence to damage recklessly or intentionally any natural features on such sites.

5. Concluding remarks: synergies and interactions

Although this paper has identified four tips for approaching policy windows, it is important to move beyond much of the previous literature which has tended to discuss individual solutions in isolation. Here, each of the four described categories has an important role to play in identifying, creating, and seizing upon policy windows, but the scale of impact is larger when they combine. For example, we suggest that responding quickly to a salient window is much easier if its opening has been *foreseen,* and hence environmentalists have been working on the issue in advance. The impact of a scientific *response* will also be improved if scientific knowledge can be *framed* saliently, and then deployed effectively into a policy environment. The latter part of this process can be facilitated by increased knowledge of policy-making, by building trusted relationships with decision-makers through ongoing collaboration, and by providing knowledge in a useable format (Reed et al., 2014). Similarly, there is often a key interaction between *framing* and *perseverance*. Dicks et al. (2015) illustrated how a policy window opened in the UK for pollinator research, in part due to a powerful narrative about pollinator decline, but also because of sustained public pressure (which individual scientists were aware of). Therefore, a good *framing* can be used both to fit research into an existing window, and to persuade governments to respond in light of public concern.

Likewise, however, the opposite is also true; if these tips are not employed in combination, then the chance of knowledge uptake may not be enhanced. For example, even if scientific knowledge is collated *ahead* of time, allowing a quick *response* to a policy window, impact might be limited by poor *framing* of that knowledge. Since scientific

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[4] Pielke (2007) is clear to state that advocates of knowledge are not necessarily dishonest.

knowledge is only one factor in the policy-making process (Rose et al., 2014b), it must be presented in a convincing way, even if the ground is fertile for uptake. Additionally, *foreseeing* an opportunity might give environmentalists a critical head-start to build necessary knowledge, but if scientific evidence is not collated in an efficient, accessible way (i.e. allowing speedy communication), then the effectiveness of *responding* to an emergent window is limited. Furthermore, *perseverance* while waiting for a window is futile if the opportunity cannot be seized upon effectively with a quick, saliently *framed response*.

We hope that this paper fosters a constructive interest in policy windows, and encourages a joined-up approach to predicting, creating, and seizing upon them for the uptake of scientific knowledge. Moreover, we hope to stimulate more empirical work on the links between policy windows and science in conservation, so that further lessons can be learned about how to produce and deploy scientific knowledge effectively. While the collective value of these actions is increased through multi-disciplinary collaboration within the environmentalist community, there is much that individuals can do by themselves, and we hope the framework suggested here can provide critical insights towards that end.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.envsci.2017.07.013.

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