The Washington State Joint Legislative Audit and Review Committee (JLARC) conducted a review of the state's efforts to conserve habitat and expand outdoor recreation. This work included a review of existing or potential objective outcome measures that could be used to evaluate the success of 13 land acquisition and regulatory programs intended to protect and conserve habitat and expand outdoor recreation. Based on the effective outcome measures found in the peer-reviewed and gray literature, communications with managers from similar programs in the U.S., and the project team's professional opinion, it was found that there is very little literature that focuses specifically on outcome measures as they relate to land acquisition intended to protect and conserve species, habitats or to expand outdoor recreation; however a number of states and regions have implemented outcome measures for acquisition, and guidance is available from the extensive literature on restoration program and project effectiveness.

Introduction

Developing strategies to effectively measure ecological outcomes that are linked to specific programs and projects is an essential, but not simple, task that remains generally elusive in practice (Dale and Beyeler, 2001; Sawhill and Williamson, 2003; Niemi and McDonald, 2004; Doren et al., 2009; Margoluis et al., 2013). There are many examples of project-level effectiveness and projects that have laid out clear outcome measures linked to the project goals, such as Hartema et al. (2014). At the programmatic and regional levels, examples of these outcome measures are more difficult to find. For an example of a regional evaluation of the cumulative effectiveness of multiple projects see Diefenderfer et al. (2016). For a model-based evaluation of restoration project impacts at a watershed scale see Roni et al. (2010).

Some researchers note that the increased demand for outcome measurement, particularly ecological outcomes, does not imply that they are useful for decision making or that they are frequently used (Turnhout et al., 2007). Others argue that aligning outcome measures (indicators and metrics) with the mission and goals of an organization, program, or project can change it profoundly.

Margoluis et al. (2013) argue that to measure success in conservation three questions must be answered: (1) are we achieving our desired impact?; (2) have we selected the best interventions to achieve our desired impact?; and (3) are we executing our interventions in the best possible manner? Another question to add to this list is (4) who is the audience and who will care about the effectiveness of our program and our actions?

Outcome measurement processes are based on the selection of indicators and metrics, and the choice of indicators and metrics will directly impact the results of the process (Behan et al., 2017). To understand which indicators and metrics have been shown to effectively measure the performance of land acquisition and regulatory actions, we focused our efforts on peer-reviewed literature, agency publications, and on programs that would help provide information about 'best practices' for outcome measures that were not found in peer-reviewed or agency publications. By best practices we were looking for *outcome measures* (i.e., indicators and metrics) and programs that were effective, innovative, or promising.

Due to the complexity and nuances related to the protection of water quality and quantity in Washington, this section is not intended to be a comprehensive compendium of the indicators and metrics used to create effective outcome measures. Rather it is a compilation of effective outcome measures and practices based on our literature search, conversations with program managers, and the opinions of the project team within the timeframe of the project. The complete report (Behan et al., 2018) provides many more details concerning the development of outcome-based indicators from the literature, along with information on all of the other related programs and subject areas evaluated in the JLARC study.

Background

The Clean Water Act (CWA) drives much of the regulatory activity of the Department of Ecology (ECY), particularly the regulations of sources of pollution, both direct or point sources, and indirect or non-point sources of pollution. Agricultural runoff and stormwater runoff are treated separately. The law requires states to compile a list of rivers, streams and lakes that do not fully support beneficial uses of water such as fish and aquatic life, as well as drinking water, recreation, industrial and agricultural uses called the (303(d) list.

Outputs

A short list of outputs identified in agency materials, or provided by JLARC, about the programs relevant to water quality and quantity:

- Streams, rivers, and lakes have clean water, and if not, the communities are working to improve their water
- Water rights are met
- Discharges of pollutants into water bodies are prevented or identified and limited
- Sewer and stormwater systems are developed, improved or maintained to prevent pollution
- Groundwater is clean and sustainably managed

Outcome statements

The primary outcomes the project team identified from the objectives in the enabling legislation of the program:

- Water bodies provide needed habitat to maintain native fish and other aquatic species
- Clean water is available to recharge aquifers
- Clean water provides the agricultural, industrial or municipal drinking community needs
- Rivers, streams and lakes support recreation

Many states use the decline in the number of water bodies on the 303(d) list acts as the indicator of the success of regulatory programs. However, in practice, rivers and streams are sometimes included on the list because of one particular factor. In the Pacific Northwest, that factor is often a temperature that is too high to support salmon and trout. As a result, inclusion in the list does not do a very good job of describing how clean the water is, or how well the water bodies meet peoples' needs. For 303(d) water bodies, the ECY establishes a "total maximum daily load" or TMDL, that defines the maximum amount of the pollutant or factor such as heat, a water body can accept while still meeting the water quality standards. Staying within TMDL limits can be used as an indicator of water quality success. However, the beneficial uses defined in the law actually represent the most important outcomes of the water quality regulatory programs, and would represent the most relevant indictors of program success.

Water quantity and availability are determined by water rights, generally available based on seniority; and often a source of disagreement or uncertainty within water allocation systems. Since most of the watersheds in Washington have more people who want to use the water than there is available water, competition for water can be intense. As a result, measuring the effectiveness of water distribution programs in terms of outputs to communities can be complex.

Literature

A major activity used to manage water quality is stream restoration, including riparian buffer management. Many peer-reviewed papers document the success or failure of stream restoration activities, using measures of the array of stream functions (Davis and Jackson, 2006). These papers and a set of relatively new Stream Function Assessment Method (SFAM) protocols identify a number of measures that provide information about the condition of streams, and stream functions. None of these are explicitly tied to outputs, although most assume there are direct links between stream conditions and functions, and meaningful outputs of regulatory or restoration programs. Ecosystem Services researchers papers say that functions only link to outputs if they directly lead to benefits people need (Tallis et al., 2008; Olander et al., 2015).

Water quantity metrics are relatively straightforward compared to other metrics of ecological condition. Nonetheless, they must be tailored to end users' needs, including biota, in order to be effective indicators of outcomes. For Washington State, the identified users are salmon and other aquatic species and the human consumers in the residential, commercial and industrial sectors.

The literature on ecological flows identifies multiple metrics of flow thresholds and durations that support salmon movement and survival (e.g., Willis et al., 2016). More recent research has noted the important synergies between quantity and quality. For example, dam release patterns can have a strong effect on water body temperature. As a result, the recent literature emphasizes a need for indicators to comprehensively characterize the seasonality and variability in stream temperatures or other limiting factors on habitat (Olden and Naiman, 2010; Stahlnaker and Wick, 2000). Generic metrics do not seem to be available, but rather flow requirements are tailored to the geomorphology of the system (Stahlnaker and Wick, 2000; Willis et al., 2016).

The most common water quality indicators described in the literature and used by agencies in practice are assemblages of data complied into a Water Quality Index or WQI. Ecology currently uses the WQI as an indicator of stream health throughout the state (Results WA, 2017). Many other states use, in lieu of or addition to a WQI, an Index of Biotic Integrity or IBI. IBIs summarize data about a set of aquatic organisms found in the water, characterized by the species that occur in disturbed or more polluted waters, versus species that occur in more pristine rivers, streams and lakes. IBIs, because they require identification of microorganisms and insects, can be more expensive and more difficult to complete than WQIs, but are used because they help differentiate the very high quality areas. However, a problem with both WQI's and IBIs is that they rarely show rapid changes, and the standard methods often do not reflect smaller improvements made by restoration or regulatory programs.

As noted in the wetlands discussion, a few publications, particularly Palmer et al. in 2011 have identified indicators of stream and wetland outcomes, including those related to the hydrologic regime and water quality, with the benefit-relevant indicators concept used to tie the program outcomes with specific communities.

In practice

Promising practice: Massachusetts. The Massachusetts Department of Energy and Environmental Affairs worked with staff at the EPA Office of Water to pilot a set of indicators now integrated into their environmental monitoring program. As part of this work, they evaluated important water needs and beneficiaries within each of the watersheds in the state. This helped define their primary goal for the Massachusetts surface monitoring program, which is to "Collect chemical, physical and biological data to assess the degree to which designated uses, such as aquatic life, primary and secondary contact recreation, fish consumption and aesthetics, are being met in waters of the Commonwealth". The Massachusetts Water Resources Authority has developed monthly and annual Water Quality report cards for drinking water, while Warren Kimball and Massachusetts Department of Environmental Protection worked with Lilian Busse at the California State Water Resources Control Board to pilot an Automated Water Quality Report Card System now being used in both states on a trial basis (Busse et al., 2012).

Best practice: Minnesota. The state of Minnesota has developed what appears to be a model program of indicators to assess the effectiveness of their clean water restoration, protection and regulatory programs. The state created the Clean Water Fund, and an interagency team from their pollution control agency and their large Department of Natural Resources, to work together with the other state agencies (Agriculture, Health, Water Resources, etc.) to create the report and integrate their monitoring efforts to address the indicators. The legislature created both the fund, and the requirement that the effectiveness be monitored as an interagency effort, which may explain why these indicators have been so successful. Their biennial report list both effort and outcome based results. And, because it is tied to funding effectiveness, is likely the one most relevant to JLARC's interests. According to staff who developed the initial report (David Wright, Minnesota Department of Natural Resources and Pam Anderson. Minnesota Pollution Control Authority, personal communication), the development of the first report was relatively expensive ($750,000). The initial cost reflected their need to assure that annual monitoring was in place to update the indicators each year. Yet the indicators and the report were developed together to allow simple annual updates which their DNR and Pollution Control agencies can accomplish within their existing budgets. The outcome based measures they include are listed in the table below, along with those from Massachusetts or the published literature.

In the Pacific Northwest, water quality indicators are often closely tied to indicators of watershed health and salmon health. A 2009 report by the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) provides northwest centric lists of indicators and criteria focused on water quality, which should be updated by the indicators project that PNAMP is currently completing.

Conclusions

Methods for developing meaningful outcome-based indicators are clearly identified in the literature. They are being put into practice successfully in a few states, but generally very sparsely across the country, and rarely for species and habitat focused land acquisition programs. When evaluating program success, most agencies tend to focus on gathering information they need for adaptive management – either data needed to determine if their actions are achieving their goals, or the information needed to develop plans or strategies. These focus on their need to understand the effectiveness of their actions to restore habitats or to address threats to species and habitats on property they manage – both important issues for agencies wanting to understand the priorities for their work. However, understanding priorities for action or the effectiveness of actions may not inform if the overall program is achieving the desired outcomes.

The most effective programs for evaluating program success in land acquisition, water quality protection, and restoration had a few commonalities. First, the legislation that created these programs was relatively specific in describing the types of outcomes desired, so designing an outcome based set of indicators was more straightforward for agencies. Second, the legislation required that indicators of program success be developed and reported on some regular schedule, and at a minimum funded the development of the indicators and their implementation, often requiring interagency cooperation, which is essential as many agencies and local or regional governments may be involved in program implementation. And lastly, they required statewide (or jurisdiction wide for regional governments such as Tahoe) evaluation of outcomes – which helps to assure the development and measurement of the indicators are not focused on plans or projects.

To understand if water quality, stream restoration, aquifer protection and water rights mitigation are effective at protecting water quantity and quality in Washington, it is critical to have a reasonable understanding of the baseline conditions in all areas in the state. Without this information, it is impossible to understand if any existing programs are making a difference. Statewide assessments are necessary to understand statewide outcomes. A plan or strategy to restore a watershed or improve water quality in a watershed, with identified problems, is an important way to understand and fix a problem. But the strategy is not necessarily the information needed to describe the status and trends of water quality, quantity or salmon populations, the primary outcomes of the funding.

Getting statewide information on the status and trends of the desired outcomes may not be the information agencies need to decide what the priorities for their work should be. If understanding statewide outcomes is important, the legislature must require it be done. As exemplified through the Florida Forever Program, Minnesota's Clean Water Fund, Missouri's Aquatic Gap, and Washington's Puget Sound Partnership, methods have been identified and outcome-based indicators have been used in other states. The large numbers of government agencies, watershed groups, tribes and organizations interested in water may make it more difficult to develop a strategy to collect this statewide data in Washington than states like Minnesota and Massachusetts, but this is a barrier that the state has experience in addressing. It just needs to be a priority to happen.

Table 1. Indicators and metrics for water quality and quantity outcomes identified in the literature or effective practices

Measure Categories	Indicators and Metrics (Units of Measurement)	Source(s)
Water Quantity	• Water supply reliability index (e.g., % time flow meeting user requirements • Extreme low flow duration • Fish supported at measured flows	Paulson et al., 2008; Willis et al., 2016
Surface water quality	• Surface water health (or the rate of impairment vs. non-impairment statewide and by watershed) • Lake and Stream Water Quality (changes in time of key WQ parameters for lakes and streams, which include: temperature, pH, conductivity, dissolved oxygen, phosphorus or nitrogen and physical properties including turbidity, sedimentation, disturbance, intact hydrology • Median concentrations of pesticides of concern in surface water statewide. • Trends of mercury in fish and statewide mercury emissions (MN). Other states replace mercury with toxins as a more general indicator. • Balance between groundwater use and recharge or groundwater levels.	James et al., 2012; Paulson et al., 2008; Bernhardt et al., 2005; Davies and Jackson, 2006
Ecosystem services *(The capacity of rivers, streams, lakes and ponds to:)*	• Support recreational opportunities such as swimming, fishing and boating. • Provide drinking, wildlife, agricultural and industrial water needs. • Support aquatic biodiversity.	Baron et al., 2002 Keeler et al., 2012; Olander et al., 2015
Groundwater	• Provide sufficient levels of water for drinking water needs • Provide sufficient groundwater water quality (low levels of toxins, nitrates)	James et al., 2012

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