Scenario Planning Around Resource Challenges (SPARC): A Management-Centered Approach to Scenario Planning for Climate Adaptation

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Abstract--*Scenario planning is a strategy or framework that aids making decisions under uncertainty. Inspired by widespread use in the areas of military and business, recent work has applied the strategy to anticipate the effects of climate change on natural resource management. Most scenario planning efforts identify scenarios based on uncertain response in two key drivers of change (e.g., climate, ecology, land use) and then consider the resultant effects on the system and possible changes to management protocols. We present an alternative implementation of scenario planning — Scenario Planning Around Resource Challenges (SPARC) — that produces scenarios that are driven directly by management concerns rather than by the leading scientific uncertainties. The three-step process entails (1) compiling information from the manager (resources, goals, priorities), (2) building scenarios from the leading possible outcomes suggested by the scientific literature and manager perspectives, and (3) running each scenario (i.e., outcome) one-by-one to consider adjustments to management protocols. In short, the unknowns become the scenarios that reflect management priorities. Rather than focusing on the dominant scientific uncertainties, managers spend their time considering only the uncertainties that directly affect the decisions they make. Here, we examine this approach using a case study from a landscape conservation design process led by the Desert Landscape Conservation Cooperative in the Madrean Ecoregion of southeastern Arizona, U.S.A.*

INTRODUCTION

Scenario planning is the act of planning ahead in the face of future uncertainty by considering multiple plausible alternative futures, or scenarios (Coates 2000; Peterson et al. 2003). Long used by the military and the business community (e.g., Royal Dutch Shell) to anticipate enemy or competitor responses to actions (Kahn and Wiener 1967; Shoemaker and van der Heijden 1992), the approach is now widely used for climate adaptation planning across a variety of sectors (e.g., city utilities, community development, insurance industry, military training, business supply chains, etc.). In natural resource management, efforts typically have focused on utilizing the dominant *scientific* uncertainties, especially related to climate change but also focused on ecology or human dimensions (e.g., land use or management), to construct the scenarios (Fisichelli et al. 2016; Hartmann 2012; Rowland et al. 2014; Star et al. 2016a; Symstad et al. 2017; Weeks et al. 2011). For instance, scenarios might contrast futures with mild versus strong warming, or wetter versus drier conditions (Fisichelli et al. 2016; Star et al. 2016a). Not surprisingly, management professionals have reported feeling dissatisfied by this approach for reasons that include having trouble connecting the changes in temperature and precipitation with actual decisions about management actions, having a sense that not all uncertainties are captured, or having difficulty envisioning the scenarios due to their overwhelming complexity (Rickards et al. 2014).

Here, we demonstrate an alternative approach to scenario planning — Scenario Planning Around Resource Challenges (SPARC) — that builds on a shared understanding of management priorities and uncertainties, as opposed to starting from scientific uncertainties. Moreover, current social science research findings strongly suggest effective integration of science into management requires direct collaborations between scientists and managers (Snover et al. 2013, Meadow et al. 2015, Star et al. 2016b; Enquist et al. 2017). Accordingly, SPARC is driven by actual management decisions, fostering a deliberate collaboration between scientists and managers to co-develop management-centered scenarios.

METHODS: A MANAGEMENT-CENTERED SCENARIO PLANNING APPROACH

Beginning in 2016, the Southwest Climate Adaptation Science Center (SW CASC) partnered with Sky Island Alliance (SIA) and Southwest Decision Resources, Inc. (SWDR) to pilot a management-centered scenario planning effort as part of a landscape-focused conservation process led by Desert Landscape Conservation Cooperative (DLCC). Focused on the Madrean Ecoregion of southeastern Arizona, southwestern New Mexico, and northern Mexico (Figure 1, thick solid boundary), the

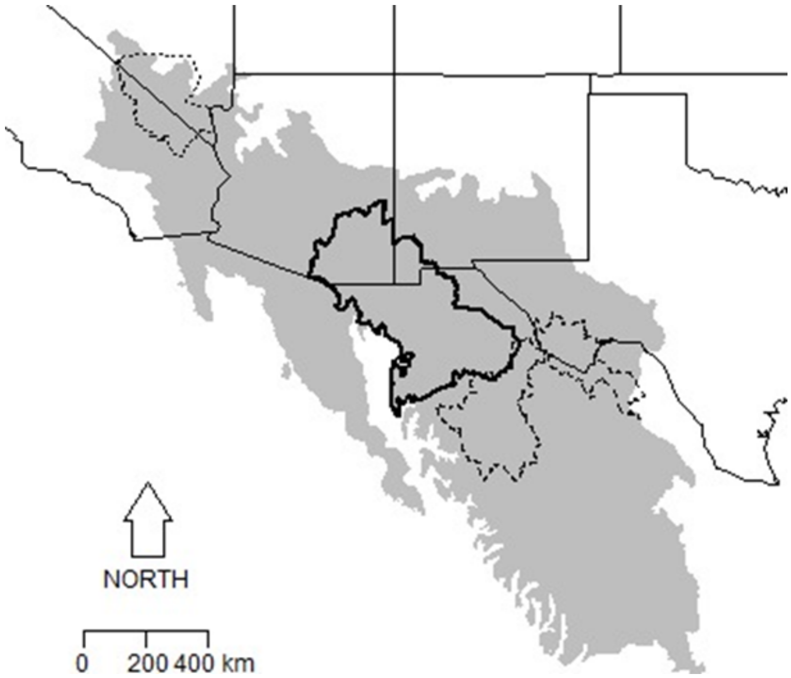

Figure 1—Boundaries of the Desert LCC (gray shading) and the three pilot sub-regions: Dos Rios-Big Bend (dashed)Madrean Watersheds (thick solid), and Eastern Mojave (dotted).

effort engaged resource managers across state and national boundaries from the start, including a kick-off workshop, followed by a series of small group meetings. The process started with the goal of establishing an understanding of shared management objectives.

As a pilot effort, SPARC evolved as the project progressed, with regular team meetings that resulted in refinements in our methodology. Here, we document the SPARC approach and share lessons learned. The team consisted of representatives from the partner organizations, regional state and federal land managers, and practitioners from conservation organizations. SPARC consists of three phases: (1) delineation of management resources, (2) identification of threats & development of scenarios, and (3) management considerations & actions.

Phase 1: Delineation of Management Resources

Phase 1 entails gathering background information from the management community on the resources they manage. Useful information includes managers' jurisdictions, resources, current actions and the overlying objectives behind those actions. The more details the team can collect, the more relevant the scenarios are and, thus, useful to managers. A good starting point is to peruse current management plans or protocols that drive managers' operations, if they exist.

Phase 2: Identification of Threats & Development of Scenarios

Phase 2 entails identifying the threats facing the resources within managers' jurisdictions and collecting information about what is known and unknown about those threats and, most importantly as these become the scenarios, *possible outcomes*. Both the management and academic communities contribute to this phase; natural resource managers are often scientists by training, familiar with the scientific literature and even conducting their own research. Managers also offer the benefit of having deep perspectives through their on-the-ground experiences, which are often more specific and nuanced than represented in the scientific literature. Logistically, it may make sense to combine Phases 1 and 2 into a single workshop for managers to minimize the number of workshops they attend. However, we recommend, and thus assume for the rest of the article, that a separate workshop devoted to Phase 2 consisting of both researchers and managers is conducted. For the sake of experts' time, we recommend multiple workshops (or breakout groups at a single workshop) with sub-groups focused on a particular resource or threat (e.g., grasslands, fire, invasive species) as opposed to systematically discussing/reviewing each resource and/or threat with all experts present. Time permitting, the team may also choose to interview experts (researchers and managers) individually rather than hold workshops. Because experts may disagree on perspectives, extra time should be allotted to allow for consensus to be reached, if possible. If not possible, areas of difference serve as a good basis for additional scenarios. When selecting researchers, prioritize experts with specialized knowledge of the resources and threats within managers' jurisdictions.

Experts (researchers and managers) begin by offering their concerns (i.e., identifying the threats) facing the resources identified in Phase 1. These concerns need not be limited to climate change but should include them, even if at a lower priority. Considerations about how climate change may exacerbate or enable higher priority concerns are encouraged, recognizing that many stressors are inextricably linked. Experts then rank their concerns through the preferred voting system, for example by asking experts to vote for their top three or four concerns and tallying the votes. Electing the top 3-4 concerns may help make the scenario planning process more manageable such that considerable time is not spent on minor or unlikely threats.

Next, experts then offer their perspectives on *what we know*, *what we don't know*, and *what could happen* regarding these threats to their resources, both according to the scientific literature and managers' on-the-ground observations. Generally, *what we know* includes information in which there is consistent support, both through published studies (observational and modeling) and on-the-ground manager observation. *What we don't know* represents cases where disagreement exists among scientists or between scientists and managers, or not enough, or any, information exists to reach consensus. *What could happen* builds off *what we don't know* by listing the various trends (i.e. scenarios) indicated by disparate studies or observations. For each resource or threat (e.g., fire, as shown in the example in Table 1), information should include trends, current statuses, and other relevant information (e.g., what we know would happen if a certain state is reached; see the example of a fuel-limited environment under *what we know* in Table 1). Trends and other information should include not only direct observations regarding the resource or threat (e.g., fires are getting larger) but also drivers or influences on the resource or threat (e.g., ecological: "fuels are getting drier"; socioeconomic: "public fear of fire inhibits prescribed burning"; etc.). Each statement should be supported by evidence in three categories: scientific measurements, modeling, and on-the-ground observation.

As you can see, scenarios in the SPARC approach derive from unknowns where options exist (proposed by either the science or management communities). In the case where options do *not* exist (i.e. in the absence of any science or manager observation support), scenarios cannot be formed. These include "unknown unknowns" (i.e., unknowns unacknowledged by either community, Rumsfeld 2002) or simply unknowns where neither science nor management observation yields any indication of future trends. The key to forming scenarios is: When faced with an unknown, attempt to locate possibilities for the future from science and/or management observation. In other words, scenarios are simply possibilities for the future. In this sense, SPARC is consistent with past approaches of scenario planning in that it is a tool for incorporating uncertainty in decision making.

Phase 3: Management Considerations & Actions

Once the scenarios are finalized (i.e., drafted and refined by both the researcher and management communities), a final workshop occurs where the final scenarios are presented to managers and managers consider actions they would take under each individual scenario. Managers first consider current management activities and decide whether the status-quo response can be maintained or if it needs to be revised or removed to meet their management objectives. Next, managers consider new, alternative management actions to improve the successful outcomes of management priorities (e.g., goals). Once a final list of actions is acquired for each scenario, participants (1) compile common actions across multiple scenarios and other "no-regrets" actions (e.g., monitoring, education), (2) consider the potential repercussions of each action on other sectors (e.g., farmers, ranchers, ecotourism, tribes, public utilities and infrastructure, etc.), and (3) detail the requirements needed to implement the actions (e.g., funding, personnel). Managers also identify indicators that they will monitor to track the development of scenarios and establish a timeline to revisit the scenarios to see which, if any or perhaps multiple, scenario(s) are unfolding. Managers should account for resource needs that are required for continuous long-term monitoring and consider how to maintain commitment given fluctuating budgets, personnel turnover, and reprioritization. Scientists also provide additional resources for managers to track the scenarios, such as maps of vegetation, land use, or other existing indicators, to help managers identify areas of highest risk from a given scenario.

RESULTS: A PILOT PROJECT WITH THE DESERT LCC

Our test case for SPARC is part of a conservation project with the Desert LCC (Figure 1, grey shading). The project aim is to connect land managers across jurisdictions to collaboratively develop an ecosystem-scale management plan that accounts for the potential effects of climate change on their ecosystems. The Desert LCC has selected three sub-regions to pilot this effort: Dos Rios-Big Bend (Figure 1, dashed boundary), Madrean Watersheds (thick solid), and Eastern Mojave (dotted). The three sub-regions are at different phases in their project with Madrean Watersheds furthest ahead and thus the focus of this study.

As outlined in the Methods, the first step (Phase 1) of SPARC is to meet with the management community to establish key resources and other pertinent information about the management context (e.g., jurisdictions, objectives, priorities, constraints, etc.). The SIA and SWDR teams held preliminary workshops to collect this information in the Madrean Watersheds region (Madrean, for short). Managers identified over seven major ecosystem types that they manage: grasslands, springs, streams, Madrean pine-oak woodland, high-elevation montane ecosystems, critical wildlife movement corridors, upland Sonoran Desert, and others. Additionally, as part of the same series of workshops, the SIA and SWDR teams completed the first part of Phase 2: identifying and ranking the primary threats facing each resource. For example, managers voted that grasslands are most threatened by, in descending order of importance: 1) Fragmentation from land development, transmission lines, and roads; 2) poorer soil quality due to increased erosion from heavier rainfalls, desertification from warmer and drier weather and increased or continued groundwater pumping, and unsustainable grazing; and 3) invasive species, especially fire-adapted species.

Following these workshops, the SW CASC team repeated the first part of Phase 2 with the academic community, consulting with landscape ecologists, hydrologists, and other scientists at the University of Arizona to identify the leading threats and knowns and unknowns related to these threats (example related to fire management in Table 1). For example, the team spoke with an expert on wildfires in the Sonoran desert region about how climate change might alter the fire regime. Current observations suggest the region is in a fire-limited regime and that area burned, fire season length, and fire intensity have all increased over the past decades (Dennison et al. 2014). As current observations, we classify these as *what we know* (Table 1). Future projections, on the other hand, are conflicted. Some projections show continuous fire-limited regime going into the future, marked by continued increases in area burned, fire season length, and fire intensity (Kitzberger et al. 2017). Another study, however, indicates that the fire regime may enter a fuel-limited state assuming fire managers conduct prescribed burns at least every 20 years to maintain low fuel densities (Fulé et al. 2013). Therefore, *what we don't know* (Table 1) is whether the Madrean will persist in its current fire-limited regime for the time being or whether the region will enter a fuel-limited regime. These two possible futures fall under *what could happen* (Table 1) and thus become the "scenarios" to be considered in Phase 3. In addition, the team compiled other relevant information, such as: In a fuel-limited environment, we know area burned, fire season length, and fire intensity declines (Fulé et al. 2013). This becomes important when considering the scenario of the Madrean entering a fuel-limited regime.

At publication of this research, the pilot project is still in progress, currently completing Phase 2. However, we outline our future steps here to illustrate the completion of the SPARC process. Next, managers will review the three columns (Table 1) and comment on the consistency of the information therein, or lack thereof, with their perceptions from their on-the-ground observations to fulfill the remainder of Phase 2.

Once completed, managers will review each scenario one by one and consider potential effects on their current management practices and potential new management goals and actions (Phase 3). For instance, considering the scenario of a continued fire-limited regime, a manager might consider the possibility of a year-round fire season — a novel environment that they may have not managed before. In such a case, managers may need to adjust their current hiring structure (e.g., budgets, timeline) to accommodate hiring more full-time employees (FTEs) that work year-round as opposed to the current system of hiring seasonal firefighters. Additionally, reservoirs may need to be replenished year-round rather than only once in the spring just ahead of the fire season. In this sample set of scenarios around fire management, natural resource managers will also need to consider management that sustains diverse forests post-fire under a changing climate (Millar et al. 2007).

Table 1—Supporting science and scenarios for the Madrean Archipeligo related to managing for fire.

What We Know	What We Don't Know	What Could Happen
Trends *Threat Itself* ➢ Fires are getting larger o Increased annual area burned observed over past 3 decades (Dennison et al, 2014) o Projections suggest continued Increase in the Southwest (Kitzberger et al. 2017) o Fire managers at Saguaro National Park observe this. ➢ The fire season is getting longer o Increased length in fire season in recent years (Dennison et al. 2014) *Drivers* ➢ Fuels are getting drier (Ecological) ➢ Fewer acres burned by prescribed Burning due to public fears about fire, reduced budgets, reduced personnel (socioeconomic) **Current Status** ➢ The fire regime is fire-limited	➢ Will the fire regime remain fire-Limited or become fuel-limited? o Fire area projected to Increase up to a point until the fire regime becomes fuel-limited and/or fire regime change (Fulé et al. 2013)	**Scenario 1:** Fire regime remains fire-limited in near to long term ➢ *Consequences:* Fire area, intensity, and length of fire season continue increasing **Scenario 2:** Fire regime continues in a fire-limited state in the near-tem but eventually becomes fuel-limited ➢ *Consequences:* Fire area, intensity, and length of fire season increase up to a point and then begin to decrease

For instance, managers might attempt to *resist* change by creating fire breaks to protect native species. Managers can also make forests more *resilient* by seed banking and widespread planting to build biological and age diversity. Finally, managers can aid forests' *response*, or transition, to changing and future environmental conditions by introducing warm-adapted species from neighboring ecosystems. Managers may also identify and acquire (if needed) land projected to remain suitable for native species under a warmer climate (e.g., higher elevations) and conserve them as "climate change refugia" (Morelli et al. 2016). As best as the state of the science will allow, managers should consider impacts over multiple time horizons (i.e., what could happen in the next 5, 10, 20, 50, or 100 years?). Even if managers are planning actions that are valid for the next 5-10 years or until the next revision when they are re-evaluated, those actions should also consider a longer term horizon.

After compiling a list of actions, managers identify common actions across scenarios. For example, in both scenarios, whether fire-limited or fuel-limited, wildfires will occur in a warmer, drier climate, allowing fires to flare up more readily and spread more rapidly. Therefore, one common action across scenarios might be to stock up on additional resources (e.g., water, budget, personnel). In addition to common actions, managers gather other "no regrets" actions that they can act upon immediately, such as setting up a monitoring network to track the fire regime, thus being able to track which scenario unfolds. As a prerequisite, managers should try to identify quantifiable indicators to adequately track the fire regime. Additionally, managers can analyze spatial data provided by the academic community to determine areas most at risk, and then develop a "watch list" to monitor those areas in most risk. A final "no regrets" action is to develop education programs about fire safety to prevent accidents such at campgrounds.

To conclude Phase 3, managers will consider the repercussions of each action against other sectors. For example, switching to replenishing reservoirs year-round will increase the amount of groundwater pumping, taking away water resources from farmers for irrigation and the public for drinking, toilets, showers, lawn watering, etc. However, by considering this challenge, managers may creatively identify alternative approaches that do not have negative consequences for other sectors. For instance, instead of groundwater pumping, perhaps the reservoir can be replenished through changes in upstream water rights laws that enable higher proportions of rain water to runoff to the region, or by rechanneling streams toward a reservoir provided no consequences to downstream ecosystems.

Also in this final segment of Phase 3, managers will consider the requirements needed for certain actions to take place successfully. For instance, hiring additional FTE firefighters to accommodate a year-round fire season will require additional financial resources for salaries, which managers can begin to request at any point regardless of scenario so that the funds are available when needed — especially important given the pace of bureaucracy. Likewise, year-round replenishing of the reservoirs will require both financial resources for the additional water and additional employees.

CONCLUSIONS

Here, we propose an alternative implementation of scenario planning in the field of climate change adaptation planning, we call Scenario Planning Around Resource Challenges (SPARC), so called for its focus on uncertainties directly affecting managed resources. Ironically, this approach relies very little on climate uncertainties (e.g., mild vs strong warming, drier vs wetter conditions) and instead focuses on the uncertainties of climate-induced ecological impacts and the implications for natural resource management. SPARC also allows consideration of non-climate drivers of change, often viewed with higher concern (e.g., socioeconomic threats). Heeding the advice from the social science literature, this approach begins with understanding the management context and involves scientists and managers working in tandem throughout the process, thus requires initial legwork prior to developing the scenarios.

While this pilot application is still in progress, managers have responded positively to the new approach thus far, likely because the scenarios better connect with the resources they manage, get at the most management-relevant uncertainties, reflect managers' perceptions on the ground, increasing credibility in the scenarios, and are more straightforward for managers to grasp. Though applied to climate change adaptation in this example, SPARC has relevance in any planning application in which uncertainty exists. As a side benefit, scenario planning, whatever the approach, prompts a conversation among managers about future conditions and how to anticipate them, thus shifting the management culture from reactive to proactive. Overall, scenario planning remains a powerful strategy for eliminating the paralysis that comes from planning under uncertainty.

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