Western Economics Forum

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One of our goals is to provide a forum for economists to discuss timely events. Therefore, we asked research and extension professionals to write about the economic consequences of the drought that has besieged the west this past year. Inside this issue, you will find five articles ranging from the impacts of rangeland fires, institutional implications for water management, how drought relates to climate change, managing cattle on private and public lands, and how crop insurance and price support programs might be changed to account for systemic price and yield risk.

This issue marks the end of our inaugural year. We already have authors invited for our next issue, which will be delivered in April. We invite you to submit your own ideas for articles so we can begin planning our issue next fall. As you write your meetings papers for this summer, please consider whether they would be suitable. You will find publication guidelines on the next page.

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The Western Economics Forum

A new peer-reviewed publication from the Western Agricultural Economics Association

Purpose

One of the consequences of regional associations nationalizing their journals is that professional agricultural economists in each region have lost one of their best forums for exchanging ideas unique to their area of the country. The purpose of this publication is to provide a forum for western issues.

Audience

The target audience is professional agricultural economists with a Masters degree, Ph.D. or equivalent understanding of the field that are working on agricultural and resource economic, business or policy issues in the West.

Subject

This publication is specifically targeted at informing professionals in the West about issues, methods, data, or other content addressing the following objectives:

- Summarize knowledge about issues of interest to Western professionals
- To convey ideas and analysis techniques to non-academic, professional economists working on agricultural or resource issues
- To demonstrate methods and applications that can be adapted across fields in economics (e.g. adapting conjoint analysis from marketing to environmental economics)
- To facilitate open debate on Western issues

Structure and Distribution

This will be a peer reviewed publication. It will contain approximately 3 or 4 articles per issue, with approximately 2,000 words each (maximum 2,500), and as much diversity as possible across the following areas:

- Farm/ranch management and production
- Marketing and agribusiness
- Natural resources and the environment
- Institutions and policy
- Regional and community development

There will be two issues per year, which will be mailed out with the WAEA newsletter in the spring and fall.

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RANGELAND FIRES IN NORTHERN NEVADA: AN APPLICATION OF COMPUTABLE GENERAL EQUILIBRIUM MODELING[1]

by

Thomas R. Harris, Chang K. Seung, Tim Darden, and William W. Riggs[2]

ABSTRACT

A dynamic computable general equilibrium model of a five county Northern Nevada economy is used to estimate the business losses and recovery efforts of a 1.6 million acre rangeland fire. In comparison to input-output or social accounting models, the dynamic computable general equilibrium model incorporates the roles of markets and prices in the estimation of this natural catastrophe. Results indicate that fire suppression and rehabilitation expenditures were not enough to offset the losses in public land grazing activities.

Introduction

In any natural disaster such as rangeland fire, drought, earthquake, etc., there is a need for immediate estimation of the monetary impacts. This impact information is used to initiate federal and state emergency programs as well as to provide information to private insurance companies. Federal agencies also use impact analysis to prioritize disaster relief funding and determine areas for additional assistance. These estimated impacts are also necessary for the formulation and development of mitigation plans that occur following a natural disaster.

During the summer of 1999, northern Nevada experienced its worst fire year with over 1.6 million acres of federal, state and private rangeland burned, which is approximately six percent (6%) of the total land in the five-county study area. Of the total acreage burned, private acreage burned was 131,963 acres or approximately eight percent of total burned rangeland acreage (U.S. Department of Interior). Lightning from thunderstorms was the primary cause of these late summer rangeland fires. At one point during the summer of 1999, more than 56 percent of the nation's federal fire fighting resources was involved in fighting these rangeland fires in Northern Nevada (U.S. Department of Interior).

The objective of this paper is to outline procedures to employ dynamic computable general equilibrium (CGE) modeling for estimation of impacts of natural disasters.

Specific objectives are to:

(1) To discuss previous economic impact studies of natural disasters,
(2) To present specifications of the model,
(3) To describe development and data for impact analysis, and
(4) To discuss application of dynamic CGE procedures for analysis of the 1.6 million rangeland fire.

Previous Natural Disaster Impact Studies

Numerous studies have used inter-industry or economic procedures to estimate impacts of natural disasters. Ellison, et al. and Guimaraes, et al. used econometric models for analyzing the impacts of natural

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disasters. Gordon and Richardson employed a multi-regional interindustry model to estimate impacts of an earthquake. Rose, et al. derived direct and indirect effects of electricity lifelines disruptions from an earthquake using specially designed input-output and linear programming procedures. Cole employed social accounting matrix (SAM) approach to estimate the impacts of an earthquake.

However, input-output and social accounting models have some limitations. In these models, prices are fixed and there is no factor substitution in production or commodity substitution in consumption. Although these models are easy to implement, they tend to over estimate the impacts because of constant multipliers and unlimited supplies of inputs as implied by these models. Additionally, behaviors of firms and households are not estimated from constrained optimization. In contrast, CGE models are based on the Walrasian general equilibrium structure, which was formalized in the 1950's by Kenneth Arrow, Gerard Debreu, and others. CGE models explicitly incorporate supply constraints, identify prices and quantities separately, and have smooth, twice differentiable production and preference surfaces. Thus, substitution in production and consumption are allowed in CGE models. Factor and commodity markets attain their equilibrium through price adjustments. For analyzing the impacts of change in productive capacity of resource-dependent industries, Seung, et al. show that CGE models are more appropriate than other regional economic impact model. For this paper, CGE models are more appropriate than a fixed-price input-output or Social Accounting Matrix models because productivity capacity of some agricultural sectors are curtailed and the impacts of rangeland fire effect economic sectors differently. These differential impacts lead to changes in relative prices, which further leads to reallocation of resource across sectors. Previous studies by Boisvert and Brookshire and McKee suggest that CGE models are advantageous for natural disaster impact analysis. Rose and Guha estimated direct and indirect economic impacts of electric lifeline disruptions cause by earthquakes using a CGE model. However, for this analysis, a dynamic CGE model will be used because rebuilding of ranches and reclamation of rangelands will be a multi-year process.

Model Specification

CGE models explicitly incorporate supply constraints, identify prices and quantities separately and have smooth, twice differential production and preference surfaces. Thus, substitution effects in production and in consumption are allowed in CGE models. Factor and commodity markets attain their equilibrium through adjustment of prices.

Most of the regional CGE models mentioned above are static. However, policy evaluations based on a single period, static equilibria can be misleading (Ballard et al.) since in the real world dynamic elements abound. For a regional economy where many dynamic elements, such as interregional population movements and capital accumulation are observed, it is more appropriate to employ a dynamic specification of a CGE model. This study explicitly incorporates such dynamics into the CGE model. The structure of the dynamic model used in this analysis is based on Adelman et al., Robinson, Ballard et al, Seung and Kraybill, and Seung, et al.

Dynamics

The structure of the dynamic model in this paper is similar to that of Adelman et al., a description of which is found in Robinson. In this paper, there are two kinds of adjustment behavior to be considered (Robinson). First, in the goods market, the adjustments of prices and quantities occur in a short period, say in a year, reducing excess demand to zero (Walrasian equilibria). Second, in factor markets, adjustment takes multiple periods because of lagged responses of factor supplies, represented, for example, by the labor migration elasticity in equation (1) below and the adjustment coefficient in the investment function (equation 2 below) in the present model. The labor migration function is given by:

(1) $$LMIG_t = LSTK\left[\left(\frac{W_t}{WROW}\right)^{LME} - 1\right]$$

where:

$LMIG_t$ denotes the net in-migration of labor in period t;
$LSTK_t$ is the aggregate stock of labor given at the beginning of period t;
W_t is the average wage rate in the study region in period t;
WROW is the average wage rate in the rest of the world (ROW) in period t; and
LME is the labor migration elasticity.
The net investment function in each sector is given by:

(2) $$NI_{i,t} = l_i(KD_{i,t} - K_{i,t-1})$$

where:

$NI_{i,t}$ is net investment in sector i in period t;
l_i is adjustment coefficient;
$KD_{i,t}$ is desired capital stock in sector i in period t; and
$K_{i,t-1}$ is capital stock at the beginning of period t.

The investment determined via equation (2) is independent of domestic regional savings. Since regions are highly open economies and investment funds appear to be geographically mobile in the United States, it seems appropriate to treat the inflow of external savings as a residual that responds to the level of investment in the region. So if the region has more savings than needed for investment, surplus savings flow out of the region, and vice versa.

Static equilibria are sequenced through time to reflect a change in capital stock, which is due to investment, and a change in labor stock, which is due to labor migration and population growth. The calculation of equilibrium in each period begins with an initial capital endowment in each sector and a labor endowment for the economy as a whole. In this study, the sequence of equilibria generated without any policy implementation is called “continuous benchmark” while that generated with a policy shock is called “continuous counterfactual.” The policy impacts are calculated by comparing the continuous counterfactual with the continuous benchmark.

Labor income is provided by the IMPLAN data set as employee compensation and proprietor income. All other income is aggregated into an “other property income” category. For the agricultural sectors, it was necessary to allocate other property income into income due to land and capital. Land endowments were estimated using information on land use and valuation from Nevada county governments in the study area. Land acreage and the assessed valuation of that land are available for each county. Income from land or rental value of the annual use of land was inputted from the value of land based on assessed values. Income from land was subtracted from “other property income” category with the remainder assigned to capital. The result allowed sector factors to be assigned to land, labor, and capital for the analysis.

The labor force is assumed to grow at the same rate as the population, and net investment is assumed to be sufficient to make the capital stock grow at the same rate as the population, and net investment is assumed to be sufficient to make the capital stock grow at the same rate. The State of Nevada Demographer’s Office (Hardcastle) forecasts population growth rate for the five-county, northeast Nevada study area (Elko, Eureka, Lander, Humboldt, and Pershing Counties) area to be 1.4 percent. Labor is assumed to be mobile between sectors, while capital is sector-specific. Land is assumed fixed in supply so this factor becomes scarce over time, especially during the fire season and rangeland rehabilitation period.

Empirical Implementation

IMPLAN is used to develop ten-sector social accounting matrix (SAM) for the five-county, Northeast Nevada Study Area (Minnesota IMPLAN Group, Inc.). Calculating the effects of policy changes in a CGE model requires specific parameter values for the model equations. Some parameters such as elasticities of substitution and elasticities of transformation are specified on the basis of econometric research. The remaining parameters such as share parameters are then determined by solving the model equations with the base-year observations for model variables and the exogenous parameters substituted in the model. In this study, the adjustment coefficient in the net investment function is set at 0.08 (Treyz). Annual population growth rate for Northern Nevada is set at 1.4 percent.

Data Description

Table 1 summarizes the economic data for the five-county Northern Nevada Study Area. This data was derived from a county-level IMPLAN data set (Minnesota IMPLAN Group, Inc.). Total Agricultural Sector output was $185.292 million, which was 3.90 percent of total study area value of output. Within the agricultural sectors, the Range and Ranch Livestock Sector had the largest value of output of $79.717 million. Total Non-Agricultural Sector output was estimated to be $4,562.770 million, which was 96.10 percent of total study are output. Within the non-agricultural sectors, the Mining Sector had the largest output value of $1,959.402 million.

As for employment, Total Agricultural Sector employment was 2,325 employees or 5.17 percent of total study area employment. Within the agricultural sectors, the Hay and Pasture Sector had the highest employment of 1,077. Total Non-Agricultural Sector employment was 42,612, which was 94.83 percent of total study area employment. Within the non-agricultural sectors, the Service Sector had the highest employment with 13,811 employees.

From Table 1, total value added for the Total Agricultural Sector was $48.929 million, which was 1.91 percent of total study area value added. Within the agricultural sectors, the Hay and Pasture Sector had the highest value added with $18.070 million. Total Non-Agricultural Sector value added was $2,510.610 million, which was 98.09 percent of total study area value added. With the non-agricultural sectors, the Mining Sector had the highest value added of $857.550 million.

Table 1. Summary of Economic Data for the Five-County Study Area: Value of Output, Employment, and Value Added, 1999.

Sector	Value of Production (in million dollars)	Percent of Total (%)	Employment (numbers)	Percent of Total (%)	Total Value Added (in million dollars)	Percent of Total (%)
Range and Ranch Livestock	79.717	1.68	578	1.29	16.868	0.66
Sheep, Lamb, and Goats	2.114	0.04	66	0.15	0.425	0.02
Other Livestock	25.113	0.53	97	0.22	6.019	0.24
Hay and Pasture	61.358	1.29	1,077	240	18.070	071
Other Crops	16.990	0.36	507	1.13	7.547	0.29
Total Agriculture	185.292	3.90	2,325	5.17	48.929	1.91
Mining	1,959.402	41.27	7,897	17.57	857.550	33.50
CMTCPU[1]	749.415	15.78	5,041	11.22	314.482	12.29
Trade	356.980	7.52	7,494	16.68	266.850	10.43
F.I.R.E.[2]	396.486	8.35	1,809	4.03	277.409	10384
Services	781.716	16.46	13,811	30.73	502.943	19.65
Government	318.770	6.71	6,560	14.60	291.376	11.38
Total Non-Agriculture	4,562.770	96.10	42,612	94.83	2,510.610	98.09
TOTAL	4,748.082	100.00	44,937	100.00	2,559.539	100.00

[1]CMTCPU stands for the Construction, Manufacturing, Transportation, Communication, and Public Utilities Sector.
[2]F.I.R.E. stands for the Finance, Insurance, and Real Estate Sector.

Burned Area Emergency Recovery (BAER) teams were established by Congress as a means of providing support to communities within urban and suburban wildland and wildfire interface areas. The BAER teams are comprised of specialists that create sub-teams that are charged with analyzing natural disasters and then developing a comprehensive plan to address the losses associated with the disaster. These are basically first response teams that develop plans that are then fast tracked to Congress for funding.

In response to the large Nevada fire disaster, various teams of professional were organized to address numerous impacts relating to fire. In order to predict economic losses, as requested by federal agencies, state and local elected officials and private landowners, a survey team with expertise in ranch and community economics was formed. The economic survey team-included representatives from the University of Nevada Cooperative Extension, USDA's Natural Resource Conservation Service (NRCS) and Eureka County Public Lands Department. Additional information was provided to the team by Nevada Farm Bureau, Nevada Cattlemen's Association, USDI Bureau of Land Management, Nevada Division of Wildlife, BAER reports and local county officials. This local team was formed at the onset of the fires and was charged with gathering needed information and generating economic impacts.

The economic team utilized a survey instrument to solicit information from private and public landowners and/or managers concerning losses and damages resulting from the fires. The instrument was designed to gather information concerning major losses yet still allow for a quick response time. Survey categories and their corresponding questions were designed in cooperation with those persons impacted, to determine what economic losses would be measured, what amount was lost and for how long would that loss be continued. For example, the instrument included questions on animal unit months (AUM) of forage impacts, miles of fence lost or damaged, type of structures damaged, livestock killed or injured, and ranch inputs devoted to fighting the fires (i.e. labor, supplies, equipment, etc.) Once the instrument was designed, personnel at the county level were assigned to gather the information. Given emergency constraints, all methods of data collection, telephone surveys, mail in surveys, producer meetings, etc. were incorporated to gather the needed information. The methods used depended on resources available in each county. Current data from University enterprise budgets, commodity market reports and input prices were used to assign monetary value.

County data were sent to University of Nevada Cooperative Extension offices in Pershing, Humboldt and Eureka Counties where it was compiled into spreadsheets. Cooperative Extension then generated and distributed economic impact reports to other agencies and public officials.

At the ranch level, data derived from surveys found that total AUM's lost due to the rangeland fires in the study area were approximately 133,180. It is assumed that rangeland used for public grazing of range cattle will not be used for the first two years of rehabilitation. After these two years, range cattle will be gradually introduced back on to the public lands. For this first year (2002), only 25 percent of the AUM's will be allowed, followed in 2003 with 50 percent, following in 2004 by 75 percent and, finally by 2005 the rangeland is assumed to be rehabilitated to support AUM's similar to before the rangeland fires. Also, none of the ranchers in Northern Nevada qualified for federal emergency funding, so there were no expenditures to rehabilitate private lands.

Bureau of Land Management furnished information as to public land expenditures for fire suppression and rangeland rehabilitation. It is assumed that fire suppression and rangeland rehabilitation expenditures occurred during the first year of the rangeland fire (1999). Table 2 shows the federal expenditures on rangeland fire suppression and rehabilitation activities within the five-county study area. The expenditures in the Service Sector are from lodging and firefighters and rehabilitation personnel in local motels and hotels, hiring of contract personnel, and leasing and renting of vans, trucks, helicopters, and airplanes. Since these are expenditures on public lands, there is no private sector insurance coverage.

Table 2. Federal expenditures for rehabilitation and fire suppression by sector

Sector	Rehabilitation Expenditures	Fire Suppression Expenditure	Total Expenditure by Sector
CMTCPU[1]	$19,686	$223,520	$243,206
Trade	$118,297	$887,896	$1,006,193
FIRE[2]	$117,637	0.0	$117,637
Services	$3,383,657	$5,092,208	$8,475,865
Total	$3,639,277	$6,203,624	$9,842,901

[1] CMTCPU stands for the Construction, Manufacturing, Transportation, Communication and Public Utilities Sector.
[2] FIRE stands for Finance, Insurance and Real Estate Sector

RESULTS

Tables 3 and 4 show the cumulative ten-year impacts on sectoral and regional value of output and employment from the rangeland fire in the five county Northern Nevada study area. Table 3 shows that the total regional value of output differences between rangeland fire (counterfactual) scenario and the no rangeland fire (benchmark) scenario was approximately $22.0 million or 0.04 percent less than the continuous benchmark. As for the agricultural sectors, total value of production decreased by $19.8 million or was 1.36 percent less than the continuous benchmark. Given that cattle were not allowed back on the range in numbers prior to the rangeland fire for six years, the Range and Ranch Livestock Sector realized the greatest impacts with a decrease in value of production of $14.84 million or 3.14 percent less than the continuous benchmark.

As for the nonagricultural sector, total value of output decreased only $1.52 million or approximately 0.003 percent less than the continuous benchmark. Given federal fire suppression and rehabilitation expenditures, the Service Sector realized a $3.871 million or 0.04 percent increase in value of production when compared to continuous benchmark values. This increase in the Service Sector is due to the fire suppression and rehabilitation expenditures and the inflow of labor released from the agricultural sectors. Given total study area value of production decreased of $19.8 million when compared to the continuous benchmark, this implies that increased activity by the Service Sector was not enough to offset decreases in the other regional economic sectors from the rangeland fire.

Table 4 shows that when output is reduced in the agricultural sectors, labor is released from these sectors. The released labor will either be employed by some other nonagricultural sector or out-migrates to the rest of the world. Employment in the agricultural sectors declined by 423 jobs or was approximately 2.02 percent less than the continuous benchmark. Of the agricultural sectors, the Range and Ranch Livestock sector realized the largest job decrease of 135 jobs or approximately 4.18 percent less employment when compared to the continuous benchmark results. As for the nonagricultural sectors, employment decreased by 12 jobs or was 0.002 percent less than the continuous benchmark. The service sector because of federal fire suppression and rehabilitation expenditures and employment of released agricultural sector employment realized an increase of 79 jobs or was 0.04 percent greater than estimates from the continuous benchmark. Overall, employment in the study area decreased by 433 jobs or was 0.09 percent less than the continuous benchmark. However if rehabilitation of the burned rangeland is protracted which means range cattle release upon the rangeland is delayed, difference between the continuous benchmark and counterfactual results will be greater.

CONCLUSIONS

This paper presents a dynamic CGE model of business losses and recovery efforts associated with 1.6 million acres rangeland fire covering a five-county northern Nevada study area. For perspective, the 1.6 million acres is approximately six percent (6%) of the total study area acreage. Dynamic CGE models are especially adept at analyzing the role of markets and prices in the extent of mitigation of economic losses due to the 1.6 million acre rangeland fire.

Table 3. Cumulative Impacts of 1999 Rangeland Fire on Sectoral Output Over a Ten-Year Period.

Sector	Benchmark (in million dollars)	Counterfactual (in million dollars)	% Change
Range and Ranch Livestock	472.356	457.516	-3.14
Sheep, Lambs and Goats	25.125	24.998	-0.51
Other Livestock	98.384	97.894	-0.50
Hay and Pasture	377.403	375.518	-0.50
Other Crops	487.242	484.784	-0.50
Total Agricultural Output	1460.51	1,440.71	-1.36
Mining	23,695.296	23,695.449	0.00
CMTCPU[1]	8,115.208	8,111.390	-0.05
Trade	3,723.337	3,722.014	-0.04
FIRE[2]	2,795.338	2,794.935	-0.01
Services	10,968.525	10,972.396	0.04
Total Nonagricultural Output	49,297.704	49,296.184	-0.00
Total Output	50,758.214	50,736.255	-0.04

[1] CMTCPU stands for the Construction, Manufacturing, Transportation, Communication and Public Utilities Sector.
[2] FIRE stands for Finance, Insurance and Real Estate Sector

Table 4. Cumulative Impacts of 1999 Rangeland Fire on Sectoral Employment Over a Ten-Year Period

Sector	Benchmark (numbers)	Counterfactual (numbers)	% Change
Range and Ranch Livestock	3,232	3,097	-4.18
Sheep, Lambs and Goats	570	561	-1.58
Other Livestock	471	463	-1.70
Hay and Pasture	8,247	8,113	-1.62
Other Crops	8,453	8,316	-1.62
Total Agricultural Output	20,973	20,550	-2.02
Mining	101,582	101,583	0.00
CMTCPU[1]	64,936	64,896	-0.06
Trade	83,883	83,840	-0.05
FIRE[2]	11,855	11,848	-0.06
Services	221,350	221,429	0.04
Total Nonagricultural Output	483,605	483,596	-0.00
Total Output	504,579	504,146	-0.09

[1] CMTCPU stands for the Construction, Manufacturing, Transportation, Communication and Public Utilities Sector.
[2] FIRE stands for Finance, Insurance and Real Estate Sector

This paper is only a preliminary application of CGE analysis for potential estimation of rangeland fire impacts. Other applications for future analysis would be to complete a similar analysis but use fixed-price input-output procedures. This could potentially show the advantages of CGE analysis for rangeland fires impact estimation. The results might also support findings by Rose and Guha who found that typical CGE model, even based on short-run versus long-run substitution elasticities, was far too flexible and is likely to understate impacts of a natural disaster. Therefore, Rose and Guha suggest that deliberate efforts should be taken to incorporate real world rigidities as well as resiliency in the typical CGE model for natural disaster impact estimation.

Also additional analysis could investigate the impacts and welfare impacts of added federal fire fighting expenditures. Following procedures by Seung et al. and Schreiner et al., the costs-benefits of the added federal fire fighting expenditures could be estimated. For this example, there was little if any recreation on the public lands of this 1.6 million acre fire. However, if outdoor recreation existed, the impacts of reduced outdoor recreation would have to be included in the analysis. Also, labor was assumed mobile between all sectors.

Another analysis could separate labor between agricultural and non-agricultural labor and allow alternative factor mobility outside the study area. Lastly, improved rangeland production data would greatly enhance the production responses to rangeland fires that are primary input to the CGE analysis.

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DROUGHT, STRIFE, AND INSTITUTIONAL CHANGE

By

Richard E. Howitt

Introduction

Crises in the supply of natural resources are often stimulants for beneficial change in the institutions. In a recent paper on the evolution of federal and state water policy in the West, Getches (2001) concludes that "It takes a crisis" to initiate water policy reform in the West. Currently, many western states are in the grips of very severe drought. The National Oceanic and Atmospheric Administration (NOAA) weather statistics show that in the past year, two states (Arizona and Colorado) suffered a rainfall that is the lowest ever recorded. Five neighboring states (Utah, New Mexico, Wyoming, Kansas and Nebraska) are equal to, or lower than, the lowest 10% ever recorded. This drought, coupled with an unprecedented total demand for water clearly constitutes a crisis. However, it is unlikely that the current western drought will result in beneficial change to western water institutions. In what follows we discuss the reasons why some crises are useful stimulants, but also why the current drought will probably not stimulate useful change and merely increase the level of strife among western water users.

The Costs of Changing Institutions

Resource institutions are in the public domain because the supply of institutions usually requires discrete changes whose costs are dominated by fixed and irreversible costs. These fixed costs are both financial and political. This cost structure, coupled with the exorbitantly high costs of reversing a change in institutions once the rents from a resource have been renegotiated, makes institutional change essentially irreversible. In addition, there are the inevitable interest groups, such as agricultural irrigation districts and crop processing cooperatives, whose water rents are maximized under the status quo.

The application of standard capital theory to this situation results in theoretical conditions that require that the net returns to change have to exceed a hurdle rate for change to occur. For resources with a naturally fluctuating scarcity value, the fiscal hurdle rate condition results in discrete periods when hurdle rates are exceeded (Howitt 1995). Any change in institutions will result in a shift in the rents that are accrued from the institutions. This shift in rents gives rise to a political hurdle rate that can only be overcome by sense of urgency for change within the electorate. This sense of urgency is not present in times of normal scarcity for the resource, but emerges in times of supply reduction due to drought, or rapid shifts in the demand for resources that may be triggered by an environmental event.

The Returns from Changing Institutions

The property rights to use water in the western US vary between states, but were largely allocated on the two principles of prior appropriation, and rural development stimulated by the provision of federally subsidized water supplies. Clearly the private and social value of this initial water allocation depends on the continuation of the markets and technologies that underpin the predominantly agricultural value of water. The changes in the demands for agricultural products over the past fifty years, coupled with large changes in crop and irrigation technologies have changed the relative value of water between locations and uses in the west. In addition, the pressure for western development that drove western water projects in the early twentieth century, has now reversed itself with many environmental groups opposing water development as a method of restricting growth.

Several studies show that there are potential gains in social and economic efficiency from the reallocation on of some western water (references to be added). However, the current property rights are dominated by concerns for equity and attuned to the transaction costs of water allocation that were prevalent when the water was developed.

Given the inelastic demand for urban and environmental water, the efficiency gains from reallocation are dominated by the cyclical dry and drought years when the marginal values of water in these growing uses are very high. This means that the returns to the fixed political and fiscal costs of changing water rights is a stochastic variable that depends on an inevitable, but uncertain, series of weather events.

The increase in the expected value of changing institutions during droughts is based on three reasons, two financial and one political. The first financial reason is that there is the prospect of an immediate payoff during the current drought year, and the second reason is that the conditional probability of payoffs in the immediate future is higher. This second effect is not because drought years are auto correlated, there is no convincing evidence for this for western watersheds, but because under drought conditions, the reservoirs have been drawn down. Thus, although the rainfall probabilities do not change, the probability of below normal supplies of water being available is higher. In addition to the increase in the expected returns from institutional change, the political inertia preventing change is reduced by the sense of urgency for drought related action.

However, there are always some parties who will lose short run revenues from an institutional change. Any successful change must satisfy “n” person game theory core conditions to elicit cooperation from the majority of parties involved. The three conditions can be summarized as: (i) For individual players, the cooperative solution is preferred to the non-cooperative case. (ii) The allocation to any combination of players under the cooperative case is preferred to an allocation in any sub-coalition that they can establish, and (iii) The benefits from the cooperative allocation equal or exceed the cost of forming the cooperative solution.

Bardham (1993) points out that the pessimistic view of cooperation and trading that results from the traditional prisoner’s dilemma game may not be appropriate for water institutions. The most important difference is that the game is repeated many times under different scarcity conditions. Thus, while there may be a strong incentive to defect from a cooperative solution in a single game, for repeated games where the reputation of individuals or agencies is based on previous actions, the incentives to cooperate are much greater. The difference in the scarcity values of water between years can also provide an incentive for cooperation. If the use of water by urban and agricultural users is in equilibrium when supplies are at an average level, then in years of drought or high supply a theoretical water market will swing between situations of excess demand and supply. Extremes of water supply occur more often than average years in most western river catchments. While the dominant advantage is to water sellers in dry and drought years, there are advantages for buyers in other years. A solution to this situation of uncertain future market conditions is the contingent water contract that makes the trade conditional on the realized level of water scarcity such as a river flow index.

Drought crises have triggered advances in water institutions in the past. In 1991 California was facing the worst drought in thirty years, and it was clear that some water uses would have to be cut. Faced with the threat of reallocation by government mandate, water users and agencies agreed on a restricted water market. The Emergency Drought Water Bank operated in 1991, 1992, 1994, and was prepared for 1995. It is generally agreed that, despite some rigidities, the water bank equated water supply and demand under extreme shortage and by doing so generated substantial social benefits for the California economy.

Given the advantages of forming types of market institutions during drought shortages, why are these outcomes not happening during the current western drought? The reason is that the current drought occurred rapidly, and is very severe. Under these conditions two factors undermine the potential for cooperative trading solutions. First, the severity of the drought has already eliminated agricultural water uses that have an elastic demand for water and moderate marginal value products. Many agricultural water users are in survival mode where their remaining water sources are slated for the maintenance of a basic breeding herd, or high value irrigated crops that are forward contracted. In short, the water supply curve for a potential market has shifted sharply upward. The second reason is that this drought situation is unlikely to be repeated for most users, and thus they perceive the game as a single instance in which the advantages are not to participate, rather than a repeated game.

The relationship between the probability of a cooperative market solution and the scarcity of the resource can be thought of as an inverted "U" curve. Imagine that water scarcity values are measured on the horizontal axis, and the probability of institutional change on the vertical axis. At low scarcity values, the fixed costs of institutional change mean that its probability is very low. As scarcity values increase so does the probability of change. There is some scarcity value after which the probability of change starts to be reduced, and at extreme scarcity values it returns to zero. It is likely that water scarcity values in the central western states have passed the critical point.

The Current Situation with Western Water

Water rights in the west are largely vested in the states. Paradoxically, local action or the federal government has initiated most of the institutional innovation over the past twenty years. The federal role results from the large proportion of western water that has been developed by Bureau of Reclamation and Corps of Engineers projects. Most of these projects were designed to meet fixed demands, using excess capacity to dampen the effect of droughts and floods on supply. The central paradigm of modern western water management is to make the demand for water more responsive to the changing supply situation by some type of market mechanism.

NOAA reports that there have been twelve different drought events since 1980 that resulted in damages and costs exceeding $1 billion each. Compared hurricanes, floods, and tornadoes, droughts are slow in developing. Because of this, damage to economic interests can be substantially reduced if a socially acceptable reallocation mechanism is in place before the drought gains momentum. However, despite many calls for unified drought response strategy, water law and policy is largely based on the priorities of the first half of the last century.

Getches (2001) provides a comprehensive review of western water rights in which he examines the recent metamorphosis of western water policy and examines the role of federal and locally initiated water policy versus the slow and halting shifts that the western states have taken to modify their water rights.

Evidence of the inability of states to implement institutional change is shown by the resolution from the Western Governors Conference Park City workshops, and the more recent Enlibra policy statement. Getches summarizes that:

"The components of Enlibra include collaboration, use of local solutions to meet national standards, recognition that solutions cannot be limited by political boundaries, and use of markets instead of mandates".

Despite these laudable principles, the response to the current drought seems to be one of lurching through with stop-gap responses and calls for supply augmentation, but no major change in institutions to increase the flexibility of water allocation. The western states need to implement non-structural methods of improving demand flexibility that have the same effect as supply augmentation, but at a lower cost.

In response to the severe drought in the southwest in 1996 the governors of western states adopted a Drought Response Action Plan in November 1996. Further calls for action were forthcoming in 1997 and 1999. The Western Drought Coordination Council developed an effective drought response policy plan that is still waiting for implementation. The western governors backed the National Drought Preparedness Act of 2002 but, as of October, the act is still waiting passage although some commentators feel that Congress is now poised to act on the recommendations in the bill.

This interminable cycle of short run panic and long run inertia has been termed the "hydro-illogical cycle" by members of the National Drought Mitigation Center. This phenomenon is not new to the west. John Steinbeck, who grew up in the Salinas valley, described the reaction of California water users in East of Eden as:

"I have spoken of the rich years when rainfall was plentiful. But there were dry years too, and they put a terror on the valley. There would be five or six wet and wonderful years when there might be nineteen or twenty-five inches of rain and the land would shout with grass. And then the dry years would come, and sometimes there would be only seven or eight inches of rain. The land cracked and the springs dried up and the cattle listlessly nibbled dry twigs. And it never failed that during the dry years people forgot about the rich years, and during the wet years they lost all memory of the dry years. It was always that way."

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DROUGHT AND CLIMATE CHANGE: IMPLICATIONS FOR THE WEST

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The prolonged drought over large portions of the West generated a set of adverse and costly effects in 2002, ranging from record wildfires in Oregon, to large fish kills in California's Klamath River triggered by warm water temperatures. In some regions of the West, drought has persisted for nearly a decade, leading to severe stress on vegetation and water resources. The intensity and frequency of recent droughts has raised concerns that fundamental climate shifts may be occurring in the western U.S. and elsewhere, due perhaps to the generally rising temperatures observed globally over the past decade. This paper reviews the current understanding of possible links between drought and global climate change, the physical and economic consequences of drought, and the potential to mitigate the adverse consequences of such climatic events using long term climate forecasts and other meteorological information.

A range of potential effects of global climate change on water resources and agricultural management has been suggested. These include increased surface temperatures and evaporation rates, increased global precipitation, increased proportions of precipitation received as rain, not snow, earlier and shorter runoff seasons, increased water temperatures, and decreased water quality. Variability in precipitation patterns is also expected to increase, resulting in more frequent droughts in the U.S. and elsewhere (see Adams et al. 1999, for a review of the effects of climate change on agriculture and agricultural resources).

The economic consequences of drought are well documented. On average, annual costs in the United States due to drought are estimated at $6 to 8 billion (Knutson, 2001). Flooding and hurricanes, though more publicized than drought, are responsible for only $3.6 to 7.2 billion in annual damages combined (Knutson, 2001). Some of these economic costs arise from the direct physical impacts of drought, such as crop failure, municipal water shortage, wildfires, and fish and wildlife mortality. Indirect effects also occur. For example, water deficits reduce hydroelectric power generation, and increase electricity prices. The National Oceanographic and Atmospheric Administration (2002) and Claussen (2001) offer comprehensive discussions of the physical and socioeconomic impacts of drought in the United States.

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Water resource managers, agricultural producers, and policy makers can reduce the negative effects of drought through a number of strategies. These include revising water storage and release programs for reservoirs; adopting drought tolerant crops and cropping practices; adjusting crop insurance programs, and supporting water transfer opportunities. The ability to anticipate and efficiently prepare for future drought conditions is currently limited by imprecise long-term weather forecasts and climate models. Improvements in some forms of climate forecasts, such as those associated with the El Nino-Southern Oscillation phenomenon (ENSO) , offer potential for reducing the impacts of drought. However, economic costs associated with drought could be further reduced if drought forecast improvements increased the ability to detect drought farther in advance, enhanced forecast accuracy, and improved the geographical detail of forecasts to pinpoint drought location, intensity, and duration.

Global climate change, drought and implications for the West

The ability of the earth's atmosphere to trap solar radiation, and increase global temperature (the so-called "greenhouse effect"), has been recognized for at least 150 years. More recently, global climate change, or "global warming," associated with human activities, such as the burning of fossil fuels, has been a topic of intense scientific and political debate.

Certain evidence is unequivocal; carbon dioxide concentrations (the most abundant greenhouse gas in the earth's atmosphere) have been increasing steadily for over a century. The decade of the 1990s was the warmest (on a global scale) in over a century. Specifically, CO_2 levels have increased 30%, since the late 1800s, and are higher now than they have been in the last 400,000 years (National Assessment Synthesis Team or NAST, 2000). Average annual temperature of the United States has risen almost 0.6° C (1.0° F) over the 20th century (NAST, 2000). The role that humans have played in recent global warming is still debated. The belief that global warming will continue, however, is becoming more widely accepted.

Several general circulation models (GCMs) have predicted U.S. average annual temperatures to rise 3 to 5° C (5 to 9° F) over the next 100 years (NAST, 2000). Atmospheric scientists anticipate numerous climatic effects to arise from these increasing temperatures. For example, precipitation, which has increased in the U.S. by 5 to 10% over the 20th century (IPCC, 2001a), is predicted to continue to increase in many regions, particularly those at higher latitudes (Frederick and Gleick, 1999; Gleick, 2000). Increases in precipitation, given warmer atmospheric conditions, will not necessarily mean more available water at the state or regional level; as noted earlier, global warming is expected to bring more frequent and intense drought to several regions (IPCC, 1998).

Water quantity, timing, and quality

Drought can result from water quantity shortages, inappropriate timing of water availability (precipitation), and impaired water quality. The computer-based GCMs predict that selected regions of the U.S. will experience decreased precipitation due to global warming. Areas in the immediate lee of the Rocky Mountains, for example, are expected to receive less precipitation during this century than the current average (NAST, 2000). Two GCMs, from the Canadian Climate Centre, and the Hadley Centre in the United Kingdom, have projected precipitation changes across the U.S. These include 25% precipitation increases in the Northeast, 10 to 30% increases in the Midwest, 20% increases in the Pacific Northwest, 10% precipitation decreases in the southern coast of Alaska, and up to 25% declines in the Oklahoma panhandle, north Texas, eastern Colorado and western Kansas (NAST, 2000).

Areas receiving increased precipitation will not necessarily see net increases in available water. The higher evaporation rates that accompany rising temperatures are expected to result in less water available in many regions (Frederick and Gleick, 1999). For example, GCMs project global average evaporation to increase 3 to 15% with doubled CO_2 levels (Gleick, 2000). Simulation studies suggest that precipitation must increase by at least 10% to balance evaporative losses resulting from a 4° C temperature increase (Gleick, 2000). Projections of rising evaporation rates indicate they will outpace precipitation increases, on a seasonal basis, in many regions (IPCC, 1998; Gleick, 2000). The greatest deficits are expected to occur in the summer, leading to decreased soil moisture levels and more frequent and severe agricultural drought (IPCC, 1998; Gleick, 2000).

Shifts in the form and timing of precipitation and runoff, specifically in snow-fed basins, are also likely to cause more frequent summer droughts (Adams et al., 1988). More precisely, rising temperatures are expected to increase the proportion of winter precipitation received as rain, with a declining proportion arriving in the form of snow (IPCC, 2001b; Frederick and Gleick, 1999). Snow pack levels will form much later in the winter, accumulate in much smaller quantities, and melt earlier in the season (IPCC, 2001b).

These changes in snow pack and runoff are of particular concern to irrigated agriculture and to commercial and recreational fisheries. For example, if the runoff season occurs primarily in winter and early spring, rather than late spring and summer, water availability will decline during crucial spring and summer months, causing water shortages to occur earlier in the growing season. Shifts in runoff, precipitation, and evaporation patterns may also enhance interstate water allocation conflicts, as water managers struggle to meet obligations of compacts and court decrees, given more variable water availability and timing in headwater areas (Adams et al., 1988).

A shift in stream hydrographs to more winter flow may also disrupt the life cycle of anadromous species, like salmon, which depend on late spring flows to "flush" young salmon to the ocean. Unless reservoir systems are in place to capture and store winter runoff for late spring or summer use, reduction in summer flows is expected to lead to higher water temperatures. Summer temperatures now exceed the lethal levels for salmonids and other coldwater fish species in some streams; further warming could lead to more frequent fish kills, such as those observed this summer in the Klamath River of northern California.

Water quality impairment is predicted to increase under climate change (IPCC, 2001b; NAST, 2000; Gleick, 2000). Specifically, precipitation is expected to occur more frequently through high-intensity rainfall events, causing increased runoff and erosion. Sediments and pollutants, like fertilizer, will be transported into streams and groundwater systems, decreasing water quality (Gleick, 2000). Water quality will also be impaired in areas receiving less precipitation, as nutrients and contaminants become more concentrated (IPCC, 2001b).

Rising air and water temperatures will impact water quality by increasing primary production, organic matter decomposition, and nutrient cycling rates in lakes and streams, resulting in lower dissolved oxygen levels (IPCC, 2001b). Increased evaporation rates from open water-bodies threaten to increase the salinity of surface water. Lakes and wetlands associated with return flows from irrigated agriculture are of particular concern (IPCC, 2001b). Water quality impairment is thus a threat to agricultural water supplies, as well as to fish and wildlife.

Coastal areas are at additional risk of water quality impairment, due to saltwater intrusion (Nuttle, 1993;Frederick and Gleick, 1999). As global temperatures increase, seawater warms, causing ocean density to decrease and sea levels to rise (Solow, 1993). Sea levels are also rising in response to the melting of land ice, which includes glaciers, and the Greenland and Antarctica ice sheets (Solow, 1993). Global sea levels rose 10 to 20 cm during the 20th century (NAST, 2000). The Intergovernmental Panel on Climate Change projects a sea-level rise over the next century of 38 to 66 cm (Claussen, 2001).

Rising sea levels may also affect water availability indirectly by causing water tables to rise. Higher water tables cause surface runoff to increase at the expense of aquifer recharge. Groundwater quality and recharge are impaired by rising sea levels and saltwater intrusion. Radical changes to the freshwater hydrology of coastal areas, caused by saltwater intrusion, threaten many coastal regions' freshwater supplies.

<u>El Nino-Southern Oscillation and seasonal to interannual climate variability</u>

The possible long-term effects of global warming on drought and other extreme weather phenomenon are based on climate models that are associated with high levels of uncertainty, particularly at the regional or state level. A more immediate and predictable climate phenomenon is the increased frequency of ENSO events and increased intensity of ENSO-related droughts and flooding, which are expected to accompany global climate change (IPCC, 2001a; Gleick, 2000).

The El Nino-Southern Oscillation (ENSO) is a natural weather phenomenon resulting from interactions between the atmosphere and ocean in the tropical Pacific Ocean (Trenberth, 1996). Concurrent weakening and strengthening of ocean and air currents causes warm and cold ocean currents to mix, with one covering the other (warm water over cold during an El Nino; cold water over warm during a La Nina) (IPCC, 2001a). Changes in the thermal profile of ocean currents alter wind, sea surface temperature, and precipitation patterns in the tropical Pacific, and drive climatic effects throughout much of the world (IPCC, 2001a).

El Nino and La Nina events are associated with both drought and flooding in many regions of the United States. For example, El Nino events cause drier winters in the northwestern U.S. and the Great Lakes region, but results in increased precipitation in southern California, where the ENSO "signal" is particularly strong (IPCC, 1998). The affect of global warming on the behavior of ENSO events is uncertain. However, more frequent ENSO events, as suggested by Timmermann et al. (in Gleick, 2000), would enhance the variability of precipitation and streamflow in many ENSO-sensitive regions of the western US (IPCC, 1998), leading to greater risk of droughts and floods (IPCC, 2001a).

The negative economic consequences of ENSO events have been measured in a number of studies (e.g. Adams et al., 1995; Chen et al., 2001). ENSO-based drought has historically generated billions of dollars in damage annually in the United States, as has ENSO-related flooding. Increased drought frequency and intensity under global warming scenarios threatens to increase these damages, unless adaptive measures are taken.

Coping with drought: the use of climate forecasts

The first step in preparing for potential increased frequency and intensity of drought or ENSO events is an improved understanding of potential regional precipitation and evaporation shifts under a changed climate. The reliability of seasonal or longer forecasts is likely to affect their adoption by farmers and other resource managers. Providing reliable year-to-year forecasts of precipitation is difficult; decadal forecasts as provided by GCMs are even more problematic. However, some types of forecasts, such as those associated with ENSO events, are becoming more reliable (NAST, 2000; Trenberth, 1996). Adaptation strategies to ENSO events, such as changing crop mixes, are currently being practiced in many parts of the western hemisphere.

Improved seasonal to interannual weather forecasting will be needed to efficiently manage resources under the more extreme interannual weather variability expected to accompany global warming. Improving the accuracy and lead-time of drought forecasts can reduce the risk for decision makers and decrease economic losses due to drought (see NOAA, 2002).

With more precise, timely and reliable forecasts, current drought management tools can be reassessed and revised in preparation for more frequent seasonal drought. For example, drought insurance programs may need revision in order to provide efficient and affordable coverage. Increased crop diversity on individual farms or in economic regions could reduce losses during extreme weather events (IPCC, 2001b). Reservoir capacity, timing of water releases, and safety will need to be reconsidered and updated. Voluntary water transfers, with or without climate change, will become an increasingly important tool to mitigate water distribution problems. Municipalities are currently considering the vulnerability of their fresh surface and groundwater supplies to drought, pollution and saltwater intrusion, and may need to consider new protection programs and supplemental water sources. Improved confidence in regional forecasts of climate change impacts is, however, of primary importance in helping regional managers understand risk levels, identify management priorities, and define realistic adaptations.

Summary

Global climate change is likely to increase the frequency and intensity of drought for many regions of the western United States. Although subject to substantial uncertainly, regional forecasts of long term climatic change from GCM's do offer a glimpse into possible future drought conditions. Predicted impacts vary by region, but include increased temperatures and evaporation rates; increased, but more variable precipitation; higher proportions of winter precipitation arriving as rain, not snow; earlier and more severe summer drought, and decreased water quality.

Drought currently results in substantial economic losses in the United States annually. These losses occur across a range of sectors, from agriculture to energy to recreation, and have profound effects on local communities. Increases in drought imply increased costs to society, unless agricultural producers, water users and others are able to adapt to these changes in seasonal weather patterns (as forecast by some GCM analysts). Improved forecasts concerning future drought conditions, particularly at the regional scale, are thus necessary for managers and policy makers to identify efficient adaptive strategies, and reduce the economic costs of drought.

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Impacts of the 2002 Drought on Western Ranches and Public Land Policies

by
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Precipitation received for the 12 months prior to 31 August, 2002 place last year's drought as one of the worst on record since 1885 for much of the West. States that have set records for their driest September to August overall precipitation ever recorded include Arizona, Colorado, Nevada, and Utah while Wyoming recorded its second driest period ever between these months (NOAA, National Climatic Data Center). Areas rated by the US drought monitor as experiencing exceptional drought conditions by this date include northern Arizona and New Mexico; southern Utah; western Kansas, Nebraska, and South Dakota; and large portions of Colorado and Wyoming. The states of California, Oregon, and Washington were also greatly impacted by this drought. Pasture conditions were rated as very poor to poor for 90, 63, and 51 percent of these states' respective grazing lands for the week ending 1 September, 2002 (USDA/NASS).

The objective of this article is to examine how last year's drought has affected cattle ranching in the West. We review beef cow slaughter numbers, where herd liquidations were most intense, the fallout for public land grazing issues, and future management strategies for both public and private landholders. Management strategies to withstand the drought have included reducing stocking rates, purchasing supplemental feeds, weaning calves early, shipping cattle to other areas, and/or grazing pastures more intensely. Management options were more limited for ranchers that rely heavily on using public lands, which significantly altered how some of them will recover from the drought. Restrictions on public lands that resulted from the drought are attributed to bringing an alignment between ranchers in some areas and environmental groups to push for legislation to buyout federal grazing permits. This article discusses how these political movements and the drought will likely impact future cattle numbers and the western range landscape.

Drought Severity in the West

Even though the drought of 2002 was preceded by dry years in 2000 and 1996 for much of the Southwest, the drought of 2002 has a long ways to go to set a duration record if one considers precipitation received for seven or more consecutive years (Brown). One of the first indices established to measure the intensity, duration, and spatial extent of drought was the Palmer Drought Severity Index (PDSI). PDSI values are derived using precipitation, air temperature, and local soil moisture, along with historical values of these measures. PDSI values range from -6.0 (extreme drought) to 6.0 (extreme wet) and are standardized so that comparisons can be made across regions (NOAA, Paleoclimatology Program). Long-term drought conditions are cumulative so that the intensity of a drought is dependent on both current and cumulative weather patterns.

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At the turn of the 20th century, drought conditions persisted for over seven years from 1897 to 1904 in the Southwest. The PDSI was never above -3 from 1900 to 1904, whereas the PDSI has been positive for several periods in the West during the last four years. Much of the US was affected by the Dust Bowl drought in the 1930s and drought conditions persisted for up to eight years in some regions of the High Plains (NOAA, Paleoclimatology Program). The 1950s drought was characterized as having both low rainfall and high temperatures, and much of the Plains and Southwest recorded negative PDSI values from 1952 to 1957. Yet paleoclimatology indicates that multi-decade droughts occurred from around 1030 to 1040 and 1145 to 1155 (Cook et al.), and a mega-drought covered the Southwest from around 1550 to 1590 and extended across the continental U.S. in the 1560s (Stahle, et al.). This mega-drought was so severe that it far exceeded any drought of the 20th century and it was probably the most extreme drought in the last 2000 years. Sustained drought may be the reason that sophisticated cultures of the past have abandoned their homelands, such as the Anasazi people that left their multi-storied dwellings near the Four Corners area.

Public and Private Stocking Decisions

Although the drought of 2002 was not nearly as extensive as preceding droughts, drought intensity and federal land management criteria were such that many ranchers were forced to remove all of their cattle from public lands for the first time since the Forest Service (FS) became a "range regulator" in 1905. For example, roughly 95 percent of all the cattle have been removed from the Tonto National Forest (NF) in central Arizona (Sprinkle). Except for small private or "base properties" of around 20 to 80 acres that are tied to federal grazing permits, ranches in the area depend exclusively on public grazing for their livestock forage. The Tonto NF grazing allotments have elevations that range from 2,000 to 6,000 feet and normally receive 15 to 27.5 inches of rainfall per year, depending on location and elevation. Topography of the area is rolling to mountainous and it is considered good-yearlong cow country since grazing permits allow a yearling carryover.

With hay prices exceeding $100 per ton for even poor quality hay, and the expectation that partial restocking will not be allowed for several months, or perhaps more than a year, many ranches in the intermountain states were forced to liquidate most if not all of their cow herd. Some intermountain ranchers have secured pasture as far away as Oregon to the west or Missouri to the east so that they can preserve genetics that they have been selecting and developing for decades. Besides retaining genetics suitable for their region, this preserves some cattle that know where the water tanks are and how to navigate trails between pastures is viewed as critical for many mountainous ranches.

While pasture resources were equally limited for many ranches in South Dakota, Nebraska and Kansas, these operations typically had better access to grain and other alternative feed resources such as corn stalks or wheat pastures; and therefore, fewer cattle were liquidated in these areas. Furthermore, the majority of pastureland in these states is privately owned; thus, individual ranchers, rather than governmental agencies made the stocking decisions. Some producers weaned calves earlier than normal and supplemented their cows to reduce grazing pressure and to extend their grazing season. Others may have simply overgrazed their pastures and may be forced to reduce their stocking rates in subsequent years.

The Droughts Impact on the Cattle Cycle and Cow Prices

While federal grazing permits account for a significant share of the beef cow industry for many western states, all federal grazing permits in the US account for only 2.6 percent of the January 2002 beef cow herd inventory. All of the western states account for less than 20 percent of the beef cow herd, or about 3 percent more than what the state of Texas produces. Therefore, given that Texas, the Midwest, and the Southeastern states were not greatly impacted by the drought of 2002, the impact of this drought on total U.S. cattle numbers is rather dampened.

Where did all the cows go that were liquidated from drought stressed pastures this summer and fall? Apparently, they did not go to slaughter. The USDA reports that beef cow slaughter for 2002 through the 23rd of November was down 1.3 percent from 2001 for the same time period. This would imply that many of the cows that were shipped out of the drought stricken areas were purchased by cattle producers in other areas, rather than being sent to slaughter.

While total beef cattle numbers may not have declined due to the drought of 2002, herd growth was likely limited in 2002. This has ramifications for cattle producers throughout the U.S., since it appears that this drought will lengthen the current cattle cycle. The number of beef cows in the U.S. has been declining since 1995. This is a seven-year decline and if numbers are down for 2003 it will be eight years in a row. With most cattle cycles, the herd reduction phase has generally lasted four to six years.

The current stage of the cattle cycle has economic ramifications for ranchers who have been forced to liquidate their cows. It appears that while they have been liquidating cows, other areas of the country have increased cow numbers due to the expectation of higher cattle prices. With past cattle cycles, the highest prices for calves, bred heifers and cows have occurred in the first couple of years of herd re-building. If the drought ends in 2003, and producers in the drought stricken areas begin to restock their ranches in 2004 they will likely be paying higher prices for cows and replacement heifers. Furthermore, by the time these replacement heifers are into their most productive years in another three to five years, cattle numbers may have increased to the point where prices for calves will begin to decline again with another cattle cycle.

Another concern related to the cattle cycle is total beef production. Beef production in 2002 was at a record level. This level of production is not only greater than in 1995 when cattle numbers were at the peak for this cycle, but it is also greater than the mid 1970's when there were 30 percent more cattle in the U.S. than today. Why has beef production increased when cattle numbers have declined? There are several plausible answers, but in general, technological and biological advances have changed how cattle are managed and the industry responds to market signals (Brester and Marsh and Marsh). Fed cattle are being marketed at a younger age (more calves 12 to 16 months and fewer yearlings 18 to 22 months) with heavier carcass weights. Weights have been trending up about 5 pounds per year since the 1970's. The reality of the cattle industry is that today it takes fewer cattle and fewer cowboys to supply the same amount of beef than it took just a few years ago. The implication is that it may not be economically advisable for many of the producers who have liquidated their cows to ever get back into the ranching business.

Political/Policy Responses

The federal government owns and manages about 43 percent of the estimated 770 million acres of rangelands in the US (http://www.fs.fed.us; http://www.blm.gov; http://www.publiclandsranching.org). Several areas of the West are very dependent upon public grazing lands. For example, federal lands account for over 65 percent of Arizona's grazing capacity outside of Indian reservations. Additionally, federal lands make up about 9.5 percent of the 22.25 million animal unit grazing months authorized on Bureau of Land Management (BLM) and FS lands. These two agencies utilize somewhat different criteria to manage rangelands even though both are mandated by law to manage for multiple uses. These multiple uses include, but are not limited to wildlife habitat, recreation, livestock grazing, logging, and watershed values. Permits can be issued for up to a 10-year term and they are renewed if the holder has complied with all permit conditions. Under current law, agency managers are required to transfer grazing permits to new owners of small private land holdings or "base properties." However, in some cases, Congress has authorized permit buyout or eliminated grazing permits on specially designated lands. Given that many ranchers have no cattle left and that they are frustrated with current federal land management policies and administrators, an alliance was formed with environmental and conservation groups and several ranchers last year to propose federal legislation that would retire federal grazing permits.

The National Public Lands Grazing Commission (NPLGC) sent an information letter to about 29,000 ranchers in April of 2002 and some are just calling to see if the voluntary buyout proposal is still alive (Sneller). A similar but more focused proposal is gaining momentum to be introduced in Congress from the NPLGC and Tonto NF area ranchers that would buyout federal grazing permits only in Arizona. This proposal is entitled "Arizona Grazing Permit Buyout Campaign -- A Cooperative Solution to Meet the Changing Needs of Public Lands Grazing." Both documents propose a voluntary buyout of $175 for the average Animal Unit Months

(AUMs) permitted over the last 10 years to each permit holder to encourage participation. This amounts to $2,100 per animal unit year permitted. Because around 75 percent of all federal AUMs permitted are currently used, the cost is about $2,800 per animal unit year on the range.

While the Taylor Grazing Act states that permit holders are not entitled to any "right, title, interest, or estate in or to the lands," the buyout would "recognize a value of the permit only to extinguish it." The compensation amount is viewed as above market value for most grazing permits. This is intended to eliminate the need for appraisals, cover a wider range of permit market values, and provide a "transition grant" to help permit holders adjust to a different business and possibly a new residency. The buyout would not include any private property, so ranchers could still operate a dude ranch, bed and breakfast, hunting lodge, or other recreational services from their private land holdings. Water rights associated with spring diversions from federal lands that serve private lands are also not affected. How federal rangelands are faring with no livestock grazing would be evaluated 10 years after the buyout, consistent with current 10-year permit renewals.

The proposal is being sold as a "good deal" for taxpayers by reducing the administrative costs associated with providing grazing permits to ranchers, reducing disaster subsidies paid to livestock producers, and by arguing that it is more important to preserve public lands than the federal treasury. A cash injection to permit holders is also discussed as being important so ranchers can recover their investments without selling off their private lands. The buyout is argued as being affordable since the cost of buying all federal permits would be less than $4 billion, less than half the recent drought bill legislation and a fraction of the cost of the 2002 Farm Bill.

Future Management Lessons

The drought of 2002 is likely to revive the concept of forage banks or saving pastures for grazing in case of drought as a risk mitigation tool. The Conservation Reserve Program (CRP) has served as a forage bank for many areas because grazing of CRP lands during drought for a reasonable price is generally allowed. However, areas heavily dependent upon public land grazing with little CRP acreage may need to re-examine their risk management practices. A few ranchers in Arizona were able to fight the FS's ultimatum letter for removing all their livestock this last summer, in large part due to a forest fire that had gone through their area a few years earlier. Although the forage was coarse, grass was still knee-high in places and presented a case for adequate forage availability.

Some ranchers have used geographic diversification to better withstand drought impacts by purchasing multiple ranch operations that are located over 100 miles apart and usually have different seasonal rainfall patterns. Although Arizona had its driest September to August period ever, areas of Southeastern Arizona received some relief through monsoon rains that are known to be spotty, but bring heavy precipitation to some areas in a short amount of time. The importance of having adequate private land holdings to maintain top genetics is also likely to be given closer scrutiny after this year's drought.

Federally supported livestock reinsurance pilot programs such as the Livestock Risk Protection (price protection for hogs in Iowa) and the Livestock Gross Margin (price of market hogs, corn, and soybean meal in Iowa) programs are available, but they currently offer no protection for production risks and do not cover range livestock. The Adjusted Gross Revenue pilot program is based off an entity's Schedule F tax form and may not offer substantial protection from the full impacts of drought either, because the program does not account for the cumulative effect of lower drought-induced returns. The Risk Management Agency (RMA) recently approved an alternative computerized model approach for study. The RMA model uses weather, environmental characteristics, and plant growth to determine coverage and losses for pasture and rangelands that could offer substantial drought protection for ranchers in the future (Davidson). Participation and payouts are likely to be high and favorable in the West for any future reinsurance products that cover production risk of drought, if premiums are subsidized in accordance with crop insurance policies. However, due to the dynamics associated with forced culling decisions, it is unclear how much financial risk protection would be available with a forage-based insurance policy. Disaster assistance has historically followed drought for livestock as well, but the payouts are typically after expenses have been occurred for feed costs. Ranchers from counties that received primary disaster designation were eligible for a cash infusion of $18 per beef cow this last fall. These drought funds were delivered through the Livestock Compensation Program and the $750 million program was financed using Section 32 funds.

Last but not least, the drought of 2002 has brought home the importance of having solid income sources besides cattle if one wants to maintain the ranching lifestyle and pass the operation on to the next generation. It appears that most of the ranchers interested in the federal buyout program in Arizona are individuals that depend mainly on ranching as their source of income. Individuals that are less likely to take a buyout option are those that consider ranching as a secondary, or even minor source of their income.

Summary

The drought of 2002 has had varied impacts on western ranches. Ranches that rely heavily on public lands for grazing have likely been the most adversely affected. In many cases, they have had few options other than to liquidate most if not all their cows. Many public land and private ranches are having a difficult time penciling out a profitable restocking plan. A proposed buyout of federal grazing rights for $175 AUM is viewed as a lucrative alternative compared to restocking for many public land ranches. Ranchers with private land holdings in scenic areas are also questioning whether they should subdivide and sell their land holdings as ranchettes, sell out to someone with adequate capital to buy their entire operation, develop complimentary recreation activities, or switchover from a cow-calf to a stocker operation. Ranches with adequate capital may see this as a time to secure additional land holdings that are nearby as well as located at a distance if the ranch can offer some climatic diversification and strength to withstand another drought.

While the drought of 2002 may not have had a substantial impact on total beef cow numbers in the U.S., it may have garnered strength for changes in federal legislation. The proposed federal grazing permit buyout was in large part initiated due to the severity or opportunity caused from the drought of 2002. This legislation would provide immediate economic relief to ranchers that participate, but some politicians may be reluctant to approve this proposal unless it can be shown that the long-term future of selected rural economies will not be devastated. Federal legislation to subsidize premiums for range forage like RMA does for commodity crop insurance may also have gained momentum from the drought of 2002. Range livestock has already been identified as an “underserved commodity” and last year’s drought will provide ample examples of how finances for the ranching community would have been greatly different if “affordable” forage based insurance products were readily available prior to the drought. A subsidized forage based insurance product would help keep many small cow-calf ranches in the West solvent and more viable.

In spite of federal disaster assistance and potential new legislation, the drought of 2002 may simply have hastened the exodus of ranching that has been gradually giving way to recreational and environmental interests on public and private lands in many areas of the West. In other areas, independent, hardy cowboys may tighten their belt, tighten their cinch, climb in the saddle and ride for another day.

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DROUGHTS AND FARM POLICY

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DROUGHTS AND FARM POLICY

Droughts are of economic interest not because of the physical damage they cause, but because of the financial consequences that result from the physical damage. This distinction is not trivial, as physical damage may not result in economic loss. In an article recently published in *Agricultural Policy for the 21st Century* (Iowa State University Press (ISUP)) and adapted for a forthcoming article in *CHOICES*, I discuss an empirical finding that the price flexibility obtained by regressing the spring-to-harvest change in harvest futures price on the spring-to-harvest change in average U.S. yield has not differed significantly from -1 over the period beginning with the 1974 crop year for corn, cotton, oats, soybeans, and wheat. This finding implies that, on average, the product of market-level price and market-level yield, i.e., average U.S. per acre cash receipt, does

[1] Note from the author:

This paper is based in part on an analysis presented in "Income Variability of U.S. Crop Farms and Public Policy," *Agricultural Policy for the 21st Century*, edited by Luther Tweeten and Stanley R. Thompson, Iowa State Press: 2002, pages 91-108. It also is adapted from "Rethinking Price Supports and Insurance: How Risky is Market Risk," *Choices*, Summer 2002, pages 10-14.

The author thanks Paul Barkley, Barry Goodwin, Dana Hoag, Constance Jackson, Allan Lines, Matt Pullins, Luther Tweeten, and anonymous reviewers for their comments on earlier drafts.

Note from the editors:

We asked Dr. Zulauf to expand on his earlier two articles for the WEF because of the relevance of his article to the recent drought. Of particular interest is how the west may be an exception to his national systemic risk findings and how his policy suggestion might affect western farmers and ranchers.

not change as average U.S. yield changes from spring to harvest. The procedures are discussed briefly in the appendix.

Risk is conventionally divided into (1) systemic risk, or risk at the market level, and (2) idiosyncratic risk, or risk unique to the individual. Thus, the above finding can be interpreted as implying that, on average, systemic U.S. yield risk does not translate into systemic U.S. cash receipt risk. In other words, on average the so-called "natural hedge" between U.S. average price and U.S. average yield was perfect over the last quarter century for these five major U.S. field crops. Until recently researchers have focused on understanding idiosyncratic farm-level risk. However, understanding systemic risk is also important, especially for policy. In the following sections implications for U.S. farm income supports and crop insurance are discussed. I also briefly discuss how the west may be an exception to the perfect natural hedge and how policy can account for this differential.

Implications for Crop Insurance

Recent research has pointed out that the existence of systemic risk means that private insurance is prone to fail because many policy holders will collect when the systemic event occurs—e.g. during wide-spread drought, many U.S. farmers collect on crop yield insurance (Goodwin, 2001: Mahul, 2001; and Miranda and Glauber, 1997). For example, American Agrisurance, the largest U.S. crop insurer, was recently taken over by the Nebraska Insurance Department and the U.S. Department of Agriculture's Risk Management Agency (Barnaby, 2002). While a full assessment has not been completed, one factor appears to be the substantial number of policyholders affected by drought and other abnormal growing conditions in 2002 (Wiesemeyer, 2002).

Private insurers manage systemic risk by diversifying their portfolio and using the international reinsurance market, but these managerial responses usually generate higher costs. Public subsidies are another option. However, a third option is to create insurance products that remove the systemic risk. This approach seems especially warranted for yield insurance for major U.S. field crops because systemic yield risk does not carry an associated systemic per acre cash receipt risk.

In the ISU and *Choices* articles, I propose such an insurance product, yield-difference insurance. Yield-difference insurance would pay an indemnity based on the difference between the change in yield on an individual farm insurance unit and the change in average U.S. yield between planting and harvest. For example, average U.S. corn yields declined by nine percent between the May and November 2002 *World Agriculture Supply and Demand Estimates* (*WASDE*). Under yield-difference insurance, an individual corn insurance unit would collect only if its yield declined by more than 34 percent, assuming a 25 percentage point deductible.

Fewer farmers collect smaller indemnities under yield-difference insurance than under conventional Multiple Peril Crop Insurance when widespread abnormal growing conditions affect national average yield (Zulauf, 2002). By substantially reducing the probability of large payout years, yield-difference insurance may be viable as private insurance because the capital requirement needed to maintain viability in years with widespread abnormal growing conditions is sharply reduced. Or, society may choose to continue public subsidies, but at lower levels.

Adoption of yield-difference insurance will allow insurance companies to focus on helping farmers manage idiosyncratic yield risk. In particular, yield-difference insurance will increase indemnity payments when national yield increases between planting and harvest. To illustrate, a 15 percent decline in an individual farmer's yield when national yield increases by 10 percent is as financially damaging as a 25 percent decline in individual yield when national yield does not change. Thus, yield-difference insurance should better match insurance indemnities with financial damage resulting from declines in idiosyncratic yields between planting and harvest.

Improvement in the efficacy of crop insurance should benefit all producers, but particularly those with the highest idiosyncratic cash receipt risk. For most field crops, idiosyncratic cash receipt risk is likely to be higher in the U.S. West than in other regions. For example, Harwood, Heifner, Coble, Perry, and Somwaru (1999, pp. 13) find that county level yield-price correlations for corn over the 1974-1994 period are more negative in the Corn Belt and less negative for non-core regions, such as the Great Plains, South, and East.

While the preceding discussion has focused on yield insurance, it is important to note that revenue insurance has a systemic risk associated with leftward shifts in domestic and international demand. A leftward shift in market-level demand causes market-level price to decline, which translates into a decline in local prices. A large enough decline in market demand can lead to widespread claims against revenue insurance. To illustrate the potential importance of this systemic risk, four times since 1990 U.S. average yield stayed the same or increased between spring and harvest while U.S. average cash receipt per acre declined by more than 20 percent for one of the five crops analyzed in this study. Reason for the decline in cash receipt per acre was a substantial decline in the harvest futures price. These observations and associated decline in U.S. average cash receipt per acre were: (1) oats, -42 percent in 1990; (2) cotton, -33 percent in 2001; (3) corn, -25 percent in 1996; and (4) wheat, -24 percent in 1994.

Implications for Farm Income Supports

While droughts do not cause a systemic per acre cash receipt risk, the increasing prices that result from widespread droughts interact with price target programs, including marketing loans, to create a systemic per acre income risk. This situation occurs when the harvest-time price expected at harvest is less than the price target. The 2002 corn crop illustrates this situation. Using the May and November 2002 *WASDE* estimates for U.S. corn production and the midpoint estimate for average U.S. cash price and assuming the average harvest basis for recent years, projected cash receipts for U.S. corn increased by 12 percent, from $19.4 to $21.6 billion, from May to November. A 23 percent increase in price more than offset a nine percent decline in production. In contrast, when expected loan deficiency and counter-cyclical payments are included, projected gross income decreased from $23.4 to $21.6 billion, or by eight percent.

The preceding discussion implies that a rationale for *ad hoc* disaster assistance is to compensate farmers for the systemic income risk that price target programs create when widespread drought occurs. This implication raises questions regarding the efficacy of price target programs since they can create the need for another government program. On the other hand, price target programs generally will stabilize income when a leftward shift in demand or higher than expected production (i.e., rightward shift in supply) causes market price to decline and price is below the price target. Furthermore, price target programs generally will increase farm income if production is higher than expected (i.e., supply shifts right) and price declines below the price target. In short, impact of price target programs on farm income depends on the situation: they may reduce farm income, stabilize it, or increase it.

A reviewer raised an important observation: farm policy appears concerned with year-to-year variation in farm income. Thus, what is the relationship between year-to-year changes in U.S. average cash price and yield? To address this question, the same type of regression equation discussed in the appendix was estimated, except that the variables were change in average U.S. yield and change in average U.S. cash price between adjacent crop years. The results are presented in Table 1.

Except for cotton, the results are similar to the results reported in the ISU and *Choices* articles for the regression of change in harvest futures price against change in average U.S. yield between spring and harvest. Specifically, the slope coefficient does not differ from -1. Thus, for corn, oats, soybeans, and wheat; on average, year-to-year variation in U.S. average yield does not cause average U.S. cash receipt per acre to change from year to year.

Table 1. Regression of Crop Year-to-Crop Year Change in ln U.S. Average Cash Price against Crop Year-to-Crop Year Change in ln Average U.S Yield, 1974-2002.

Crop	Slope Coefficient	R^2
Corn	-0.74	0.46
Cotton	-0.28*	0.06
Oats	-1.18	0.41
Soybeans	-1.17	0.61
Wheat	-0.99	0.19

* Significantly different from -1 at the 95 percent level of confidence.
Source: Original calculations using data from the US Department of Agriculture

A Suggested Integrated Farm Policy

The preceding discussion suggests the need to rethink farm income and risk policies. One possible set of integrated farm policies is described below.

(1) Yield-difference insurance should replace Multiple Peril Crop Insurance. Furthermore, government should progressively lower public subsidies to determine if private yield-difference insurance can be viable.

(2) If society decides that farmers should receive public subsidies, potentially economically justifiable subsidies include those based on (1) positive environmental amenities provided but not compensated by the private market, (2) marginal social savings achieved by using subsidy payments to reduce negative environmental externalities rather than alternative mechanisms such as command and control, and (3) lack of viable private insurance for price risks caused by demand factors. As noted above, private insurance for price risks caused by demand factors is not likely to be viable because leftward shifts in demand create systemic price/income risk. In the author's opinion, private yield-difference insurance and the offsetting changes in market price and market yield can address the income risks created by changes in yield.

Potential public policy mechanisms for providing protection against risks caused by adverse changes in demand are price target programs and subsidized insurance products. Note risk will need to be separated into supply and demand causes, with subsidies provided only for risks associated with demand. For example, an initial step in pricing an insurance product for adverse changes in demand could be to reduce the put option premium on the harvest contract by an amount that can be attributed to the risk of price decline associated with changes in U.S. average yields. An important caveat to this recommendation is that, while separation of risk into supply and demand causes is theoretically possible, it will be difficult to implement empirically.

(3) Crop insurance indemnities and price target payments should be based on a moving average of recent realized yields, including those on which crop insurance is collected. These tie-ins will reduce moral hazard and adverse selection associated with crop insurance. The reason is that cheating on current year's yield to maximize current crop insurance indemnities will reduce future insurance indemnities and/or farm program payments.

I readily acknowledge (1) that other policy combinations exist and are feasible, (2) that each proposal has problems and will create other problems, and (3) that additional research is needed on the relationship between changes in average U.S. price and yield, including analyses for other crops. But, I hope this set of proposals encourages dialogue, criticism, debate, and creativity that will lead to a truly integrated farm safety net which in an economically justifiable way addresses the idiosyncratic risk needs of individual farmers while recognizing the importance of systemic market risk.

Appendix on Procedures

The estimated regression equation was:

$[\ln(F_{H,H}) - \ln(F_{H,S})] = \alpha + \beta [\ln(Y_H) - \ln(Y_S)] + \varepsilon$,

where $[\ln(F_{H,H}) - \ln(F_{H,S})]$ is the change between spring (S) and harvest (H) in the natural logarithm (ln) of the price of the harvest futures contract (F_H), and $[\ln(Y_H) - \ln(Y_S)]$ is the change between spring and harvest in the natural logarithm of average U.S. yield (Y). Harvest futures contracts were September for oats and wheat (Chicago Board of Trade), November for soybeans, and December for corn and cotton.

Spring price was the first closing harvest futures price not at the daily price limit following release of the first new crop estimates in the U.S. Department of Agriculture's *World Agriculture Supply and Demand Estimates* (*WASDE*). This release occurred in late April/early May. Harvest price was the first non-limit close following release of the September *WASDE* for oats and wheat, and the November *WASDE* for corn, cotton, and soybeans. If available, yields were taken from *WASDE.* Except for a few scattered years prior to the 1993 crop; the spring WASDE did not forecast yields. For these years, expected yield equals the average of U.S. yields for the five previous years excluding the high and low yields.

For additional details on the analytical procedures, see Zulauf (2002).

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