Future Tools Literature Review

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1. Introducing Futures Research

The future management of ecosystem services[1] will face a number of complex challenges (Carpenter et al. 2009, Fischer, 2009). Environmental, social and economic drivers of change are likely to have unpredictable and multi-layered affects. In addition, many ecosystem services are characterised by uncertainty and unpredictability, due to the many interacting ecosystem functions that lead to their provision (Carpenter et al. 2009). When anticipating the future provision of ecosystem services a range of different pathways are possible, each with their own multitude of alternative future possibilities. Therefore, futures research typically evaluates a variety of "possible futures" for the provision of ecosystem services (see Masini 2009).

There are a number of useful tools that can be used to identify, analyse and communicate insights about the future (Lowe & Ward 2009, Masini 2009, Sardar 2010). They range from highly quantitative, predictive approaches based on scientific evidence (e.g. forecasting), to more qualitative approaches based on a combination of local/lay and scientific knowledge (e.g. visioning). The UK Government defines futures research as: *"The systematic examination of potential threats, opportunities and likely future developments which are at the margins of current thinking and planning. Futures research may explore novel and unexpected issues, as well as persistent problems or trends" (*Defra, 2002*).* Futures research may inform policy development or informs spatial planning within the public sector, and it is used widely in the private and third sectors to anticipate and prepare for future shocks and facilitate long-term planning (Cole 2001, Roney 2010).

Futures studies first date back to the period between World War I and II, and were developed for war-oriented planning (Sardar, 2010). Studies were often associated with significant planned changes to civil society; for example, much work is associated with World War I and II, the Great Depression, Communist Russia, Fascist Italy and Nazi Germany (Bell, 1997; 1999). Despite a growing body of academic work in this field, "futures" is often perceived as a quasi-scientific discipline (Lowe & Ward, 2009). As a result of the many different approaches to futures work, there is substantial variation in terminology, approaches and uptake (Aeltonen, 2005, Sardar, 2010) along with some overlap and conflation between the terms and methods used. For example, Foresight is a well-known umbrella concept that involves a variety of Futures methods (Figure 1) to critically review and strategically plan for impending events (Loveridge, 2009). Foresight has been used in areas varying from management studies (Costanzo and MacKay, 2009) to strategic studies (Kuosa, 2012) including determining the future of ecosystems. In the context of fisheries management, FAO (2012) used foresight (and other future tools) to construct the Ecosystem Approach for Fisheries (EAF). Due to the broad-range of tools incorporated in a Foresight approach it can cope well with any mechanism which aims to predict, or anticipate the future: from scenarios and brainstorming to visioning and forecasting (see section for descriptions of these tools), foresight is used 'for thinking ahead, investigating the future, and supplying insight' (Steele & Price, 2008).

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[1] The multiple values that ecosystems provide to all sectors of society and, by implication, their equally diverse value systems (MEA, 2005). Ecosystem services are categorised by the Millennium Ecosystems Assessment as (i) provisioning (e.g. timber), (ii) regulating (e.g. water quality and quantity; climate, including carbon sequestration), (iii) supporting (e.g. pollination and pest control) and (iv) cultural (e.g. well-being; MEA 2005).

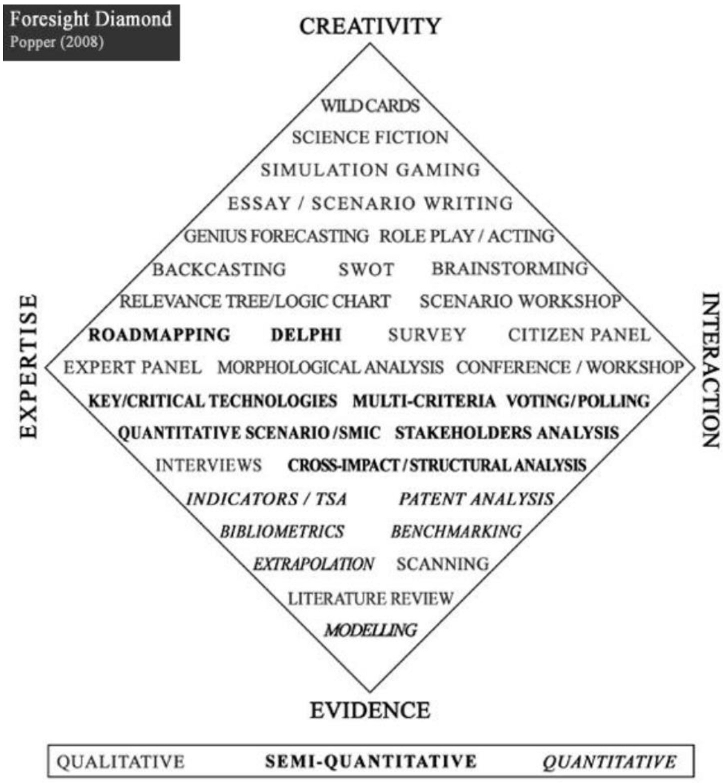

Figure 1. The foresight diamond, outlining the approach (Popper, 2008)

In this review, we:

1) Unpack the generic nature, scope and purpose of futures tools;

2) Review the development of influential futures tools and methods that are used in everyday practice, signposting readers to reviews that have been carried out as part of the follow-on to the National Ecosystem Assessment; and

3) Identify where and how futures tools have been used to operationalise the ecosystems approach and to work with ecosystem services.

2. Unpacking Futures Tools

Tools available for anticipating and planning for the future vary according to the epistemological[2] assumptions that underpin them. To help clarify, Aaltonen (2005), when unpacking futures methods for the Millennium Ecosystem Assessment (MEA) summarised the work of Ansoff (1975) Arbnor & Bjerke (1997), Dervin et al. (2002) and Stacey (2001), and classified futures tools according to the key questions they help answer (other ways of classifying Futures tools are discussed by Turturean 2011). These questions are as follows: What is the nature of reality? Orderly or Chaotic? What is the nature of human beings? Rational or muddled? What is the nature of knowing? Objective or non-objective? And: What is acceptable as an explanation of how reality works? How is the movement from a past in the present and towards a future considered?

[2] Our understanding of the nature of knowledge

Aaltonen (2005) mapped out the landscape in which current futures tools are used in relation to these epistemological assumptions (Figure 2). Here, the vertical dimension (where design is contrasted with emergence) focuses on the way in which a system is assumed to function, and the horizontal focuses on the way we assume that system could be controlled and/or guided. Through this process, Figure 2 identifies four areas, two with the longest history and in wider use (engineering approaches and systems thinking) and two that are not yet widely used (mathematical complexity and social complexity). These areas represent a divergent yet complementary view of how the future emerges (Aaltonen, 2005).

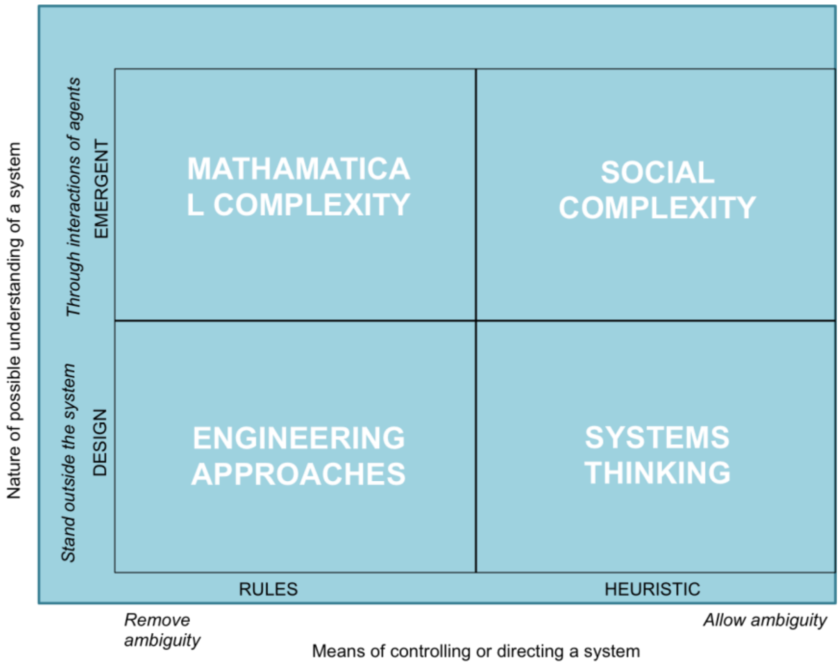

Figure 2. Model of epistemological assumptions analysis, the vertical dimension looks at how a system is assumed to function, and the horizontal focuses on the way we assume that system could be controlled and/or guided (Aaltonen 2005)

Future tools were mapped on to Figure 2 to reveal their underlying qualities (Figure 3, Aaltonen 2005). Tools in the lower left quadrant are well known and easy to use by those without specialist training/expertise. Those of the upper left are more sophisticated, requiring mathematical and/or computer programming skills. Tools in the lower right hand quadrant are better at handling ambiguity, yet, are limited by the number of interactions that they are able to account for. The tools of the upper right-hand deal with phenomena that tend to be poorly understood, emergent and non-linear. These tools focus on creating explanations and understanding (Snowdon 2002, Aaltonen, 2009) and are the least utilised of those shown (Aaltonen 2005). Most of these tools are used to remove ambiguity from decision-making. Those in the upper quadrants are more complex, due to their assumptions about the future. Here, the future emerges in response to human interaction, which each future influencing resultant human strategies.

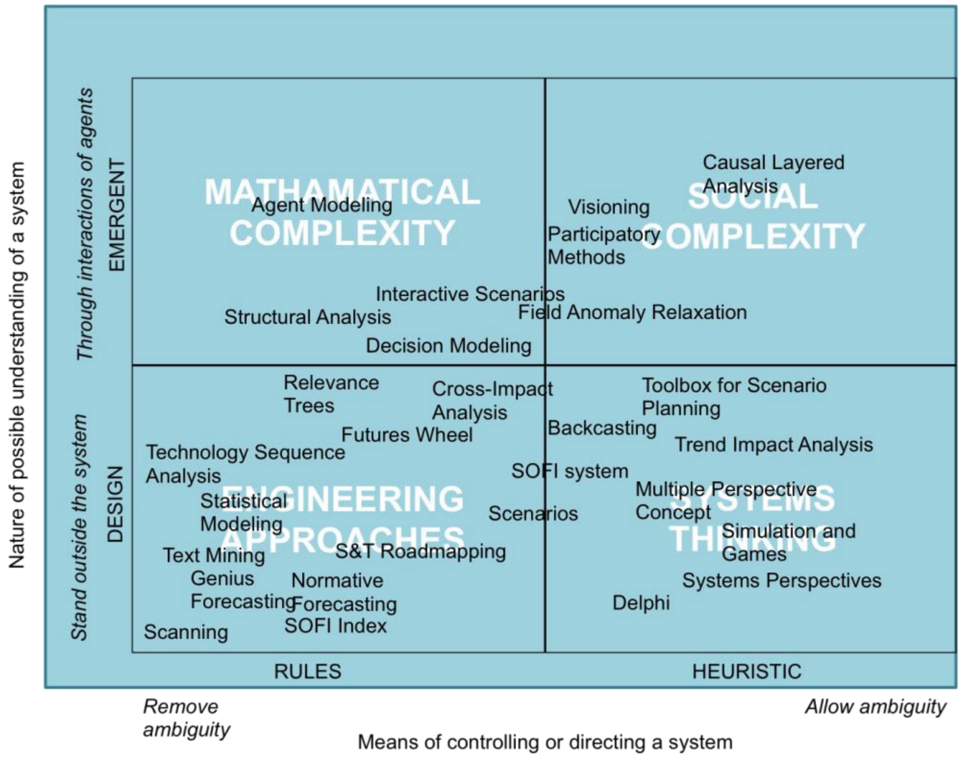

Figure 3. Model of epistemological assumptions analysis (EAA) with Future Tools mapped out to show their embedded qualities (adapted from Aaltonen 2005)

3. The development of influential futures tools for ecosystem service futures

As shown in section 2, a range of tools are used in Futures research, each with their own underlying assumptions. In this section we discuss the Futures tools that are most commonly used, and those with particular relevance to ecosystem service futures. To improve clarity, we present the tools as they fit within the epistemological assumptions analysis (Figures 2 and 3) as illustrated in Figure 3, there remains some overlap due both to shared assumptions underlying some tools and the fact that some tools tend to be utilised in tandem with others.

3.1. ENGINEERING APPROACHES

3.1.1. Futures Wheel

First developed and described by Glenn (1994, 2003) the futures wheel places a starting time at the centre of the exercise. From this point, “spokes” lead to possible consequential developments. Later developments are places sequentially further from the centre point. Futures wheels are often created as a participatory exercise, due to the simplicity of the tool and the role it can play in communicating complexity (Pimentel et al. 2012, Pruenau et al. 2012). Mind maps are similar to the future wheel except that the radiating dimension differs (Bishop et al. 2007, Heitenan et al. 2011). In the case of mind maps it is scale of a concept rather than time. The Futures Wheel tool has yet to have much use in environmental or ecosystem service related work (Bengston et al. 2001, Bengston 2012).

3.1.2. Forecasting

In futures research, the term “forecasting” is restricted to quantitative, predictive forecasting (Armstrong & Scott 2007, Makridakis, 1998). Forecasting often looks at how something has been in the past (i.e. the amount of product purchased) and extrapolates those trends to create future scenarios. Originating in renaissance Italy, it was not until the 19th century that forecasting became common (Armstrong & Scott 2007). By the late 20th century both the tools used and complexity had increased (see for example, Makridakis et al, 2008). Software development enabled forecasting calculation to become more accurate and precise, enabling more complex and statistical procedures to be developed. Yet, despite short-term accuracy of predictions, longer-term forecasts do not have the same level of accuracy (Wright & Rowe, 2011). In attempts to gain environmental foresight, substantial effort has been devoted to forecasting the future of social-ecological systems, for example in the climate projections of the IPCC (Carpenter & Gunderson 2001, Carpenter 2002, Ehrlich & Pringle 2008, Thrush et al. 2009). However, attempts in environmental forecasting have had a poor track record (see Bengston 2012 for examples), perhaps due to the complex interactions of people and ecosystems ensure that ecological forecasts are fundamentally uncertain (Bengston 2012, Makridakis et al, 2011). Although, helpful in guiding decision making the precision of forecasts may provide decision-makers with a false sense of certainty, meaning they prepare for a narrower range of futures, only to discover at a later date that the models were incorrect.

3.1.3. Horizon scanning

Horizon scanning, also called scanning, environmental scanning, or critical trends analysis, covers a number of processes for identifying and understanding emerging changes to the external environment of an organization (e.g., a government agency, corporation, or nongovernmental organization) or area of interest (e.g., biological diversity, climate change, or ecosystem services). Horizon scanning techniques were developed by military intelligence officers to gain insights into emerging developments in enemy countries (Bengston 2012, Sutherland et al. 2010). Scanning was used extensively during World War II, and as a result it has become standard practice in business and many government agencies. Aaltonen (2005) divides scanning into six sub-methods: expert panels, database literature review, internet searches, hard-copy literature review, essays on issues by experts, and key person tracking and conferencing monitoring.

Scanning is a widely used futures method. Its use in environmental contexts and organizations is relatively limited, although remains significant. Sutherland and Woodroof (2009) describe scanning applied to environmental issues and present a taxonomy of scanning methods, and Sutherland et al. (2008, 2010) outline scanning exercises for biodiversity and global conservation issues. Scanning has been successfully used in a number of significant projects. For example, the National Advisory Council for Environmental Policy and Technology recommended that the U.S. Environmental Protection Agency (EPA) create an ongoing, institutionalized scanning system (U.S. EPA 2002). The U.S. Army has an Environmental Policy Institute that conducts futures scanning on environmental issues (http://www.aepi.army.mil/). The longest running effort to apply futures research to environmental issues is the work carried out by the U.S. EPA, dating back to the early 1970s (U.S. EPA 1973, Elgin et al. 1975) Olson (2011) identified several lessons from this work, including making an ongoing horizon scanning system a core activity (Bengston et al. 2012). More recently, the iKnow project (http://wiwe.iknowfutures.eu) which considers the Future Ecosystem Services, used Scanning as one of its key futures tools, alongside Delphi.

3.2. SYSTEMS THINKING TOOLS

3.2.1. Delphi

Named after the ancient Greek oracle, this tool was developed at the RAND Corporation in the early 1950s to investigate the potential impact of nuclear war (Linstone and Turoff 1975). Delphi has a number of variations to approach, and generally involves gathering feedback from a panel of assembled experts over multiple rounds (Bengston 2012). In a typical process, panel experts respond to questions without knowledge of the other panelists responses. In the following rounds, responses are then presented back to each expert along with their own. Participants are given opportunity to revise their individual responses based on those of other participants. It is usual to have approximately three rounds, after which consensus or contrasting views emerge. The aim is not to reach consensus (Critcher and Gladstone, 1998, Helmer & Dalkey, 1983) rather, stability of responses is the objective, where no one panelist would change their view, even though they may disagree. The technique explores contrasting and minority views and opinions and can help understand uncertainty. Early applications Delphi were in science and technology (Gordon 1994). It has been used in internationally across many studies and fields, for a wide range of purposes (Bengston 2012). The Delphi method has occasionally been applied to natural resource and environmental issues. An early application looked at “future leisure environments” (Moeller 1975). Other environmental applications of Delphi include those by Ratnapradipa et al. (2011) and Plummer and Armitage (2007).

3.2.2. Scenarios

Scenarios straddle Engineering and Systems thinking and enable choices to be better structured for stakeholders, strategic planning and decision-making to be carried out. This can then act as a platform for considering the implications of a range of options when the future is uncertain, whilst facilitating participation in the development process and allowing conflicting opinions and different worldviews to be voiced. Scenarios aim to provide a degree of certainty in times of uncertainty (Bohensky et al., 2006). The UK NEA recognise the importance of scenarios multi-purpose nature (O’Neill et al. 2008), generating not only plausible futures, but also social learning (for a definition of social learning see Reed et al. 2010). The UK NEA (2011b) further states that ‘scenarios are neither predictions nor projections and sometimes may be based on a “narrative storyline.” Scenarios may include projections but are often based on additional information from other sources.’ Fundamentally, scenarios enable an actor, or several individuals, to critique decision-making and refine practice (Chermack et al. 2001).

Within UK NEA (2011a) working with scenarios is considered important for visualising the future in an accessible way that allows decision-makers to appreciate the sensitivity of UK ecosystems to a range of drivers of change and in so doing, tailor responses accordingly. Scenario tools are widely used for managing future change in the context of the environment (Lindgren and Bandhold, 2003; Marchais-Roubelat and Roubelat, 2007). Alcamo (2008) provides a wide-ranging examination of the practice of scenario analysis applied to the environment. The approach has been used in a variety of ecosystem service related areas, from anticipating risks with regards to food security, to planning for climate change agenda. Furthermore, the use of scenarios has become more prevalent over time triggered by Shell’s use of the technique to anticipate the 1970s oil shortage, leading to other organisations and key actors realising it's potential (Kass *et al*., 2011). A growing number of studies include or are based on scenario methods. Examples include the Intergovernmental Panel on Climate Change (IPCC) reports (IPCC 2007), the Millennium Ecosystem Assessment (Carpenter et al. 2005, Haines-Young, 2011, Raskin 2005), and the World Water Vision Exercise (Cosgrove and Rijsberman 2000). Most climate change scenario analysis under IPCC used quantitative modeling (e.g., Nakicenovic et al. 2000, 2005, Morita et al. 2001, Carter et al. 2007). However, recent IPCC scenario analyses include quantitative modeling combined with narrative approaches using participation, and more holistic approaches to climate scenario development (Carter et al. 2007).

Participatory scenarios (Reed et al. 2005, Evans et al. 2010) have also been used in several contexts. For example, in forest communities in Bolivia and Vietnam (Evans et al. 2010) social resilience in climate-vulnerable communities (Gidley et al. 2009), and future ecosystem services in northern Wisconsin, USA (Peterson et al. 2003).

3.2.3. Backcasting

Backcasting was first discussed by Robinson (1982), yet the term is believed to have been coined earlier in quantitative forecasting (see Dreborg, 1996). Backcasting is opposite to forecasting. With forecasting, the use of the tool begins in the past and/or present and a time-line is then created into the future. With backcasting, the tool begins with the desired end state, and then works backwards to the present in order to determine how that end-state can be achieved (Dreborf 1996). There are a number of variants to backcasting methodology. Robinsons form of backcasting is explicitly normative and design-oriented. Here, the aim is to explore the implications of alternative paths. Future goals and objectives need to be defined, and then used to develop a future scenario. Once the future has been envisioned the steps to get to this vision are defined, starting at the point nearest to the future and working back to the present time. Backcasting has been used to plan for time periods (up to 10 years) and has been applied to the marketing of innovations (e.g. Boons et al. 2012, Wang & Guild, 1996), and as an-add on to scenario planning (Robinson et al. 2011). Back casting has been used in environmental analyses, particularly in Canada (e.g. Gleeson et al. 2012, Newton et al. 2002, Robinson 2003). Everard *et al.*, (2009) have been the closest to using back-casting in relation to ecosystems in their work on an integrated catchment value systems model. Manning et al (2009) use backcasting to provide a structured framework for achieving large-scale ecosystem restoration, along with milestones and scenario planning.

3.2.4. Wind tunnelling

Wind-tunneling is similar to backcasting in that it involves a similar process of reflective thinking to achieve a desired outcome. The tool differs by involving a form of test as to whether the decision will be particularly effective in the future (see for example Windtunneling, 2011). Although a relatively new concept, van der Steen and van Twist (2012) argue that it is the most relevant for today's policy makers, which leads to these actors continually scrutinising decisions and thus planning better for the future. For example by asking them to consider 'what will happen if we use intervention a in system b and how will this lead to the intended effects? What other – unintended – effects can be expected? Are there unexpected effects to be expected, and what can we learn about their probable nature?'.

3.3. SOCIAL COMPLEXITY TOOLS

3.3.1 Causal layered analysis

First developed by in the 1990s by Inayatullah (1998), this tool efficiently assesses the present as well as predicting the future by focusing on categorising the causes of likely change. To date, very few ecosystem service futures studies have used causal layered analysis (see Cork et al. 2009 study). Causal layered analysis separates categories of causation into a set of sequential layers, demonstrating how each layer influences the layer above. In Inayatullah's conception, these layers are:

1. The "litany" (quantitative trends, problems, often exaggerated, often used for political purposes, this information is usually presented by the news media);
2. Social causes (e.g. economic, cultural, political and historical factors, here quantitative data is interpreted, and the results are often articulated by policy institutes and published as editorial pieces in newspapers or in quasi-academic journals)

3. Structure and worldview (here the task is to find deeper social, linguistic, cultural structures that are common to each individual. Discerning deeper assumptions behind the issue is crucial here as are efforts to revise the problem)
4. Metaphor and myth (these are the emotional level experiences to the worldview under inquiry, they may be difficult or impossible to articulate).

3.3.2. Visioning

Visioning is the process of identifying a clear expression of future aspirations. A vision articulates clearly (literally and graphically) how the future will be. Visioning involves predicting and understanding long term challenges and imminent problems (Steele and Price, 2009). Visioning processes are often linked in with scenario planning as scenario planning helps generate and evaluate alternative future patterns. Scenario planning is an analytical process that helps people imagine and understand how they can shape their community's story to realize a long-term vision. Visions are constructed by several actors in a group, with each adding to the idea and working out how to implement the vision in reality (Kallis et al., 2007). Visions can be informally constructed, through conversations, or more formally in workshops (Van Der Helm, 2008). The Visions tool can involve community members, and more marginalised viewpoints (O Brien and Meadows, 2001). In Scott et al., (in press) visioning was combined with reality to lose the abstractness often associated with this technique. Here, participants were asked to construct a vision of a specific place, based predominantly on the visual information presented to the actors involved. The vision tool then acts as a compelling statement of the future that a group or organization wants to create based on shared deep values and purpose (Bezold 2009), or an idealized state that conveys the possibility of future attainment (Huber 1978).

Perhaps one of the most successful series of visioning exercises were those performed in Detroit following the collapse of the car industry (Giorda, 2012). Workshops created ideas for how to use the space abandoned by this industry and identified urban farming as an approach (Boggs, 1998). This late 90s Visioning exercise became a reality in the early 21st century and Detroit is now viewed as an exemplar of this growing practice (Tracey, 2011).

The Visioning tool has been utilised in a number of environmental cases, including DEFRA's Food 2030, which aims to addresses the food concerns (Marsden, 2010), and Wilkinson and Mangalagiu (2011) who explored a vision for climate change impact on organisations. Bookman (2000) describes a comprehensive example of visioning applied to the future of coastal areas in the U.S. The National Ocean Service of the National Oceanic and Atmospheric Administration coordinated development of the vision among 10 diverse national organizations involved with coastal areas. The process included a conference on coastal trends and a forum on coastal stewardship. The final vision for "Coastal Futures 2025" addressed 11 major themes (Bookman 2000). Then, a six-month long Internet based "Town Meeting on America's Coastal Future" was conducted to disseminate and promote. Analysis of results of the town meeting showed widespread support for most of the 11 themes and their specific goals and objectives, as well as areas of dissent, and many ideas for implementing the vision.

4. Conclusion

Futures tools have been productively applied to many subjects and situations in the last 50 years, however, they are still relatively new to environmental issues, with the exception of scenario analysis (Bengston et al. 2012). The challenges to ecosystems services are characterised by a long-term dimension (time), and need to ascertain a number of policy options to ensure effective functioning into the long-term. Challenges faced by ecosystem services are complex and fast-moving and not suited to our current governance systems. We face a more risk-laden future, requiring ‘anticipatory governance’ (Guston 2007). Such governance requires new tools for thinking about and planning for the future. However, current tools and practices for ecosystem service planning, such as forecasting, have proven to be less effective than hoped due perhaps to the complexity of ecosystems and the time frames over which reliable predictions can be made, whilst other methods such as scenarios, visioning, foresight and backcasting show promise, but require greater evaluation and accumulation of evidence as to their effectiveness for ecosystem service planning in the long-term.

We have used the matrix in Figure 3 to describe the epistemological landscape of Futures tools. The vertical dimension relates to understanding the system, and the horizontal at controlling or directing the system. What the tool accomplishes, and what kinds of solutions they provide is indicated by their location within the quadrants. Those tools that lean toward a future by design, believe a manager, leadership group, expert or researcher can stand outside a system and design the system as a whole. With emergent systems, the system cannot be understood or managed as a whole, because the system emerges through the interaction of the agents (people, processes, technology, government etc.) that act on local knowledge and their own principles, the system is therefore more likely to be complex, multi-layered and unpredictable. In the horizontal rules (which could be restated as “process”) remove ambiguity, which is contrasted with heuristics (which could be referred to as “values”) provide direction with a degree of ambiguity that can adapt to changing contexts. An element of design still exists to emergent systems, but this is accounted for in various ways to influence a systems evolution over time rather than having it led by any agent. Mapping tools onto the quadrants can therefore act as a useful starting point in the selection of Futures tools for ecosystem services. Due to the complexity of ecosystem services one conclusion could be that Futures tools selected should this should shift from ambiguity reducing strategies to ambiguity absorbing ones. The quadrants can however, help select tools which may be required in contexts requiring a high level of certainty, here tools such as forecasting, can provide accurate short term predictions. Forecasting of the short term has shown to be valid for the IPCC, in it’s first report (1990), projections suggested global average temperature increases between about 0.15°C and 0.3°C per decade for 1990 to 2005, an actual 0.2°C increase per decade occurred (IPCC web), strengthening confidence in near-term climate projections and making it easier to enact policy options.

This review leads to the suggestion that Futures tools used in order to plan for the security of ecosystem services will have to have the following features:

1. **Agile** - Tools should be able to produce predictions over different time spans. By keeping Futures data-bases updated regularly, via systematic environmental scanning (Choo, 2001), predictions can be made as required, perhaps within weeks, instead of years.
2. **Heterogeneous** - tools should enable a multiplistic approach encorporating a diverse range of data, in order to take into account the complexity and inter-relatedness of the issues involved.
3. **Scalable** - Tools should be both comprehensive and able to manage complexity.
4. **Transparent**. Tools need to inspire trust, as a result the tools and the assumptions underlying their use need to be clear and visible.
5. **Valid** - Although they do not have to be precise, tools should be designed and used in a way that allows them to be verified and monitored.
6. **Valuable** - Tools should have the ability to help policy makers and stakeholders anticipate and plan for change.

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