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Informing watershed planning and policy in the Truckee River basin through stakeholder engagement, scenario development, and impact evaluation

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ABSTRACT

In this study, we evaluated the water quality and quantity impacts of five restoration and land protection scenarios in the Truckee River watershed, in the context of regulatory goals. We used spatially explicit biophysical models to create scenarios with targeted places where the greatest water quality and supply benefits could be realized. We quantified how these scenarios would impact the sediment load, nitrogen load, phosphorous load, and annual water yield with hydrologic models. The scenarios included a "Business as usual" based on existing conservation plans (2015–2020) and four additional model-generated scenarios: a "Targeted" scenario using the "Business as usual" budget, two targeted "Increased budget" scenarios, and a "Targeted-climate smart" scenario adjusted based on climate change. We expected the model-generated scenarios to have a greater impact on biophysical factors than "Business as Usual," and that the "Increased budget" scenarios would reach water quality regulatory goals. The "Targeted" scenario produced a small improvement in water quality over "Business as usual," but did not meet regulatory goals. The "Increased budget" scenarios could meet water quality goals in one additional subwatershed if the budget is allocated to the most cost-effective activities to reduce sediment. Incorporating climate change caused the targeted locations of activities to shift in space, but the overall impact on biophysical factors was similar. This study demonstrates how science-based planning with stakeholder input can inform conservation investments across existing boundaries and lead to greater water quality improvements. By identifying where to implement different types of conservation activities and how much to invest, as well as revealing shortcomings in current assumptions about which activities to implement, this study can enable smarter and more effective land management investments.

1. Introduction

Payments for watershed services, sometimes called 'water funds,' are investment mechanisms that maintain or improve the services provided by natural ecosystems. These provisioning and regulating services range from water purification to surface and groundwater flow regulation. A water fund can diversify the types of stakeholders who fund conservation and lead to greater collaboration across different land ownerships in a watershed (Goldman-Benner et al., 2012). Developing a water fund can involve the use of a model to target locations for conservation investments to provide the greatest improvement in water quality or supply (Vogl et al., 2016, 2013). Models are also commonly used to quantify the impact of conservation activities on biophysical factors, or to link changes in biophysical factors to ecosystem services (MEA, 2005; Nelson et al., 2009; Smith et al., 2011; Guerry et al., 2015; Ouyang et al., 2016; Schroder et al., 2016). Developing models in an iterative process with stakeholder input can create the enabling conditions to inform decision making, policies, and implementation (Ruckelshaus et al., 2015).

Stakeholders in the Truckee River watershed in California and Nevada currently invest in land protection and restoration activities, and there has been considerable investment in the Lake Tahoe subwatershed to maintain lake clarity. The Tahoe Regional Planning agency coordinates funding for investments in the Lake Tahoe subwatershed through the 'Environmental Improvement Program.' This payment for watershed services program only covers a portion of the entire watershed. Additionally, investments

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are typically opportunistic, not spatially targeted for impact, and success is measured in acres or miles protected rather than in water quality improvements that investors are seeking to achieve. As a consequence, there is little sense of the scale of financial investment needed, or which activities should be implemented, to achieve the water quality goals.

To fill this gap, this study demonstrates how modeling and stakeholder input can be combined to determine where to spatially target conservation activities, and the amount of investment needed, in which activities, to reach water quality regulatory goals. Past modeling studies at subwatershed scales in the Truckee River watershed identified dirt road removal and maintenance, decreased road sand application, revegetation, and ski-area restoration as investments that can be implemented to attain regulatory sediment reduction goals (Grismer 2014; McGraw et al., 2001). We developed four future land use scenarios, with activities targeted to the best locations for water quality and supply improvement, using the Natural Capital Project's Resource Investment Optimization System (RIOS) model (Vogl et al., 2013). These scenarios were based on common stakeholder priorities, different budget levels, and climate change projections. We estimated how the scenarios, along with a business as usual scenario based on existing plans, affected water quality and yield with the Integrated Valuation of Environmental Services and Tradeoffs (InVEST) models (Sharp et al., 2014). We collaborated with stakeholders who were interested in, benefit from, or that have specific regulatory requirements that could be met by improving water quality and supply in the watershed.

We addressed how different conservation investment levels and climate change inputs affect water quality and quantity outcomes at a watershed-scale, compared to existing plans for conservation. We expected that the model-generated scenarios would provide more improvement in water quality and supply than the business as usual plan. Additionally, we expected that with increased investment there would be greater improvements in water quality that could meet regulatory goals in the subwatersheds. The purpose of the study was to inform stakeholders about the potential of a water fund. We included climate change because of the threat it poses for water supply under hotter and drier projections and to test how targeted activities might shift in space (U.S. Department of the Interior, 2015). We asked three questions that have relevance more broadly to planning for multiple objectives with a diverse group of stakeholders.

1. Does a model-generated scenario of restoration and land protection provide more water quality and supply improvement than the business as usual plan?
2. What level of conservation investment is needed to meet the regulatory water quality goals?
3. If climate change projections are incorporated into the model, does that change the targeted location for conservation investments or their total impact on water quality or quantity?

2. Methods

2.1. Study area

The Truckee River watershed (4512 square kilometer area) is a place where land management to improve water quality, reduce wildfire risk, and protect biodiversity are high priorities, providing a useful case study for implementing multi-benefit planning to improve outcomes. The Truckee River flows ~193 km from its headwaters at Lake Tahoe in the Sierra Nevada, California to Pyramid Lake, terminal lake in the Great Basin of Nevada. On the California side, water utilities rely primarily on groundwater for water supply, while in Nevada the river supplies drinking water for more than 400,000 people. In Nevada, downstream of the city of Reno, members of the Pyramid Lake Piute Tribe (residing within the Pyramid Lake Indian Reservation) use the river for water supply, agriculture, and the fishery for food and recreational income.

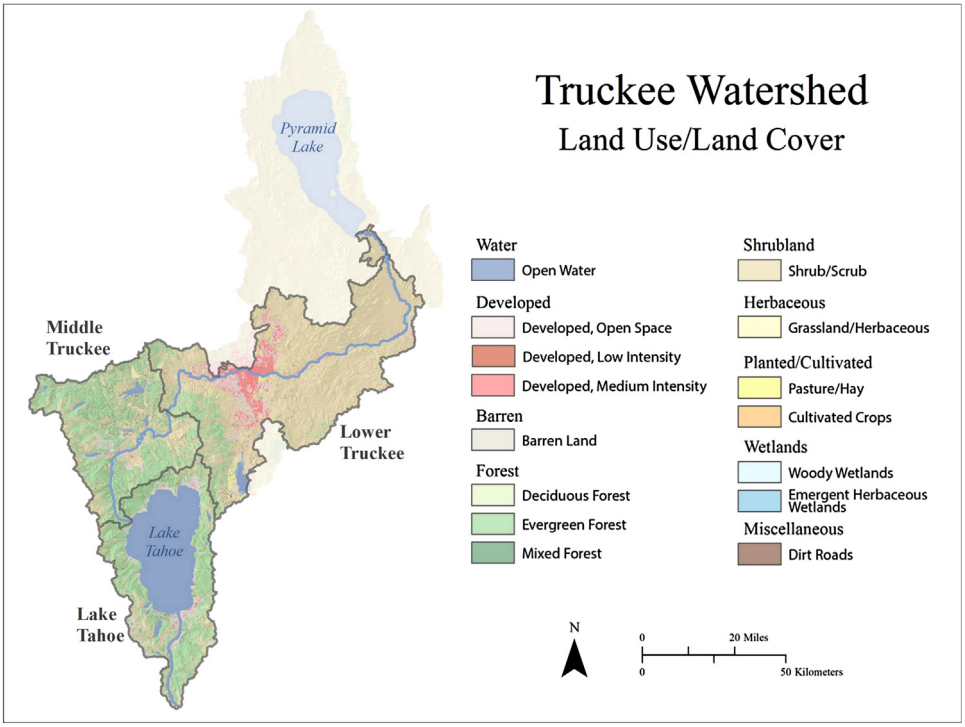

Fig. 1. Land cover map of the Truckee River watershed and the three subwatersheds.