Allocating Resources Between Taking Action, Assessing Status, and Measuring Effectiveness

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1. When Monitoring and Evaluation Goes Wrong

Monitoring and evaluation (M&E) is the process of periodically collecting and using data to inform management decisions. There is currently a great deal of interest among practitioners and donors in developing and implementing M&E systems for conservation projects at all scales. M&E is vital for helping practitioners get the information they need to improve their work. It is also essential for helping donors to assess the return on their investments.

Unfortunately, all too often, conservation practitioners seem to struggle with determining the right level of investment to make in their monitoring work. Several common problems are illustrated in the following cases, which although fictitious, are composites drawn from real-world situations.

> **Case #1: Funding Basic Research In the Name of Monitoring –** A non-profit organization is working with the government to manage a large tract of remote Alaskan wilderness. At the moment, there are no known threats to the conservation targets in the reserve, which is largely inaccessible for most of the year. The two senior scientists involved with the reserve both studied caribou biology for their Ph.D research. To this end, the scientists develop an elaborate and expensive research study to monitor long-term caribou populations, convincing their superiors that the caribou are an important indicator for monitoring the health of the park. Although the studies are published and well received, data are never used to make any management decisions….
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> **Case #2: A Stitch in Time Could Have Saved Nine** – An NGO is working with a local community to promote coral reef conservation on a small island in the Pacific. The community has been harvesting fish and marine resources from nearby coral reefs for generations. As the NGO considers how to allocate their limited resources, they decide they do not need any fisheries monitoring. Their rationale is based on the steady total harvest levels over the last 10 years. Unfortunately, the steady harvest levels are a consequence of annual increases in fishing effort each year that mask declining populations of the harvested fish species. Undetected population declines continue until the fish populations suddenly begin to crash, making management efforts dramatically more difficult….

Case #3: Collecting Way Too Much Data Instead of Taking Action – An international NGO is attempting to preserve a large remote tract of intact rainforest in the Amazon Basin. The primary threat is clearcut logging by large multinational companies that are currently working in other regions of the country. The project team, having been admonished by their organization to focus on monitoring and evaluation, duly begins a regular regime of identifying animal and plant species, surveying bird populations, tagging trees, counting hunting parties, sampling water quality, and tracking resource extraction permit applications. All of these data are put into an electronic database back at the NGO's headquarters, which gets bigger and bigger. Then the project runs out of money. A few years later, a technician cleaning up the computer notices this big data file that hasn't been modified and moves it to an archive….

Case 4 – All Action and No Reflection – An invasive perennial grass is invading wetland systems throughout an ecoregion and creating monotypic stands. Conventional wisdom points to a single strategy that most land managers are implementing – treat the invasive stands with herbicides in June at peak flowering. There is little post-spraying monitoring to evaluate control of the invasive species or spray effects on native species. Typically, all green vegetation turns brown within a week of spraying, suggesting that the spraying kills all vegetation. Unfortunately, the following year the invasive species is back at nearly the same density and cover as before treatment. The typical management response is to apply more herbicide. Thousands of gallons of herbicide are applied annually throughout the ecoregion yet the invasive grass continues to spread….

Case #5: A Lost Cause – A land trust is working to conserve forest in a fast growing sunbelt state. They are planning to conserve a collection of small fragments of forest in an area of fast growing suburbs around a major city. Most of the fragments are on private lands and are threatened by outright conversion to shopping malls, roads, and houses. The state prioritization effort has deemed that these are important tracts of forest based on historical records of rare plants and animals. As a result, the project team attempts to spend huge amounts of money to purchase and manage the tracts of land, only to find they are extremely fragmented and degraded….

2. The Resource Allocation Problem

Although these five cases are obviously simplified versions of reality, they are symptomatic of the problems faced by conservation practitioners. In a world in which there are vast challenges and limited resources, the managers of any given conservation project have to allocate an appropriate amount of resources across two primary decisions. The first allocation decision involves finding the right balance between investing in taking action versus monitoring. The second allocation decision involves subdividing monitoring resources across different types of monitoring indicators.

In this paper, we first explore each of these questions in some detail to define the problem and consider potential solutions in different situations. We then integrate these two problems into a general decision tree that will help practitioners figure out what to do at their specific sites. We then revisit the five cases to illustrate different logical outcomes from the decision tree. Note that in this paper, we are assuming that practitioners have already gone through a prioritization process and have selected a given site as being important for conservation; we are not addressing the question of how you prioritize across multiple sites. We also assume that practitioners have completed a situation analysis of the threats affecting the biodiversity targets at the site.

Balancing Investments in Conservation Action vs. Monitoring

The first major decision facing practitioners at any given site is how much to invest in taking action versus monitoring. The key factors to consider here are the presence of clearly defined threats to biodiversity and whether you have clear and feasible actions you can take to counter these threats.

As an analogy, think about how a doctor might care for a patient. If the patient appears to be healthy and has no obvious complaints or symptoms of disease, then there is no point in the doctor providing treatment. Instead, the doctor merely conducts a basic checkup to catch any signs of potential problems (as described in more detail in the next section). If the patient has an obvious problem such as a broken leg or a bacterial infection, then the doctor should take action to fix the problem. If, however, the patient has a problem for which there is not yet a standard treatment, then the doctor may have to try multiple treatments to see if one will work. Integral to this approach is the need to monitor the results of these treatments very carefully.

It's the same for conservation. If you know there are no major current or future threats facing the target biodiversity at your site, then you don't need to take action. Instead you should merely invest in monitoring the situation (again, see the next section). If there are obvious threats that you can deal with, then you should take action to counter them and monitor the results. And if there are threats, but you are unsure how to effectively deal with them, you may have to experiment with different actions and monitor the results.

Investing in Different Types of M&E

The second major decision facing practitioners is how much to invest in different M&E efforts. Two of the most common reasons for undertaking M&E include:

- **Assessing Status** – Answers the question "How is the biodiversity we care about doing?"
- **Measuring Effectiveness** – Answers the question "Are the actions that we are taking having their intended impact?"

Obviously, these two types of M&E are broadly related to one another. We often take actions in places with biodiversity that we care about. And to measure whether our actions are having their intended impact, we have to understand the conservation status of biodiversity and threats where we are working. Although the same indicator may be used for both status and effectiveness measurements, the key distinction is whether we are looking for an assessment of the health or integrity of the system, or whether we are focusing on understanding the specific consequences of conservation interventions (see also Box 1 for additional discussion and examples).

Returning to our medical analogy, status assessments most commonly occur when the patient appears to be healthy and has no obvious complaints. In this case, the doctor is not going to undertake a detailed investigation of one organ or system. Instead, the doctor will undertake a routine checkup that covers broad indicators of health such as temperature, blood pressure, and resting pulse rate. If one of these general *early warning indicators* is outside of the normal range, only then will the doctor follow-up with more specific diagnostic tests to understand specifically what problem might be developing. In conservation, this is the case in which there

are no major or current threats facing the target biodiversity at your site and so you don't need to take action. All you need to do is track the general early warning indicators, which can be either target or threat-based (see Box 2).

Effectiveness measurements, by contrast, occur when the patient is receiving treatment for an obvious problem. In this case, the doctor will want to follow up the treatment by focusing on *diagnostic indicators* that help determine whether the specific treatment is working as planned such as repeatedly x-raying the patients broken leg over time to ensure the cast is holding the bones in place or doing a blood culture to ensure that the antibiotic is working. However, even if a patient has a broken leg, the doctor will still monitor the early warning indicators to make sure that no other problems are developing such as a secondary infection. In conservation, this is the case where you are taking action to counter specific threats and need to monitor whether your actions are having their desired outcome, but also need to track new and potential threats.

Although diagnostic indicators are typically associated with effectiveness monitoring, they are also often used in status assessment. In our medical analogy, this is the case in which the patient has no current problems, but faces potential risk factors that need to be checked. For example, a person working in a radiology lab may be screened more often for early detection of cancer. A person with a family history of diabetes should be tested to see if they are maintaining proper blood sugar levels. In this case, the doctor is checking specific diagnostic indicators in addition to the early warning indicators. In conservation, this is the case where you suspect certain threats may be coming, but they do not currently warrant action to counter them. To this end, you monitor both your early warning indicators as well as specific diagnostic indicators (again, either target or threat-based) that may help you detect these threats.

There is also one special case in which diagnostic indicators are used that involves neither status nor effectiveness measurements – when *triage* decisions need to be made. For example, in a battlefield hospital, if a patient is brought in with a severe wound to the heart, the doctor will focus on diagnosing the condition of the heart in deciding whether or not to invest in taking care of the patient at the expense of others. In this case, it doesn't really matter if the patient has a pre-disposition to diabetes; the critical factor is the status of the heart. In conservation, this is the case where you are working with a site facing one or more large threats that may be very difficult to abate. You need to assess both the viability of the targets and the scope of the threats to decide whether you should invest any more resources in the site.

Finally, there is one other factor that needs to be considered in deciding how to allocate your monitoring effort – the level of confidence that you have in your understanding of the situation. If a doctor has less confidence in his or her diagnosis of the problem, he or she may monitor a broader array of indicators to try to confirm the diagnosis. Similarly, in conservation, if you are relatively confident that you understand the system that you are working in, then you can reduce the amount of resources you put into assessing both early warning and diagnostic indicators. If, however, you are not so confident that you understand the system, then you have to make a higher investment in monitoring to ensure you are not missing serious threats to your conservation targets.

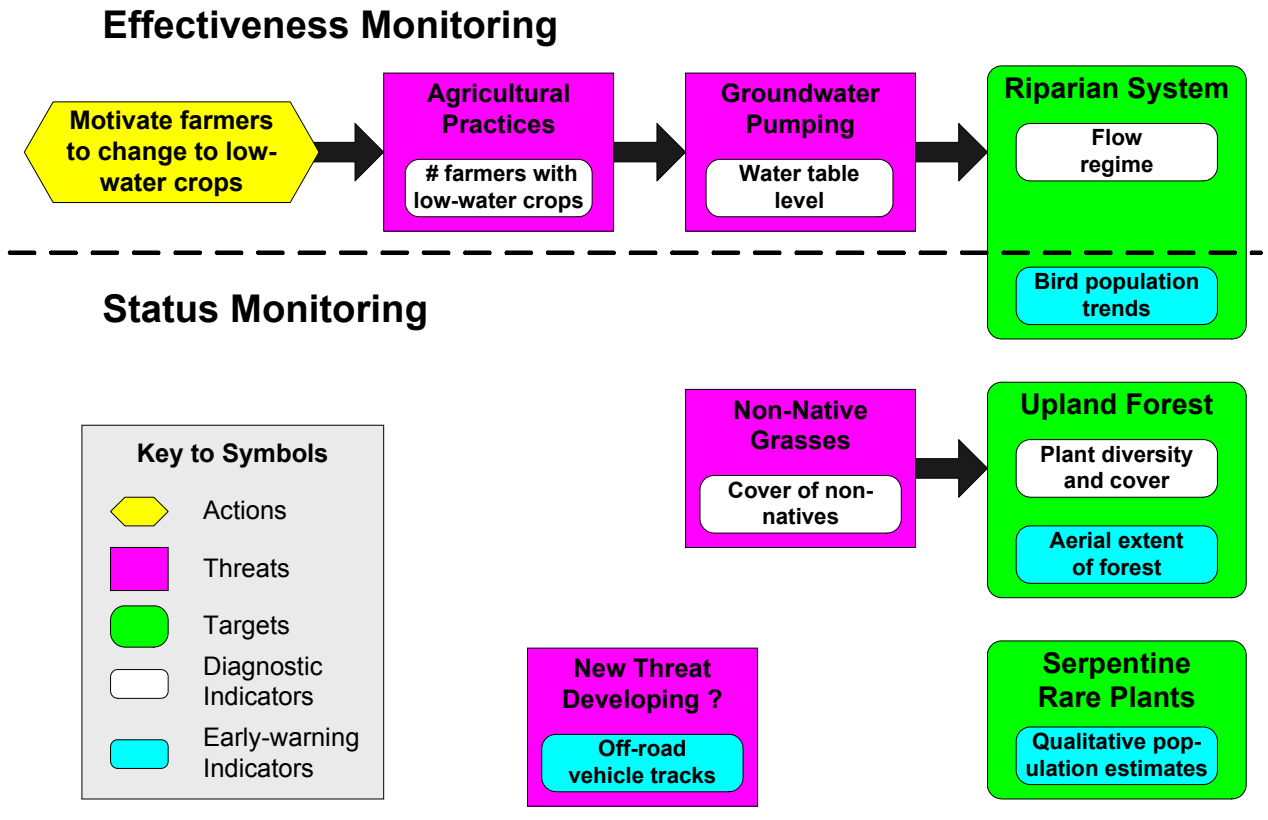
Box 1. Assessing Status vs. Measuring Effectiveness

The distinctions between *status* and *effectiveness* monitoring and between *diagnostic* and *early warning* indicators can be illustrated with the following simplified conceptual model of a project with three focal conservation targets.

The Riparian System target is directly threatened by groundwater pumping which is in turn is affected by the indirect threat of agricultural practices. The project is taking action aimed at the indirect threat by using incentives or legislative mandates to convince farmers to switch to crops that require less water. Effectiveness monitoring includes tracking changes in the status of the indirect threat (agricultural practices), the direct threat (groundwater pumping), and the key ecological attributes that are impacted by the direct threat (river flow measured as the number of days per year that river flows drop below a specified flow regime). These three indicators are all diagnostic indicators of effectiveness because they are designed to measure the response of known threats that are the subject of current conservation interventions. In addition to the ground water pumping threat, the Riparian System target will have other key ecological attributes unrelated to the hydrological regime that may have no known threats such as the status of bird populations in riparian forests. The project team will devote some resources to assessing the status of early-warning indicators related to these attributes that can potentially signal the presence of currently unknown stresses to the target.

The Upland Forest target is threatened by non-native understory grasses, but this threat is not currently the focus of any current conservation actions. The project is monitoring the status of the non-native species population along with changes in the overall plant community diversity as diagnostic indicators of the impact of the non-native species. The primary purpose of this monitoring is to determine whether conservation actions are warranted. As with the Riparian System example, the project may also track other indicators such as the aerial extent of the Upland Forest, that serve as early-warning indicators of new potential problems.

Finally, the Serpentine Rare Plant target occurs on unusual soil types and lacks known threats. Thus, there are no diagnostic indicators for this target and the only monitoring required is low-cost status monitoring to validate the project's assumption that the population is stable and secure. In addition to tracking early-warning indicators for the status of conservation targets, the team should vigilantly work to detect new threats. The most cost-effective threat abatement solutions are often found by directly discovering and acting on new threats rather than waiting until the threat is detected via changes in target status monitoring indicators. For example, the project team may be able to react to a new threat to the Serpentine Rare Plant population if they find tire tracks from off-road vehicles during a routine monitoring visit and install a gate to bar the vehicles from entering the area.



Box 2. Selecting Specific Indicators

In addition to the fundamental decisions affecting the allocation of resources between taking action, assessing status, and measuring effectiveness, there are numerous additional monitoring decisions that we are not addressing in this paper. We wanted to mention two of these decisions here because of their relevance to doing both status and effectiveness monitoring: (1) choosing between biodiversity target-based vs. threat-based indicators; and (2) selecting the most sensitive and efficient indicators among a myriad of indicator possibilities.

Biodiversity Target-based vs. Threat-based Indicators

Over the past few years, there has been a substantial discussion over whether conservation projects should focus on monitoring attributes of conservation targets, or on monitoring threats to the biodiversity. As outlined in Salafsky & Margoluis (1999), target-based measurements have the advantage of being more direct measures of biodiversity and potentially less subjective in nature. Threat-based measurements, on the other hand, have the advantage of being more sensitive to changes over short time periods and being simpler to collect and understand. We believe that most conservation projects will have to collect some combination of target and threat-based indicators to both assess status and measure effectiveness. The exact combination will depend on the specific situation at your project site and, in particular, on the degree of certainty in understanding the causal chain between threats and targets. As a general rule, in situations in which causation is clear (e.g., strip mining = biodiversity loss) and you are doing effectiveness monitoring, your emphasis will typically be on threat-based indicators that track the effectiveness of strategies to abate the threat itself with minimal target monitoring. Where causation is unclear (e.g., are current cattle grazing levels compatible with biodiversity conservation) and you are doing status assessments, there will typically be a greater need to track key attributes of the targets themselves. More than anything, however, the key is to select indicators that are as sensitive and efficient as possible, regardless of whether they are target or threat-based.

Selecting Sensitive and Efficient Monitoring Indicators

In any project situation, there are inevitably a large number of potential monitoring indicators to select among. Alternative choices often vary widely in sensitivity to detecting changes in the underlying system. They also vary widely in their efficiency, which we can define as the amount of useful information they provide divided by the cost of collecting the data to measure them. The ideal indicator will be as sensitive and efficient as possible.

One key to finding sensitive and efficient indicators is to continually improve your understanding of the system in which you are working. For example, consider a saguaro cactus forest. Nocturnal pollination by moths and bats is a key ecological process necessary for sexual reproduction of saguaro cacti. Habitat fragmentation might raise concerns regarding the status of pollinators and whether they are able to adequately locate the remaining saguaro habitat patches. But instead of trying to monitor the population status of specific pollinators by spending endless nights chasing after moths and bats, it may be sufficient to once a year sample the presence of saguaro cactus seedlings in the area of interest, since seedlings are good indicators of past pollination (assuming there is not a persistent seedbank). If there are new seedlings, then we can assume that pollination is occurring. But if there are not new seedlings, then we have to do some more diagnostic work to determine what the root cause might be. As we improve our conceptual model of the system, we can find increasingly sensitive and efficient indicators. These improvements can come from both direct experience and through review of the scientific literature and consultation with experts who work on these types of systems.

3. So How Do We Best Allocate Our Resources?

Figure 1 presents a flowchart designed to help practitioners and managers think about how to best allocate their resources. Note that we are making no assumptions about scale here – a site can range in size from a small pond to an ecoregion to an entire continent.

Start: Priority Conservation Site?

The starting point for our flowchart involves determining whether a given defined site is a priority for conservation. As a general rule, prioritization decisions are based on a number of criteria such as biological importance, degree of degradation, degree of threat, and conservation potential. There are many tools and techniques designed to help determine what data need to be collected to complete this prioritization (see for example, TNC 2000a; Williams et al. 2002). In this decision tree, we assume that you have already collected the data necessary to make these decisions and rank this site relative to other comparable sites. If the site is not a priority, then it is dropped from further consideration. If it is a priority, however, then we also assume the project team will go on to identify the biodiversity targets it will focus on, the causal chain of threats affecting these targets, and the team's specific target and threat objectives. This analysis can be completed using TNC's 5-S framework (TNC 2000b), conceptual modeling (Margoluis & Salafsky 1998), or whatever other technique the project team finds useful.

Substantial Threats?

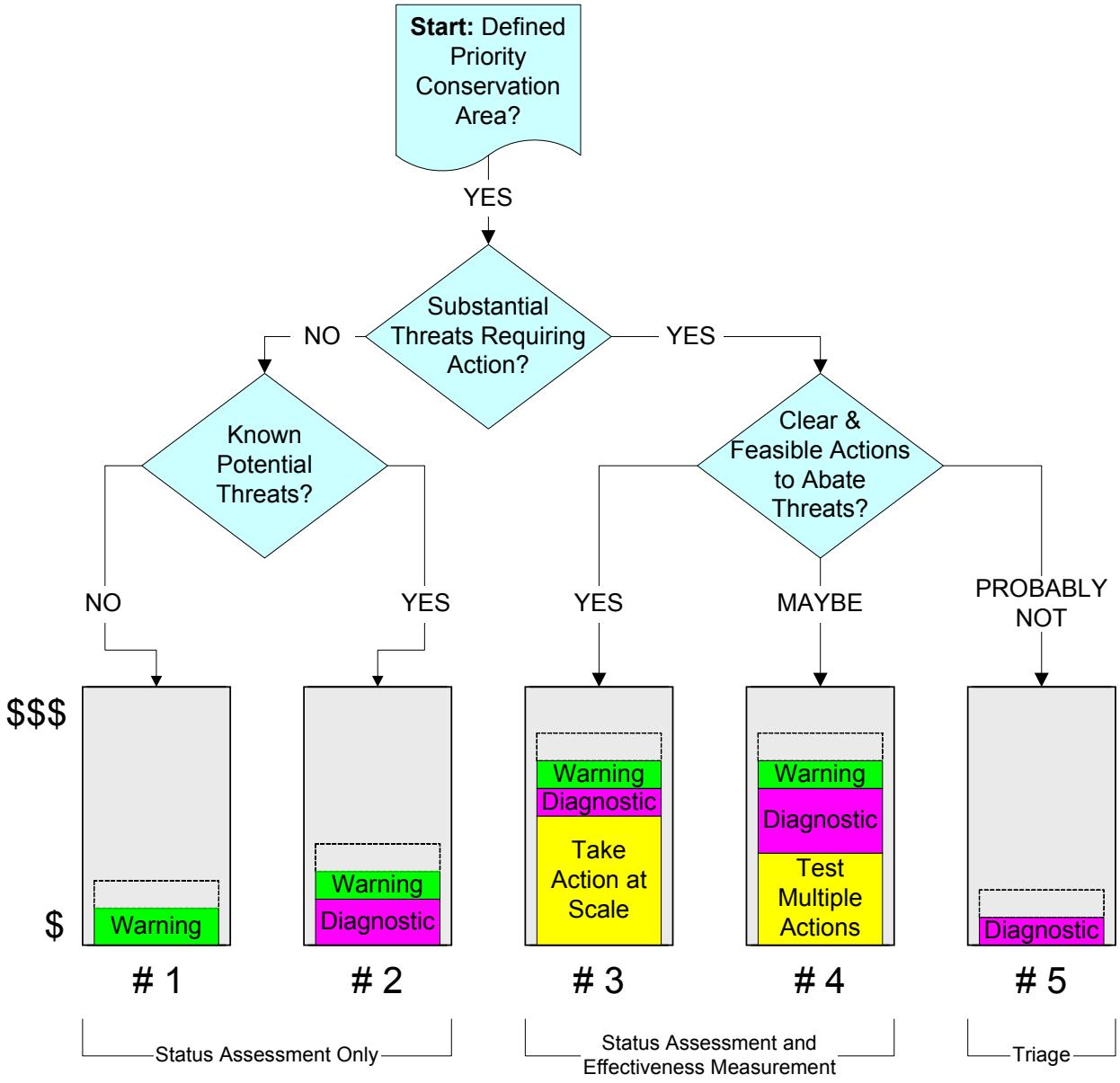
The first decision node asks the question "Are there substantial threats facing the targets at the site?" In TNC parlance, this would translate into having threats that receive a ranking of *High* or *Very High*. If there are no substantial threats, then there is going to be no need to take conservation action. Instead, the project team will merely invest in early-warning indicators to detect potential threats that may arise. If there are substantial threats, then the project team will have to take action and conduct both status assessments using early warning indicators (to detect potential threats) and effectiveness measurements using diagnostic indicators. Note that in cases where there are no current threats, but the targets require restoration from the impacts of past threats, you can treat your situation as if you have substantial threats requiring action; the only difference is that you will be taking restoration actions rather than threat abatement actions.

Known Potential Threats?

If there are no substantial threats, then the next decision node asks the question "Are there known potential threats?" If there are not, then the project will merely have to invest a small amount of resources in monitoring early warning indicators to detect any new threats that might develop (Case #1 in the flow chart).

> **Example of Case #1: Alaskan Wilderness –** At the moment, there are no potential threats to the targets in the site so there is no need to take any action or monitor diagnostic indicators. The project team responsible for this site should devote a small amount of resources towards monitoring relevant government agencies in Washington DC and the state capital to ensure that no plans are being developed that would allow resource extraction in the project site. The team should also fly over the site once a year to ensure that there are no signs of human resource extraction activities and conduct periodic ground surveys to detect any non-native species invasions. The two scientists could apply to NSF for funding to conduct their caribou research.

Figure 1. A Decision Tree for Allocating Resources



If there are known potential threats, then the project will have to invest a bit more resources in diagnostic indicators that are focused explicitly on these threats as well as the more general early warning indicators (Case #2).

> **Example of Case #2: Pacific Island Coral Reef** – Here the primary threat is from the fishing done by local subsistence fishers. The harvest levels appear stable, but without additional monitoring information it is not possible to determine whether the current resource extraction levels are sustainable. In this case, the project team should focus primarily on monitoring the fish species that are being harvested by working with the fishers to assess catch per unit effort and average size of fish caught. (By involving the local community in the monitoring, the team also greatly enhances the chances that the fishers will be willing to modify their harvest practices.) In addition, the project team should also monitor status indicators such as the extent of coral reef cover and presence of disturbance-linked species (such as crown-of-thorns starfish) to obtain early warning of whether other problems might be developing.

Clear Actions to Abate Threats?

If there are substantial threats, then the next decision node asks the question "Are there clear and feasible actions to effectively abate the threats that have been identified?" If there are, then the project team should invest the bulk of their resources in these actions at the appropriate scale needed to abate the threats (Case #3). The project will also need to spend a limited amount of resources on diagnostic indicators of the effectiveness of these actions as well as on early warning indicators to detect new potential threats.

> **Example of Case #3: Amazon Basin Rainforest** – In this situation, the primary threat is from logging by large multinational companies. In this case, the project team knows that their best hope for protecting the forest is to have it declared as a national park and to then build up the National Park Service's ability to manage the site. To this end, the team should allocate almost all of their resources toward taking action to help gazette the park and to train and equip Park Service staff. The team should also invest a little bit in assessing how well they are doing in reaching the appropriate government officials and a little more in periodically obtaining satellite imagery to ensure that there are no unexpected roads being built into the project site.

If there might be clear and feasible actions that can be taken, but the project team is not certain which action is most appropriate, then the team will have to test multiple actions and invest more of its resources in diagnostic indicators (Case #4).

> **Example of Case #4: Wetlands in the Ecoregion –** Here, the project managers repeatedly used a single control strategy, the spraying of herbicides in June, without checking to see if it was working as planned or evaluating alternative strategies. The project should invest some resources in experimenting with different ways of applying the herbicide and other control mechanisms. They also should invest in carefully monitoring the results of these experiments to see if they can test the assumptions they are making. In doing so, the project team might discover that spraying is more effective in fall when the invasive species are sending nutrients down towards their large root systems rather than upwards towards their flowers and leaves. In doing so, the team members are advancing both their and (if they share their results) the

world's knowledge. The team should also invest in early-warning indicators to detect new potential threats.

Finally, if it is likely that there are no clear and feasible actions that can be taken, the project team will want to merely focus on a few diagnostic indicators to help them make a triage decision (Case #5). If the indicators show that action is feasible and the site is worthy of investment, the situation will evolve into either Case #3 or Case #4. But if it is not, then the team will have to consider abandoning the site in favor of other locations that are more tractable.

Example of Case #5: Fragmented Forests in the Sunbelt – In this case, given the fast growing human population, the obvious conservation strategy is to purchase the land outright. Unfortunately, this strategy is extremely expensive. Before diving in, the team should invest some limited resources in collecting diagnostic indicators that help assess the quality of the targets at the site and the willingness of local residents to help support conservation issues. If the target forest proves to be too fragmented and/or there is not enough local interest, the project team will report to their organization and take the site off of the priority list and perhaps try to find a local open-space conservancy to take on the project.

Confidence in Situation Analysis?

Although it is not shown explicitly in the diagram, the final decision node asks the question "Does the project team have confidence in its situation analysis?" If the answer is yes, the team is reasonably sure they have identified all the threats and only has to invest minimal funds in assessing the status of the site over time. If, however, the answer is no, then the uncertainty means that the project team should probably invest a bit more of its resources in assessing the status of the site by increasing investment in early warning and/or diagnostic indicators as shown by the dashed lines in each of the boxes.

As an example, consider a project that has been working to protect a large tract of floodplain habitat. The project team did an initial situation analysis and concluded that the major threats to the biodiversity in this project are habitat destruction for housing developments and altered flooding processes (caused by levees) that interfere with the establishment of riparian plant communities. Based on this analysis, the project team invested a great deal of money in acquiring land and removing the levees and restoring the floodplain. Effectiveness monitoring reveals that this work has been very successful in producing expansive stands of valley oak riparian vegetation of multiple size classes supporting a wide range of wildlife species. Over time, however, the project managers were puzzled by the fact that despite the availability of prime habitat, many birds were having low nesting success. The team then invested some more funds to install video cameras at a sample of nests. Their cameras captured images of black rats (an exotic species) taking eggs and young from nests. A previously unknown threat, black rats, was causing large-scale declines that escaped detection under the effectiveness monitoring program. In this case, the initial situation analysis proved to be incomplete; by investing a bit more money in a status assessment and by using their situation analysis to uncover hidden problems, the team was able to identify and then deal with a critical and previously unknown threat.

4. A Final Word

The examples that we presented in this paper are obviously simplified versions of reality. In the real world, situations are generally much more complex and difficult. For example, in many cases you may have clear actions to abate some threats and not have clear actions to deal with others. If we have learned one thing, it is that the optimal allocation of resources across action and different types of monitoring indicators at any given site must be determined by the specific conditions present at that site. This allocation decision is influenced by the types of targets you are working to protect, the threats you are facing, the level of resources that you have available, and your own knowledge and capacity. It is our hope, however, that the framework and decision tree presented in this paper will give you some helpful guidance in making these critical decisions.

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