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Futures Research Methods and Applications in Natural Resources

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ABSTRACT

Futures research is a transdisciplinary field of inquiry that uses a variety of methods to explore possible, plausible, and preferable futures. The goal is to develop foresight—insight into how and why the future could be different than today—to improve policy, planning, and decision making. Scores of futures research methods have been developed or adapted from other disciplines, beginning with pioneering work in the US military and RAND Corporation in the 1950s and 1960s. But many social scientists and natural resource professionals are unaware of these methods and most have never heard of futures research as a distinct field of study. This paper presents a framework for categorizing futures research methods, reviews selected methods, and provides examples of their application to natural resource and environmental issues.

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Introduction

Futures research, also called strategic foresight, is a little known social science field that is rich in novel methods (Bengston, Kubik, and Bishop 2012; Cook et al. 2014). Developing foresight is the goal of futures research, i.e., insights into how and why the future could be different than today (Lum 2016), and to use the insights gained to build resilience in organizations and improve planning and decision making. Futurists have developed many innovative methods to create foresight that are widely used in business, all branches of the military, and throughout the intelligence community. But few natural resource professionals or researchers are familiar with these methods or recognize futures research as a distinct transdisciplinary social science. It is an invisible field of inquiry to most natural resource social scientists and professionals.

Some scholars have traced the origins of futures research to utopian writings that explore preferred futures (Bell 1997) or to much more recent calls for "professors of foresight" (Wells 1987 [1932]). But it was during the early post-World War II era that futures research began to emerge as a distinct field of study. In the United States, the RAND Corporation began work on the future of military technology in the 1950s. Many leading first-generation American futurists (e.g., Herman Kahn, Theodore Gordon, and Olaf Helmer) were engaged in this work, and classic futures research methods (e.g., scenario planning and the Delphi method) were developed (Bengston,

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Table 1. Common futures research methods.

Agent modeling	Normative forecasting
Backcasting	Online social network analysis
Bibliometrics	Patent analysis
Causal layered analysis	Prediction markets
Content analysis	Relevance tree
Cross-impact analysis	Scenario planning
Data mining	Science and technology road mapping
Delphi	Science fiction prototyping
Ethnographic foresight	Simulation modeling
Field anomaly relaxation	State of the Future Index (SOFI)
Foresight panel	Structural analysis
Futures wheel	Substitution analysis
Futures polygon	Technology sequence analysis
Gaming	Text mining
Horizon scanning	Trend impact analysis
Megatrend analysis	Visioning
Morphological analysis	Wild cards

Source: Adapted from Popper (2008) and Glenn and Gordon (2009).

Kubik, and Bishop 2012). A separate and distinct school of futures research known as *La Prospective* developed in France at the same time. Where the early US approach often focused on quantitative forecasting and expert-based methods, *La Prospective* focused on "building the future" through participatory methods and workshops (Godet 2012).

The volatile 1960s and 70 s were a time of growing interest in futures (Rejeski and Olson 2006). Methods such as scenario planning began to be used in corporations at this time, several futures professional societies and think tanks were founded, the first academic futures research journals were established, and *Future Shock* (Toffler 1970) and other popular futures books were published. Following a period of declining prominence in the 1980s and most of the 1990s, futures research has experienced a resurgence of interest and activity, especially in countries outside the US and in the private sector (Rejeski and Olson 2006). After more than 60 years of development, futures research has become a well-established field with many original or adapted methods for creating foresight.

This article briefly reviews the often novel and sometimes controversial methods of futures research. The review is not intended to be comprehensive, but rather an overview of selected individual methods that illustrate the range of approaches that have been developed. The next section presents a three-part framework for classifying futures research methods. This is followed by a review of six selected methods and examples of their application in natural resources. The appropriateness and acceptability of futures methods vis-à-vis traditional forecasting and modeling in natural resources are briefly discussed, and a concluding comment touches on the usefulness of futures methods in understanding human-ecological relationships and improving planning and decision making in natural resources.

A Framework for Futures Research Methods

Many futures research methods have been developed within the field, borrowed from closely related fields such as technological forecasting, or adapted from other social

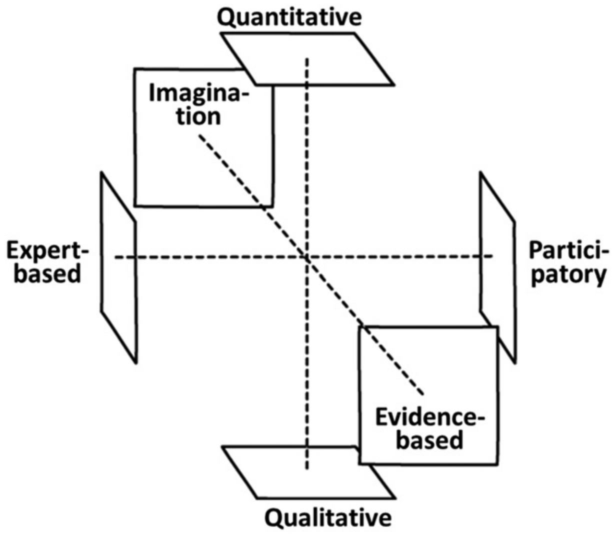

Figure 1. Three dimensions of futures research methods.

science disciplines (Table 1). For example, Popper (2008) reviewed and classified 33 methods, and Glenn and Gordon (2009) reviewed 36 methods. Some of these are quite familiar to social scientists (e.g., bibliometrics, content analysis) and some are not (e.g., science fiction prototyping, causal layered analysis). Popper (2008) and others have classified futures research methods using three continua:

- expert-based to participatory
- quantitative to qualitative
- evidence-based to creativity- and imagination-based

These three dimensions of futures research methods are illustrated in Figure 1. Expert-based methods, such as foresight panels and traditional Delphi, depend on the specialized knowledge of individuals in a specific field or subject area. Methods relying heavily on expert knowledge dominated early futures research in the US, but participatory methods that engage stakeholders with diverse perspectives and expertise have rapidly gained ground in recent decades. The development and use of participatory futures research methods (e.g., scenario workshops and public Delphi) have been spurred by growing evidence that diverse groups are more effective at solving complex problems than leading individual experts (Page 2007).

Quantitative and semi-quantitative methods are common in futures research, including simulation models, other modeling approaches, and quantitative scenarios that include probabilistic analysis of the likelihood of occurrence of key events. But, perusal of Table 1 reveals that the majority of futures methods are qualitative in nature. Visioning is a prime example, as well as the futures wheel, wildcards, and other methods that involve structured brainstorming.

Most futures methods are evidence-based to some degree. Consistently supporting futures research with reliable documentation and analysis is a hallmark of the work of futures researchers in academia, the corporate world, and highly regarded consulting firms. But there are limits to evidence-based approaches to studying a future that does not exist. Bell (1997, 148) observed that "The future is nonevidential and cannot be observed; therefore, there are no facts about the future." The creativity- and imagination-based dimension is what sets futures methods apart from most other social science research methods. Seeing beyond the constraints of linear change and the expected future to a broad range of possible and plausible alternative futures requires imagination, intuition, and creativity (Lombardo 2006). A special issue of the *Journal of Futures Studies* on "Intuition in Futures Work" (Markley 2015) highlighted a variety of techniques to stimulate fresh, outside-the-box thinking to develop foresight.

The exact location of a particular method within the 3-dimensional space depicted in Figure 1 will depend on the details of how it is applied—most methods have a range of sub-methods with significant variability. For example, Bishop, Hines, and Collins (2007) conducted a comprehensive review of scenario development techniques and identified eight broad categories of methods with a total of 23 variations. Scenarios may be expert-based or participatory; quantitative, semi-quantitative, or qualitative; and evidence-based or creativity-based. A fourth criterion that could be used to characterize futures research methods is whether a method was developed within futures studies (e.g., scenario planning, Delphi) or was borrowed and adapted from another field (e.g., gaming, content analysis).

Review of Selected Foresight Methods

This section presents overviews of six futures research methods: Horizon scanning, the futures wheel, gaming, scenario planning, science fiction prototyping, and visioning. These six methods occupy different areas in Figure 1. Some of the methods are widely known and well-established, and others are unfamiliar and have been developed recently. The intent is to provide brief introductions to selected methods that, with deeper investigation of the details, could be applied by social scientists and practitioners in natural resources to generate useful foresight and improve planning and decision making.

Horizon Scanning

Horizon scanning, also called environmental scanning, is a collection of techniques for identifying, collecting, and exploring the meaning of emerging issues, trends, and other signals of change that may be relevant for an organization or an area of interest (Bengston 2013; Gordon and Glenn 2009). The goal is to find nascent indicators of change and create an early warning system to detect potential future opportunities and threats. There are many models for horizon scanning processes, but they all include the following basic elements:

- Scanning: Searching a wide range of information sources for indicators of emerging trends and issues, called scanning hits. Scanning should include both focused and exploratory approaches. Focused scanning provides an in-depth perspective on internal change (i.e., within the domain of interest), and exploratory scanning provides a big-picture view of external change.

- Scoping: Prior to scanning, it is important to define how broadly to scan. If the scope is too narrow, there is a risk of being broadsided by external surprises (e.g., a forest products scanning exercise that neglects scanning for advances in other materials that could replace wood-based products). At the other extreme, if the scope for scanning is all-encompassing, there is a danger of overwhelming decision makers with irrelevant signals (e.g., a global scan of all things related to and affecting natural resources and the environment).
- Collecting: Categorizing and storing scanning hits. Horizon scanning hits are tagged with descriptors and stored in a searchable database.
- Interpreting: Analyzing scanning hits to gain insights about their possible meaning and significance for planning and policy. A wide range of techniques is used to prioritize and make sense out of the diverse scanning hits collected.

Formal horizon scanning originated in the US military (Cornish 2004) and is a core method in futures research. Horizon scanning has been characterized as "the central input to futures research" (Gordon and Glenn 2009, 4) because the output of horizon scanning—early signals of change—is an input into many other methods used in futures research. Futurists have found that changes originating outside of a particular field can have surprising and significant effects, and therefore horizon scanning in futures research is often broader than scanning in the business world (Hines 2003; Slaughter 1999). Schwartz (1996, 60) identified strategies for "hunting and gathering" signals of change, with an emphasis on seeking signals and trends on the periphery of society and from unorthodox sources and thinkers, rather than in the mainstream. Artificial Intelligence (AI) and text analytics are beginning to transform horizon scanning through the application of systems that search news, social media, and the web for signals of change. For example, the foresight firm Shaping Tomorrow uses an AI-driven horizon scanning system.[1]

Although horizon scanning is a common method in futures research, its application in natural resource and environmental contexts has been limited. A notable exception is the work of William Sutherland and colleagues, including a taxonomy of horizon scanning methods (Sutherland and Woodroof 2009) and a series of scanning studies on conservation and biodiversity (Sutherland et al. 2018). These horizon scans have been published in the January issue of *Trends in Ecology and Evolution* for nine consecutive years. Another natural resource example is the US Forest Service "Forest Futures" horizon scanning system, created in cooperation with the graduate program in Foresight at the University of Houston (Hines, Bengston, and Dockry 2018). This is an ongoing scanning exercise that includes volunteer scanners, uses an online database for collecting scanning hits, and produces a wide range of scanning outputs (e.g., the database of scanning hits, blog posts, a bi-monthly newsletter, and in-depth articles and technical reports that explore emerging issues).

Futures wheel

The futures wheel method is a structured brainstorming process that uncovers possible direct and indirect consequences of any type of change (Bengston 2015). One application of the futures wheel is to explore the implications of emerging signals of change identified in horizon scanning. The group process of the futures wheel facilitates "cascade thinking," that is, "how one event or implication leads to multiple possibilities, each of which, in turn, leads to additional possibilities" (Barker and Kenny 2011, 2). Planners and policy makers can use cascade thinking to help proactively consider longer-term and surprising effects of change to better prepare for it.

The first step in conducting a futures wheel exercise is to clearly define the change to be examined. The change could be a social trend, a technological innovation, a new or modified policy, or any other substantial change, and it should be described in enough clarity and detail for non-expert participants to understand. Diverse perspectives are a key to a successful futures wheel exercise, so participants should be as diverse as possible. When participants are assembled, they are briefed about the change and the ground rules for participating and brainstorming about possible first-order consequences begins. Participants offer suggestions in turn, which are added to a wheel-like diagram with the change of interest in the center and first-order consequences branching out from the center. Participants are encouraged to generate both positive and negative implications. When the group has identified a reasonably complete set of first-order consequences, second-order consequences are identified for each first-order, and then third-order consequences are identified for each second-order. Some approaches to the futures wheel include participant ratings of each consequence generated. The Implications Wheel® is a more structured version of the futures wheel in which participants score each consequence they have identified for its perceived desirability for a specific stakeholder group and its likelihood of occurrence.[2] Scoring highlights the most important consequences and suggests opportunities and challenges. Identification of opportunities allows managers and policy makers to take early action to encourage the desired change. Identification of challenges can facilitate the design of management actions to reduce the likelihood of an undesirable outcome.

A recent application of the Implications Wheel approach in natural resources examined the lack of age-class diversity in US Northern forests—a major trend with important implications. Bengston, Dockry, and Shifley (2018) conducted a series of Implications Wheel exercises exploring this trend. Participants generated and scored 384 possible implications. Analysis of the implications suggested the possibility of daunting challenges, such as increasing conflict and decreasing forest management options in the short-run. Positive implications also emerged, indicating long-term opportunities for forest planners and managers to create more diverse, healthy, and resilient forests.

Gaming

The use of a wide range of gaming methods in futures research has grown significantly in the past decade. A symposium on "Gaming the Future(s): Pedagogies for Emergent Futures" was held at the Graduate Institute of Futures Studies at Tamkang University, Taiwan in 2016 (Milojević 2017). Gaming approaches discussed at the symposium included foresight card decks, board games, immersive role-playing experiences, futures labs, and various types of online games. Diverse approaches to gaming are highly participatory, creative, and usually qualitative (Figure 1). An important rationale for the use of gaming methods in futures research is that active learning methods are often most effective. In the context of futures and creating foresight, gaming approaches have been found to be effective ways to get participants to "pre-experience" alternative futures and gain understanding about preferred futures (Dator 2017).

"Gamification" or "serious games" have been used for many purposes in many fields in recent years, including engaging communities, informing planning, educating participants, and solving real-world problems. As an example of problem-solving, gamers on Foldit solved a puzzle related to the development of AIDS in just three weeks. Scientists had been unable to resolve the issue despite years of research (Khatib et al. 2011). The Serious Games Initiative at the Woodrow Wilson International Center for Scholars has developed an online game in which participants attempt to solve the federal budget deficit.[3] "Budget Hero" has been played more than one million times, with each game run stored in a database. Analysis of these runs can reveal innovative solutions to balancing the budget in the face of real-world complexities and constraints.

There is a growing literature applying gaming methods to conservation in recent years (e.g., Dorward et al. 2017; Fletcher 2017; Sandbrook, Adams, and Monteferri 2015). One of the recommendations of a study on the future of wildfire management was that gaming methods could help address complex fire management challenges and train fire managers and homeowners (Olson et al. 2015). It was recommended that the wildfire community work with the Serious Games Association and other organizations working with serious games in order to create educational and fun games related to various aspects of wildfire management.

Scenarios

Scenario planning is the most widely known and used futures research method (Bishop, Hines, and Collins 2007). There are many definitions of scenarios, but most characterize scenarios as stories that describe plausible futures, connect the present to the future using cause and effect links, and illustrate key events, decisions, and consequences in the narrative (Glenn and The Futures Group International 2009). Broad horizon scanning is often an input to creating scenarios, which helps ensure that the scenarios are not merely minor variations on a single business-as-usual future. The product of a scenario exercise is a set of wide-ranging but plausible stories about the future. Scenarios are not predictions. Rather, they are intended to portray an array of plausible futures to help decision-makers prepare for change by building adaptive capacity and resilience. Scenario planning is not a single method but encompasses multiple approaches and techniques (Schüll and Hoogstra-Klein 2017).

Scenarios have been used extensively in environmental contexts in recent years (Alcamo 2008), unlike most futures research methods. For example, Hoogstra-Klein, Hengeveld, and de Jong (2017) reviewed and evaluated 129 scenario studies focusing on forest management in Europe that were carried out in the last decade. Examples of large-scale environmental analyses based on scenario planning include the Intergovernmental Panel on Climate Change (IPCC 2007) and the Millennium Ecosystem Assessment (Carpenter et al. 2005).

In addition to these global environmental assessments, scenario planning has also been widely applied at local and regional scales in recent years. For example, an effort to engage forest stakeholders in planning and decision making at the Center for International Forestry Research involved participatory scenario planning with forest communities in Vietnam and Bolivia (Evans et al. 2010). Many other studies have applied participatory scenario planning at the community level, including an effort to build resilience in Australian communities vulnerable to climate change, and two case studies focused on adaptation to climate change in the Western United States (Murphy et al. 2016).

Science Fiction Prototyping

Science fiction prototyping (SFP) is a recent and somewhat unorthodox futures research method. It is situated high on the imagination end of the evidence-imagination axis in Figure 1. Also known as creative fictional prototyping, SFP "uses storytelling imagery based on science fact as a design tool to explore the social and economic consequences of innovation" (Graham, Greenhill, and Callaghan 2013, 1). Whereas scenario planning encompasses an array of techniques (qualitative and quantitative, participatory and non-participatory) to develop a range of plausible futures and describe how they could unfold, SFP uses a qualitative and generally non-participatory approach to create a visionary and normative "virtual reality" prototype for generating discussion, exploring consequences, and producing creative approaches to solving practical problems in business and other domains. The "prototype" in SFP is a fictional but plausible depiction of a new product, technology, policy, or other change.

Although science fiction and futures research have a long connection (Elkins 1979; Miles 1993), the SFP method has been stimulated in recent years by futurist Brian David Johnson's design and use of the method at Intel Corporation (Johnson 2011). SFP has been used to imagine the future of warfare by the US Marine Corps (USMC 2016), to explore possible technology and business futures (Birtchnell and Urry 2013; Wu 2013), to aid the development of arts policy (Rhisiart 2013), and many other applications. There is a small but growing SFP literature, including special issues in the journals *Futures* and *Technological Forecasting & Social Change* highlighting the method (Graham, Greenhill, and Callaghan 2013, 2014).

SFP varies in practice, but often follows the broad outline identified by Johnson (2011) for SFPs involving new products and technological innovations:

- Identify a future technology and begin building your world: Specify the area of technological or scientific interest, identify current trends in this area and society, and sketch out an initial story with characters, locations, initial explanation of the technology, etc.
- The scientific inflection point: Project current technological and social trends to a future point of inflection or discontinuous change, such as a major technological breakthrough.
- Ramifications of the technology/science for people: Explore the implications of the discontinuous change in technology on the world described in the preceding

steps: In what ways does it change people's lives? What problems or opportunities does it create?

- The human inflection point: Describe how the characters respond or adapt to the change in technology.
- What did we learn?: Identify possible lessons from all of the preceding steps. How might people and systems change as a result of the technological prototype described? Does the technology need to be modified? What are the needs for research to help people adapt?

A challenge in carrying out SFP is the rarity of researchers who have both the scientific or technical knowledge to identify key trends and possible discontinuities, and the creative writing skills to craft a vivid science fiction vignette. In some cases, established science fiction writers have been recruited to create compelling vignettes (e.g., Roberts and Middleton 2014).

One of the few applications of SFP to natural resource management is a recent exploration of marine fisheries futures (Merrie et al. 2018). This study used SFP to create four imaginative vignettes that fit into a 2×2 matrix. The vertical axis of the matrix represented the social dimension, ranging from "connected" to "fragmented," and the horizontal axis was the ecological dimension and ranged from "collapsed" to "sustained." The goals of this study were to explore nonlinear change in ocean futures, especially the dynamics of oceans and humans, and encourage scientists and other stakeholders to think more broadly about marine fisheries futures.

Visioning

Identifying a shared preferred image of the future—or vision—is an important step in most comprehensive futures projects (Hines and Bishop 2006). Bezold (2009) noted that a vision is based on a group or organization's shared values and purpose, and should represent a compelling expression of the future the group aspires to achieve. Ideal characteristics of shared visions of the future include group buy-in, shared understanding, strategic orientation, specific imagery, and clarity (Lippitt 1998). The vital importance of positive and inspiring visions of the future was established by sociologist and futurist Fred Polak (1973) in his classic of futures studies *The Image of the Future.* Polak's conclusions about the importance of our collective image of the future were expressed by Costanza in the context of environmental futures: "The most critical task facing humanity today is the creation of a shared vision of a sustainable and desirable society" (2000, 1).

Participatory methods to create shared visions of aspirational futures date back to the early 1960s. Futurist Robert Jungk designed and conducted three-day visioning workshops in Europe beginning in 1962 (Jungk and Mullert 1987). Jungk's "future workshops" included learning about and critiquing the specific context being addressed, brainstorming possible elements of a vision, democratic selection of the best ideas, and developing detailed action plans. In the United States, Edward Lindaman and Ronald Lippitt created a similar participatory process they called Preferred Futuring (Lippitt

1998). Tens of thousands of groups and organizations have used this process to create shared visions of preferred futures and strategies to achieve them.

Various approaches to visioning have been applied in many fields, including some applications in natural resource and environmental contexts. For example, Bookman (2000) describes a large-scale visioning exercise focused on coastal areas in the US. A unique feature of this project was a national effort to gain feedback on, refine, and disseminate the final vision. A recent forestry visioning exercise used participatory workshops to identify and compare visions of desired forest futures of stakeholder groups in Sweden (Sandström et al. 2016). Four key stakeholder groups were identified and eight workshops—two with each stakeholder group—were held. The goals of the workshops were to create forestry visions for each group and sketch the policies and events needed to achieve them. The final visions were analyzed and compared to identify tensions and synergies between stakeholders, in the hope of reducing conflict and deadlock in forest policy.

Futures Methods and Traditional Forecasting in Natural Resources

This sample of futures research methods and others listed in Table 1 have been used in many fields, but have had limited application in natural resources. Traditional forecasting methods—designed to predict a single future—are dominant in environmental and natural resource-related fields. But the accuracy of traditional forecasting methods has repeatedly been shown to be poor at best when applied to complex social-ecological systems (e.g., Sarewitz, Pielke, and Byerly 2000; Pilkey and Pilkey-Jarvis 2007). This dismal track record is due to factors such as the sensitive dependence of these systems on initial conditions and their emergent nature. Emergent properties cannot be predicted from the parts of a complex system (de Haan 2006). Gunderson and Longstaff (2010) noted that surprise is widespread in social-ecological systems, which implies irreducible uncertainty in long-term forecasts. In addition, the presence of many external drivers of change (e.g., management interventions, demographic change), unknown feedbacks, and the changeable behavior of humans result in fundamental uncertainty (Carpenter 2002). People and ecosystems interact in complex ways that ensure the inaccuracy of traditional forecasting methods.

Futures research methods offer a fruitful but underused set of alternative approaches to developing foresight in the context of irreducible uncertainty in complex social-ecological systems. But there are many challenges in applying these methods more widely. Natural resource professionals trained in traditional quantitative forecasting and modeling are often skeptical of futures methods that are qualitative and involve creative, playful, and outside-the-box thinking. Such approaches are not valued or accepted in conservative fields and organizations (Candy 2018). There are significant institutional barriers to wider adoption of futures methods in planning and regulatory environments oriented towards quantitative forecasting. But there are signals of change, such as the growing use of scenario planning in many contexts, including applications in European Union countries related to forestry (Schüll and Hoogstra-Klein 2017), the most recent US Forest Service Resources Planning Act Assessment (USDA Forest Service 2016), the

Millennium Ecosystem Assessment (Carpenter et al. 2005), and in many other major national and international environmental analyses.

Concluding Comments

Each of the methods briefly described in this article has unique strengths and limitations for generating practical foresight. To overcome the limitations of individual methods, multiple methods are often used in combination in comprehensive, multi-method foresight approaches. For example, the Institute for Alternative Futures' "aspirational futures" method (Bezold 2009) involves horizon scanning, identification of trends and key drivers of change, development of forecasts of main driving forces, creation of scenarios, and visioning. Other multi-method foresight approaches include the "framework foresight" method (Hines and Bishop 2013) and the "4 steps to the future" model (Lum 2016). Methodological pluralism—embracing multiple methods and multiple theoretical perspectives—is essential to advancing high-quality foresight.

Taken together, futures research methods constitute a powerful and practical toolkit for exploring possible, plausible and preferable futures and developing foresight to improve natural resource policy, planning and decision making. Some of these methods have been applied in a variety of different fields and contexts for more than a half century. New futures research methods continue to be developed. The recent application of a core futures method, scenario planning, has shown its usefulness in environmental planning and management from local to global scales. In a world of rapid, accelerating, and surprising change, the need to plan in the face of uncertainty and develop forward-looking policies suggests that use of a broader range of futures methods in natural resource contexts could make important contributions.

1. https://www.shapingtomorrow.com/
2. http://www.implicationswheel.com/
3. http://www.wilsoncenter.org/budget-hero

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