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Conserving water in arid regions: Exploring the economic feasibility of alternative crops

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ABSTRACT

Urban expansion in western arid regions has increased competition for available water supplies, encouraging more efficient agricultural water use. The implementation of alternative low water-use crops is one option for producers, but is it economically feasible? This study uses the EPIC model to model yields to alternative crop production under differing irrigation levels. Risk analysis, or the distribution of returns, to alternative crop production is examined through the use of SIMETAR. Data on current and alternative crops for this study include cost and return studies, producer interviews, and field trials in Northwest Nevada. Study results show that there are alternative crops that could be feasibly substituted for alfalfa or used as a diversification strategy, while reducing water use by at least one-half.

1. Introduction

In the western United States, hydrological cycles have changed considerably in the last 50 years, largely due to human intervention (Barnett et al., 2008). Population growth in western states creates additional water needs for civil, recreational, and hydropower generation purposes (Diaz and Anderson, 1995). Increased competition for water supplies, due to both urban expansion and declining water availability from changing hydrologic cycles, is forcing agricultural producers to become more efficient in their water use for irrigation purposes. Additionally, even in years with adequate or above-average stream flows at headwaters, downstream users are faced with chronic low supplies due to upstream development, variation in precipitation, and over-allocation of water rights (Gaur et al., 2008). Alternative crops may provide a vehicle for continued agricultural solvency in regions where water is scarce and there is social pressure to reduce water use (Gaur et al., 2008). Examples of transition to alternative crops include farmers in the Punjab region of India who replaced rice and wheat with cotton and soybeans and farmers in the Lower Rio Grande Basin of Texas who replaced sugar cane with corn (Jalota et al., 2007; Santhi et al., 2005).

This study examines the feasibility of alternative crops for arid regions using the Walker Basin region in Nevada as an example. Walker Lake is a rare freshwater terminal lake in northwest Nevada, one of only six in the world (Sierra, 2009). Its inflows come from the West Fork and East Fork of the Walker River, both of which originate in the Sierra Nevada mountain range of California and meet in the Mason Valley of Nevada. In the last 150 years, water has been diverted from these inflows for irrigation purposes at five major agricultural areas in the Basin. These diversions have resulted in dramatic drops in the level of the lake and in dramatic increases in the salinity of the lake, affecting the habitat and populations of Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*), a federally recognized threatened species (Dickerson and Vinyard, 1999). Tui chubs (*Gila bicolor*) and other native aquatic life are being severely reduced in number (Marioni et al., 2005); some species of zooplankton, an important link in aquatic food webs, have become extirpated (Beutel et al., 2001). The collapse of the fisheries is not only negatively impacting recreational use of the lake, but also has negative consequences on the more than two hundred species of migrating birds that visit the lake, a biannual food and rest stop on the Pacific Flyway for thousands of birds (Western, 2006). The proposed solution to save Walker Lake is to buy agricultural water rights from producers and leave the water in the river to make its way downstream to increase lake levels.

Agricultural production is the major source of revenue for local residents, and producers are dependent on irrigation for their livelihoods. Buying out agricultural producers and removing all irrigation from the fields without planting cover crops is not an option; leaving the ground fallow in these areas could result in these previously verdant areas becoming dust bowls. Annual precipitation

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in northwest Nevada ranges from 5.5 in. to 10.9 in. annually (Country Studies, 2008). Low precipitation combined with high temperatures and often severe wind conditions exacerbate problems caused by bare fields. A similar situation has already occurred in the Swingle Bench area just north of the Walker Basin in Churchill County, where dust storms are resulting from non-productive farmland. These areas where irrigation has been removed are creating hazards to health which include poor air quality and impeding vehicle safety among other issues caused by wind erosion; federal and local agencies are working to alleviate the situation (NRCS, 2004).

The major crop grown in the Walker Basin is alfalfa (*Medicago sativa*), an extremely high water user typically requiring flood irrigation in this area. Alfalfa uses four acre-feet of water, the maximum legal allotment allowed per acre in Nevada. Due to the quality of the alfalfa grown, alfalfa production yields high prices, involves little risk for producers, and is an excellent source of revenue. The largest agricultural downstream user of surface water for irrigation, the Mason Valley, has been planted with alfalfa by numerous producers since at least 1880 (Davis, 1913). In order to be able to feasibly sell water rights, producers would have to be able to grow a crop that would use less water, yet yield equal or greater profit over time. This alternative crop would need to thrive under the sometimes harsh conditions that exist in this arid region.

It was desirable to be able to offer producers as wide a spectrum of options as possible when considering alternatives. Investigation into crops suited to the region was conducted and local experts were consulted about experimental crops currently grown on test plots within the region. Four categories of crops were considered: vegetables, fruits, cereals and legumes, and industrial crops and grasses.

To determine the viability of these crops for both the region and the market, EPIC (Environmental/Policy Integrated Climate model) and SIMETAR were used. EPIC is a simulation model that can forecast yields under varying irrigation methods/levels, weather conditions and soil types (Anonymous, 2006). SIMETAR is a risk analysis modeling program (Richardson et al., 2008) that can utilize the varying yield results obtained from EPIC to determine which alternatives would incur the least amount of risk for producers.

2. Alternative crop choice

In order for an alternative crop to be economically feasible in arid regions, it must meet several criteria: the ability to thrive under climatic conditions that exist in these regions such as aridity and high winds; suitability for the soil types prevailing in arid environments; low water use relative to alfalfa; minimal impacts on investment such as equipment and machinery to facilitate the transition from alfalfa; a market within shipping distance must exist for the product and the product must be able to be harvested and shipped with no degradation in quality; and yields and market prices must be high enough to allow producers to switch crops and receive as much or more profit from their efforts than from alfalfa. Published information of crop parameters was reviewed and numerous crops in the previously mentioned four categories were submitted for consideration as possible alternatives. At least one potentially optimum crop was then selected from each category.

Of the vegetables under consideration, bulb onions (*Allium cepa*) and leaf lettuce (*Lactuca sativa*) were chosen as the optimal alternatives. Bulb onions are a proven producer in the area, currently being grown on 6% of the acreage in Mason Valley (UCRS, 2008). Bulb onions can be grown under drip irrigation, using more than one acre-foot per acre less water than alfalfa. Leaf lettuce is currently grown on a small scale in the Basin, but has been shown to be successful on a large scale in other arid environments (Meister, 2004). Leaf lettuce requires only one acre-foot of water to be harvested as baby greens when grown using drip irrigation and commands premium prices.

Most fruit crops that fell within the threshold limits for irrigation needs were susceptible to numerous changes in conditions, making them too risky as an alternative to alfalfa. Wine grapes (*Vitis interspecific*), however, are not as impacted by climatic changes and increase in quality with decreased irrigation, using less than one-half of an acre-foot per year per acre. Wine grapes have been grown on small scale trial plots by area producers since 1990. Tahoe Ridge Winery has planted over 20,000 vines to research 37 cultivars since 1990, and the University of Nevada, Reno has been testing twelve trial varieties in its experimental vineyard in northwestern Nevada since 1995 (Cramer, 2008; Halbardier, 2006). Preliminary investigations into the economic comparison between alfalfa and wine grapes show substantial improvements in returns from grapes (Henry, 2005).

In the cereal and legumes category, teff (*Eragrostis tef*) is one of the optimal choices for numerous reasons, one of which is its short growing season of three months from planting to harvest (Anonymous, 2007). A drawback of this crop is its less than optimal water use for seed production, using three acre feet. Two-row malt barley appears to be another good choice in the cereal and legumes category. It is easily grown using the same equipment as other grain crops and most of northern Nevada is suitable for its production; malting barley has been produced in Nevada in the past (Davison et al., 2001). It uses two acre-feet per acre of water per year, only half the water required by alfalfa.

The potentially optimal industrial crops and grasses include Great Basin wildrye (*Leymus cinereus*), a native perennial grass that was once abundant in the Walker Basin. It has been grown for seed production using only one acre-foot of irrigation. When Great Basin wildrye was being grown in test plots in the area under study through the University system, it grew well and showed promise as a revegetation and forage alternative (Perryman, personal communication, 2008). Switchgrass (*Panicum virgatum*) is under consideration as a biofuel source. It is an American native that was once widespread (Wolf and Fiske, 1995) in its native region east of the Rocky Mountains where precipitation is more abundant; here in the arid west it requires three acre-feet of irrigation to reach its full potential. Research into its potential as biomass for cellulosic ethanol production has been ongoing since approximately 2001 (Fransen et al., 2006). Economic studies have also been undertaken on the costs to produce the crop at a commercial level (Duffy and Nanhou, 2002). Its economic potential has also been investigated with regard to greenhouse gas emission mitigation (Schneider and McCarl, 2003). In 1993, five varieties were planted in test plots at the Newlands Research Center in Fallon, Nevada; all appear to be well adapted for the climate and soils in the area (Davison, 1999).

3. Data and methods

Investigation of economic feasibility is not a simple computation as crop yields may be stochastic. Farmers who are *risk-averse* would be concerned with the stochastic of crop yield as large variability in crop yield is not preferred, nor is large variation in net return. Simulation of net return from adopting alternative crops is the best way to describe risky alternatives through probabilistic distributions of net returns. Decision makers would compare these probabilistic distributions and the economic feasibility. As alluded to, this task requires projected or simulated crop yields and a sophisticated simulation method.

EPIC was chosen as the model to generate crop yields over differing cropping systems in the study region following consultation