Prioritizing Environmental Water Acquisitions: Making the Most of Program Budgets

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Introduction

Those who manage water acquisitions for environmental needs must balance various factors – budget constraints, reliability of supplies acquired and tradeoffs with urban and agricultural water uses. Striking this balance means grappling with which water acquisitions to pursue and which to pass over. In this report, we review how others have worked out this problem by prioritizing water acquisitions. We also suggest how these strategies might be used and improved.

Imagine an environmental program seeking to acquire 10,000 acre-feet of water from agriculture to seasonally supplement instream flows. There are 100,000 acre-feet consumed on croplands in the relevant watershed. Which farms should the program focus upon? What criteria should be considered when prioritizing which crop lands to engage in fallowing?

Identifying and ranking various environmental and financial benefits and costs associated with water acquisitions is the main goal of prioritizing. Benefits could include farm location, water quality effects, and ease of measuring and monitoring reductions in farm consumptive use. Purchase price often is the foremost cost, but costs related to water conveyance, evaporation losses, satisfying legal requirements, political sensitivities, and community impacts need to be considered as well. Prioritizing offers is a systematic way to tally important costs and benefits, and choose the most advantageous acquisitions to pursue.

Before prioritizing begins, we assume that croplands under consideration have already met basic eligibility requirements. We treat cropland eligibility and prioritizing as two distinct issues. Prioritizing is about identifying which specific opportunities will best meet water acquisition goals, and most cost-effectively. In contrast, setting basic eligibility rules has to do with screening out participation from unsuitable growers and locations.[2] A common eligibility rule screens out acquisition of "paper water," known in Australia as "sleeper rights" (Chong and Sunding 2006). These rights represent water that has not been regularly or recently used for irrigation. The acquisition of paper water secures no actual "wet water", a crucial factor when environmental improvements are sought.

In some cases, eligibility rules may be all that a program needs. In Imperial Irrigation District (IID), fallowing offers from growers are not prioritized. If offers from eligible growers exceed program needs, IID uses a lottery to pick which ones to accept. Offers not picked for the current year are given priority the next year (IID 2010). For IID, prioritizing is not worthwhile because farms in their district are similar enough that prioritizing based on farm location and other characteristics would not improve the effectiveness of their water acquisitions program.

The following section discusses programs to acquire water for environmental purposes in the western United States. We focus on prioritizing which water assets to acquire to best accomplish program goals, although prioritization among multiple goals is often a necessary

[2] See Colby and Bark (2008) and Table 3 Examples of Water Transfer Eligibility Criteria

first step. The prioritizing process can be generalized to three steps: identifying the priorities of the acquisition program, simplifying those priorities into a practical ranking scheme, and applying the scheme to choose which water assets to target.

Prioritization Case Examples

Lahontan Valley, Nevada

The degradation of wetland habitat in the Lahontan Valley led to a federal water purchase program beginning in the 1990's. Water rights are still being purchased to support environmental improvements in the area. The program buys water from farmers, ranchers, and other willing sellers at market prices for environmental restoration (FWS 2012). Isé and Sunding (1998) surveyed participants, examined the program's performance, and suggested how it might be improved. They surveyed water sellers to find out what influenced sales and asked sellers for suggestions on improving the program. Although the program is ongoing, Isé and Sunding's 1998 analysis of its early years provides suggestions that are still relevant to prioritization in acquisition programs. Their finding that characteristics unrelated to the program strongly influenced sales also suggest that prioritizing is needed to source water that is the best fit for a program.

Isé and Sunding (1998) found that personal characteristics strongly influenced who sold water. Farmers were more likely to sell if they were having financial or personal problems, and not necessarily because their land or water was a good fit for the program's environmental goals. Isé and Sunding (1998) warn that, for these reasons, the program's acquisitions likely have decreased agricultural production and profits more than was necessary given the quantities of water acquired.

One of the survey respondents suggested that the program purchase water on poor quality fields that were difficult to irrigate. Isé and Sunding (1998) followed up by suggesting that acquisition programs target water associated with, "the worst types of soil, topography less suited to farming, and land with the highest conveyance losses." The authors warn that this approach will likely cost more to implement due to additional screening.

Isé and Sunding recommend soil type, topography and conveyance losses as ranking system elements. We offer a few suggestions related to soil quality and distance from irrigation source. If data on crop yields or soil quality are available for recent prior years, water acquirers might focus on the lowest productivity farmland for fallowing. The Natural Resources Conservation Service (NRCS) publishes detailed data including soil type, crop yields, and characteristics like pH and salinity. This data can be downloaded as a geospatial database from the Soil Data Mart.[3] It may also be viewed online and downloaded in report form via the Web Soil Survey.[4] Figure 1 is a Web Soil Survey yield map for alfalfa in the Lahontan Valley near Fallon, NV.

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[3] "Soil Data Mart," NRCS, last accessed August 27, 2012, http://soildatamart.nrcs.usda.gov/.

[4] "Web Soil Survey," NRCS, modified February 17, 2012, http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

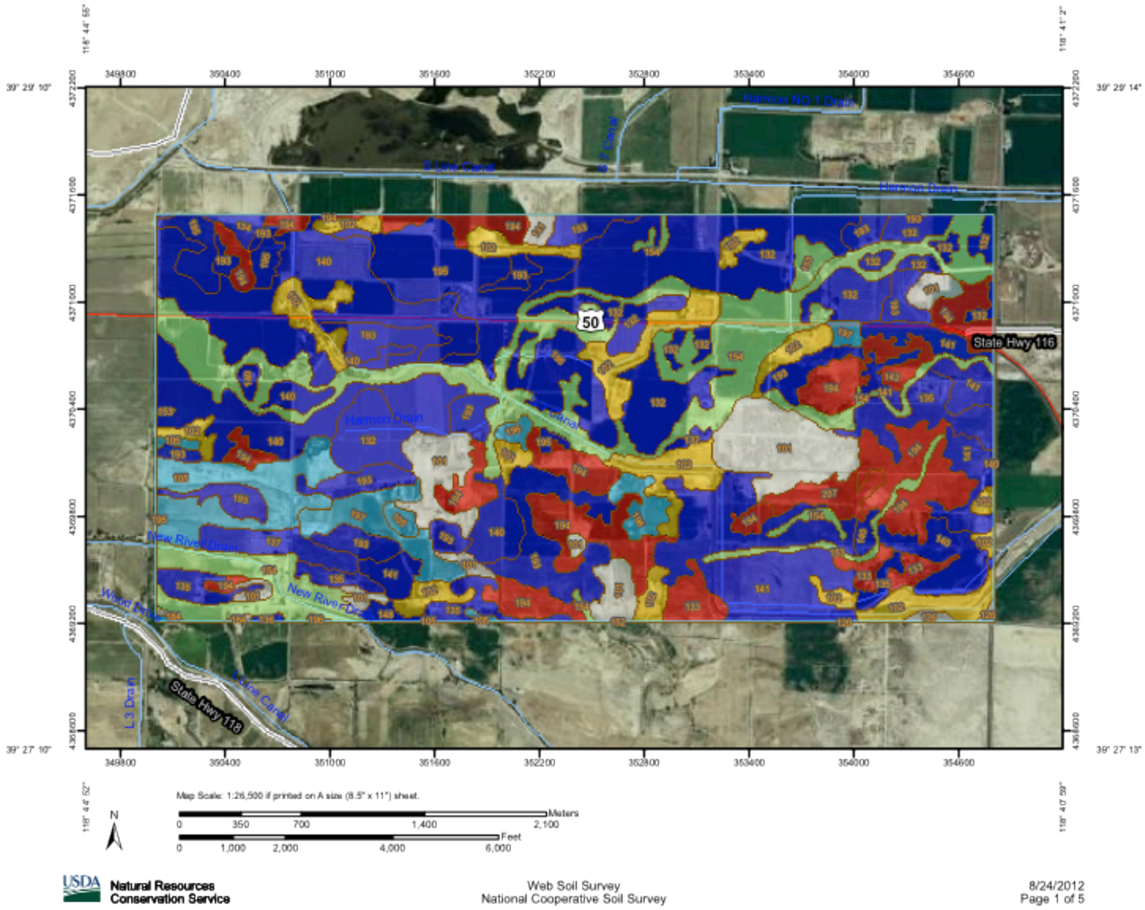

Figure 1 Yields of Alfalfa hay (tons), Fallon area survey, Nevada, February 2012

<= 0.22   > 0.22 and <= 0.4   > 0.4 and <= 3.39

> 3.39 and <= 4.93   > 4.93 and 5.68   not available

This map shows ranges of alfalfa hay yields in tons per acre. Yields range from less than .22 tons per acre (red) to as much as 5.68 tons per acre (violet).[5] With maps like the one above, water acquisition programs could give preference to water leases on cropland that falls in the red, yellow, and green soil zones. Additional kinds of maps are available for some locations, such as farmland rating and irrigation features.

Conveyance losses may be a consideration for acquisition programs in some areas. While seepage from unlined ditches can replenish water tables and support aquatic habitat, it also causes higher volumes to be diverted from streams to deliver adequate water for crop requirements. In areas where reduced conveyance losses are helpful for environmental

[5] The Web Soil Survey homepage describes the steps to download soil reports and maps. There are 10 options to delineate the map area, including address or latitude and longitude. Maps are limited to an area of 10,000 acres. The maps are populated with the most recent data available, which in this case is February 2012.

restoration, distance from primary water source and type of conveyance infrastructure can be used to score crop land. For example, the distance from the irrigation source to the field could be multiplied by a conveyance loss factor based on conveyance type, capturing the influence of greater distance and unlined or open ditches. Fields farther from primary water sources and supplied by open, unlined ditches would receive a higher ranking for program participation. Fields supplied by pipes with minimal conveyance loss would receive the lowest ranking.

Columbia River Basin

The Northwest Power and Conservation Council (NWC) in the Columbia River Basin oversaw the creation of management plans for 58 tributary watersheds and mainstem segments of the river, over the period 2000-2005. The subbasin plans, approved in 2005, were developed collaboratively by multiple agencies and funded by the Bonneville Power Administration. "Subbasin plans identify priority restoration and protection strategies for habitat and fish and wildlife populations," in the Columbia River Basin.[6]

The Salmon River subbasin, for example, has the Salmon Subbasin Management Plan (SSM Plan) (Ecovista 2004). It offers guidelines for prioritizing restoration programs in the 14,000 square mile Salmon River subbasin. It does not cover prioritizing fallowing bids but it does provide insight into prioritizing among species restoration programs in general. One of the guiding principles of the SSM Plan that might be considered for any restoration project is to, "build from strength," or "work from the areas in the best condition outward" (Ecovista 2004). According to this principle, conservation should focus on preserving the areas in the best shape first before spreading out into more degraded areas.

The SSM Plan splits prioritizing into two categories: within watersheds and between watersheds. To prioritize restoration programs within watersheds, the SSM Plan workgroups compiled extensive lists of biological, environmental, and socioeconomic problems and objectives in the basin. They prioritized projects based on the highest priority environmental problems. The Upper Salmon Model Watershed Council developed a questionnaire to provide an additional level of prioritization in cases where several projects addressed high priority environmental problems. The questionnaire is summarized in Figure 2. Projects receive points based on their attributes for a total of up to 115 points. Basic project eligibility is included, at least to some extent, in the questionnaire. Instead of requiring projects to pass eligibility requirements related to targeted fish species or habitat improvement before being considered in a ranking, the SSM Plan included these options in the first two scoring categories.

The SSM Plan is a starting point for the level of detail possible in prioritizing. Not all of the project categories would be applicable to prioritizing among individual water transfer bids but many are adaptable. Instead of giving a higher ranking to projects that complement each other, a higher ranking could be given to bids that complement each other in any way that increases overall program benefits or lowers overall costs. For example, fallowing adjacent

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[6] "Process to review and adopt subbasin plans," accessed February 23, 2012, http://www.nwcouncil.org/fw/subbasinplanning/admin/reviewprocess.htm

fields might lower conveyance and monitoring costs. To promote larger groups of fallowing instead of randomly distributed fields, bids would receive points based on the total number of acres offered for fallowing in a given program quadrant. On the other hand, excessive impacts on one sector might be avoided by scoring bids lower if too many of them fallow the same crop. In this example, the fallowing acreages for each crop would be totaled. Bids for the most popular crop in each season would be given fewer points.

Question six in Figure 2 asks the reviewer to compare the costs and benefits of the project under consideration. However, the benefits of the project are still being quantified at this point. If the benefits of the project were well known, the questionnaire would be unnecessary. Asking the reviewer to judge the benefits compared to the costs brings ambiguity into the prioritizing process. The approach taken by the Edwards Aquifer Authority (EAA) in its 1997 Irrigation Suspension Program, described in the next section, was more straightforward. The EAA scored bids based on their attributes and then divided the scores by the bids' per acre costs. The EAA method would produce more defensible results, as it doesn't rely on judgments about whether benefits might be "high" or only "substantial" compared to costs. Following EAA's example, scoring based on perceived benefits would be left out of the questionnaire. Instead, the final project score would approximate benefits, which would then be divided by the project costs (on a total, per acre, or per acre-foot basis).

Figure 2 Salmon Subbasin Management Plan Ranking Questionnaire

Project attributes	points
1. Fish species expected to benefit	
Targeted fish	15
Other listed fish	10
Other native fish	5
No native fish	0
No target fish	project ineligible
	____
2. Habitat expected to be protected or increased	
Extensive habitat improvement	20
Greater than 2 miles of stream or 20 percent of watershed	15
From .5-2 miles of stream or 10-20 percent of watershed	10
Less than .5 miles of stream or 10 percent of watershed	5
No habitat improvement	project ineligible
	____
3. Immediacy of threatened species	
High threat of loss	10
Potential threat of loss	5
Minimal threat	0
	____
4. Long-term effectiveness	
Multiple problems solved	15
Original problem solved	10
Original problem partly solved	5
Cause of problem not dealt with	0
	____
5. Protecting, restoring, or enhancing (summing all that apply)	
Stream channel by dredging, etc.	2
Stream banks by armoring, etc	2
Spawning and rearing habitat by water quality, etc	4
Fish passage by increased flow, etc	5
Bank and channel cover	2
	____
6. Benefits versus costs	
Benefits high compared to costs	10
Benefits substantial compared to costs	7
Benefits and costs about equal	5
Costs exceed benefits	3
Costs greatly exceed benefits	0
	____
7. Cost sharing or in-kind services	
Multiple funding sources and/or in-kind landowner support	10
Funding *and* in-kind landowner support	7
Funding *or* in-kind landowner support	5
Funding from project agency only	3
No funding	0
	____
8. Complements other projects or land management goals	
Complements 2 or more projects or goals	10
Complements 1 project or goal	5
Addresses other goals	3
	____
9. Time to realization of benefits	
Up to 2 years	10
2-10 years	7
10-20 years	5
20+ years	3
	____
	Total ______

Adapted from Ecovista (2004)

The questionnaire was intended to rank projects within a single watershed. The SSM Plan workgroups also considered how projects between watersheds could be ranked. However, in the end, prioritizing between watersheds was deemed infeasible because of the large variation in geography, land use, and population. The SSM Plan does, however, list basic factors to consider in prioritizing projects between watersheds. The factors are summarized in Table 1.

Factors identified as important for ranking projects between watersheds might also be used in ranking individual bids. Field topology and soil characteristics including salinity, location of fields' diversions and return flows, and local water table depth might all contribute to ranking offers to participate from specific farmers and fields.

Table 1 Prioritizing Between Watersheds

Human Impact What is the current state of the watershed? What kind of restoration potential does it have? How will continuing human impacts affect restoration program goals?	*Abundance* How abundant is the species in the proposed restoration area? At what scale is restoration needed to improve species abundance? Will the restoration program significantly affect numbers?
Species/population weighting How do the socioeconomic and ecological conditions in the watershed compare? Is there reason to focus on one above the other? Are there listed species in the watershed? What is the unemployment rate?	*Watershed topology* What natural features make the watershed more or less attractive for restoration programs? Examples: high naturally occurring salinity, sediment loads, water storage capacity, historic and current water table level, location of water diversions and return flows.
Diversity What is the current and historical species diversity in the watershed? Will the restoration program offer other benefits, e.g., reduced water treatment costs, improved future crop yields, recreation, and eco-tourism?	*Spatial characteristics* Where are restoration programs proposed and how closely can they be linked to target areas? Is the watershed remote?
Time scale How long is the restoration project? How long has the watershed been impacted? How does project timing align with water needs (seasonal water needs, crop rotations)?	*Productivity* How productive is the proposed restoration area? Have targeted species recently or historically thrived there?

Adapted from Ecovista (2004) with additions

A related program in the Columbia Basin began in 2002: the Columbia Basin Water Transactions Program (CBWTP). The CBWTP has committed over 5.8 million acre-feet of water to instream flows in the Columbia Basin (NFWF 2012). The nonprofit National Fish and Wildlife Foundation (NFWF) manages the program. The Bonneville Power Administration is a partner on the program and provides major funding in cooperation with the NWC (Northwest Power and Conservation Council).[7] Participants interested in the CBWTP must go through one of the program's partners. Partners include local and state entities like The Freshwater Trust or the Idaho Department of Water Resources. Hardner and Gullison reviewed the program in 2007. Prioritization was not used to narrow accepted bids down—many partners reported having too few water sellers to meet flow targets (Hardner and Gullison 2007).

The transaction submission process likely makes prioritization unnecessary. Unlike many programs that require bids to meet only basic eligibility criteria, the CBWTP requires an extensive proposal with responses to multifaceted criteria. The proposal criteria are provided in a document on the CBWTP's website.[8] According to the document, the NFWF will prioritize proposals for BPA funding based on ability to meet the outlined criteria (NFWF 2004). The criteria include requirements ranging from basic to complex. Basic requirements include valid and verifiable water rights. Complex ones require the proposal to address hydrological, biological, innovation, and watershed criteria. Not all of these criteria must be met for a proposal to be accepted, however exceptions need to be explained in a separate cover letter.[9]

The NFWF provides a checklist for partners to submit with transaction proposals (NFWF 2009). Hydrological criteria relate to the location, timing, and amount of water being transacted. Locations where low flows limit fish survival are preferred. The water also needs to be available at a time of year that will benefit fish and wildlife. The amount of water needs to be estimated and must contribute to restoring flows (NFWF 2004). Partners are asked to submit the name of the stream(s), approximate river miles that will benefit, and GPS coordinates for the original diversion point (NFWF 2009). As many as possible of the biological criteria should also be satisfied. Listed species, other native or wild fish, or wildlife should benefit from the proposal. Water quality should also be expected to improve. Innovative methods to increase tributary flows are preferred. Transactions also need to be cost-effective in terms of local market prices and based on standard valuation methods.

Monitoring criteria includes collecting monitoring data and storing that data and reporting it. Water flow, species benefit, and water quality are the monitoring components. Proposals should detail plans to make data available in regional public database systems. Regular reports of monitoring data analysis are expected. The proposal should also provide documentation of short and long-term flow increases (NFWF 2004). The watershed criteria deal with the proposal's relationship to other activities already taking place. This includes,

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[7] "The Program—Overview." Columbia Basin Water Transactions Program, accessed March 8, 2012. http://www.cbwtp.org/jsp/cbwtp/program.jsp

[8] "The Program—Applying for Funds." Columbia Basin Water Transactions Program, accessed March 8, 2012. http://www.cbwtp.org/jsp/cbwtp/program/apply.jsp

[9] Ibid.

collaboration with other partners, documented exploration of cost-sharing opportunities, consideration of synergies with other conservation efforts, and relationship to existing subbasin plans.

Another brief example of prioritizing from the CBWTP (Columbia Basin Water Transactions Program) was cited by Hardner and Gullison (2007). The partners prioritized transactions to reduce enforcement problems. In streams lacking clearly defined water rights, the location of sellers posed a potential problem. Instream flows purchased high in a stream were in danger of being diverted for use downstream. If downstream water users diverted instream flows before they could reach their targeted stretch, the purchase would be null. The partners avoided this problem by only purchasing water from lower in the basin, at the confluence of streams (Hardner and Gullison 2007).

The CBWTP program provides an example of an alternate way of selecting transactions. Many programs set basic eligibility criteria and then choose the best among a presumably larger pool of transactions. The CBWTP proposal criteria are detailed and partners submitting proposals must either answer all the questions on the checklist or explain why they are not answering. This approach might discourage participation from smaller or less sophisticated water users. On the other hand, this approach probably lowers the NFWF's costs because they do not need to screen as many proposals. We recommend new water transaction programs avoid extensive eligibility criteria, like those used in the CBWTP, until interest in the program is established. Policies that discourage participation from the start may limit the ability to secure water. If excessive or inappropriate transaction proposals create a burden on administrators then stricter eligibility criteria can be phased in over time.

Edwards Aquifer, Texas

The Edwards Aquifer, in central and south Texas, is an artesian aquifer serving about 1.7 million people.[10] Edwards Aquifer Authority (EAA) manages the aquifer and is responsible for conserving, preserving, and protecting it, and increasing recharge. The EAA began operating in 1996 (EAA 2011a). Cities, springs, agriculture, and federally protected species all inhabit the aquifer region and rely on its water to sustain themselves. The EAA has used irrigation suspension programs since its inception to manage these competing demands.

EAA's management is, however, the subject of a recent lawsuit. In early 2012, the Texas Supreme Court ruled on a challenge by landowners to EAA's groundwater regulation. The court found that landowners have ownership rights in the groundwater beneath their property and are entitled to constitutional protection against takings.[11] While the implications are still being sorted out, this ruling could significantly affect the EAA and its voluntary forbearance program.

[10] "Where is the Aquifer Located," Edwards Aquifer Authority, last accessed September 27, 2012, http://www.edwardsaquifer.org/display_education_portal_m.php?pg=education_where_is_the_aquifer_located
[11] *The Edwards Aquifer Authority v. Day*, Texas Supreme Court, February 24, 2012

Despite these uncertainties, the EAA initiated a new irrigation suspension program with a letter to irrigators in August 2012, informing them of a Voluntary Irrigation Suspension Program Option (VISPO) starting in 2013 (EAA 2012). In the early stages of this program, prioritizing will be based first on location and then on contract length. The program will first target irrigators from Atascosa, Bexar, Comal and Hays counties to reach the 40,000 acre-feet conservation goal. Irrigators from Medina and Uvalde counties will be chosen to make up the balance. Of the irrigators applying for the program from Medina and Uvalde, preference will be given to those choosing the 10-year contract option (EAA 2011b). EAA's first program, the 1997 Irrigation Suspension Program, included a more comprehensive prioritization system and is examined in greater detail here.

The EAA 1997 Irrigation Suspension Program sought to increase water levels in the aquifer to sustain flows at Comal Springs (and other springs necessary to support habitat) by suspending irrigation on 10,000 acres of farmland. Cropland was chosen for the program based on a bidding and ranking process. The EAA received 125 bids for 26,880 acres. Of these bids, 120 met the basic eligibility requirements (land irrigated within the EAA during 1995 and 1996). The EAA devised a scoring and ranking system to choose the best bids from the 120 eligible.

The EAA needed less than half the acreage offered to reach their 1997 Irrigation Suspension Program goal. In the end, 39 fields were selected (Keplinger et al. 1998). To prioritize the bids, the EAA scored and ranked them based on farm characteristics and per acre bid price. Bids received points base on land location, recent crops, irrigation equipment, and potential dryland operations. More desirable characteristics received more points. The points were then summed and divided into per acre bid price to get the final score. The EAA selected bids with the lowest scores until the 10,000-acre program goal was met (Keplinger et al. 1998).

The aspects the bids were scored on favored land and practices that would have the greatest impact on Comal Springs' flow. The first aspect was location. Farms with wells closest to Comal Springs received the most points (11). Wells located farther from the Springs received fewer points (from 10 to 6). The second aspect was 1995 and 1996 crop type. Alfalfa, pecans, and Coastal Bermudagrass received the most points (10). Corn; cotton; peanuts; sorghum, wheat, and hay; and cabbage, cauliflower, and cantaloupe received progressively fewer points (8 to 4). Double and triple planting of crops on the same field within a year received 1.3 and 1.6 times the single crop score. The third aspect was irrigation equipment. Flood irrigation received the most points (10). Furrow, traveling guns, high-pressure pivots, low-pressure pivots, LEPA pivots, and drip received progressively fewer points (9 to 3).

The final scoring aspect was intended to help protect agricultural economies and communities (Keplinger et al. 1998). It favored bids in which the farmer committed to dryland farming during the program. A "yes" to dryland farming commitments received a 10 and a "no" received zero (Keplinger et al. 1998). A hypothetical score from a farm located in Northeast Medina County historically growing a double corn crop using a high-pressure pivot system with a commitment to dryland farming is summarized in Table 2.

In their evaluation of the EAA's irrigation suspension program, Keplinger et al. (1998) noted that 82 percent of bids received subtotal scores between 32 and 38. Because of the small range, the final ranking was determined largely by the per-acre bid price. Keplinger et al. also said that including dryland farming in the ranking probably increased program costs even though most irrigators would have planted dryland crops without any incentive. They suggested an alternative set of equations that would minimize costs by ranking bids in terms of modeled springflow effect.

Table 2 Bid Ranking Example

Criteria		Scoring
Location	NE Medina County	8
Crop type	Corn (double crop)	8 x 1.3 = 10.4
Irrigation type	High-pressure pivot	6
Dryland	Yes	10
		34.4
Bid price	$300 per acre	
	Final score	8.72

Source: Keplinger et al. (1998)

In the Keplinger et al. ranking system, springflow effect would be estimated by multiplying reduced irrigation in acre-feet by modeled springflow effect in acre-feet. The springflow effect is estimated with a statistical regression model developed by Keplinger and McCarl (1995) that uses hydrological data from a groundwater simulation model. It estimates springflow effect based on the location of the well and the amount of reduced irrigation.

Keplinger et al.'s alternative method for ranking bids has the potential to provide more accurate estimates of a bid's effect on springflow. However, the increased accuracy may not be outweighed by the extra calculation costs of developing and running hydrological and statistical models in order to estimate springflow effects. The EAA's method, which assigns bid scores based on easily observed and verified farm characteristics, is more practical to implement. The scoring may be refined over time using springflow model parameters. For example, instead of scoring a farm based on it's county, a farm could be scored on its distance from the spring, soil type, or underlying geography. A ranking approach like the EAA's, based on county and other farm characteristics, could be sufficient depending on the reason for water acquisitions and the program area. Texas counties around the EAA's program area are relatively small. In places with larger counties, ranking bids by county may be useless. In those cases, the benefits of Keplinger et al.'s model-based ranking could outweigh the costs.

Keplinger's et al.'s suggestion to remove dryland farming from the decision process also brings up an interesting point about bringing non-water related objectives into the ranking process. In this case, the EAA hoped to encourage farmers to keep some production going to reduce the program's economic impacts. Keplinger et al. (1998) suggested that including dryland farming in the ranking process increased costs without having any real impact on the rate of dryland farming. Water managers should consider the effect ranking criteria would have on farmers' decisions to offer water and their offer price. In programs allowing farmers to continue dryland operations on enrolled land, most participants would be expected to dryland farm if it were economically advantageous, so no additional incentive is needed. If conditions made dryland farming uneconomical, water managers should examine the importance to their program objectives of promoting dryland farming. Other non-water related program goals may be promoted in bid ranking, but unintended consequences and possible counter-program results should be considered.

Klamath Water Bank

The Bureau of Reclamation (BOR) solicited bids for the 2007 Klamath Water Bank (called the Water Supply Enhancement Study) for up to 100,000 acre-feet of water. The BOR described their ranking and selection process in their bid solicitation announcement. The main ranking criterion was lowest price per acre-foot of conserved water. The price per acre-foot of conserved water was determined based on evapotranspiration (ET) or irrigation requirements (BOR 2007). ET per acre was estimated based on historic crop type and soil texture using a GIS model. Bid price per acre was then divided by ET per acre to get the per acre-foot price of conserved water. For groundwater substitution bids, estimated irrigation requirement was used instead of ET. The estimated irrigation requirement was also estimated with a GIS model using crop and soil types. Bids were ranked first on price but preference was also given to bids that contributed to larger contiguous groups of acres.

The Klamath Water and Power Authority (KWAPA) administered subsequent programs that followed the Klamath Water Bank, under various program names. In the 2010 Land Idling Program, bids were also ranked based on lowest price for conserved water. The KWAPA Executive Director calculated the price per acre-foot of conserved water based on crop, soil, ET, and other unspecified criteria deemed relevant (KWAPA 2010).

Prioritizing options and tools

Salinity

Salinity damages in the U.S. range from \$500 to \$750 million per year.[12] Reducing salinity would benefit water users throughout salinity-affected basins. However, prioritizing based on salinity loading from cropland has not been used by any of the large fallowing programs. Salinity, in this context, is a broad term used to describe a variety of dissolved solids in water. Dissolved solids occur naturally in water but human activities contribute to higher concentrations. “Dissolved solids” include multiple ions, like bicarbonate, calcium, potassium, and sodium. Higher dissolved solids mean higher salinity. Natural salinity comes from geologic formations and soil. Human salinity contributors include agricultural and urban irrigation and wastewater (Anning 2008). Irrigation leaches salts from saline soils increasing dissolved solids and salinity in drainage.

Salinity is an attractive prioritizing factor for several reasons. Farmers with high salinity soils might be willing to accept lower payments than farmers that are similar in other respects. They

[12] “Colorado River Basin Salinity Control Project,” last modified April 18, 2011, http://www.usbr.gov/projects/Project.jsp?proj_Name=Colorado+River+Basin+Salinity+Control+Project

likely have lower per-acre crop yields, higher costs (Jacobson 2006), and therefore lower profit margins. And, acquisition programs might be willing to pay more for this water because it can accomplish multiple goals of acquiring water for environmental purposes while reducing salinity levels. Fallowing highly saline soils would improve runoff water quality and would lower damages for all downstream users. If fields in the upstream reaches of a basin were fallowed, the benefits would be compounded because of reduced salinity at all downstream locations. The benefits of lower salinity include lower treatment costs, increased crop yields, and in the case of the Colorado River Basin, potential savings in meeting salinity requirements at the U.S.-Mexico border. Cost sharing with agencies investing in salinity control might also be possible.

Prioritized salinity control has long been underway at a number of approved irrigation project areas in the Upper Colorado Basin, including Grand Valley and Uncompahgre Valley on Colorado's west slope, and the Price-San Rafael and Uintah sub-basins in Utah.[13] Prioritizing within approved project areas or outside of them however, could be challenging. Field mapping technology that has been used to map soil textures could be used to map field salinity. The problem with mapping field salinity is that it is a moving target—after a field is irrigated or exposed to flooding or drought, salt distribution in soil changes.[14] Using average field salinity to rank a bid might ameliorate this problem. The Colorado River Basin Salinity Control Forum has adopted a protocol and map using average values of salinity loading from irrigation in the Upper Basin to evaluate the funding of salinity control outside of currently approved project areas. This method is based on a USGS model called SPARROW (Kenney et al. 2009). Because these model outputs are available both within and outside of approved salinity control project areas, they could provide a consistent but static framework for evaluating environmental water acquisitions across the Upper Colorado River Basin. Salinity mapping by remote sensing is also possible, although calibrating satellite imagery with on-the-ground measurements is crucial. Imaging methods do not work as well as microwave and other penetrative methods for detecting salinity (Metternicht and Zinck 2003). Salinity varies with soil depth. The resolution and frequency of remote sensing data is also a limitation.

Australia

In a 2006 report, the Australian Government's Productivity Commission (PC) suggests ways to use and improve the existing water market in order to promote the National Water Initiative. The National Water Initiative is a national water reform agreement between the Commonwealth of Australia and New South Wales, Queensland, South Australia, the Australian Capital Territory, and Tasmania. The PC report was created to support water market mechanisms, encourage efficient rural water use, and address environmental

[13] Ibid. See also "NRCS Colorado Environmental Quality Incentive Program (EQIP) – 2012," NRCS, last modified September 11, 2012, http://www.co.nrcs.usda.gov/programs/eqip/eqip.html. NRCS funding of on-farm irrigation improvements is often combined with Reclamation funding of distribution system improvements under Title II of the 1974 Colorado River Basin Salinity Control Act. Such interagency projects are coordinated through the Colorado River Basin Salinity Control Forum.

[14] Kurt Nolte, Area Extension Agent, University of Arizona Cooperative Extension Yuma County, interview by Elizabeth Schuster, June 10, 2011

externalities (PC 2006). The report focuses on developing water markets but includes a few ways to prioritize market transactions.

The market may be used, for example, to address salinity problems. All irrigation areas in Australia deal with some form of salinity (PC 2006). Ways in which market incentives might be tapped to help counter salinity problems include salt cap and trade programs, salinity offset programs, zoned taxes that penalize activities that increase salinity, or subsidies for activities that decrease it. Cap and trade, and offsets are described in Box 1.[15] Victoria has a zoned salinity tax on certain water trades. Victoria has defined high and low impact zones. Trades into low impact zones are taxed per megaliter to offset salinity impacts. Trades into high impact zones are not allowed (PC 2006).

Box 1

Cap & Trade

Cap and trade is a market-based method to reduce pollution (carbon, salinity). The first part, the cap, is a pollution limit. The cap is set for a given region and time period. For example, a yearly salinity cap might be set for the Murray River at its lowest diversion point. River users are then given salinity permits that allow them to contribute a set amount of salinity to the river. The total of the permits is equal to the cap. The second part is trade—the buying and selling of permits. Users contributing less salinity than their permits may sell to users contributing more. This gives incentives for the users who can reduce salinity for the lowest cost to reduce their salinity and sell their excess permits for a profit. The cap can remain stable or can be reduced over time to improve resource quality. Cap and trade programs are in widespread use in many nations.

Offset Programs

Offset programs may be used in conjunction with cap and trade programs or by themselves. In an offset program, an increase in pollution for a specific region and time is prohibited without a balancing reduction somewhere in the same region. For example, any new or changed use of the Murray River that will increase salinity must be offset with an equal reduction in salinity. Users who increase salinity must purchase offsets from other users. The offsets sellers reduce their salinity contribution in order to sell offsets. Offset markets exist for many regulated pollutants in nations around the world.

[15] For general information see, "Cap and Trade," US Environmental Protection Agency, last accessed October 17, 2012, http://www.epa.gov/captrade/

ELOHA

Ecological Limits of Hydrologic Alteration (ELOHA) was developed to help river managers assess trade-offs in environmental flows at a regional scale in the absence of specific river studies. ELOHA often begins by classifying rivers based on flow and other characteristics. Flows alterations can then be related to river ecosystem health by comparing the river's flows to reference flows for its class (Arthington et al. 2006). Figure 3 shows a basic flowchart outlining ELOHA.

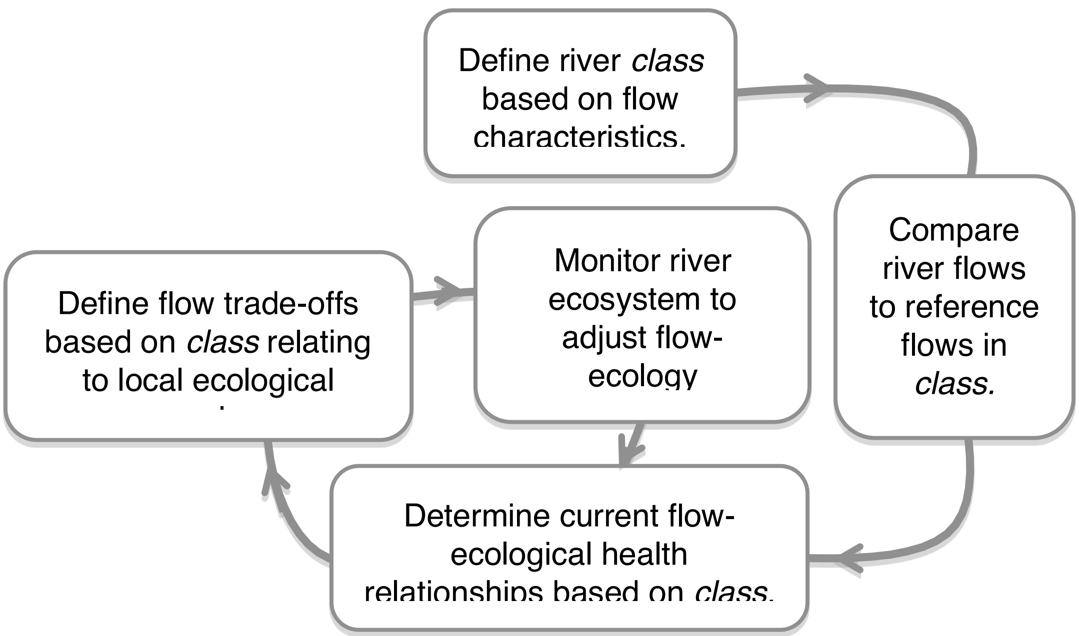


Figure 3 Simplified ELOHA Flowchart (Poff et al. 2010)

ELOHA has been used in basins throughout the world. Case studies from the US, Australia, and others are available on The Nature Conservancy's ConserveOnline website.[16] ELOHA could be used, especially in basins and rivers that haven't been extensively studied, to help water managers prioritize river conservation. ELOHA is well suited to evaluate trade-offs with differing flows at regional scales. Although the flow evaluation may be coarse, it will be consistent across the region and could be used to prioritize environmental water acquisitions within the region. More site-specific flow assessment may then be needed before proceeding with any set of prioritized transactions.

Ranking by Evapotranspiration Maps

Evapotranspiration (ET) varies across fields depending not just on crop, soil, and irrigation types but also on other site-specific characteristics. Remote-sensed ET maps could provide a more accurate way for acquirers to rank bids. Such ET mapping requires skilled staff, so their use would be limited to agencies with the necessary resources. To keep costs

[16] "ELOHA Case Studies," ConserveOnline, last accessed September 27, 2012, http://conserveonline.org/workspaces/eloha/documents/template-kyle

down, maps based on remote-sensed data might focus on one month or season that is locally important for water conservation. Such ET mapping could potentially replace ranking based on irrigation equipment and crop records. Prioritizing schemes that use crop records and irrigation equipment are trying to approximate ET. Remote-sensed ET maps may provide a more precise estimation. Intrinsic farm characteristics combined with farm management choices influence actual ET but these factors aren't taken into account in rankings based on historic crop and irrigation use only. Two farms growing alfalfa with flood irrigation would receive the same score in a traditional ranking scheme, but remote-sensed ET might show that one farm had higher ET. Instead of approximating water savings based on only two farm characteristics (i.e., crop types and flood v. sprinkler), remote-sensed ET maps would show the combined impact of the multitude of factors affecting ET.

Allen et al. (2007) have supported ET map use in Idaho using remote-sensed temperature and local weather station data. Others using similar methods include Elhaddad et al. (2011) in Colorado and California; French et al. (2010) in Arizona; and Taghvaeian (2011) in the Lower Colorado River basin. Glenn et al. (2010) have promoted an alternate and somewhat less complex ET estimation approach based on remotely-sensed vegetation indexes. Vegetation indexes have also been used by Tang et al. (2009) in the Klamath River basin; Hunsaker et al. (2007) in Arizona; and Nagler et al. (2009) in the Lower Colorado River basin. These authors describe many techniques for using remote-sensed data to estimate ET. Prioritizing transactions is not a primary aim of remote sensing research but many of these basins have water transaction programs. Prioritizing transactions could become an important byproduct.

Price Differentiation

Price differentiation could be used in addition to prioritization to secure more of the most sought after water. If irrigated lands are already being prioritized then adding a payment incentive is relatively straightforward. Offering higher payments based on superior features encourages more participation from agricultural water users whose lands and water entitlements have the best characteristics to address environmental objectives. The features being sought and prices on offer can be published with the call for water. For example, lands located in a hydrologic zone with closer connections to an important spring would receive a higher payment than lands with little hydrological connectivity to the spring. The overall effect on acquisition program cost effectiveness may be positive if higher payments result in more appropriate water offers. If the water acquired has a greater affect on the streams and wetlands targeted then, programs may be able to acquire less water overall and be able to afford to pay more for that water.

Need to Prioritize

Not all fallowing programs prioritize across eligible irrigated lands. The purpose of the acquisition program might make prioritizing unnecessary. In areas where fallowing from all farms has relatively similar effects on consumptive use and water quality, prioritizing could be unnecessary. Basic eligibility criteria would screen out unsuitable bids and croplands. The remaining bids could then be selected for the program based on any equitable system. For instance, Imperial Irrigation District picks fallowing bids based on a lottery. Fields that are not chosen for the current program are given priority in a future program (IID 2010). Table 3 outlines examples of water transfer eligibility standards for fallowing programs. These examples are summarized from multiple agencies including Imperial Irrigation District, Edward's Aquifer Authority, and Palo Verde Irrigation District. Following each standard is a short description of how it may be implemented. Colby and Bark (2008) examine fallowing program eligibility criteria in greater depth.

Table 3 Examples of Water Transfer Eligibility Criteria

Enrollment standard	Description
Participant's total water consumption must decrease equal to quantity of water transferred to program	Farmers can't enroll one field in the program then use more water on another field
Minimum acreage	Enrolled fields meet a minimum size requirement (10 acres, for instance) to help control program administration costs
Whole fields	Partial fields may not be enrolled
Valid water right based on recent and regular water use	Only recently and regularly irrigated fields may be enrolled
Water use history	History of field water use for a minimum number of years required
Legal right to fallow	Enrolled fields must be owned by enrolling party or have documented permission from field owner; participating farmers must prove they have the right to use water proposed for transfer
Account in good standing	Field owners may not have delinquent charges with a water agency
Water right seniority	Water must be at least a certain priority date
Location	Field must be located within the water district and/or sufficiently close to an environmental amenity
Historical crops grown	Transfer not allowed from fields traditionally growing certain crops, e.g., tree crops or crops with ambiguous consumptive water use

Enrollment standard	Description
Physical control over water delivery	Enrolled fields must have closable and/or lockable water access
Past fallowing program participation	Fields may not participate in a fallowing program for more than a specific number of consecutive years (intended to rotate benefits of participation among a wider group of farmers)

Illustrating Prioritizing Tools: Colorado's West Slope

Colorado's west slope is a prime spot to illustrate how prioritizing tools can be used to target water conservation for both flow quantity and quality management. The US Drought Monitor September 25, 2012 report shows the west slope as being in either severe or extreme drought.[17] The state is experiencing widespread drought and is undertaking a reconnaissance study of a water bank on its west slope to protect against curtailment of water use under the Colorado River compacts. Many of the tools mentioned in the previous sections might be useful for the west slope. For example, Colorado has its own ELOHA variation, the Watershed Flow Evaluation Tool (Sanderson et al. 2011). This tool has only been applied so far to the Upper Colorado and Yampa-White sub-basins (Sanderson 2012a, Sanderson 2012b) and so would need to be extended to the Gunnison, Dolores-San Miguel, and San Juan sub-basins to evaluate flow trade-offs consistently across Colorado's west slope. The SPARROW model and map is already being used by the Salinity Control Forum to evaluate the funding of improved irrigation management to reduce salinity loading outside approved project areas across Colorado's west slope. These tools might be used separately or in conjunction with simpler tools, like Web Soil Survey maps, to prioritize water conservation and quality transfers. One important criterion is that the tools and their data need to be readily accessible across the west slope or any region to which the prioritization will apply.

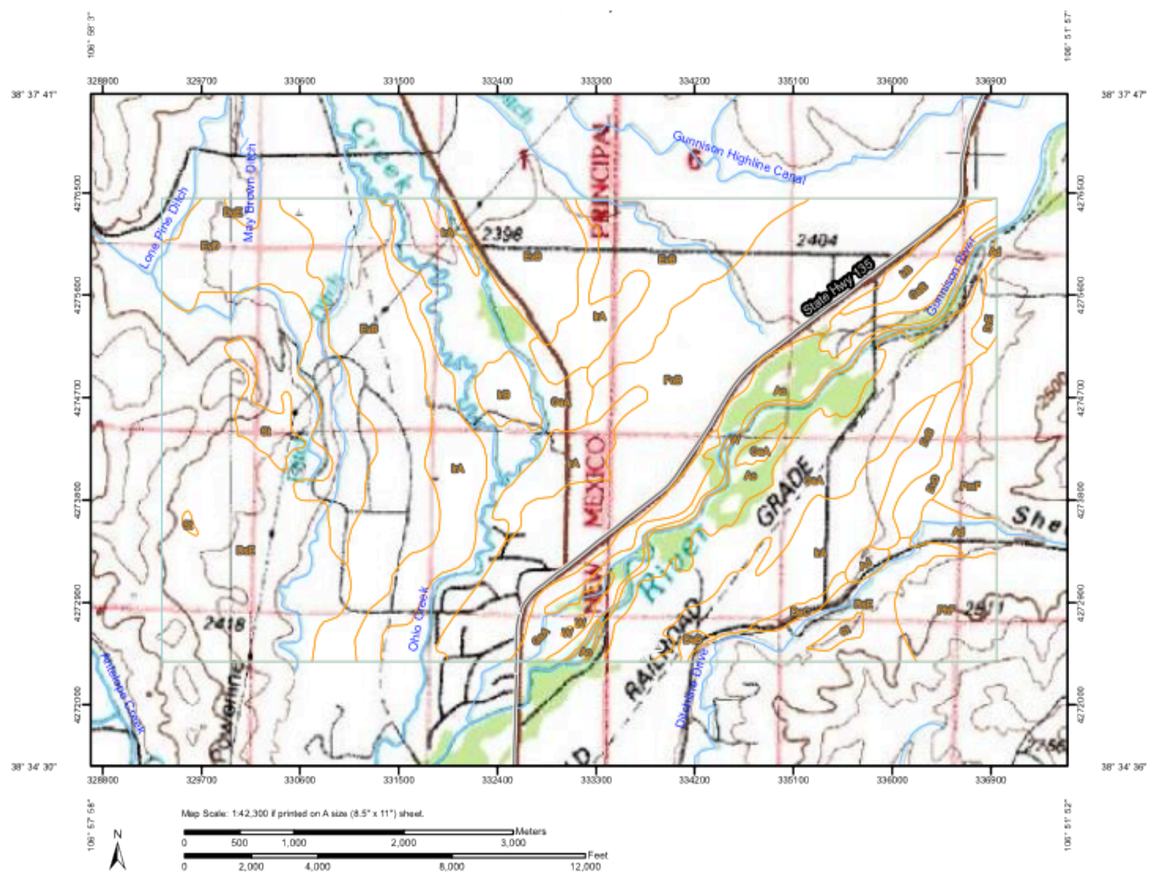
Web Soil Survey maps might be used to prioritize water transfers for either conservation or salinity.[18] Depth to water table maps could be used when prioritizing fields for deficit irrigation programs. With deficit irrigation, crops are irrigated below their full water use potential. Yields decrease with deficit irrigation but profit losses can be offset by water conservation payments.[19] Prioritizing may be particularly important for deficit irrigation agreements because deeper rooted crops like alfalfa or safflower can mine shallow groundwater (CDWR 2009). Thus, reducing application of surface water on these crops under a deficit irrigation agreement may inadvertently increase consumption of groundwater and result in less "savings" in net consumptive use than anticipated. Range production maps could be used to prioritize among

[17] "U.S. Drought Monitor Colorado," U.S. Drought Monitor, released September 27, 2012, http://droughtmonitor.unl.edu/DM_state.htm?CO,W

[18] "Web Soil Survey," USDA, modified February 17, 2012, http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

[19] See Lindenmayer et al. (2011) for a review of deficit irrigation of alfalfa in the great plains and intermountain west.

fields for pasture fallowing or deficit irrigation. Aerial photography maps could be used to prioritize fields based on manmade or natural features. Topographic maps could be used to prioritize fields based on elevations, ditches, and water bodies. The process of downloading Web Soil Survey maps is described here to illustrate prioritizing tools in Gunnison County, Colorado. Two maps and two map views were obtained: depth to water table and range production, and aerial photography and topographic map. Figure 4 shows a section of Gunnison County, CO north of Gunnison. The Gunnison River, ditches, and creeks are some



of the features discernable on the map.

Figure 4 Gunnison County, CO Topographic Map section

Figure 5 shows the same area as Figure 4 but with a smaller area designated as the Area of Interest (AOI). The Area of Interest must be 10,000 acres or less. The colors in the selected area show rangeland production for a normal year in pounds per acre per year. Finally, Figure 6 shows the depth to water table for the same area. Depth to water table is rated in centimeters. The blue area in the map is depth to water table greater than 200 centimeters. The tan area is depth to water table of between 25-50 centimeters. The yellow area is depth to water table of between 50-100 centimeters.

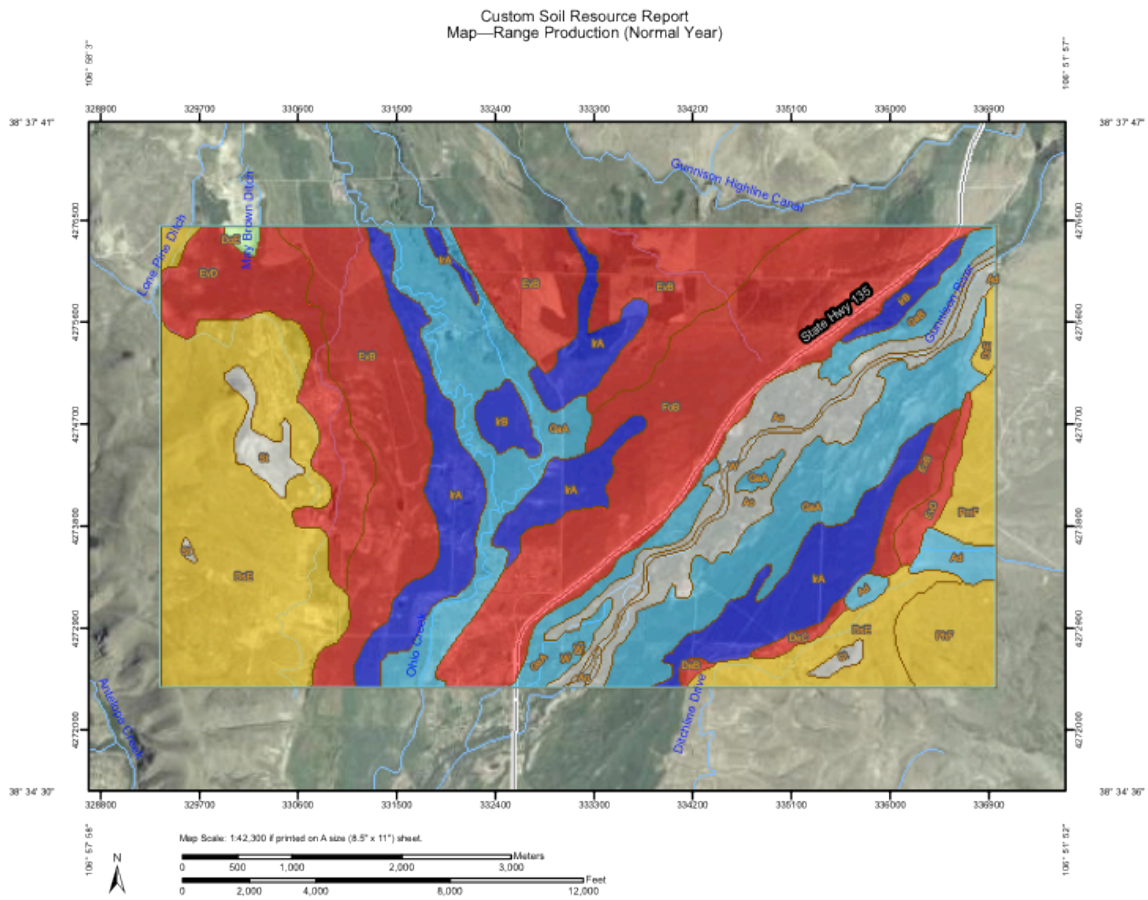


Figure 5 Gunnison County, CO Rangeland Production (Normal Year) 2008

Map Legend (pounds per acre per year)

- <= 800
- > 800 AND <= 1178
- > 1178 AND <= 1800
- > 1800 AND <= 2700
- > 2700 AND <= 3060
- Not rated or not available

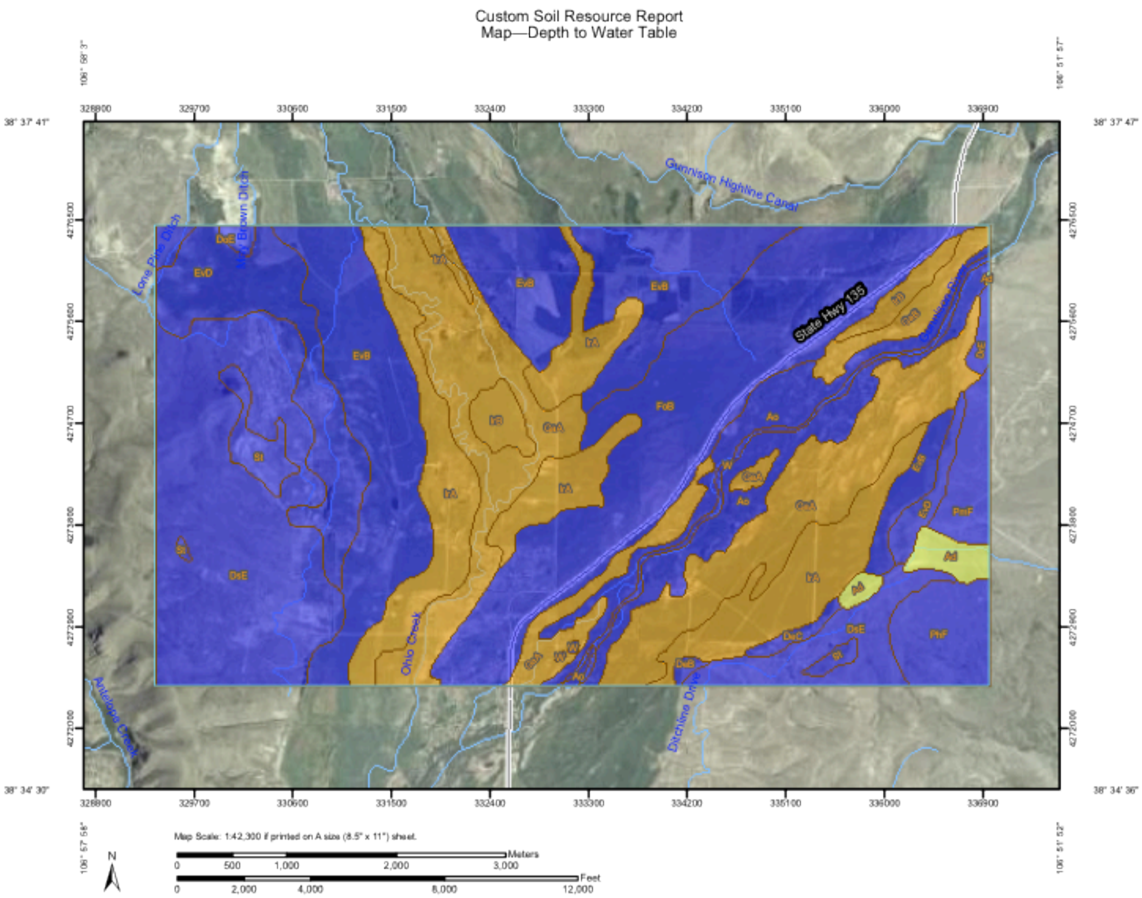


Figure 6 Gunnison County, CO Depth to Water Table

These maps shown here were downloaded in a single report from the Web Soil Survey.[20] The area of interest was defined using the map and select tools. If specific farms submitted fallowing or deficit irrigation proposals, addresses or parcels numbers could be used in Web Soil Survey. Once the area is defined, the maps are created using the Soil Data Explorer tab. Range production is found under Suitabilities and Limitations for Use, Vegetative Productivity. Depth to water table is found under Soil Properties and Qualities, Water Features. Once the map type is selected, the View Rating button creates the maps. The Legend button, on the top left of the map, has display options (including topographic map) and the map key. Maps may be downloaded by adding them to the shopping cart (free) and then checking out. They are available for immediate download.

Based on these maps, areas shown as blue in Figure 6 might be preferred for fallowing or deficit irrigation. They have lower water tables and also appear to correspond to the red and yellow areas in the rangeland production map, indicating lower production levels. Lower water tables make mining of groundwater by deep-rooted crops (like safflower or alfalfa) less likely in deficit irrigation programs. In areas with high water tables, these crops may continue to

[20] "Web Soil Survey," USDA, modified February 17, 2012, http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

consume water via deep taproots despite deficit irrigation, leading to higher than anticipated water consumption. Areas with lower rangeland production may be preferred as there are lower ranch profit losses when these lands are fallowed.

Conclusion

Water acquisition programs that support banking water to protect against drought shortfalls, or for habitat and species restoration are no longer a novel tool. Their continued use and refinement will make prioritizing among water acquisition opportunities more important. The process of prioritizing water transfers need not be complicated to offer advantages over random selection. Easily acquired data like field location, crop production, and irrigation infrastructure may all be used to choose cropland best suited to program goals.

In deciding how complex a prioritization scheme to adapt, it is crucial to consider the quality of scientific understanding that links cropland forbearance to effects on habitat and environmental amenities (Hardner and Gullison, 2007). Watershed-specific scientific studies needed to finely prioritize croplands for environmental benefits are not be available everywhere. The best methods for prioritizing in different basins will depend on the understanding of hydrologic and ecosystem connections and on the scope of available data.

In basins where necessary understanding and data is available, adopting a prioritization scheme could significantly enhance a program’s cost effectiveness. Accomplishing program goals at a lower cost helps funding agencies, local economies, and ecosystems. The degree to which these diverse sectors benefit depends upon how the ranking is done. Any factor can be favored in a ranking scheme—minimizing job displacement and other socioeconomic impacts, targeting best quality habitat, or reducing salinity. Careful program design can target the most essential values and improve program cost effectiveness. Programs may focus on environmental benefits by giving preference to water leases with the best connection to high priority streams. Programs may focus on reducing negative economic impacts on farm net income by acquiring water from the least productive land first. Programs may focus on farm-linked jobs by taking crops with lowest employment impacts out of production first.

Two underlying considerations in prioritizing acquisitions are worth re-emphasizing; eligibility criteria and legal restrictions. Some programs have strict eligibility requirements that limit the cropland that can participate and the amount of water that can be obtained. This reduces the need to prioritize but also discourages participation. Programs may need to revise eligibility criteria if too little cropland and water is made available. State and federal laws impose various procedural requirements and restrictions on water transfers. Laws may limit water transfers across boundaries like counties, basins, management areas, or states. Where applicable laws restrict certain kinds of transfers, basic program eligibility needs to screen out these transfers from program consideration.

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