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Groundwater and the Land Value Tax:

Some Dimensions of the Problems Facing Fiscal Specialists in Applying Rent Taxation to Underground Resources

By BRUCE YANDLE*

ABSTRACT. Application of the *land value tax* has been described for many *natural resources.* However, the problems encountered with *flowing underground resources* have not been fully discussed. *Groundwater* is one such flowing resource that affects the value of *surface land.* The underground water is also subject to its own market forces. If a Georgist tax is to be applied to groundwater or to land affected by it, the administrator of the tax must consider the interplay that occurs between the two resource markets. A system of *separable property rights* to the two resources offers the prospect for efficient use. But the *monitoring of ground water use* must accompany such a separation.

I

Introduction

FOR 100 YEARS, a debate has raged any time a serious proposal has been put forward for applying a land value tax on urban or suburban land, even where implementation seemed feasible.[1] However, the application of a Georgist tax on the naturally endowed qualities of land becomes more complex when the subterranean features of a site are considered. Underground pools with dimensions exceeding a particular surface parcel, as in the case of petroleum or liquified sulfur, pose one kind of problem. Underground streams or aquifers that supply groundwater pose yet another problem.

While all resources in their naturally endowed state become valuable through the pressure of demand on an inelastic supply, flowing resources have a natural elasticity that can confound the responsiveness of supply at a given location. In other words, a rising price for oil or water at one location can inspire a given producer to install larger pumps and thereby extract a larger quantity of the resource from the common pool or aquifer, simultaneously decreasing the flow at other locations. The construction and application of a land-value tax in these situations may call for a separation of subterranean flowing resources from fixed resources on the surface.

Unrelated to concerns about taxation, perhaps, regulatory intervention has been applied to address the common pool problem. Proration techniques, for

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example, are ostensibly designed to maintain a maximum economic flow of petroleum from a given field (common pool). State imposed limits on well spacing and the withdrawal rate of ground water are other regulatory approaches used for dealing with the problem. Both approaches, however, have recognized efficiency weaknesses, and neither approach is designed to deal directly with taxation, although one would expect that any such approach would relate to the creation and maintenance of rents.

With or without proration or other regulations which add some security to property rights of petroleum and other minerals, a perfectly administered tax on rents could have the effects intended by Henry George. Ricardian rents could be extracted without affecting the demand-derived production of the resource. But, efficiency arguments suggest that such a tax would not be levied exclusively on the site above the common pool. Indeed, it will be shown that for efficiency reasons rights to the use of a resource associated with a surface site that can itself be transferred should be treated separately from the use of rights that cannot be transferred, while the same owner occupies the site.

This article focuses on that proposition and uses groundwater as the subject of analysis. Some background on groundwater is given in the next section of the article, which is followed by a theoretical discussion. A final section of the paper then relates the earlier sections more directly to the land value tax.

II

Some Background on Groundwater

GROUNDWATER IS ONE of man's key natural resources. Although the full dimensions of the vast flowing streams and reservoirs below the earth's surface are not completely understood, it is recognized that these aquifers supply 50 percent of the drinking water for the U.S.; constitute 96 percent of all the fresh water in the nation; and contain 50 times the volume of all the nation's surface water.[2]

The importance of groundwater extends, of course, across the earth's surface. Indeed, one commentator has indicated that groundwater constitutes "97 percent of the water on earth excluding the oceans, ice caps and glaciers."[3]

Man's use of groundwater is surely as old as time. Every well, oasis or artesian well drains from a water table that itself is evidence of an underground aquifer. And rules for managing use of the resource are equally old and diverse.[4]

Like any common access resource, groundwater provides no direct signal to a given user when his use is affecting that of another person. Lacking that knowledge, and in the absence of controls, each user has an incentive to withdraw water so long as the added benefit to that user exceeds the direct costs of drawing more water. Such unrestrained behavior creates no particular problem so long as the consumption rate does not exceed the recharge capabilities of an aquifer. While recharge can occur through the flow of surface waters some distance from the user, large proportions of water withdrawn may ultimately return to the same aquifer, depending on the consumptive use. Water used for irrigation of agricultural crops, for example, becomes partly embodied in the food produced, partly evaporated, but also partly returned through the earth's surface to an aquifer.

When withdrawal exceeds the recharge capacity of an aquifer, mining of water is said to occur. And while that may be economical, depending on the value created and the cost of moving to other locations, mining at one location can lead to land subsidence at other locations.[5] Alternatively, reductions in historic patterns of withdrawal can lead to buckling of the earth's surface elsewhere. Further, as aquifers are drawn down, it is also possible that underground streams will change their flow directions; or in coastal regions, that salt water will be infused into freshwater aquifers.

In addition to the effects on aquifer supply capabilities of withdrawals and consumption, disposals of waste affect the quality of groundwater. For example, the underground injection of industrial wastes, the final disposal of municipal wastes, and the run-off of chemical fertilizers can contaminate aquifers and reduce their value as a source of drinking water.[6]

Property rights to the use of groundwater in the U.S. are primarily effected by state and common law doctrines.[7] And the treatment of the underground resource by law has tended to parallel the treatment of surface water. In the eastern U.S., for example, where a common law interpretation of riparian rights has evolved for surface water, that a land owner adjacent to a stream has access to beneficial and reasonble use of water from the stream, groundwater law gives correlative rights that allow the owner of overlying land to withdraw aquifer-provided water.

In the arid western states, early mining practices led to the development of prior appropriative rights for surface water—a rule of first in time, first in right. Groundwater rulings have tended to give similar standing to senior users over later, junior, appropriators.

Growth in demand for groundwater tends to destabilize all existing rules governing use, mainly because of the common access problem and the fact that many aquifers underlie several states, if not more than one country. Partly because of the trans-state characteristic and the lack of clear property rights to use, several federal initiatives have been taken to develop regulations governing aquifers.[8] Some of these call for explicit state regulation or management, where that activity has been fragmented or is lacking totally, and for a classification system designed to recognize and control endangered aquifers, those that are "over-mined" or contaminated.

To the extent that groundwater is being used at various locations in non-economic ways, that action suggests that property institutions supporting the allocation of groundwater use lack a fundamental component—the capability to monitor and meter use. Monitoring technology exists in the form of wells drilled for the purpose of observing levels and flows. The evidence so obtained has to then be evaluated in the context of the stochastic aquifer process. The typical user, however, is unaware of losses—a permanently lowered water table, salt water infusion, land subsidence at remote locations—until after the events have occurred. And even though these events do occur, suggesting that efficiency losses accompany them, there is always the possibility to consider that alternative monitoring and regulatory costs could impose even higher efficiency losses.[9] In other words, it is by no means apparent from physical evidence that alternative approaches for managing water quality and use would in fact produce a net social dividend. Simply put, institutional changes have to be weighed carefully.

It is obvious, however, that an oasis is more valuable per acre than the surrounding desert, that agricultural land with available water for irrigation is more valuable than similar land lacking access to groundwater, that groundwater can and does contribute value to surface land. Furthermore, since groundwater is usufruct, save where steps have been taken to renew or reproduce it, its value depends on socially driven demand. And since groundwater is not sold separately from land, a value component of land is derived from subterranean streams.

All of this suggests that if a Georgist tax makes sense when applied to the unimproved component of land, it seems clear the same logic would support a similar treatment of groundwater. What is not clear is how a Georgist tax might be developed and applied to the aquifer component of overlying land.

III

A Theoretical Analysis

CONSIDER NOW a well defined geographic region in which all parcels of land are in the hands of private owners. The region's economy is diverse. There are agricultural, industrial, and commercial activities, as well as residential development. The region has a government that provides typical services—streets, police protection, schools, public health services, dispute resolution services, and the other more commonly provided public services. The government is funded from a mixture of tax sources, along with certain user charges. In other words, the fiscal policy of the region is rather typical of most modern political jurisdictions.

One could describe the determination of land prices in the region by using the well-known rent bid device.[10] In effect, the amount offered for particular sites would be determined by transportation costs to commercial centers, the cost of attracting people to particular locations, and the usual ceteris paribus variables of population, population density, income, tastes, the prices of sub-

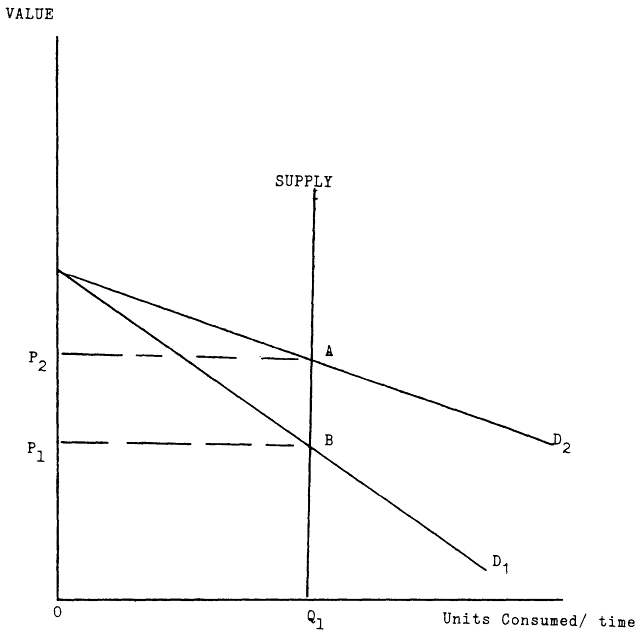

Figure 1 : Analysis of Demand for Groundwater

stitute goods and locations, and the relative costs of publicly provided services.

Assume further that land is sold in fee simple, with titles that attach all subterranean mineral and water rights to the parcel. In short, surface rights are extended to include resources that could be appropriated by surface activity. Initially, there are no flowing subterranean resources being exploited by surface owners in the region. Simply put, an equilibrium site value for each parcel obtains, and it is based on surface activities, with no expectations of subterranean gains.

The initial equilibrium may be described for one parcel by the intersection of the demand curve D_1 with the inelastic supply curve in Figure 1. As indicated in the figure, a Ricardian rent of OP_1AQ_1 is generated by private market forces.

Now, suppose a fixed cost drilling technology is discovered and applied so that a flowing reservoir of groundwater is found below certain locations in the region, including the parcel described in Figure 1. There is demand for fresh water in the region, and given the opportunity cost of alternative sources of water, the demand for advantageous sites increases, as reflected by D_2 in Figure 1. If the regional government should determine that a Georgist tax is to be applied to the increment of rent generated by the newly found groundwater, that tax would be slightly less than the area P_1P_2AB shown in Figure 1. Any later change in the demand for groundwater will affect the value of each site, but such changes in demand cannot be distinguished from other factors that might affect location values.

For example, changing weather patterns that reduce the amount of rainfall could increase the demand for groundwater, while other constant relationships leave the site values unaffected. Alternatively, population increases, rises in transportation costs, and increases in the demand for water could all interact to bring changes in site values. It would be impossible to disentangle the effects of the changes so as to isolate the rents associated with the groundwater.

Of course, the regional government could theoretically solve the problem of confounded demand changes by applying the Georgist tax to the full site value. In that case, a tax slightly less than the area of OP_2AQ_1 would be levied on the location described in Figure 1. The equilibrium value of the site described in the figure by the intersection of D_2 and supply would still obtain, assuming that demand relationship captured all relevant market information, including the adjustments caused by the newly expanded tax (assuming other taxes would be reduced).

Under the regime described, owners of sites would have an incentive to increase their pumping of groundwater if demand so dictated. The owners' share of management costs would still be left after applying the Georgist tax, and the share would grow with increases in demand. However, increases in the withdrawal of water at one location above a given aquifer could eventually decrease the available water at each and every location. The number of locations being held constant, their value could decline as the common access resource was mined.

Since rents from sites could be a primary source of revenue for the regional government, only a smaller amount going to site owners, government would have an incentive to maintain maximum rents from sites, an incentive that would translate into a managed sustained yield from the aquifer.

Protection of groundwater rents could occur if the government monitored withdrawals and enforced property rights for shares in the aquifer. In other words, some allocative rule would have to be applied to the aquifer so that site-owner management would occur. A system of correlative rights might develop, allowing each site owner to withdraw maximum quantities of water in a specified time period. Any transfer of such rights among site owners would affect relative land values, causing a needed reassessment of the Georgist tax. Because of such transactions costs, the government might forbid such transfers. In other words, water rights would have to be used or lost. Alternatively, government could appropriate the rights to groundwater and charge for its withdrawal. The Georgist tax could be converted to a user fee. A tax on the residual component of site value could continue to be levied.

In any case, the defining of flow or aggregate consumption for a given time period would determine ultimately a component of value of all sites as well as the total value of groundwater available for withdrawal from each site.

The institutional design for managing an aquifer can have marked efficiency effects that translate into the aggregate value of the resource itself. The difference in total value that obtains through different institutions will be determined fundamentally by the transferability of access to the resource and the demand for access at different locations.

If each site in the region is equally accessible to groundwater users—for example, there being uniform distribution of demand across space—transfers of access will have no value.[11] But, if the demand for groundwater is concentrated at any location, or if there are economies that develop in pumping at any location, transfers of access or use will have value.

Of course, any such differentials in rents could be eroded away through transfers of title to locations. But there could be instances where an agricultural user has a high demand for water, but little demand for additional parcels of land. In those instances, transfers of land would be an inefficient way to gain access to groundwater.

If each site owner had withdrawal rights to the underlying aquifer, and if those rights were protected by monitoring withdrawals, owners could then buy and sell rights, thereby accommodating differences in demand and cost across space. Transactions would lead to a maximization of rents obtainable from a stated total withdrawal of water and thereby maximize the tax revenues on those rents.

Finally, an entrepreneurial government, seeking to maximize rents from groundwater, while monitoring and charging for all withdrawals, could also obtain theoretically an efficient solution by transferring access across space, charging auction-determined prices for withdrawal rights. Under this last regime, total land rents would fall by the amount obtained by the government-entrepreneur, relative to a regime where site owners buy and sell withdrawal rights.

Assuming a cost-minimizing, rent-maximizing government, total rents from land and the aquifer would be at a maximum under either of the above-described regimes. This statement assumes, of course, that monitoring and transactions costs would be the same in either case. That assumption is rather heroic, given the incentive structure faced by the relevant decision makers.

IV

Georgist Considerations

HENRY GEORGE'S PRESCRIPTION for taxing rents explicitly excluded a role for an activist government.[12] Indeed, under his proposal, government would be limited by the revenues generated from *privately* generated rents. Additionally, George did not comment on the possibility that government might control the amount of land subject to private ownership, thereby establishing some targeted level of revenue obtainable from land rents. That result, too, was to be determined by private action. Government would, however, protect property and enforce contracts, with particular attention being paid to the protection of improvements to and on land.

The problem in applying the Georgist tax to groundwater, an issue he did not discuss, is this: Groundwater flows below many sites. To protect the implied property rights, government must first define the physical dimensions of what accrues to a given land parcel. To have the certainty equivalent of the overlying land, the definitions of the aquifer must be final, fully accepted by market participants, and not redefined. To do less allows for strategic behavior by economic agents who will be motivated to influence the political mechanism for private gain. Certainty can be provided by the court treatment of groundwater claims if a correlative rights definition is used and the rights are absolute for a specified period of time. With such a definition, land value components would be determined, as they relate to aquifer use, and the property owner could take action against others who might reduce the value of his property, or be acted against if his use diminished the value of another's property, as with subsidence of land. A Georgist tax could then be applied.

Instead of applying the land value tax, George might have recommended his alternative solution to the groundwater problem, had he considered it. He might have chosen to auction absolute rights to the highest bidder. Conceivably, an entire aquifer could be sold, even with uncertainty regarding its dimensions. In that way, the auctioneer, government, would extract estimates of the rent, and society would be left with a possible monopolist offering the resource to the highest bidder.

One cannot, however, assess the relative merits of having a private monopolist inspired to allocate a resource to its highest value use and doing so in a least cost fashion as opposed to a government monopolist influenced by the political process or, alternatively, a system with many private land owners who must deal with unpredictable law enforcement through court decisions. None of the possibilities is fully comforting, though that might be too much to expect.

When the relative merits of the various alternatives are considered, there is more than a suspicion that suggests a private monopolist would do no worse than a government monopolist, and that there are strong incentives at play for the private firm that suggest it would do better. Economic agents with the private firm would share directly in the gains obtained through cost reduction programs; government water managers would not.

V

Conclusion

STARTING WITH THE PROBLEM of groundwater and the possibility of applying a Georgist tax to the value that resource contributes to overlying land, this article has provided some background on the resource, current developments concerning it, and applied a theoretical model illustrating some associated management problems. The problem of groundwater management, like that of any natural resource, is far more complex than portrayed in this article. Even so, some basic dimensions of the problem have been sketched out.

While groundwater and aquifers are of immense value to society, it is highly likely that they will not be treated with owner-like concern, at least not in the foreseeable future. The rents enjoyed by current users are large; adjustments in their use would bring high costs. Additionally, the technical knowledge desired for making allocations or for taxing rents still leaves much to be desired. And there are serious problems that stem from the fact that aquifers are interstate and multinational in size and scope.

Even with all those problems, however, it is clear that decisions regarding the use, management and taxation of groundwater will be made. That being so, it seems only logical that steps would be taken to provide the first framework for any efficiency that could obtain. That step implies the development of monitoring capability.

There can be no assured property rights, no certainty of rents, no potential for a Georgist tax—if one should be desired—until monitoring and metering of use is feasible. But like the chicken and the egg, monitoring capabilities may await the economic incentive that arrives when wealth can be created and protected. In other words, economic agents who might find the management tools for dealing efficiently with groundwater may be waiting for government to signal the arrival of a time when the resource will become subject to the private creation of rents.

Notes

1. For an excellent summary of the controversy, see Robert V. Andelson, ed., *Critics of Henry George: A Centenary Appraisal of Their Strictures on Progress and Poverty* (Cranbury, N.J.: Fairleigh Dickinson Univ. Press, 1979).

2. See Donald V. Feliciano, "Groundwater Contamination and Protection," Issue Brief Number IB83091, Library of Congress, Congressional Research Service, July 5, 1983.

3. Robert D. Hayton, "The Law of International Aquifers," *Natural Resources Journal,* Vol. 22, (1982), p. 81.

4. Islamic law provides an interesting and old example of groundwater control. Under Muslim law a well and its water are the property of the one who dug it. Further, water sources are surrounded by a zone in which no other person may dig or drill for water. This and other examples of groundwater law from other countries are given in Robert D. Hayton, "The Ground Water Legal Regime as Instrument of Policy Objectives and Management Requirements," *Natural Resources Journal,* Vol. 22 (1982), pp. 71–93.

5. Land subsidence and compaction problems in California have led to losses of 29 feet of altitude in the San Joaquin Valley. Some 4200 square miles of land have experienced subsidence exceeding one foot. For discussion see Douglas L. Grant, "Reasonable Groundwater Pumping Levels Under the Appropriation Doctrine: The Law and Underlying Economic Goals," *Natural Resources Journal,* Vol. 21, (1981), pp. 1–36.

6. Feliciano, op. cit., reports there are over 200,000 underground injection wells in the U.S.; 19.5 million private septic systems; and over 180,000 waste impoundments at some 80,000 sites that could affect groundwater quality.

7. For discussion of the various doctrines and examples of treatment under them, see Robert D. Hayton, *op. cit.,* H. Stuart Burnes and James P. Quirk, "Water Law, Water Transfers, and Economic Efficiency: The Colorado River," *Journal of Law and Economics,* Vol. 23, (1980), pp. 111–34, and Bruce Yandle, "Resource Economics: A Property Rights Perspective," *Journal of Contemporary Law,* forthcoming.

8. For discussion of proposed legislation, see Feliciano, *op. cit.*

9. These points are discussed more fully in M. T. Maloney and Bruce Yandle, "Building Markets for Tradeable Pollution Rights," a chapter in Terry L. Anderson, ed., *Water Rights: Scarce Resource Allocation, Bureaucracy, and the Environment,* Pacific Institute for Public Policy Research, forthcoming.

10. The standard device is developed in Hugh O. Nourse, *Regional Economics,* (New York: McGraw-Hill Book Company, 1968).

11. See discussion by Maloney and Yandle, *op. cit.*

12. An excellent discussion of this point, and a modern interpretation of it, is given in Robert V. Andelson, "Neo-Georgism," in his *Critics of Henry George, op. cit.,* esp. pp. 387–89.