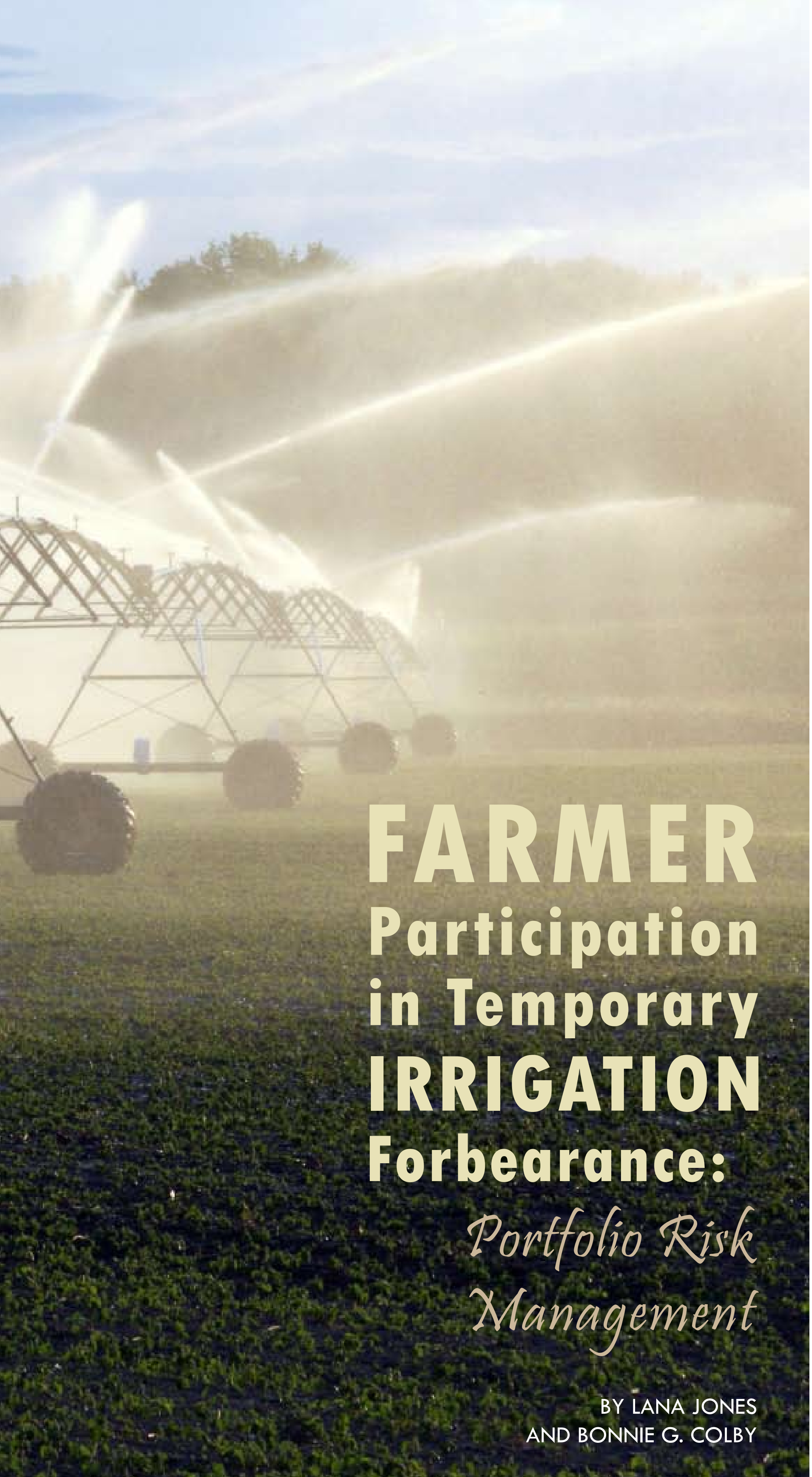

FARMER Participation in Temporary IRRIGATION Forbearance: *Portfolio Risk Management*

BY LANA JONES AND BONNIE G. COLBY

Introduction

The regular occurrence of extended drought in the West, combined with future prospects of more extreme drought episodes associated with climate change, particularly in the Southwest (Seager et al., 2007), imply that interest in water transfers from agricultural to municipal and environmental uses will remain high. Cities and conservation groups continue to look to agriculture for water because farmers and irrigation districts hold entitlements to large shares of reliable water. Permanent transfers of agricultural water ("buy and dry", like those from Owens Valley to Los Angeles in the early 20th century), were once the norm (Libecap, 2007). However, temporary transfers have become more common. Temporary water transfers put a smaller financial burden on the purchaser, who may only need the water to fill in gaps in urban supply reliability or water for fish recovery programs during dry years. Temporary transfers have lower negative impacts on agricultural communities because land is not permanently retired from agriculture. A potential drawback of temporary transfers is their inability to provide long-term water supply assurance. Dry-year option agreements that span multiple years or decades can solve this problem, providing farmers with a stable stream of revenue for their participation while filling in drought-related gaps in water needs of cities and habitat restoration programs.

The terms of dry-year option agreements (DYOs) vary with local needs. Typically, the buyer (a city, conservation organization or wildlife management agency) pays farmers to enroll some of their acreage in the DYO and then pays an annual fee per acre enrolled for the life of the agreement. When water is needed, the buyer notifies farmers to refrain from irrigating their enrolled land (irrigation forbearance or fallowing) and takes delivery of the water. The buyer uses it for their purposes and participating farmers receive an additional payment based on the amount of water transferred. The allowed timing, magnitude, or number of fallowing requests is generally specified in the agreement and limited over its life.

Cropland fallowing is not uncommon in agriculture. Farmers may periodically fallow fields to build up soil moisture and nutrients, discourage pests, or participate in USDA programs, such as the Conservation Reserve Program. DYOs provide income for fallowing. The willingness of cities or conservation organizations to pay more to use agricultural water during drought than some farmers provides incentive for these agreements.

Two DYOs are currently operating in southern California. In 2005, The Metropolitan Water District and the Palo Verde Irrigation District entered into a 35-year agreement (PVID-MWD). Farmers enrolling in the program receive a one-time payment of $3,170 per acre for each acre enrolled plus a payment each year fallowing is requested. Payments start at $602 per acre and are escalated annually by 2.5% for the first five years and 2.5-5% each of the remaining 30 years (PVID-MWD, 2004). In 2003, San Diego County Water Authority entered into a similar 15-year agreement with Imperial Irrigation District (IID, 2008). Fallowing payments are based on acre-foot of water conserved instead of acre. In 2005 payments were $60 per acre-foot conserved up to a maximum of $360 per acre (IID, 2005). Unlike the PVID-MWD agreement, where landowners enroll a portion of their land for potential fallowing over the life of the agreement, eligible IID farmers apply each year. Several smaller pilot programs have occurred in western Arizona, with the U.S. Bureau of Reclamation paying irrigation districts to arrange with member farmers to fallow a specific number of acres for a year in order to provide water for instream needs in the Lower Colorado River Basin (US Bureau of Reclamation, 2006, 2008ab, 2009). Voluntary, temporary fallowing also has been used in Oregon's Klamath Basin as part of the Klamath Water Bank. That program, which began in 2001 and has operated under various names ("Demand Reduction Program" in 2001), has gone through considerable changes in order to become a more well-accepted and cost effective mechanism for making water typically used in irrigation available for fish recovery needs (O'Donnell and Colby, 2009; US Bureau of Reclamation). Such programs are likely to become more widespread, presenting farmers and irrigation districts with a new set of financial and farm management considerations to weigh.

Farmers considering enrolling in a DYO in their region will naturally want to consider what effect participation can have on the expected return and risk of their crop portfolio. There are no published studies on the effect of fallowing on crop portfolio risk although studies on the economic benefits of transferring water from agricultural to municipal uses and the value of water in agriculture abound. For example, Michelsen and Young (1993) describe DYOs from agricultural to urban uses and estimate the value of programs to municipalities. They find that dry-year options are cost effective under a variety of conditions. Michelsen and Booker (1999) estimate the cost of temporarily transferring water from agriculture to instream flows in the Yampa River Basin based on the water's value to farmers. Payments designed to keep farmers as well off as if they had used the water in production were estimated to be between $17 and $160 per acre-foot depending on the crop grown.

In this article, we complement existing research on temporary water transfers by examining how payment-supported fallowing programs affect farmers' portfolio of crop activities and risk. The approach we demonstrate here may help farmers decide whether or not to participate in such programs, and to what extent, while enabling policy makers to design fallowing programs. Programs that better consider farm portfolio and risk management strategies could prove more attractive to a broad range of farmers.

Conceptual Model

Farmers routinely encounter risks in producing crops related to: their decisions, the market, the possible return on water as an asset, and the investments they make in technology or efficiency improvements (Shaw, 2005). The USDA (1997) groups agricultural risks into five main categories: production, marketing, finance, legal, and human resources. Unpredictable weather, changing prices, the cost and availability of debt financing, tax planning, and hiring labor are among the risks that agriculture faces (USDA, 1997). See Figure 1 for a breakdown of losses reported to the Risk Management Agency of the USDA for Arizona in 2008 and 2009.

Risk preferences dictate how farmers, and all decision makers, deal with risk. People tend to apply different risk preferences to different aspects of life. For instance, a businessperson could be risk averse in managing their business assets while still enjoying hang gliding. In this article, we focus upon farmer preferences for higher-but-more-variable farm returns versus lower-but-more-stable farm returns. Risk-neutral farmers try to maximize expected or average farm returns, without taking

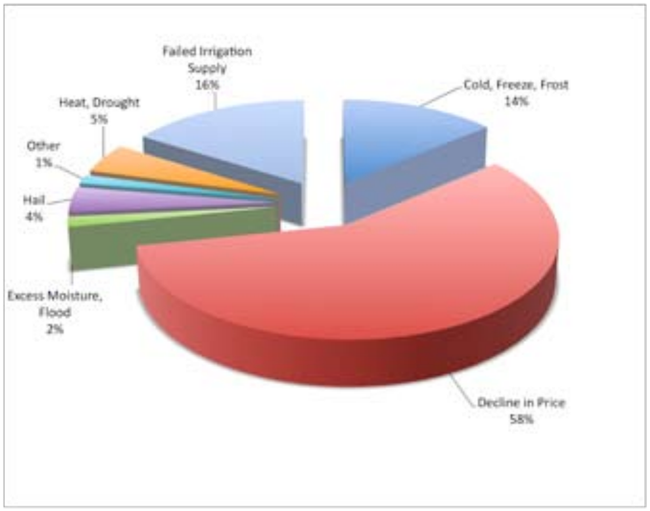

Figure 1. Breakdown of losses reported to the Risk Management Agency of the USDA for Arizona in 2008 and 2009.

the possible range, or variance, of those returns into account. Risk-averse farmers, on the other hand, would require a higher average farm return to engage in an activity that could yield a wider range of returns (Shaw, 2005). For example, a risk-neutral farmer who could produce cotton or wheat on the same field would be indifferent to the choice if they both yielded an average return of $50 per acre – even if cotton would likely yield from $0 to $100 per acre and wheat would likely yield from $25 to $75 per acre. A risk-averse farmer, on the other hand, would prefer wheat because although it has the same average return, the range of possible returns is smaller. Risk-averse farmers can reduce risk in one or more ways. They can hold on to their crops in the hope that prices will go up, for example, or diversify their operations (USDA, 1997).

Diversification of farm revenue-producing activities is a frequently suggested technique to reduce risk and income variability from year to year (Teegerstrom et al, 1997). Farmers diversify by planting different crops, combining crop and livestock production, or seeking alternate income sources. Participation in DYOs could also be viewed as a source of alternate income. DYOs may be more attractive than other forms of diversification (e.g., planting different crops), which can be prohibitively capital intensive and are subject to weather and pest risks. The diversification offered by option programs can be used as a farm risk-management tool. Since the payments are virtually risk-free once a farmer has enrolled in a program and has a contractual agreement, risk-averse farmers could benefit even if the per-acre payment were not as high as average - but uncertain - crop returns.

Diversification combines activities with varying degrees of correlation to reduce overall risk. Diversifying by growing wheat and cotton is less risky than growing cotton alone because cotton and wheat returns are not perfectly correlated. Combining positively, but not perfectly, correlated activities will reduce some risk but combining negatively correlated activities will provide the greatest risk reduction (Sonka and Patrick, 1984). The difference between positive and negative correlation is in how the two items change relative to one another. Gas prices, for example, are positively correlated with food prices – they tend to rise together in a relatively predictable pattern. Different crops may have highly correlated returns that move up and down together because of their shared reliance on weather (Markowitz, 1959). The payments from an option program, on the other hand, are fixed and so will have low correlation with crop returns. Dry-year options can offer farmers a fruitful way to reduce risk by diversification. A crop portfolio analysis is useful to examine how DYOs may benefit risk-averse farmers.

Portfolio Analysis and Results

Portfolio analysis involves combining investments in various proportions and picking the best combination based on investment criteria. In basic portfolio analyses, the decision maker is assumed to have two basic objectives: high return and low variability in that return (Markowitz, 1959). For farmers, the potential portfolio consists of revenue-producing activities such as crop production, DYOs, off-farm employment and other choices. If a risk-averse farmer were given the choice of multiple portfolios that all had the same average or expected return, she would prefer the least risky portfolio. The least risky portfolio is the one with the smallest variance, or the smallest range of probable returns. The best portfolios are those that have the lowest risk for a given level of return. In situations where a high-risk, high-return portfolio is compared to a low-risk, low-return portfolio, the specific risk

Table 1. Crop Returns, Yuma County, Arizona.

Yuma County, Arizona	2000	2001	2002	2003	2004	2005	2006	2007	2008	AVG
Hay Alfalfa										
Acres Harvested	30000	31500	32000	31000	28000	28000	21500	25000	25000	28000
Yield/Acre (tons)	8.7	8.3	8.6	9.7	10.0	9.1	9.1	9.4	9.8	9.2
Price/Ton ($)	94.00	99.00	100.00	89.50	99.50	124.00	128.00	151.00	186.00	119.00
Gross Returns/ Acre ($)	814.98	816.75	862.00	866.36	995.00	1129.64	1160.96	1419.40	1822.80	1098.65
Cotton, Upland										
Acres Harvested	25300	25500	17900	24500	26700	27300	21900	16800	9800	21744
Yield/Acre (lbs)	1385	1129	1397	1254	1438	1213	1315	1457	1420	1334
Price/lb ($)	0.40	0.28	0.46	0.66	0.44	0.52	0.53	0.60	0.57	0.50
LDP/lb ($)*	0.04	0.30	0.14	0.04	0.13	0.15	0.09	0.00	0.00	0.10
Gross Returns/ Acre ($)	610.81	654.12	847.29	887.80	829.81	805.62	813.71	868.37	809.40	791.88
Wheat, Durum										
Acres Harvested	38600	36400	44300	46000	42500	36300	35000	36200	43100**	40050
Yield/Acre (bushels)	101.7	95.8	96.5	102.7	100.0	103.0	106.0	107.0	107.3**	102.5
Price/Bushel ($)	3.50	3.95	4.40	4.65	4.25	4.20	4.85	7.11	8.30	5.39
Gross Returns/ Acre ($)	355.94	378.64	424.70	477.40	425.10	432.60	514.21	760.77	890.70	560.78
Lettuce, Head										
Acres Harvested	50300	51800	50000	49600	46500	49600	47600	39900	32700	46444
Yield/Acre (cwt)	350.0	365.0	350.0	360.0	360.0	325.0	330.0	365.0	360.0	351.7
Price/cwt ($)	13.10	16.50	38.70	10.30	22.20	14.60	14.10	21.00	15.80	18.48
Gross Returns/ Acre ($)	4585.00	6022.50	13545.00	3708.00	7992.00	4745.00	4653.00	7665.00	5688.00	6511.50

*LDP: Loan Deficiency Payments are a form of US price support. Farmers may request and receive LDP when cotton price falls below an established minimum.
**2008 Acres Harvested & Yield/Acre unavailable for Wheat, Durum at county level. Average of 2007 and 2009 values used.

Table 2. Crop Returns, La Paz County, Arizona.

La Paz County, Arizona	2000	2001	2002	2003	2004	2005	2006	2007	2008	AVG
Hay Alfalfa										
Acres Harvested	59000	61100	63000	61000	65000	70000	55000	60000	57000	61233
Yield/Acre (tons)	8.5	8.4	7.9	8.0	6.9	8.1	8.0	7.6	8.6	8.0
Price/Ton ($)	94.00	99.00	100.00	89.50	99.50	124.00	128.00	151.00	186.00	119.00
Gross Returns/ Acre ($)	796.18	829.62	794.00	718.69	688.54	1000.68	1024.00	1143.07	1599.60	954.93
Cotton, Upland										
Acres Harvested	17900	17000	12000	16000	20400	17900	15400	11800	8200	15178
Yield/Acre (lbs)	1378	1200	1248	1350	1553	1421	1465	1546.0	1832.0	1443.7
Price/lb ($)	0.40	0.28	0.46	0.66	0.44	0.52	0.53	0.60	0.57	0.50
LDP/lb ($)*	0.03	0.27	0.00	0.00	0.18	0.12	0.00	0.00	0.00	0.07
Gross Returns/ Acre ($)	582.89	664.75	577.82	896.40	972.39	902.61	769.13	921.42	1044.24	814.63
Wheat, Durum										
Acres Harvested	6500	5100	5600	8000	10000	5000	4000	6800	7650**	6375
Yield/Acre (bushels)	94.7	96.2	92.7	101.3	88.0	92.0	87.5	97.3	100.7**	93.2
Price/Bushel ($)	3.50	3.95	4.40	4.65	4.25	4.20	4.85	7.11	8.30	4.26
Gross Returns/ Acre ($)	331.43	379.95	407.83	471.20	374.09	386.40	424.46	692.04	835.91	396.48

*LDP: Loan Deficiency Payments are a form of US price support. Farmers may request and receive LDP when cotton price falls below an established minimum.
**2008 Acres Harvested & Yield/Acre unavailable for Wheat, Durum at county level. Average of 2007 and 2009 values used.

preferences of the farmer dictate which portfolio is preferred.

Portfolios including major crops grown in the Yuma and La Paz Counties in Arizona are examined in this paper. Yuma and La Paz County are each located in western Arizona along the Colorado River, which is their primary source of irrigation water. The per-acre returns for the crops considered are summarized in Table 1 and Table 2. In Yuma County, head lettuce has the highest average per acre return and the largest average acreage harvested. However, as shown in Table 3 it also has a high standard deviation of return and coefficient of variation (a standardized measure of riskiness) compared to the other crops. It is highly profitable but also highly risky. The lowest returns are coupled with the lowest standard deviation of returns and coefficient of variation in both counties.

The correlations of crop returns (including fallowing) are in Table 4. The payment for fallowing used in the portfolio analysis comes from the average per acre payment in the PVID-MWD agreement (PVID-MWD, 2004). The payment started in 2005 and escalates by 2.5% each of the first five years. Since payments were not available for years prior to 2005, the payment was assumed to be 2.5% less for each preceding year, compounding annually. Most crops' returns are positively correlated, although some are lower than others. Cotton and wheat returns are highly correlated in both counties so portfolios containing a combination of those crops would only slightly reduce risk. A portfolio containing wheat and fallowing, on the other hand, would be expected to be very effective at reducing risk. The portfolios used in this analysis are summarized in Table 5. They are: 100% in each crop; a 50/50 cotton and wheat split (CW); a 50/50 wheat and lettuce split (WL); a 45/45/10 cotton, wheat, and fallowing split (CWF); and a 45/45/10 wheat, lettuce, and fallowing split (WLF).

The portfolio analysis indicates that in all cases adding fallowing reduces the expected return of the portfolio, and also

Table 3. Crop Return Variation.

Yuma County	Std Dev	CV
Hay Alfalfa	337.78	31%
Cotton, Upland	95.06	12%
Wheat, Durum	183.65	33%
Lettuce, Head	3001.15	46%
La Paz County		
Hay Alfalfa	285.36	30%
Cotton, Upland	172.39	21%
Wheat, Durum	170.31	43%

Std Dev: Standard deviation of crop return.
Example: Yuma, AZ Hay Alfalfa has an expected return of $1098.65. Most years the return on alfalfa in Yuma will fall between $337.78 above or below this expected value, or between $760.87 and $1436.43.
CV: Coefficient of Variation is a standardized measure of risk.
Example: The CV of Yuma lettuce is higher than the CV of alfalfa. Lettuce is a riskier crop.

Programs that better consider farm portfolio and risk management strategies could prove more attractive to a broad range of farmers.

Table 4. Crop Return Correlations.

	Yuma Crop Correlations					La Paz Crop Correlations			
	alfalfa	cotton	wheat	lettuce	fallow	alfalfa	cotton	wheat	fallow
alfalfa	1.00					1.00			
cotton	0.35	1.00				0.51	1.00		
wheat	0.95	0.43	1.00			0.87	0.63	1.00	
lettuce	-0.11	0.26	-0.04	1.00					
fallow	0.91	0.60	0.86	-0.12	1.00	0.80	0.79	0.79	1.00

Combining positively correlated crops will reduce risk less than combining negatively correlated crops. Diversifying a lettuce-only portfolio with cotton (correlation = .26) will reduce risk less than diversifying the same portfolio with alfalfa (correlation = -.11).

reduces risk. Combining fallowing with portfolios containing a mix of other crops reduces the coefficient of variation (risk) compared to the same portfolio without fallowing. Generally, the analysis reveals that higher returns are coupled with higher risk in single crop portfolios. The most preferred portfolio would depend on the risk aversion of the individual farmer.

Concluding Remarks

Portfolio analysis reveals that risk-averse farmers could benefit by enrolling in DYOs and adding fallowing to their crop portfolio. Expected returns would be slightly reduced but the variation of those returns would also be lower, leading to a lower variation per dollar of return. These results could be used by policy makers seeking to enter into DYOs with farmers to structure the price in such a way that it reduces income variability while still maintaining a base level of expected return. Farmers may also use a similar technique to determine the optimal amount of fallowing in their portfolio. While most programs impose a limit on the amount of fallowing any single farmer may do, the farmer must choose the optimal participation within that limit based on their risk preference.

For decision makers requiring a more sophisticated analysis, an extension of the approach presented here could specify varying levels of risk aversion and then solve for the expected value-variance efficiency frontier (Robison and Barry, 1987). Using this more detailed analysis, a farmer who knows their own level of risk aversion could rank the different portfolios and identify the optimal portfolio for their risk preference. In addition, scenario analyses could be combined with the portfolio analysis to determine if a farm's optimal portfolios change under different crop price and input cost conditions and with different payment levels for participating in temporary fallowing. However, in this brief article we wished to simply introduce the idea of DYO participation as a risk management strategy for farmers and to illustrate a basic approach to considering how participation can be considered in a farm's overall portfolio of revenue producing activities, each with their own variance. The type of analysis used here can be applied in any region where there is good information about crop production revenues and expenses, such as the farm production budgets commonly produced by agricultural economists at land grant universities in each state. ■

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Additional Resources

These three recently completed guidebooks for stakeholders provide practical information for water supply climate change adaptation through using water banks, water auctions and dry-year contracts. The guidebooks provide a review of where and how these mechanisms have been used, implementation steps, and their strengths and weaknesses.

Michael O'Donnell and Bonnie Colby, Water Banks: A Tool for Enhancing Water Supply Reliability, January 2010, University of Arizona, Department of Agricultural and Resource Economics. http://ag.arizona.edu/arec/people/profiles/colby.html

Michael O'Donnell and Bonnie Colby, Dry-Year Water Supply Reliability Contracts: A Tool for Water Managers, October 2009; University of Arizona, Department of Agricultural and Resource Economics, http://ag.arizona.edu/arec/people/profiles/colby.html

Michael O'Donnell and Bonnie Colby, Water Auction Design for Supply Reliability: Design, Implementation, and Evaluation, May 2009. University of Arizona, Department of Agricultural and Resource Economics. http://ag.arizona.edu/arec/people/profiles/colby.html

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Table 5. Example Portfolios.

Yuma, AZ Portfolios									
Year	Alfalfa	Cotton	Wheat	Lettuce	Fallow	CW	LW	CWF	LWF
2000	814.98	610.81	355.94	4585.00	620.99	483.37	2470.47	497.13	2285.52
2001	816.75	654.12	378.64	6022.50	634.59	516.38	3200.57	528.20	2943.97
2002	862.00	847.29	424.70	13545.00	648.54	635.99	6984.85	637.25	6351.22
2003	866.36	887.80	477.40	3708.00	662.85	682.60	2092.70	680.63	1949.71
2004	995.00	829.81	425.10	7992.00	677.52	627.45	4208.55	632.46	3855.45
2005	1129.64	805.62	432.60	4745.00	692.57	619.11	2588.80	626.45	2399.18
2006	1160.96	813.71	514.21	4653.00	707.62	663.96	2583.60	668.32	2396.00
2007	1419.40	868.37	760.77	7665.00	723.05	814.57	4212.89	805.42	3863.90
2008	1822.80	809.40	890.70	5688.00	738.86	850.05	3289.35	838.93	3034.30
Exp. Return	1098.65	791.88	560.78	6511.50	678.51	654.83	3514.64	657.20	3231.03
Std. Dev.	337.78	95.06	183.65	3001.15	40.39	120.12	1499.88	111.09	1341.27
CV	30.7%	12.0%	32.7%	46.1%	6.0%	18.3%	42.7%	16.9%	41.5%
La Paz, AZ Portfolios									
Year	Alfalfa	Cotton	Wheat		Fallow	CW		CWF	
2000	796.18	582.89	331.43		620.99	457.16		473.54	
2001	829.62	664.75	379.95		634.59	522.35		533.57	
2002	794.00	577.82	407.83		648.54	492.83		508.40	
2003	718.69	896.40	471.20		662.85	683.80		681.70	
2004	688.54	972.39	374.09		677.52	673.24		673.67	
2005	1000.68	902.61	386.40		692.57	644.51		649.31	
2006	1024.00	769.13	424.46		707.62	596.79		607.88	
2007	1143.07	921.42	692.04		723.05	806.73		798.36	
2008	1599.60	1044.24	835.91		738.86	940.08		919.95	
Exp. Return	954.93	814.63	396.48		678.51	646.39		649.60	
Std. Dev.	285.36	172.39	170.31		40.39	154.64		141.89	
CV	29.9%	21.2%	43.0%		6.0%	23.9%		21.8%	