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Perspective

Perspectives on the Open Standards for the Practice of Conservation

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ABSTRACT

The Open Standards for the Practice of Conservation (OS), and its software platform Miradi, are becoming central tools for conservation management. There is, however, very little literature on either after 5 years of widespread implementation. We applied the OS, using Miradi, to five widely varied conservation projects as the foundation for this perspective. We find, in general, that the OS are logical, clear, and provide a robust hierarchical structure from which to organize management action and track progress toward conservation project goals. One goal of the Conservation Measures Partnership in creating the OS is to foster a community of practice for conservation. To better accomplish this, we recommend working toward: (1) creating a library of case studies to illustrate tension between structure and flexibility in the OS for project management; (2) broadening definitions of conservation targets and threats to accommodate the variety of conservation projects; (3) developing critical linkages between the OS to complementary conservation tools (e.g., structured decision-making, spatial planning tools); (4) clearly distinguishing between using threats rankings for action prioritization given expert opinion versus testing hypotheses to gain a mechanistic understanding of cause and effect; and (5) developing rapid assessment tools for the OS to better discern when conservation projects should invest in the cost of fully developing a plan using the OS. We call on both academics and the conservation practitioners to better engage with one another for the benefit of training, cross-project learning and better conservation action.

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1. Introduction

In 2002, a group of conservation organizations convened at the Society for Conservation Biology meeting in Canterbury, England to form the Conservation Measures Partnership (CMP, 2010). What emerged from this coalition, among other things, were the Open Standards for the Practice of Conservation (OS), a framework used

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Table 1
A list of student collaboration projects using Miradi to implement the Open Standards for the Practice of Conservation from spring 2009, along with notes on challenges associated with each project.

Project partner	Focal ecosystem(s)	Conservation objective	Project notes
Sonoma Land Trust, Sonoma County, California	Sears Point Coastal Grasslands	Develop plan to integrate volunteers and citizen scientists in grassland restoration projects	Integrating well-established non-native plants as a "threat" was a challenge as they are not a threat to maintaining current habitat quality, but rather a barrier to improved habitat quality
UC Davis Land Management, Davis, California	Putah Creek Riparian Woodlands	Develop a plan to restore oak woodland riparian forest on creek buffer	The Miradi software over-engineered the solution when the partner simply wanted (1) a plan to do just one thing: restore native trees and (2) to understand whether non-native forbs are a barrier to that process
California Audubon, Central California	Blue Oak Woodland	Develop a plan to integrate landowner contact programs with landscape goals of blue oak woodland protection	The resulting plan was embraced by the end user.
California Nature Conservancy, Central California	Central Valley Vernal Pools	Develop region-wide strategies for vernal pool ecosystem protection	Difficulties emerged in integrating alternative climate change scenarios. Climate projections suggest this region will get either wetter or drier, with contrasting indications for habitat management. The non-spatial nature of Miradi limited the applicability of the project.
Paso Pacifico, Nicaragua	Coastal Dry Hardwood Forest Zone: ocean to inland	Develop a regional plan to integrate citizen science in coastal forest restoration, sea turtle beach egg protection and mangrove habitat management	Lacking an existing formal action plan for this recently formed NGO, the project developed primarily into a tool for fund-raising by highlighting project needs, which was viewed as a positive outcome.

to plan and prioritize conservation actions based on project priorities, the assumed linkage between action and outcome, the likelihood of success, and the cost of implementation (CMP, 2007; Dietz et al., 2010). Along with the development of the OS framework, the desktop software package Miradi was developed to operationalize the use of the OS (Miradi, 2007). In less than 5 years, Miradi has been downloaded by over 5500 users in 167 different countries and has been implemented in over 115 projects managed by The Nature Conservancy, just one of the 21 Conservation Measures Partnership organizations (V. Swaminathan, Personal Communication).

We offer this perspective on the strengths and weaknesses of the OS as a conservation management framework from the perspective of a group of students who have employed the OS through Miradi on a suite of short term projects with a broad suite of partnering organizations. Early in 2009, the lead author and a group of twenty UC Davis graduate students embarked on a project to learn how conservation organizations implement ecosystem-based management for conservation. Partnering with Foundations of Success, we used the OS framework to learn the essential structural elements of conservation management: planning, implementation, monitoring and evaluation (CMP, 2007; Dietz et al., 2010). To solidify our understanding of the OS, we worked in small groups with five conservation organizations (Table 1) to cooperatively develop conservation plans using Miradi and the Foundations of Success training manual for the OS. These projects differed substantially in purpose and scope. Our group met twice weekly for 10 weeks, during which we allocated time to: (a) develop skills in the OS practices and Miradi software features, (b) discuss peer reviewed papers on conservation management and the conceptual underpinnings of the OS, and (c) review and discuss issues faced by group projects.

We were motivated to write this perspective in part by the observation that, relative to other conservation frameworks (e.g., Margules and Pressey, 2000; McCarthy and Possingham, 2007; McDonald-Madden et al., 2008; Pressey et al., 2007; Pressey and Cowling, 2001; Regan et al., 2005; Rich et al., 2004; Sutherland et al., 2004; Tallis et al., 2010), there is very little written about the OS evaluating its structure or effectiveness as a conservation tool. Further, we are compelled by calls for information sharing to improve the practice of conservation (e.g., Mace et al., 2000; Pullin and Knight, 2001; Sutherland et al., 2004). We believe that the practice of conservation is improved by an open and inclusive discussion on best practices, we offer this evaluation of the OS as a bridge between the academic community and the growing "community of practice" surrounding the OS.

A "community of practice" is a well-recognized organizational structure that fosters the application of a set of skills to a broadly distributed problem (Brown and Duguid, 2001; Wenger and Snyder, 2000). Numerous efforts are currently underway to build a community of practice around the OS. The Foundations of Success coordinates training for students and conservation practitioners in the OS through the use of a training manual that conceptualizes projects, planning actions and monitoring in Miradi (FOS, 2009; TAMN, 2012). To date, over a dozen academic institutions have engaged in training the OS. In addition, the Conservation Coaches Network (CCN, 2012) provides assistance to practitioners implementing the OS. Most recently, the Conservation Measures Partnership sponsored two Measures Summits (in 2010 and 2011) to bring together donors and practitioners to integrate results-based management in conservation (Measures Summit, 2011). The Measures Summits included a detailed review of results-based management to date (Muir, 2010). However, despite this broad implementation of the OS both in training and in practice, there remains a very sparse peer-reviewed literature on the OS.

2. Overview of strengths of the Open Standards

One of the key steps in the OS is to help resource managers develop a conceptual model of their system that prioritizes clearly defined conservation targets (e.g., a wetland system or a species of concern) within a project scope, including specific indicators of success for achieving goals set for each target. Developing a conceptual model also provides an opportunity to engage multiple stakeholders to identify critical system components. One of the most compelling aspects of the OS are that they require practitioners to state *specific* goals that are *measurable, impact-oriented, realistic,* and *time limited* (e.g., area occupied by a target plant population increases by 20% in 10 years). A graphical conceptual project model (e.g., Fig. 1) is then used to frame a process for ranking key threats to primary conservation targets, evaluating contributing factors, and identifying strategies that could best achieve management goals for each target. These steps foster prioritization of strategies based on projected impact toward achieving conservation goals. Repeated evaluation and prioritization

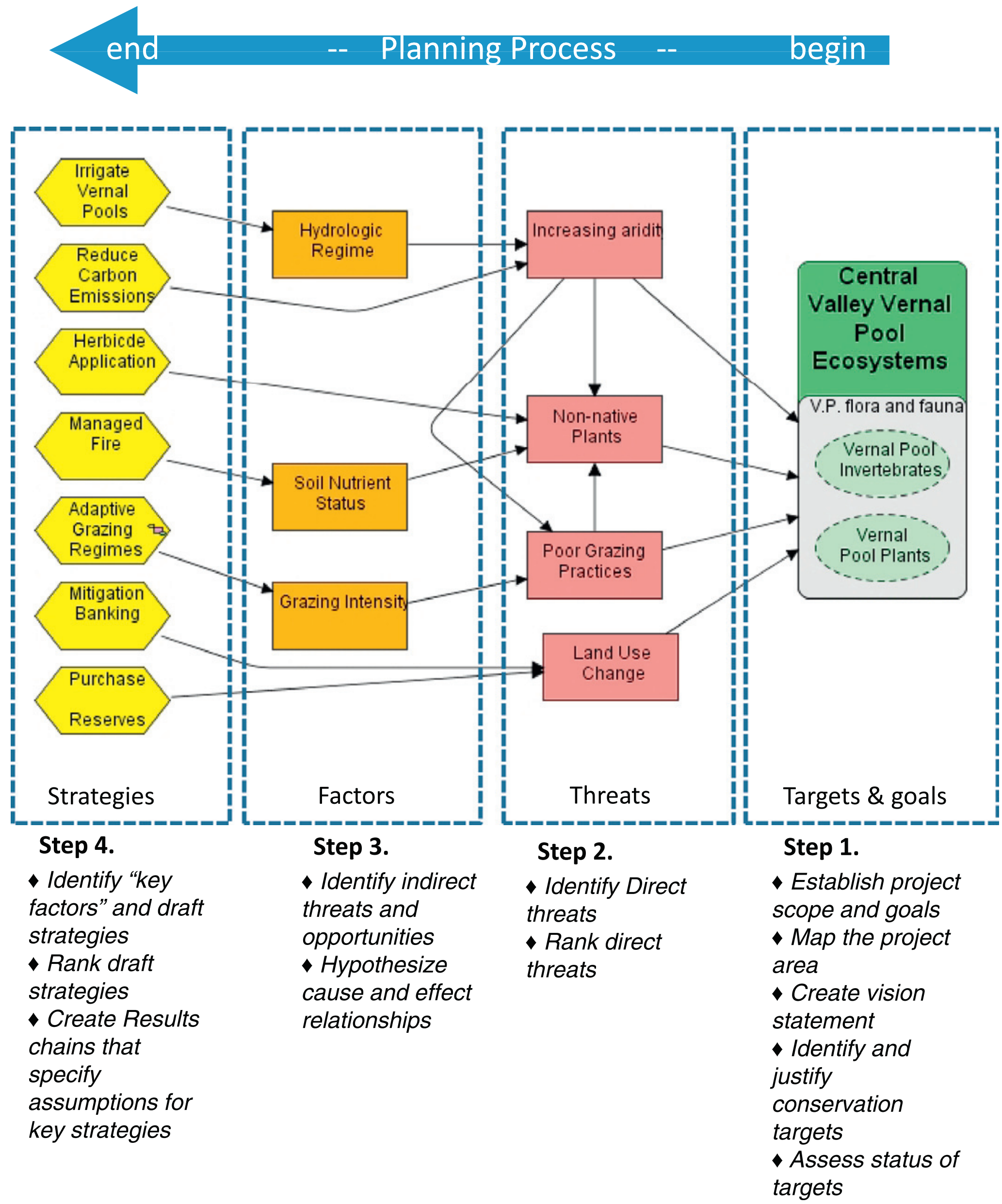

Fig. 1. Critical components of the Open Standards for the Practice of Conservation (OS) as illustrated by simplified versions of a (a) *situation analysis* for vernal pool ecosystems in California's central valley, and a (b) *results chain* for the same location. The situation analysis is diagrammed to explain the OS planning process. The results chain is simplified to illustrate how they are used to explicitly express the assumptions about causal mechanisms leading from a strategic intervention to an impact on the conservation target.

based on measured results are then central to maintaining a coherent a project plan. Thus, the OS have an explicit cyclic adaptive management structure tied to project goals and outcomes. Being explicit in guiding planning and management is viewed as essential to effective conservation management and fosters transparency regarding perceived causal relationships between strategies and outcomes (Wilhere, 2002). Detailed attributes of the OS (e.g., defining project scope, targets and goals, identifying stakeholders) are described elsewhere (CMP, 2007; Dietz et al., 2010) and thus not presented here.

The OS helps resource managers and stakeholders to brainstorm and then prioritize potential management actions. This process is structured in a particularly regimented way, through the construction of a diagram-based situation analysis (Fig. 1a, Dietz et al., 2010). This situation analysis leads to a threats assessment that helps users to prioritize strategies. Strategies are framed using results chains (Fig. 1b and c), which are themselves linked to the situation analysis, and used to illustrate expected outcomes of implemented actions. These results chains present an expectation of how the system should respond to a management intervention, and provide both a magnitude and a time frame for system response. Thus, the OS require practitioners to formalize assumptions about how the target ecosystem functions, how human actions are impacting that ecosystem, and how systems are expected to respond to project interventions to achieve target goals. This process fosters transparency regarding perceived causal relationships between strategies and outcomes.

The OS, like many other conservation frameworks that we evaluated, expect planning, implementation and evaluation to be explicit (Table 2). This was viewed favorably by our group, with the following caveat. Learning to conceptualize and plan conservation projects through the Foundations of Success training manual of the OS (FOS, 2009) is regimented and prescriptive in how to think about a problem, the order that steps are taken, and constraints

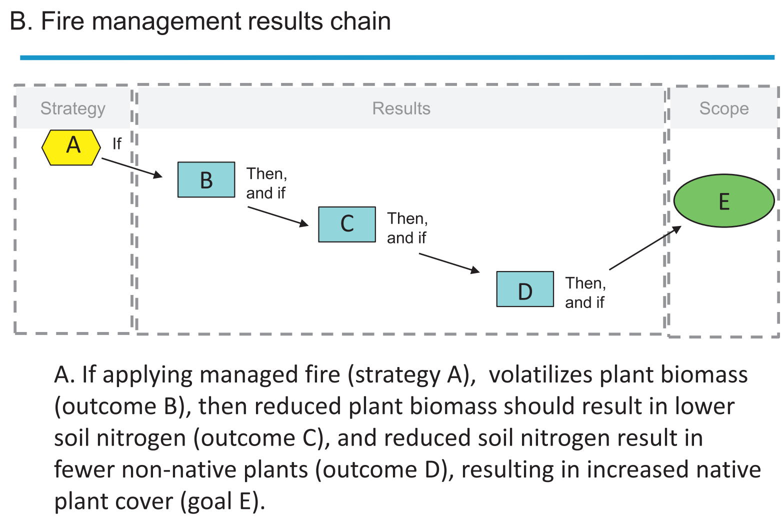

Fig. 1 (*continued*)

on what may be included in the project plan. While this prescriptive structure helps users focus on key issues, we also found it to be somewhat constraining given the diversity of conservation problems. We understand that this prescriptive constraint is a deliberate choice, favoring structure in order to achieve uniformity in planning. Nevertheless, the OS are compelling, in part, because they are general and flexible guidelines capable of being molded to fit individual situations (M. Morales, H. Balasubramanian, Personal Communication). This tension between the flexibility of the OS and the specificity of the training manual may be alleviated through experience as users become comfortable bending the prescriptive structure detailed in the manual to meet the OS guidelines for specific conservation problems. Training in the OS should integrate this need to consider the structural elements of the OS, while thinking flexibly and creatively about individual applications.

In summary, we find the OS to be a thorough framework for the complexities associated with project management, and a remarkably lucid and compelling framework for allocating effort among the diverse suite of goals represented within any one conservation project. Miradi, as a software application of the OS, is straightforward to learn and use. The training manual is structured and paced appropriately for graduate-level students learning these methods. The OS are flexible with respect to planning teams such that they can be used in single agency planning; cross-agency planning; or engaging stakeholders even when those stakeholders diverge in resource protection perspectives, ecological knowledge or technological capacity. That is not to say, however, that implementing the OS for a conservation project is easy; developing an OS project management requires a lot of work.

3. Recommendations

Based on our experience applying the OS through Miradi and using the Foundations of Success training manual with partnering organizations (Table 1), we present recommendations in five areas to increase the generality and usability for application of the OS. We present these recommendations from the perspective of an academic community learning practitioner skills and engaging with the emerging community of practice around the OS.

3.1. Structure versus flexibility

As mentioned above, there is an inevitable tension between providing structured guidelines and rules for the application of the OS and flexibility to handle the wide array of conservation applications that would benefit from the OS. While the written materials for the OS and Miradi are explicit and prescriptive in their approach, the Miradi software is an extremely flexible graphical project management planning tool that could be used for virtually any kind of planning (e.g. conservation, a small business, a family vacation). Indeed, Miradi's open source code should allow sophisticated users to add features such as specialized prioritization algorithms; however, there does not appear to be an established process for distributing user contributed add-ons or plug-ins to Miradi.

While structure is a necessity for any broad conservation planning framework, we needed additional guidance on the bounds of acceptable flexibility to rules stipulated training materials for implementing the OS. Having access to published examples of the application of the OS through a sharing library (e.g., AFWA, 2011, www.conserveonline.org) would help practitioners decide on when and how to modify application of the OS while retaining the essential attributes that allow cross-project or interagency learning. In particular, as the OS mature, additional training materials would be helpful that address how others have used the OS to tackle exceptions to the 'typical' conservation project. In our brief period of using the OS, we struggled with adapting project plans in numerous areas: (a) scenario planning for uncertain alternative futures; (b) dominant threats as externalities to the project (e.g., ocean acidification); (c) spatially variable threats that drive differential strategies across the project area; (d) ecosystem restoration not as a strategy to achieve a goal but as a project goal; and (e) multiple-use project goals that include conservation but do not necessarily prioritize them over education, recreation, or sustainable human communities (Table 1). Striving to stay true to the instructional materials, we made mistakes. We eventually learned ways to deal with most of these situations, but the process taught us that difficult situations may be the norm rather than the exception in the real world of conservation. Building an accessible reference library of such cases would be a large step forward in building this community of practice and should be a top priority.

3.2. Defining targets and threats

We encountered a suite of related concerns regarding the terminology associated with both target definition and threats assessment. Terminological complexity is an inevitable consequence of a diverse and complex set of actions that fall under the rubric of conservation management. A major accomplishment of the Conservation Measures Partnership, in fact, has been a glossary that

Table 2
A suite of conservation project management frameworks t compared to the Open Standards Framework for the Practice of Conservation (OS) demonstrating a similar tendency to create explicit planning structures for conservation. As described in the text, the OS provide explicit guidelines for each of the steps described by the column headings. Following Pressey and Bottrill (2009), frameworks that were similarly explicit in their guidelines are described as converging on a similar process as the OS. Those that do not, contrast to the OS.

Framework	Framework goals	Define goals (desired outcome)	Assumptions behind interventions	Implementation of goals	Monitoring structure	Adaptive management structure
Birdlife International (2010)	Develop species action plans, including identifying key target areas	Converge	Contrast	Converge	Converge	Contrast
Systematic Conservation Planning (Margules and Pressey, 2000)	Engage stakeholders in a systematic process of identifying locations for biodiversity protection based on representation and irrep1aceabi1ity	Converge	Converge	Converge	Converge	Converge
Dept. of Interior Adaptive Management Guide (Williams et al., 2007)	Tailored to the mission of each agency	Converge	Contrast	Contrast	Contrast	Contrast
Partners In Flight (Rich et al., 2004)	Identify key bird habitat areas	Converge	Converge	Converge	Converge	Converge
Natural Community Conservation Plans (Atkinson et al., 2004)	Sustain and restore species and their habitat through stakeholder agreements and mitigation	Converge	Contrast	Converge	Converge	Converge
Natural Capital Project	(www.naturalcapitalproject.org)	Maintain critical	components of ecosystem function	Converge	Converge	Converge
Converge	Converge					
Summary		Converge	Mixed	Converge	Converge	Mixed

compares terminology among organizations (Salafsky et al., 2008). The terminology of the OS, although carefully chosen and carefully defined, constrains applicability. For example, the OS are clear that targets must be biodiversity targets (Fig. 1). Projects, however, are often broad and include goals that are not related to biodiversity conservation (e.g., education, sustainable livelihoods, Salafsky, 2011). One of our project partners was the UC Natural Reserve System, which has a balanced mission of providing field teaching and research facilities as well as resource conservation. Excluding real project goals, such as maintaining secure research access to reserves, because they are not related to resource conservation, resulted in poor prioritization of actions. The Conservation Measures Partnership is currently working to address this issue through a section on human well-being targets (e.g., sustainable resource extraction livelihoods, V. Swaminathan, Personal Communication). Human well-being targets, however, can cause confusion regarding means versus ends (Salafsky, 2011). Further, human well-being is not the only alternative target for conservation projects. Most public lands, in fact, have a multiple-use mission that includes education or recreation in addition to conservation; the OS would be more functional if it were built to explicitly recognize this.

The definition of 'threats' similarly presents challenges to planning. Although human impacts may legitimately be the primary threats to effective conservation, stakeholder engagement may be jeopardized when a plan explicitly labels the actions central to the livelihood of a critical stakeholder as a threat (Fig. 2). These 'threats' (e.g., ranchers who set grazing intensities in vernal pool habitats) may legitimately rebuke overtures to cooperate from conservation organizations that label their livelihoods as threats. Terminology viewed as inflammatory is not helpful to collaboration and compromise, and thus alternative terms for threats in sensitive situations are warranted. Again, the Conservation Measures Partnership will consider a new version of the OS (3.0) with the term 'pressures' proposed as an official synonym for direct threats (V. Swaminathan, Personal Communication).

Following on this topic, alleviating threats, *per se*, may not be a feasible management goal. The OS focus the attention of conservation managers on reducing threats to achieve goals. In some cases, however, external and uncontrollable threats (e.g., climate change, sea level rise, ocean acidification) may drive goals for targets, rather than the other way around. Thus, conservation managers are likely to lack the capacity to mitigate threats within their project scope, but may still want to implement management to reduce the stresses to targets imposed by these threats. Given the magnitude of climate change and the high profile it now has in natural resource planning, the OS should specifically consider protocols that guide managers to mitigate the stresses imposed by threats that are outside the control of individual projects.

In a specific example of this constraint, we found the OS to be awkward with respect to projects where restoration of a target community type is a critical goal. This is because the structure of the OS assumes that alleviating threats is the major impediment to success and therefore focuses on actions that accomplish this goal. In contrast, conservation is often focused on using habitat restoration as a strategy to alleviate impacts of historical threats that have already degraded system attributes. Along these lines, two of our projects targeted goals for the restoration of native plant communities degraded by invasive species (Table 1). In this case, the threat of the *introduction* of the invasive species to these ecosystems was largely historical. Our project leaders, being new to the OS, were eager to follow the rules stipulated in the instructional materials and had a difficult time making Miradi fit a habitat restoration focus where the goal was not to alleviate a historical threat but to alleviate the legacy of impacts that those threats caused (e.g., reduced native species distribution and abundance). We recommend revisiting instructional materials for the OS to explicitly integrate key concepts from restoration ecology (Clewell et al., 2005; Hobbs, 1996) and provide examples of how ecosystem management projects with a restoration focus work within the context of the OS.

3.3. Integrating emerging conservation tools with the OS

This set of recommendations revolves around opportunities to develop linkages between the OS and complementary conservation tools. New conservation tools are continually emerging. In order to maintain the OS as standards of practice there must be continual horizon-scanning for promising new tools and a mechanism to determine how to link these to the OS. Borrowing a mobile computing metaphor, the OS might best be presented as a standardized operating system like Android or iOS, and the conservation tools as apps that function within that environment, can be added based on need, and made popular based on user experience.

As an example, we encountered problems with non-standard threats when the magnitude, or even the direction, of a threat was highly uncertain. One of our projects sought to consider climate change in developing a regional plan for vernal pool conservation (Table 1, Fig. 2). The population performance of vernal pool invertebrates and plants are most likely driven by winter precipitation (Pyke, 2005). With continued uncertainty whether the future in this region is likely to be drier or wetter (Cayan et al., 2008), planning likely requires a dual set of target goals based on different possible futures. We decided that one option would be to construct two parallel plans based on different future climate scenarios. This highlighted the distinction between iteratively adjusting management based on gained experiences (i.e., results-based adaptive management) as opposed to contingency planning. We recommend that the OS discuss how one would integrate contingency planning (e.g., scenario planning, Peterson et al., 2003) to prioritize critical uncertainties or to create alternative goals based on alternative models of the future magnitude of threats. This approach appears to be consistent with the philosophy of the OS, but adds further complexity. As a consequence, the OS may need to develop a tree-based planning structure (e.g., if you have this kind of situation, then follow these steps; if not then follow a different set of steps).

Similarly, our group was uneasy about the Miradi process of combining threats into qualitative scores ultimately used to prioritize action (Fig. 1, Step 2). The default threats rating algorithm of Miradi uses qualitative scores (''low'', ''medium'', ''high'', very high) given to three criteria (scope, severity, and irreversibility) for describing the effect of a threat on a target become rolled into one aggregate term (e.g., ''medium''). An alternative available threat rating system is based on The Nature Conservancy's stress based rating system (Miradi.org). This exclusively qualitative approach to aggregating the threats and opportunities seemed to us to be a weakness that needs to be addressed.

The application of decision science to resource management issues (e.g., Runge et al., 2011) provides quantitative structures for, among other things, combining multiple variables to rank the likely success of different actions (Lyons et al., 2008; Probert et al., 2011). Integrating quantitative decision science to Miradi would benefit action prioritization, but may add considerable computational complexity (Lyons et al., 2008; Martin et al., 2009), and thus must be applied judiciously. Not all decisions require complicated mathematical analytic support. However, we strongly endorse alternative threat roll-up procedures within Miradi. With multiple threats ranking systems, those requiring simple heuristics for threat rating can have them, while those able to provide probabilistic estimates and apply decision science could benefit from quantitative analytic tools.

Generally, developing the capacity to evaluate and integrate emerging conservation tools (spatial assessment, population modeling, risk assessment, decision science) to the OS seems a necessary step in order to achieve the general utility envisioned in the OS (CMP, 2007). Many programming platforms, such as R (R Development Core Team, 2011), allow users to contribute and use open source program code in modules. These provide examples of how one might visualize a module-based suite of software tools that support the OS goals. Miradi is, in fact, open source software, such that dedicated users can modify programming to suit their needs.

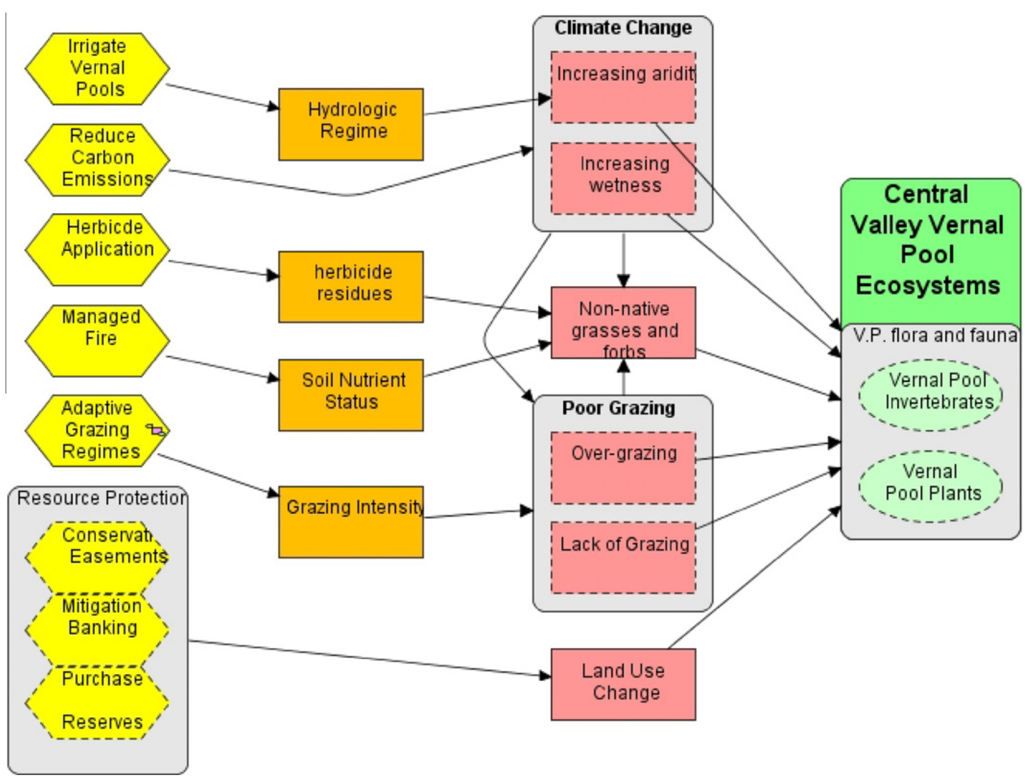

Fig. 2. A Miradi screen shot highlighting three challenges associated with a conservation situation analysis for vernal pool conservation in the central valley of California. First, climate change is considered a strong direct threat to vernal pool species, but this threat varies depending on the specifics of climate change. Thus, planning for climate change requires contingency planning. Not illustrated is the spatial context of this threat and how a spatially variable plan may be required. Further, since climate change is a global problem, no project scale strategies could possibly alleviate the threat. Second, non-native plants represent a strong threat to the system, but these populations are already at saturation. Thus, alleviating invasion threat is less of an issue than reducing barriers to restoring native plants in concert with non-native species presence. Third, landowner grazing practices have strong influence on goal accomplishment. A 'threats''analysis labels integral actions of stakeholders (e.g., grazing) as 'threats', which is likely to dampen stakeholder enthusiasm for collaboration.

However, developing a contingency approach where Miradi directs users to choose amongst threat ranking schemes, for example, based on specifics of individual projects is likely to require centralized leadership.

Perhaps the most obvious of these linkages is with spatial conservation planning tools. Even though the OS are more than simply a planning tool, the fact that the OS are non-spatial is a potential weakness for planning with the OS. All conservation projects occur in a specific location and conservation actions, generally, have a spatial component. Miradi's lack of a spatial prioritization tool may constrain the utility of the OS (e.g., if the situation analysis calls for implementing a public education program, where should the education plan be implemented, what is the spatial extent of the action, and how does the project track these decisions?). In this particular case, good spatial planning tools exist (e.g., MARXAN, Watts et al., 2009). Building additional complexity into the planning components of the OS by integrating spatial planning software (e.g., MARXAN) into Miradi does not seem necessary. Developing protocols for linking MARXAN output to Miradi data fields, in this case, seems like the more appealing approach. Nevertheless, the general issue of how to update the OS to integrate emerging technologies is a critical concern.

3.4. Distinguishing decision science from the scientific method

There is a distinction between taking a scientific approach to prioritizing management strategies, and using the scientific method to test cause and effect of conservation interventions. Decision science adopts a structured approach to making the best decisions given an operational problem (Roy, 1993), but does not require a scientific assessment of the problem itself. The OS are very careful to recognize the exploratory nature of creating a conceptual model of goals, threats and potential strategies to alleviate threats and achieve project objectives. The OS are, therefore, a set of tools to help practitioners plan and implement conservation management, nothing more. Successful outcomes of interventions may result independent of perceived cause and effect. System understanding is a likely outcome of building a conceptual model of cause and effect and then learning-by-doing; however, it is a system that is prone to mistakes because of not laboriously testing and rejecting hypotheses.

Favoring expediency over rigorous mechanistic understanding, management interventions are typically implemented without careful experimental design to test hypotheses and assess cause and effect (Wilhere, 2002). The OS instructs users to develop specific and measurable objectives and indicators as a means to determine whether a strategy is working. The use of quantitative indicators can provide data for statistical analysis. Nevertheless, this process emphasizes correlative response (doing A, B is observed to respond) but not mechanistic cause and effect (e.g., A causes B to respond).

This is understandable considering that hypothesis testing in conservation management is difficult. With low sample sizes, poor capacity for true replication, and multiple causal drivers, it is difficult to obtain enough power to make a convincing argument regarding mechanistic responses to conservation interventions. Further, including proper controls such as 'no action' may be challenging given that such a strategy may cause the demise of the conservation target.

The OS is not alone in the challenge of prioritizing efficacy in decision-making while attempting to draw on scientific knowledge. The IUCN (2008) provide an online resource to link common conservation problems with specific suggested actions. Systematic reviews, as developed by *Biological Conservation* (Pullin and Knight, 2009), build an evidence-based approach to effective actions. Both the US Geological Survey and US Fish and Wildlife Service have endorsed designing trial management actions through stochastic dynamic modeling (Johnson et al., 2002; Moore and Conroy, 2006). These tools represent scientific approaches to making management decisions, but not scientific management approaches *per se*. We recognize these tools as valuable shortcuts for efficacy, however the variability of natural systems shows that shortcuts are imperfect. Without clear recognition of the distinction between a scientific approach to decisions and a scientific approach to understanding the managed system, managers may do a poorly at implementing the adaptive part of adaptive management.

The OS vision is for broad applicability, often by those without formal scientific training, and this leads to a risk of misunderstanding the OS for a process of conducting conservation science. Scientific understanding often requires a large resource investment, and few project managers have the capacity to invest limited resources to test whether or not interventions caused the successful outcome. Conservation managers must carefully balance expediency with scientific certainty in order to recognize when experimentation, or monitoring (McDonald-Madden et al., 2010), is required. Understanding the distinction between decision science and the scientific method, we believe, is a critical skill for effective adaptive management, and training in the OS should include treatment of this distinction as a component of creating and using results chains.

3.5. When to invest in planning using the OS framework

Finally, there is a growing literature criticizing conservation management as not living up to the goals of: (a) robust planning; (b) implementing deliberate action based on thorough decision-support; and (c) monitoring outcomes in order to adjust actions (Andelman and Fagan, 2000; Cook et al., 2010; Ferraro and Pattanayak, 2006; Franklin, 1993; Muir, 2010). However, conservation resources are severely limited, leading to a separate literature highlighting that there are times and places where needed actions are not going to get done (Bottrill et al., 2008) and that monitoring might not always be the best application of limited resources (Grantham et al., 2009; McDonald-Madden et al., 2010). Similarly, there are likely times and places where engaging in time-consuming and expensive planning is not an optimal use of resources and should be postponed (Salzer and Salafsky, 2006). A question that nearly all of our collaborators asked, when finished with our class projects, was 'should we invest the time and resources required to continue down the path to fully develop an adaptive management plan using Miradi?' This question was expressed principally upon the recognition of the large effort required to transition from an existing operational management plan to one using Miradi for project management.

Given that established conservation programs have ongoing management structures, there must be consideration of the time investment to populate Miradi versus adopting the explicitly structured principles of the OS independent of Miradi. In other cases, newly emerging programs (e.g., Paso Pacifico, Table 1) felt overwhelmed given the competing needs of time investment for a small organization. In most cases, our collaborators did not see themselves in the right position to justify the significant investment to additional planning. Had our collaborators worked for organizations that mandated the use of the OS, their perspective may have been different. In order to maximize broad utility, however, a rapid assessment version of the OS would be a welcome addition to this toolkit. Or, to borrow the cellular telephone technology analogy from above, it may be useful to advertise the capacity within Miradi to select individual functions as stand-alone apps (e.g., results chains).

4. A conservation community of practice

Within conservation, several authors make the compelling case for the need to share information in order to improve the practice of conservation (Mace et al., 2000; Pullin and Knight, 2001; Sutherland et al., 2004). Over the past decade, the emerging conservation community of practice has developed tools for sharing terminology across conservation organizations (Salafsky et al., 2008) and developed the OS (CMP, 2007; Dietz et al., 2010). Miradi is software that operationalizes the OS vision. The online training manual is one organization's interpretation of how Miradi applies the OS. As a widely recognized and implemented method for developing conservation management plans, the OS provide an over-arching framework that can work with other emerging conservation tools (e.g., MARXAN, systematic conservation planning, structured decision-making). Complementing these efforts, there are online sites aimed at fostering this information sharing (e.g., EBM Tools Network, 2012).

Numerous challenges remain for catalyzing an effective community of practice for conservation. Among these are cross-organizational challenges such as: (a) the high cost of allocating effort toward information sharing; (b) competition within the community for limited funding; and (c) an academic community that values individual novel ideas over effective outcomes. Nevertheless, the shared mission of conservation management provides strong incentive for developing a community of practice if it results in more effective management.

An important component of building this conservation community of practice has been the Conservation Measures Partnership, the OS, and Miradi. However, publishing an accessible peer-reviewed literature has not been a high priority of all group members. To better engage the private, governmental and academic communities of conservation there needs to be an accessible literature that evaluates the efficacy of these emerging tools. In order for the academic community to effectively train young professionals with skills that conservation organizations value, conservation organizations must participate in defining what constitutes training in those skills. We call on academics, practitioners and organizations, including the Conservation Measures Partnership, to partner in a concerted effort to improve the OS, integrate the OS with other emerging conservation tools, and to train young professionals in the OS.

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