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Allocating a 'Scarce' Resource, Water in the West:

More Market-like Incentives Can Extend Supply, But Constraints Demand Equitable Policies

By VICTOR BRAJER *and* WADE E. MARTIN*

ABSTRACT. The issue of *water marketing* in the western *United States* has generated much discussion in recent years. This is due, in part, to the commonly accepted notion that *western water* has become "dangerously" scarce. The nature and extent of this scarcity are examined in detail. While water may not be scarce in the West, cheap water certainly is. The optimality of water marketing is also dependent upon various *ceteris paribus* assumptions. These assumptions are questioned due to certain *hydrologic* uncertainties and external *costs* associated with the use and *development* of western water. Considerable benefit, particularly in expanding *residential supply,* can be achieved from more market-like incentives to *conserve* in use. But the resource's social value about rights argues for policies based on equitable sharing.

I

Introduction

WESTERN WATER INSTITUTIONS have received much attention throughout the years. A major issue in the literature has been whether water should be allocated by pure market forces or centrally allocated in some manner. In many instances this discussion has boiled down to one fundamental issue: Should water be treated as an "economic good" and allocated via market institutions, or is water somehow "different," therefore making a market allocation suboptimal, or inefficient?[1] This basic question must be answered in order to achieve the optimal institutional framework for allocating both the surface and groundwaters of the semi-arid western United States.

The approach of treating water as an economic good has been defended by the so-called "New" Resource Economists.[2] The arguments made by this group call for freely transferable water rights and unimpeded market allocation of water. This approach will result, they believe, in an efficient allocation given certain well-known assumptions. However, it is precisely the inability to assume

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away certain conditions that makes it impossible to reach Pareto optimality. These conditions include certain hydrologic, social, and legal factors which all contribute to the creation of a myriad of external effects that preclude attainment of an optimal economic solution.

An important consideration in this debate focuses on the concept of scarcity. The following section will discuss the nature of water scarcity in the West. Section three will then offer an analysis of the hydrologic uncertainty and of external costs affecting the decision-making process (costs which are especially important in the case of groundwater allocation). Finally, a concluding section highlights the principal observations.

II

Water Scarcity

THAT WATER IS PERCEIVED as being extremely "scarce," both economically and socially, in the West certainly cannot be questioned. New Mexico State Engineer Steve Reynolds, for instance, has tersely described water as "simply the limiting factor."[3] Governor Scott Matheson of Utah has asserted that "water has suddenly surpassed time as the traditional Western luxury and we have little time left to take charge of the small amount of water that gives us life."[4] Recently, Gerald D. Seinwill, of the (now defunct) U.S. Water Resources Council, said that "water is the most serious long-range problem now confronting the nation."[5] Seinwill and other reputable, knowledgeable individuals have warned of a water crisis of international dimensions in the 1980s and 1990s, of a magnitude comparable to the oil crisis of the 1970s.[6]

What intensifies this scarcity issue, however, is the simple fact that Western water has traditionally been valued on a "cost" basis.[7] Such a valuation only provides a partial assessment of the true "value" of water as a vital public resource. Simple economic theory dictates that any resource artificially priced below its "equilibrium price" will encounter excess demand, therefore compounding the scarcity issue.

Calculating an accurate supply cost of water (especially at the farm level) is a difficult task, given the subsidies that exist along its delivery route. It is easy to name numerous segments in the national water hierarchy that take part, in some form, in the hidden overhead cost of water.[8] Federal subsidies enter water management at every point of the hydrologic cycle—cloud seeding programs, matching fund construction on watersheds, action agency programs for improved water management, research and development, and pollution control programs.

Many local water distributors are supported by local taxes, receive water subsidized by state and federal taxes, and market water to the public with no recognition of the value added by such actions.[9] In a recent report for the Natural Resources Defense Council, LeVeen and King demonstrate that the actual subsidies provided to California agriculture from the Bureau of Reclamation (via the Central Valley Project) are far beyond what even Congress intended, resulting in nearly $1.5 billion of "hidden and illegal expenditures of public funds."[10] In this case, certainly, government costing and pricing of water has led to a gross misallocation of water development and supply.

Many water planners and analysts have contributed to the scarcity "misunderstanding" by implicitly holding real water prices constant in their analyses. Many western state water plans contain supply-demand projections for twenty, thirty, and even fifty-year periods which are based on simple linear extrapolations for future demand (usually holding real water prices constant), and current estimates of water supply.[11] These studies present expected water "deficits" that are typically left as problems to be resolved by possible future importation. This reflects an attitude that has influenced water allocation policy since the turn of the century—that problems are to be solved by supply augmentation, rather than by demand reduction. Such thinking has the potential of creating considerable uncertainty regarding the exact meaning of water "scarcity" by implying that at some point in time there will not be enough water—that we will "run out."

A clear understanding of the nature of water scarcity is essential when considering the relationship between western agriculture and water policy issues. Black, for one, argues that because of the importance of farm production to the nation's food supply and to general economic activity, water must continue to be made available for irrigation.[12] A 1978 study, for example, showed that in the period from 1973–77, the West provided 55 percent of the fresh fruits and vegetables marketed in 41 major U.S. cities. Also, in 1980 the West provided 40 percent of the value of U.S. agricultural exports, both feeding others throughout the world and offsetting our balance of trade deficit.[13] Furthermore, irrigated western crops have significantly higher yields than dryland crops or crops grown in the East, and irrigation permits many more types of crops to be grown, with California farmers alone raising over 200 different commercial crops. In short, irrigation provides stability to farmers, ranchers, and consumers, ensuring that high-quality crops will be available, and at a stable cost, no matter what the vagaries of the weather.[14]

Despite the attractiveness of this line of reasoning, upon closer examination the argument that Western food production is vital to the nation's economy is not a compelling one. First, cash receipts from the sale of farm products average only about five percent of the final sale of goods and services in the United States each year.[15] Second, less than one-fifth of crops produced and sold in the U.S. (about 19 percent) come from irrigated lands.[16] Therefore, a 10 percent reduction in the irrigated sector's output implies that this figure will decrease to about 17 percent.[17]

Obviously, the nation's food supply is not in any jeopardy as a result of marginal shifts of irrigated land out of crop production. Nowhere is this more evident than in the production of food and feed grains, where carryover stocks are at their largest levels since the early 1960s.[18] While it does seem inevitable that a shifting of water resources away from agriculture to industrial and urban uses will occur, and while there may be some site-specific exceptions (southern Arizona and the Ogallala area, for example), in general, agriculture will probably not be seriously affected in the foreseeable future. This is due to both the gradual nature of the adjustment, and to the gains that will likely occur through increased conservation efforts and applications of new agricultural technologies.

That these marginal adjustments can be expected to occur is manifested in two ways. First, much evidence indicates the existence of a "normal" demand relationship where water is concerned. For example, a great deal of evidence suggests that municipal water demands are responsive to price, both in the short and long run. A study conducted in 1967 by Resources for the Future demonstrated significant differences in water use patterns between households that were metered (thereby putting a price on each gallon used) and those that were not.[19] In the areas where households were not metered (a fixed monthly fee usually being charged), not only was average daily water use much higher than in metered households, but maximum daily use rates and peak hour use were much higher. To investigate the permanence of price effects, Hanke gathered and analyzed data from two major meter routes in Boulder, Colorado, prior to and after the installation of meters.[20] The analysis showed a dramatic, permanent drop in water usage. More recently, Beattie and Foster presented evidence to suggest that a 10 percent increase in the price of water would produce from 3.75 to a 12.63 percent decrease in municipal water consumption.[21]

The price responsiveness of agricultural irrigation demand has also been demonstrated fairly convincingly. A number of studies conducted in different areas of California over a period of more than a decade all indicate considerable farmer response to changes in water prices. Moore, for example, constructed linear programming models for farms on the eastern side of the San Joaquin Valley in Tulare County and found that for the range of prices considered (zero to $30 per acre-foot), demand elasticity was equal to −0.65.[22] On a larger scale, a group of researchers tested for the impacts of alternative futures on the demand for agricultural water in seventeen Western states, using a large, multi-equation linear programming model. As price was raised from $7 to $30 per acre-foot using this model, the resulting elasticity estimates ranged from −0.17 to −0.56 with an overall average of −0.37.[23] Finally, in evaluating regional resource use for agricultural production in California in 1961–1965 and for projected levels in 1980, a spatial linear programming location model constructed by Shumway, King, Carter, and Dean actually indicated an elastic demand for water.[24]

Important policy implications are contained in these elasticity estimates. If the demand for irrigation water is as "elastic" as the numbers presented indicate, farmers could reduce their water use by a far greater amount than expected by water planners over the coming years as the price of agricultural water rises. Such reductions could offset the current predictions of severe supply shortfalls calculated under the assumption of near-perfectly inelastic needs for agriculture.[25] Of course, if the demand for irrigation water is elastic, future price increases would actually reduce total water bills.

As a second manifestation of the marginal adjustments that are expected to occur, one can note that in many instances in the West, water is already moving to higher-valued uses (or at least to users who are willing to pay higher dollar amounts for the water—generally municipal and industrial users). In a recent water rights purchase for a large fossil-fuel steam power plant to be located near Delta, Utah, for instance, the Intermountain Power Project paid local farmers $1750 per acre-foot for 45,000 acre-feet of irrigated water to be converted to industrial use.[26] During the first nine years of water-master service in the Central Basin in Los Angeles County, several hundred leases or sales of water rights took place, ranging in magnitude from one acre-foot to close to a thousand acre-feet of water.[27] In the twenty years between 1960 and 1980, the value of a share of Colorado Big Thompson water increased nearly eighty times, from $30/share to a high of $2,350/share.[28] Also, in Santa Fe, New Mexico, the right to an acre-foot sold for $10,909 in 1975 compared to $900 in 1963.[29]

This evidence tends to contradict the argument that water is "different" from other natural resources. Instead, it tends to emphasize a simple economic fact: every individual, farm enterprise, industry and municipality has numerous uses for water, and depending on the cost to the user, these economic agents will use certain quantities, applying the water first to the vital or high value uses, and then to less important uses. Therefore, as the price of water rises, *ceteris paribus,* less water will be used. It may be more accurate to say that "water" is not scarce in the West, but that "cheap water" is, especially as the market institution is increasingly relied upon to allocate this resource. However, there are other factors that influence the efficiency of the market solution that must be considered. In the next section, one such factor is addressed—the existence of hydrologic uncertainty and external costs.

III

Hydrologic Uncertainty and External Costs

ANY FORM OF RESOURCE MANAGEMENT, whether private or public, requires at least some minimum amount of information on which decisions can be based. Due to the unpredictability of surface water flows, the most precise data that can be generated regarding surface water availability from year to year is probabilistic, or stochastic, in nature. In the case of groundwater, the collection and evaluation of this information may be a massive undertaking. The hydrology of aquifers is far less predictable and much less understood than is the hydrology of surface supplies. This uncertainty may affect the attainment of an optimal economic solution in two fundamental ways. First, the actual amount of groundwater in existence is unknown, and will probably become known only after considerable development has occurred. Second, the hydrologic effects of such development will be difficult to analyze with any precision. In light of the potential importance attributed in economic analysis to external costs, this can be an extremely important consideration.

Quantity Uncertainty. As an example of this type of uncertainty, conditions in the state of New Mexico will be considered. The current amount of available groundwater supplies in New Mexico, that is, water defined as being outside the "appropriation system," is estimated to be between 135 and 155 million acre-feet.[30] To put this figure into perspective, one can note that this amount of water is over four hundred times the current annual consumptive use of water from the Rio Grande system in New Mexico, which is approximately 345,000 acre-feet. Nonetheless, these figures do not necessarily imply that New Mexico is a "water rich" state to the extent that it need not be concerned with optimal allocation levels. First, the state's water resources are not evenly distributed. While the Mesilla Bolson in the south-central basin is apparently blessed with a tremendous amount of groundwater (estimates range as high as 60 million acre-feet),[31] the eastern counties overlying the Ogallala aquifer are faced with rapidly declining water levels as that aquifer is mined, and in the northwest part of the state, natural constraints severely limit the amount of good quality groundwater that exists. Further, the prospects for intrastate, interbasin transfer are unclear at this time due to legal uncertainty and funding considerations. Moreover, supply estimates such as those presented above should be viewed with caution given the difficulties involved in determining the exact amount of usable water in a groundwater basin.

In principle, determining the quantity of water in storage available to wells is simple: multiply the volume of saturated material by the specific yield.[32] In reality, however, both of these factors (yield and storage) vary continuously. Throughout the Ogallala formation, for example, the thickness of the zone of saturation ranges from less than 50 feet in many places to more than 250 feet in others. Fairly detailed data on water-level fluctuations in observation wells, along with data on pumpage, are essential in keeping track of the status of groundwater resources. This information is published regularly by both the U.S. Geological Survey and the State Engineer. However, still more information is needed on all phases of groundwater hydrology to even begin to understand the dynamics of such a complex system. This includes saturated thicknesses and hydrologic characteristics in areas of few wells, hydraulic properties of alluvial materials, quantity of water discharged by phreatophytes, amount of recharge from irrigation water, relationship of ground and surface water (in the case of tributary aquifers), and perhaps most important, water quality. The extent of this hydrologic uncertainty can be appreciated by noting that in the San Juan basin of northern New Mexico, current hydrologic estimates for unappropriated groundwater range between 1.5 million acre-feet and 21.5 million acre-feet![33]

One final example of the hydrologic uncertainty that could hamper the attainment of an optimal allocation in relation to groundwater is the so-called "bubble" of water that exists in many stream-related (tributary) aquifers. The term "bubble" refers to the finite amount of water that can be initially removed, or mined, from a tributary aquifer in excess of a permanently sustainable pumping flow. The existence of this bubble is a consequence of the time lag between the initiation of pumping from a groundwater well and the point at which the full effect of the groundwater withdrawal reaches the stream to which the aquifer is tributary. The size of the bubble is a function of a number of factors, including the hydrologic characteristics of the aquifer and the distance from the well to the stream.[34]

Although this bubble is by its nature only temporarily available it should be noted that it may be of considerable size. For example, in the upper Rio Grande it is estimated that there may be 13.8 million acre-feet available in the bubble.[35] Also, in the Rio Grande, Pecos, and San Juan river systems, the effect of the bubble results in estimates of groundwater which range from 27 million acre-feet on the low side to 46 million acre-feet or more on the high side.[36]

External Costs. Simple economic theory demonstrates that with groundwater being a common property, or common pool, resource, its unregulated development will necessarily involve certain externalities, due to the fact that no one user must bear the full consequences of the increased pumping costs, well interference or pollution that result from his own actions. At the same time, each user is forced to bear costs imposed by the actions of neighboring pumpers.

Consequently, a socially efficient use of the resource is not attained—private users deplete the aquifer more rapidly than they would if they were forced to consider the social costs of their actions.

While the existence of this externality is potentially an important ingredient in determining the feasibility of reaching economically efficient allocations, considerable confusion still seems to exist in the economics literature regarding its magnitude. A number of studies have attempted to estimate empirically externality effects and the corresponding benefits which might be realized from groundwater management; as of now, however, no consistent conclusions can be drawn.

Kelso and Renshaw, for example, show that ad hoc groundwater management policies can actually result in economic losses.[37] Studies by Young and Bredehoft and by Howitt, on the other hand, suggest benefits from groundwater management of $100–$130 per acre and $153–$454 per acre, respectively, for regions of Colorado and California.[38] In a study of the Pecos River basin in New Mexico, Gisser and Sanchez demonstrate that the benefits of optimal management may be negligible compared to a free market (competitive) solution.[39] Also, using a dynamic optimization model to investigate the expected benefits from groundwater management in the southern San Joaquin Valley of California, Knapp and Vaux show that such management benefits might indeed be substantial.[40]

On a more theoretical level, for the Ogallala aquifer, Beattie presented an interesting argument concerning the common-pool externality problem, by hypothesizing that the Ogallala aquifer was more like an egg carton than a bathtub, due to the limited lateral movement of water through the formation and the correspondingly steep cones of depression around most High Plains irrigation wells.[41] The implication of this so-called "egg carton" theory, of course, was that if this view were correct and understood by irrigators, farmers would not accelerate withdrawal rates for fear of losing their groundwater to neighbors—that is, no significant common-property externality would exist.

More recently, however, Alley and Schefter examine in detail the movement of groundwater in the High Plains aquifer in response to irrigation pumping decisions by individuals and small groups of farmers.[42] Using fairly complex hydrologic techniques, they demonstrate that even though the lateral movement of groundwater is slow and the effects of an individual well on pumping lifts at other wells decrease exponentially with distance, an irrigator in the High Plains still has very limited control over the depletion of groundwater under his land, due to the cumulative effect of other pumpers.

These empirical findings, which seemingly lend no support to the "egg carton" hypothesis, nevertheless help accentuate an important point regarding the overall externality question—namely, in what manner should the question be analyzed? While empirical economic studies have demonstrated a variety of results, and perhaps more importantly the extreme sensitivity of these results to various hydrologic and economic parameters, most of the studies have used very simple approaches to modeling the aquifers and the movement of water within them. Such models assume hydrologic uniformity and do not adequately account for the different conditions faced by irrigators in different parts of a basin.[43] Without meaningful hydrologic data and realistic modeling representations of the involved aquifers, any results obtained must be viewed somewhat tentatively. It seems clear that given the potential magnitude of this externality issue, more work needs to be done in the area where hydrology and economics are inextricably interconnected to produce any meaningful social policy recommendations.

Finally, it should be noted that the extent of external costs is not limited to increased pumping costs due to falling water levels and well interference. There exist other important negative externalities which, due to their potential significance in the West, deserve mention. First, the removal of groundwater can cause the overlying land to subside. Nationally, subsidence has affected approximately 8,500 square miles of land in various regions of the country, mostly in the Gulf Coast and in certain valleys located in the western United States. The maximum recorded subsidence was observed in the San Joaquin Valley in California, where the surface fell approximately 29 feet between 1926 and 1972.[44] Subsidence can lead to an array of surface damage, including flooding, the "tilting" of surface lands and structures, damage to wells, extensive cracking on the surface, and disruption in the operation of pipelines, canals and aqueducts.

Second, the development of an aquifer may reduce the quality of its waters. The complex geologic and hydrologic structure of aquifers creates special groundwater quality problems that do not occur with respect to surface water. While pollution of surface waters can be reduced by allowing natural surface flow to "flush" out pollutants, the fact that an aquifer is a "stock" resource implies that even a one-time introduction of pollutants may damage the entire resource. With aquifers generally being more complex and larger than surface reservoirs, such effects can also be more wide-ranging and certainly more difficult to predict. It is interesting to note that in some cases the quality of an aquifer can be reduced even when withdrawals do not exceed natural recharge—that is, where no mining actually takes place. In coastal areas, for example, the removal of any groundwater can result in salt-water intrusion—the recharge of the aquifer from formations saturated with sea-water.[45] These external costs may result in a significant divergence between the socially optimal allocation and the market solution. In any event, it is not clear that the allocation provided through a market institution will effectively consider these potential external costs.

IV

Conclusion

THE DESIRE TO USE the market institution to allocate water resources throughout the West is quite appealing at first glance. Indeed, it has been the failure to let markets price water which has led to an exaggerated notion of the seriousness of the "scarcity" problem in the first place. However, it is also important to look beyond the theoretically desirable properties of a market allocation to see if, in fact, an efficient solution will obtain. It has been demonstrated here that the existence of hydrologic uncertainty and potentially significant external costs (particularly in the case of groundwater) may hamper the attainment of a socially efficient allocation of water resources.

There is no question that considerable benefit can be achieved by including more market-like incentives into the present water management system. The fact that empirical studies have consistently revealed negative demand elasticities and strong responses to water price changes by consumers, as well as the fact that those with the greater ability to pay can attract water rights indicates that, all else equal (that is, absent any institutional, social, or legal restraints) the demand for water is negatively-sloped. In one respect, then, one might conclude that water is not different from any other natural resource.

On the other hand, that water has been treated as though it were "different" cannot be disputed either. In fact, the pervasive hydrologic uncertainties that do exist have helped to create a situation in which potentially substantial external costs have become associated with the use and development of our water resources. To the extent that these externalities are of greater magnitude, perhaps, than those connected with the use of other natural resources, a fairly compelling case can be presented for the "water is different" argument.

Finally, it should be noted that the discussion on externalities in this paper has concentrated primarily on hydrologically-related external costs. It is also possible that significant external (social) benefits may be generated by the development and use of water resources in the West. An investigation into this area, as well as an analysis of the legal/institutional framework within which water is presently allocated, needs to be considered.[46]

Notes

1. See T. L. Anderson, "The Market Alternative for Hawaiian Water," *Natural Resources Journal,* Vol. 25 (October 1985), pp. 893–910; T. D. Tregarthen, "Water in Colorado: Fear and Loathing

of the Marketplace," in *Water Rights: Scarce Resource Allocation, Bureaucracy, and the Environment,* T. L. Anderson, ed. (San Francisco: Pacific Institute for Public Policy Research, 1983); M. Gisser, and D. A. Sanchez, "Competition Versus Optimal Control in Groundwater Pumping," *Water Resources Research,* Vol. 16, No. 4 (1980), pp. 638-642; and T. L. Anderson, "Water Marketing is an Idea Whose Time Has Come," *U.S. Water News,* Vol. 2, No. 9 (March 1986), p. 7 for arguments for a market solution. For an opposing view, see F. L. Brown and H. Ingram, *Water and Poverty in the Southwest* (University of Arizona Press, forthcoming); A. Utton, "In Search of an Integrating Principle for Interstate Water Law: Regulation versus the Market Place," *Natural Resource Journal,* Vol. 25 (October 1985), pp. 985–1004; H. C. Dunning, "Reflections on the Transfer of Water Rights," *Journal of Contemporary Law,* Vol. 4 (1977), pp. 109–117; and W. B. C. Chang, "Water: A Consumer Commodity or a Government Subsidy," *U.S. Water News,* Vol. 2, No. 9 (March 1986), p. 7.

2. Again, see Anderson, ed., *Water Rights: Scarce Resource Allocation, Bureaucracy, and the Environment.*

3. "Water Battle in the Northwest: Coal, Uranium Firms Go After Rights," *Albuquerque Journal,* July 9, 1978.

4. "Matheson Urges Conserve Water Now," *Salt Lake Tribune,* December 16, 1977.

5. See T. Schwinden, "One State's Strategy for Putting Water to Beneficial Use," in *Water Scarcity: Impacts on Western Agriculture,* ed. by E. A. Engelbert and A. F. Scheuring (Los Angeles: Univ. of California Press, 1984), p. 438.

6. *Ibid.*

7. By "cost" we mean the notion of accounting cost, as opposed to economic cost, which includes all relevant implicit (opportunity) costs. See W. C. Bianchi, and D. Cehrs, "Ground-Water Reservoir Management Through Artificial Recharge," *Groundwater,* Vol. 22 (1981), pp. 266–71.

8. *Ibid.*

9. *Ibid.*

10. E. P. LeVeen, and L. King, *Turning Off the Tap on Federal Water Subsidies* (San Francisco: Natural Resources Defense Council, Inc., (August 1985), p. 2.

11. See, as examples, *Water for Texas: Planning for the Future,* Texas Department of Water Resources report (Austin, Texas, February 1983); *Oklahoma Comprehensive Water Plan,* Oklahoma Water Resources Board report (Oklahoma City, Oklahoma, April 1980); and *Arizona State Water Plan: Alternative Futures,* Arizona Water Commission report, (February 1977).

12. A. L. Black, "What Financial and Business Interests Can Do," in Engelbert and Scheuring, *op. cit.*

13. See Western Governors' Policy Office, *Water in the Eighties: The Western View,* An Advocacy Case Outline (January 1984), p. 11.

14. *Ibid.*

15. M. Duncan, "What Financial and Business Interests Can Do: Discussion," in Englebert and Scheuring, p. 401.

16. Black, *op. cit.,* p. 400.

17. With irrigated agriculture accounting for about 90 percent of total water consumption, farmers need only to yield 10 percent of their water to allow a doubling of non-agricultural uses. Such action alone will probably provide enough water to meet most urban demands well into the 21st century. See "Western govs endorse water marketing," *US Water News* (September 1986), p. 12.

18. Duncan, *op. cit.,* p. 401.

19. C. W. Howe, and F. P. Linaweaver, Jr., "The Impact of Price on Residential Water Demand and Its Relation to System Design and Price Structure," *Water Resources Research,* Vol. 3, No. 1 (1967), pp. 12–32.

20. S. H. Hanke, "Demand for Water Under Dynamic Conditions," *Water Resources Research,* Vol. 6, No. 5 (1970), pp. 1253–61.

21. B. R. Beattie, and Foster, Jr., "Can Prices Tame the Inflationary Tiger?" *Journal of the American Water Works Association,* Vol. 72 (August 1980), pp. 444–45.

22. C. V. Moore, "Economics of Water Demand in Commercialized Agriculture," *Journal of the American Water Works Association,* Vol. 54 (August 1962), pp. 913–20.

23. See E. O. Heady, *et al.,* "National and Interregional Models of Water Demand, Land Use, and Agricultural Policies," *Water Resources Research,* Vol. 9 (August 1973), pp. 777–91; and J. R. Carson, "The Price Elasticity of Demand for Water," M. S. Thesis, Engineering, UCLA (1979).

24. C. R. Shumway, *et al., Regional Resource for Agricultural Production in California, 1961–65 and 1980,* University of California, Giannini Foundation Monograph No. 25 (September 1970).

25. B. D. Gardner, "Water Pricing and Rent Seeking in California Agriculture," in *Water Rights,* Anderson, ed., p. 89.

26. Western Governors' Policy Office, *op. cit.,* p. 26. This payment is a one-time "fund" payment for the right to use the water in perpetuity.

27. See H. C. Dunning, *op. cit.*

28. Western Governors' Policy Office, *op. cit.,* p. 40.

29. See R. Khoshakhlagn, F. L. Brown, and C. DuMars, *Forecasting Future Market Values of Water Rights in New Mexico,* New Mexico Water Resources Research Institute Report No. 092 (November 1977).

30. See C. DuMars, *et al., State Appropriation of Unappropriated Groundwater: A Strategy for Insuring New Mexico A Water Future,* New Mexico Water Resources Research Institute and University of New Mexico Law School (January 1986), p. 232.

31. See L. Wilson, *Water Supply Alternatives for El Paso,* a report prepared for El Paso Water Utilities by Lee Wilson & Associates, Santa Fe, New Mexico (1981), p. C-7.

32. The "specific yield" of an aquifer is the quantity of water that a formation will yield under the force of gravity, if it is first saturated and then allowed to drain; the specific yield ratio is the percentage of the above-described yield to the volume of water in the saturated material.

33. C. DuMars, a Letter to the Advisory Board of the New Mexico Water Law Study Committee (November 11, 1985).

34. See F. L. Brown, "Managing Nonrenewable Tributary Supplies," an unpublished report prepared for the New Mexico Water Law Study Committee (September, 1985).

35. See *The Impact of Recent Court Decisions Concerning Water and Interstate Commerce on Water Resources of the State of New Mexico.* University of New Mexico Institute of Public Law, Appendix A (1983).

36. DuMars, *et al., op. cit.,* p. 9.

37. See M. Kelso, "The Stock Resource Value of Water," *Journal of Farm Economics,* Vol. 43, No. 3 (1961), pp. 1112–1129; and Renshaw, E. F., "The Management of Ground Water Reservoirs," *Journal of Farm Economics,* Vol. 45, No. 2 (1963), pp. 285–295.

38. See J. D. Bredehoft, and R. A. Young, "The Temporal Allocation of Groundwater—A Simulation Approach," *Water Resources Research,* Vol. 6, No. 1 (1970), pp. 3–21; R. A. Young, and J. D. Bredehoft, "Digital Computer Simulation for Solving Management Problems of Conjunctive Groundwater and Surface Water Systems," *Water Resources Research,* Vol. 8, No. 2 (1972), pp. 533–556; and R. E. Howitt, "Is Overdraft Always Bad?" *Proceedings of the 12th Biennial Conference on Ground Water,* California Water Resources Center, Report No. 45, Davis, California (1979).

39. Gisser and Sanchez, *op. cit.*

40. K. Knapp, and H. J. Vaux, Jr., "Barriers to Effective Ground-water Management: The California Case," *Groundwater,* Vol. 20, No. 1 (January–February 1982), pp. 61–66.

41. B. R. Beattie, "Irrigated Agriculture and the Great Plains: Problems and Policy Alternative," *Western Journal of Agricultural Economics,* Vol. 6, No. 2 (1981), pp. 289–299.

42. W. M. Alley, and J. E. Schefter, "External Effects of Irrigators' Pumping Decisions, High Plains Aquifer," U.S. Geologic Survey paper (1986).

43. One exception is the work of Young and Bredehoft (1972), which did combine an economic model with a groundwater simulation model. Even this study, however, does not specifically examine the externality issue from the point of view of the individual farmer.

44. J. C. Muys, R. G. Cummings, and K. J. Burke, "Interstate Groundwater Management," a discussion paper prepared for the Western Governors' Policy Office, Circulation Draft (November 1983), p. 15.

45. Muys, *et al., op. cit.,* p. 31–32.

46. V. Brajer, and W. E. Martin, "Water Rights Markets: Social and Legal Considerations," forthcoming in the *American Journal of Economics and Sociology.*

Word Processed Contributions

CONTRIBUTORS are tending more and more to send in manuscripts which have been composed on microcomputers equipped with popular word processing software. It would be convenient from an editorial point of view if, besides receiving two hard copies of a manuscript, we also received a disk with the copy recorded on it. The copy could be left in one file in the form the software dictates and, in most cases, it is not much of a trick for the author to also include the copy in an additional ASCII file. Both files would easily fit a single disk since our word limit is 5000 words for an article. The first file could be labelled WSJONES say for a Word Star formatted file by Professor Jones, or WDJONES for a Microsoft Word file, or WPJONES for a Word Perfect file etc. while the ASCII file could be ASJONES.

This procedure would ease the editors' tasks. They might wish to edit using the same software the contributor used or to use the ASCII version. In nearly every case they probably can produce their own ASCII file from the formatted file if need be. However they think the first way is the safer way to go if the contributor can do the conversion. It would also be easier for the editors if the disk submitted was the conventional 5 1/4 floppy but the 3 1/2 inch disk can also be accommodated if need be. Should we remind the contributors of the old rule that since editors are human it is wise to make things easy for them?

We find compelling a passage in the wonderful book by Professor Michael L. Kleper (*The Illustrated Handbook of Desktop Publishing and Typesetting,* Blue Ridge Summit, PA, Tab Books, Inc., 1987, p. 44. It is available for $33.95 from Graphic Dimensions, 134 Caversham Woods, Pittsford, N.Y. 14534). Writing