Agricultural Water Security and Instream Flows for Endangered Salmonids in Coastal California's Watersheds

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Introduction

Many rural landowners within the Western United States do not have access to a secure water supply provided by a major dam or an irrigation district. Such water users must rely instead on groundwater pumping and/or seasonal water flows from tributaries. Some of these agricultural producers choose to store winter stream flows from tributaries within onsite reservoirs to secure their spring/summer water needs. However, regulatory agencies have increased restrictions on surface water storage and diversions to improve instream flows for endangered salmon, thus reducing water security for many landowners not located along the main stem.

The majority of salmon habitat is within the tributaries located throughout a watershed. Most research regarding instream flows and water management, however, has focused on the main stem portion of a watershed and not on its tributaries. Such a focus ignores the important fact that most landowners are found off the main stem. Consequently, effective water management policies aimed at improving water security and salmon survivorship must focus on the main stem and the tributaries within a watershed. Our current research focuses on both of these critical areas.

Policy Issues

•Restrictions on appropriative surface water storage reduce the water security of agriculturalists and force certain farmers to rely more on groundwater pumping and/or riparian summer diversions from seasonal streams than on winter diversions and storage.
•Groundwater pumping and summer diversions in the vicinity of small seasonal streams can be detrimental to the survival of juvenile salmon species.
•Restrictions on surface water extraction and storage aimed at protecting winter bypass flows for adult salmon can have an adverse effect on juvenile salmon as diversions shift from the winter to the summer.
•A potential policy alternative would alleviate the situation by allowing landowners to construct low-impact, onsite reservoirs to be filled during the winter when water flows are high
•Such reservoirs would potentially improve summer instream flows for juvenile salmon by reducing demand for summer diversions; enhance water security for many farmers; and maintain the necessary winter bypass flows for adult salmon.

Figure 1: Pictures of winter and summer instream flows within the same stream

Figure 2: An onsite reservoir located next to vineyards

Study Area

The proposed study areas are the Russian River and Sonoma Valley watersheds, located within Sonoma County, California. An existing restriction on water rights for diversion and storage is having an adverse effect on salmon populations and reduces the water security of many farmers. The major crop produced in this area is grapes.

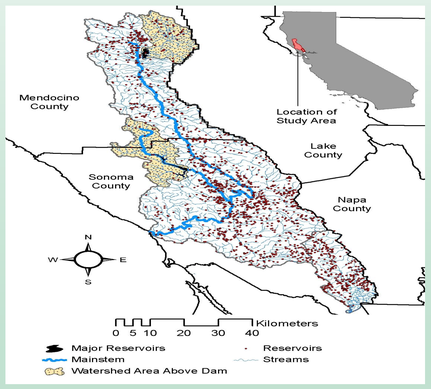

Figure 3: The Russian River and Sonoma Valley watersheds. Figure illustrates that the majority of water rights are off the main stem

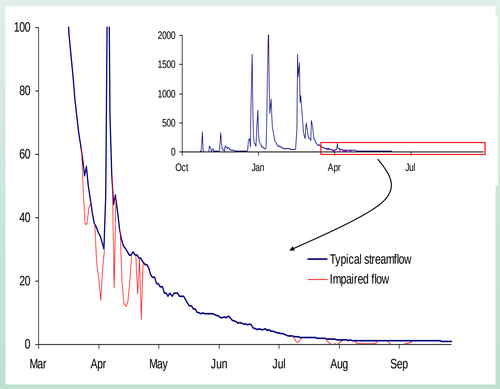

Figure 4: Hydrograph of natural streamflow and impaired flow caused by agricultural diversions and pumping (Deitch et al., in press).

Research Objectives

•Develop a spatially explicit economic model to analyze the demand for additional onsite storage with and without the existing regulatory restrictions.
•Determine which landowners have unmet demands for onsite storage versus those who prefer to pump groundwater, and thus would not request an appropriative water right for storage, even in the absence of a policy restriction.

Methodology

• Farmers are assumed to make simultaneous decisions regarding water management and vineyard plantation decisions. Estimation of water storage demand thus necessitates the explicit recognition of this simultaneous decision process.
• The demand model is a simultaneous equations model with censoring, where both variables of interest are censored below zero.
• We estimate the reduced-form version of such a model. The model in its reduced-form is a Bivariate Tobit specification:

$$y_1^* = \pi_1' x + v_1, \quad y_1 = Max(0, y_1^*)$$
$$y_2^* = \pi_2' x + v_2, \quad y_2 = Max(0, y_2^*)$$
$$[v_1, v_2] \quad BVN\left[(0,0), \theta_1^2, \theta_2^2, \tau\right]$$

Data

The dataset used to conduct the estimation consists of parcel-level GIS panel data from Sonoma County, California, for the period 1973-2006. The data contains information on the two dependent variables, which are parcel onsite reservoir size and vineyard acreage, as well as all exogenous variables, which include parcel land properties such as geology, slope, distance to the nearest highway, elevation, as well as variables that indicate whether the property has riparian access to the main stem or a seasonal tributary and climate information measured in growing-degree days.

Results

Variable	Before species listing in 1973-1993 period		After species listing in 1993-2006 period	
Vineyard development equation	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
ln Lot size (acres)	0.136324**	0.0122	0.1051826**	0.0086
Average slope	-0.0243069**	0.0016	-0.0219758**	0.0010
Main stem	0.1257667*	0.0512	0.0544	0.0403
Stream	-0.0726743**	0.0254	-0.0821986**	0.0177
Distance to nearest highway	-0.0127*	0.0000	-0.00945*	0.0000
Growing-degree days	0.8068**	0.0001	0.4305**	0.0000
Elevation	-0.1654	0.0001	-0.2598**	0.0001
Floodplain	0.0637	0.0422	-0.0291	0.0330
Old alluvium	-0.1477504**	0.0358	-0.0674003*	0.0276
Volcanic	-0.2449922**	0.0446	-0.1290502**	0.0319
Franciscan	-0.2354565**	0.0472	-0.1501751**	0.0348
Constant	-2.833679**	0.1796	-1.268403**	0.1049

Reservoir construction equation	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
ln Lot size (acres)	0.2263573**	0.0154	0.2140821**	0.0136
Average slope	-0.021177**	0.0019	-0.0206721**	0.0016
Main stem	-0.1859865*	0.0821	-0.237658**	0.0754
Stream	0.0989695**	0.0317	0.0682932*	0.0276
Distance to nearest highway	-0.0097	0.0000	-0.0099	0.0000
Growing-degree days	0.2209**	0.0000	0.1953**	0.0000
Elevation	0.2192	0.0001	0.2202*	0.0001
Floodplain	-0.0384	0.0600	-0.0511	0.0542
Old alluvium	0.3154095**	0.0533	0.2942252**	0.0475
Volcanic	0.2894303**	0.0601	0.2840492**	0.0532
Franciscan	0.2791404**	0.0632	0.291709**	0.0562
Constant	-2.23695**	0.1843	-1.985221**	0.1579
atan_rho	0.1902742**	0.0522	0.2454555**	0.0448

Conclusions/Future Directions

•Most parameter estimates are significant at the 1% and 5% levels, indicating their importance in influencing reservoir and vineyard construction decisions.
•Parameter estimates for the reservoir equation do not show significant changes across periods. This indicates that reservoir expansion was not significant following the restrictions on water rights.
•Parameter estimates for the vineyard equation do show significant changes across periods, illustrating that vineyards have continued to expand in light of water rights restrictions.
•Model estimates indicate that landowners off the main stem and near tributaries favor reservoir construction more than those along the main stem.
•We plan to integrate the spatially explicit economic model with a hydrologic model in order to analyze the extent to which regulations can be changed in order to improve agricultural water supply security and the attainment of instream flow requirements for endangered salmonids.