ADAPTIVE MANAGEMENT: HOW WATER LAW NEEDS TO CHANGE

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ABSTRACT: Adaptive management represents the future of natural resource management, including that of water and aquatic resources. Adaptive management is an inherently flexible system, and in order to fully implement its principles, resource managers need to cope with change and uncertainty, and need flexible management tools at their disposal. This need to be flexible and cope with uncertainty and change will be exacerbated by the changes in water supply wrought by global warming. Yet the needed flexibility is incompatible in significant ways with existing water law in arid regions such as the western United States. This paper addresses legal and policy reforms needed to adapt the water law of arid regions to the goals and practices of adaptive management.

KEY TERMS: water law, prior appropriation, adaptive management, global warming, droughts, floods.

INTRODUCTION

Adaptive management represents the future of natural resource management, including that of water and aquatic resources. Adaptive management is an inherently flexible system, in which resource managers establish desired outcomes, develop hypotheses and monitoring programs to test whether existing management approaches are achieving those outcomes, and then alter the approaches depending on the monitoring results. The need for adaptive management will become even more acute as arid region water resource managers struggle to cope with the additional uncertainties in water supply expected to result from global warming. In order to fully implement principles of adaptive management, resource managers need to cope with change and uncertainty, and need flexible management tools at their disposal. Yet this needed flexibility is incompatible in significant ways with existing water law in arid regions such as the western United States and other arid countries around the world. This paper addresses legal and policy reforms needed to adapt arid lands' water law to the goals and practices of adaptive management.

WATER ALLOCATION IN ARID LANDS

The prior appropriation doctrine governs water allocation in the western United States, home to a growing population expected to expand by another 28 million people in the next few decades (Case and Alward, 1997). Similar water law systems allocate water in arid countries around the world. The doctrine is considered a hard-edged, or "crystalline,"set of rules, as opposed to the looser "muddy" riparian doctrine followed in more water-rich areas (Rose, 1988). In other words, where water is a scarce and precious resource, the legal system has evolved a set of fairly rigid rules for assigning rights to water use. The prior appropriation doctrine operates on a first-in-time, first-in-right principle, where the first person to put the water to beneficial use acquires the superior legal right, and junior water rights holders must relinquish water in times of shortage. In contrast, the riparian doctrine that pertains where water is more plentiful follows a share-and-share-alike principle where everyone (or at least each riparian) is entitled to a reasonable share of the water resource, and all users cut back on a pro rata basis in times of shortage.

Prior appropriation as a system of water allocation is thus rigid in a number of ways. The doctrine locks in and protects historical uses, many of which were established over a hundred years ago in the western United States, without regard to whether those uses embody current views on the "highest and best use" of limited water. Approximately 80% of the water use is in irrigated agriculture, in a region where natural precipitation ranges as low as a few inches annually (Western Water Policy Review Advisory Commission, 1998). Shortages (which are frequent in arid regions) are handled on a strict priority basis, with the more junior water users being cut off. The doctrine does not reward efficiency; indeed efficiency improvements and conservation are often effectively penalized because any water not used for the prescribed statutory period of time is considered legally forfeited. The major goals of the system are predictability and certainty to support economic investment in consumptive uses of water. Even though water is scarce, water users know exactly where they stand in relation to each other, and users can predict on the basis of historical patterns how much water they will receive. Although attempts are being made to graft environmental demands for water onto the system, the graft has not fully taken, and water use in arid regions is still heavily tilted in favor of consumptive and economic uses such as irrigation, mining, hydropower, and municipal supply. Water rights are jealously defended as vested property rights against any alteration or interference.

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REQUIREMENTS OF ADAPTIVE MANAGEMENT

The rigid aspects of the existing water law systems in arid areas stand in stark contrast to the trend toward adaptive management in natural resource management generally. Adaptive management can be simply described as "learning by doing" (Lee and Lawrence 1986). An adaptive approach requires: flexible, adaptive policies (not rigid and locked-in policies); integrated approaches (rather than piecemeal approaches); planning and management for learning (not just for economic gains or social products); and experimentation and monitoring to test policies and identify necessary changes and responses (Coleman, 1998, Holling 1978). Furthermore, adaptive natural resource management seeks to incorporate current and emerging understanding about ecosystems and conservation biology (Ruhl 1997).

The key features of carrying out adaptive management in the natural resource context are (1) establishing the desired objectives for management of any particular resource, (2) proposing a management regime designed to achieve the desired objectives; (3) developing hypotheses and experiments to test whether the proposed management regime is in fact achieving the objectives; (4) setting up monitoring and testing programs to carry out the experiments and test the hypotheses "on the ground;" and (5) adjusting the management regime in response to the information received from the monitoring and testing, if the outcomes turn out not to be as desired. The crux of implementing adaptive management is thus to manage in the face of uncertainty, and to be able to respond quickly and flexibly to new information.

THE ADDED UNCERTAINTY OF GLOBAL WARMING

In addition to the general push to incorporate adaptive management in natural resource policy, the onset of global warming intensifies the need for resource managers to learn to cope with changing circumstances and uncertainty in water supply. Predictions of the impact of global warming on water resources include potentially widespread changes in precipitation, evaporation, and runoff (Miller 1997). A "redistribution" of both rainfall and snowpack is expected, resulting in the potential for more severe droughts and/or floods in some places (Waggoner 1990, Miller 1997). Although it is difficult to anticipate precisely how these changes will be manifested in any specific locality, it is safe to say that global warming will increase the uncertainty of water supply and therefore the challenge of water management in arid regions. Thus, arid and semi-arid areas, which already cope with a great deal of variability and little "margin of safety" in water supply, are inherently more vulnerable to the effects of global warming (Miller 1997).

Because it is difficult to predict with any precision just how global warming will play out, and where changes in drought and flood will occur, it is tempting to do nothing in advance and say that we will simply cope or adjust to the changes as they come. After all, the prior appropriation system provides eminently workable rules for handling water shortages: cut off the junior water users. Indeed, many junior irrigators on western stream systems get cut off partway through every summer when low flows are insufficient to supply all of those holding water rights. But the changes expected in the future as a result of global warming are of another magnitude entirely, with more of the already limited precipitation potentially running off as floodwater and thus unavailable for human use, and with droughts of increasing frequency and severity in many places. The prior appropriation system was designed to cope with short term shortages of the type common only in the last century. Current law is just not up to the task of handling truly severe long term changes, such as widespread multi-decade droughts, without drastic and unacceptable economic dislocations for everything from agriculture to municipal supply (Tarlock 1992).

Furthermore, the current system is already struggling with the fact that ecosystem needs are not accounted for in the existing allocation of water rights, so those uses of water would not be protected in a straight priority cutback. Indeed, the strict application of priority as the sole means of coping with severe and long term shortages would likely "be widely perceived as perverse since the highest priorities are often the lowest valued uses" (Tarlock, 1992). The highest priorities are simply the oldest uses, and severe shortages would often find economically marginal hay pasture receiving water while entire urban areas went thirsty. Simply applying existing water law as the means of adjusting to global warming would therefore be harsh in creating winners and losers (Id.). Thus, some pro-active measures should be considered to make the system more prepared and resilient, and to accommodate important but junior users and nonconsumptive water demands as well as historically vested consumptive water uses.

NEEDED ADAPTATIONS IN WATER LAW

How is the rigid prior appropriation doctrine going to incorporate flexible adaptive management principles? How does water law in the arid regions need to change in order to be responsive to new scientific information on an ongoing basis, particularly with the added wild card of global warming? What happens when a system whose very essence is structure and predictability (the prior appropriation doctrine) meets a management approach whose very essence is constant change (adaptive management)? That meeting is the subject of this paper.

Several commentators have described the challenge of incorporating the "nonequilibrium paradigm" into existing environmental law (Tarlock, 1994, Profeta, 1996, Ruhl, 1997). Tarlock notes that early American environmental regulatory statutes (such as the National Environmental Policy Act, the Clean Water Act, and the Endangered Species Act) were grounded in a now-discredited "equilibrium paradigm" understanding of ecology: that natural systems maintained a "relatively stable dynamic equilibrium" (Tarlock, 1994). The approach of the then-new laws fostering environmental protection was to try to respect and protect this "balance of nature" as much as possible by regulating human impacts to the natural systems, using a set of fixed management goals as a guide (Id.).

But the understanding of ecological principles was changing even as the old paradigm was being used as the foundation for legal schemes (Tarlock, 1994). We now realize–thirty years later–that the earlier premises were flawed, and that natural systems are not stable, balanced systems, but instead "far from equilibrium...." (Id.). Now, environmental law is playing catch-up, trying to incorporate uncertainties and feedback loops that were never contemplated when the laws were first adopted, as those laws were cast in terms of "consistent application of fixed rules to yield a single, final decision" (Id.). By contrast, adaptive management anticipates that management rules and strategies must frequently change in response to a continuous flow of scientific information. The problem with adapting water management in the arid regions of the United States to this evolving understanding of ecosystems requiring a new management approach is multiplied many fold, because the laws affecting water management are not just the environmental laws of thirty years ago, but even more so the 150-year-old property rights regimes that predate even the primitive understanding of natural systems of the 1960s and 70s. In fact, western water law is still struggling to integrate those thirty-year-old environmental regulations with its rigid allocation principles. In many areas, all of the water has been fully allocated, nature is not on the list of water rights holders, and transfers are limited both in law and in practice. Incorporating the brave new world of adaptive management into this system, especially with the overhanging cloud of global warming, is a challenging prospect indeed.

As noted, the steps of adaptive management include: (1) establishing desired objectives; (2) proposing a management regime to achieve those objectives (which should be treated as an experiment rather than a fixed choice); (3) developing hypotheses to test the management regime; (4) using a constant flow of monitoring data to learn how the management regime is working; and (5) adjusting the management regime accordingly on an ongoing basis. There are several significant ways in which prior appropriation systems of water allocation need to change in order to embrace this sequence of adaptive management: (1) improved water management planning to establish coherent management objectives; (2) institutional reorganization or coordination to bring together ecosystem management responsibilities and water allocation; (3) improved data collection and monitoring of water resources; (4) enhanced water conservation activity; (5) improved operation of water markets and government participation in those markets, and (6) enhanced flexibility in water allocation practices.

First, water management planning needs to be overhauled to be consistent with principles of ecosystem management and sustainable use of limited water supplies. To date, the term "water planning," when used in arid regions, really means primarily water supply planning for consumptive use, which has been further reduced in most places to "water storage planning." The major thrust of these efforts has been to figure out how to capture water during wet times of year and save it to be used during the dry season. So far, there has been little in the way of comprehensive basin-wide water planning that considers the entire resource and integrates other desired objectives besides water for consumptive uses, including such issues as consideration of water quality concerns, aquatic ecosystem needs, and the connection between surface water and groundwater. The uncertainty threatened by global warming only exacerbates the need for this comprehensive prioritizing to be done, with widespread public participation.

Simply saying that ecosystem management and sustainability principles will be used does not solve the problem of deciding what the management goals are going to be in the first place, however. Widely accepted definitions of "sustainability" in natural resource management recognize that sustainable resource use must provide for economic, social, and environmental products in order for the use to be both resilient and long lasting. The current water management system has been heavily stacked in favor of certain economic products, with corresponding social effects, both positive and negative. Now that environmental laws have begun to superimpose requirements for environmental products as well, the system of water allocation is under severe strain. Currently, the battles are often being waged in the courtroom, with conflicts being resolved case by case, in a win/loss fashion. Governance by litigation and court decree is not compatible with adaptive management, as it results in rigid directives. Instead, key conflicts about what to manage for need to be resolved up front so that action and experimentation can then proceed (Lee and Lawrence, 1986). It is probably safe to say that no arid lands state in the western United States has yet effectively grappled with sustainable water management planning, but jurisdictions that do so will be positioned much better to cope with the coming demands and changes. The process of involving large numbers of interests in prospective planning is bound to be difficult, time-consuming, and often frustrating, but there may be no other way to effectively reach enough agreement on how to balance social, economic and environmental desires and needs in order to move forward with management (Breckenridge, 1995, Profeta, 1996). The choices about how water is going to be used *will* be made, either by default, by post hoc litigation, or by prospective planning; the latter would seem to be the least of the three evils.

Second, water management institutions need to be reconstituted and realigned in order to be more congruent with integrated natural hydrologic systems. In the 17 arid (or partially arid) western states of the US, only a few have integrated water quantity management and water quality issues in a single agency. Only a handful of the arid states make a serious attempt to manage surface and groundwater as the related hydrologic systems they are in fact. Fewer jurisdictions still attempt to coordinate land use planning with water planning, even though development has a tremendous impact on all aspects of water management, such as growth in water demand, flooding, groundwater recharge, and water pollution. Finally, since state and local government boundaries and responsibilities follow arbitrary jurisdictional lines, the management units bear no relationship to watersheds or river basins, making comprehensive ecosystem management impossible. The thrust of current thinking in aquatic ecosystem management is to reestablish, as closely as possible, river systems that function more like undisturbed natural systems, like "normative rivers." (Independent Scientific Group, 1996). Such a goal can only be achieved

with greater congruence between the boundaries of hydrologic systems and the jurisdictions of water management institutions. The political resistance to true reorganization would of course be daunting, perhaps insurmountable in many cases. But a "second best" approach should at least be pursued, in the form of aggressive and innovative coordination among existing institutions. This includes federal, state, and local coordination, as well as interstate cooperation. As one commentator has put it: "local, state, and federal structures must combine their 'genes,'" and "engage in the political equivalent of sex...." (Ruhl 1997). The institutions resulting from this coupling should be a series of "nested" entities organized around problemsheds, ranging from local watershed councils to larger river basin institutions (Western Water Policy Review Advisory Commission, 1998, Ruhl, 1997).

Reorganization or coordination is particularly critical to bring traditional allocative water law and adaptive management within shouting distance of each other, for several reasons. Currently, adaptive management is gaining a foothold primarily in regulatory agencies and some land management agencies. For instance, the Northwest Power Planning Council, the National Marine Fisheries Service, the US Forest Service and state forestry agencies are some of the players trying to use adaptive principles in their respective spheres of natural resource management (Volkman 1999). This makes sense, of course, because these are the agencies with responsibility for managing or regulating ecosystems, or at least some component of them (either a large land area or a living resource component such as fish and wildlife), and this is the context in which the concept of adaptive management arose. But water management agencies, particularly state water resource agencies, have had a much different mandate and mission. The job of state water allocation agencies has been to "hand out" water for consumptive uses. In this sense, water has been considered a commodity or form of property completely apart from its place in the ecosystem. Other institutions have had the job of controlling water, such as the Corps of Engineers and other state and local entities involved in flood control, drainage, and irrigation. The whole point of these efforts has been to prevent water from behaving "naturally." The fact that these agencies manage water movement does not necessarily mean that they have ultimate control of the water itself, however. In most arid areas, most of the water supply is legally committed to private parties for consumptive uses, such as irrigation, municipal supply, mining, and power production.

The result of this fragmentation in mission, responsibility, and control means that the institutions on the forefront of pursuing adaptive management are not usually the entities who have physical control of the water, and thus accountability for its use. For instance, taking the Columbia River system as an example, the Northwest Power Planning Council (a federally created four-state regional body with an advisory role in managing the vast Columbia system for both hydropower production and fish and wildlife protection) has been a leader in advocating adaptive management as a means of trying to understand and manage the dwindling stocks of Pacific salmonids and the aquatic ecosystems on which they depend (Lee and Lawrence, 1986, Volkman, 1999). And yet, the actual "wet water" supporting these ecosystems is completely outside of Council control and influence. The water is partially controlled by the federal Army Corps of Engineers and Bureau of Reclamation in their operation of large federal dams for flood control, irrigation, and power production. But the water is also subject to the distribution functions of four different state water resource agencies, and ultimately in the hands of thousands of individual farmers, hundreds of irrigation districts, and a multitude of municipalities and industries. When the real day to day resource managers are in fact individual private actors like this, the whole job of using adaptive management becomes exponentially more difficult. Until control and responsibility are integrated, or at least coordinated, talking about using adaptive management in allocating water is just that–talk. In this situation, hybrid public-private institutions and partnerships need to be developed that can yoke together the various parties and get them working towards agreed-upon goals across property lines and political boundaries (Breckenridge 1995). The challenge will be to create entities that can also function with some flexibility.

A third necessary change is to get serious about data collection and monitoring of water resources, and to make sure that the data is used in decision making by those who can make a difference. An absolutely basic requirement is thus to measure all consumptive water uses, and to gage streamflows on a real time basis. This data needs to be continuously and widely available to academics, regulatory and management agencies (land, water, fish and wildlife) as well as to the water users themselves so they can assess and adjust their impact on the resource. These water supply and water use data then need to be integrated with further research on how climate changes are likely to affect particular water resource and supply regions. For instance, two scientists at the U.S. Department of Energy's Lawrence Berkeley National Laboratory in California recently integrated the United Kingdom's Hadley Centre Global Climate Model with a variety of region-specific climate models to project the impacts of climate change on particular parts of the western United States and even particular California river systems in order to specifically address California water resource management issues (Kim, 2001, Miller, 2001). More of this type of research will be needed, but the actual water users are going to have to meet the scientists and managers partway by measuring their own water consumption. Research to support policy development is a tricky business for scientists. Traditionally, some members of the scientific community have wanted to keep science "pure," separate from the political choices about how to use the results of research (Tarlock, 1994). But adaptive management, particularly ecosystem management, requires a closer alliance and integration between science and policy. Indeed, the emerging field of conservation biology is specifically conceived of as a field of applied or "regulatory" science striving to provide "useful information for regulators rather than to pursue knowledge for its own sake" (Id.). Regulatory science is also messy because it requires "scrambling" of disciplinary boundaries in order to acquire integrated and useful data (Id.).

A fourth necessary change is to intensify efforts to achieve significant water savings in existing consumptive uses. Every

drop of water must go as far as possible to meet growing demands and help buffer against increased uncertainties. Until now, there have been no comprehensive conservation efforts in the arid states except in response to local crises, and inefficient use of water is still rampant (Neuman, 1998). Past water management policies in the western United States have subsidized inefficient irrigation practices, thus providing incentives to use large amounts of water on low value crops. This is why cotton (a water-intensive crop) is grown in the Imperial Valley of Southern California, which receives a few inches of annual precipitation, and why rice (requiring flood irrigation) is grown in northern California, hardly monsoon country. What our policies should be encouraging now– and perhaps even subsidizing– is more drought-resistant dry land or low-water-use crops and agricultural practices. Such changes would decrease the vulnerability of the agricultural industry to greater uncertainties in the water supply, and would improve its resiliency for incorporating adaptive management. Further research is needed in this area, too. If arid regions such as the western United States hope to maintain an agricultural industry over the long term, the practices must become more sustainable not only in terms of the amount of water consumed, but also in terms of water pollution, soil loss, and other environmental impacts of intensive agriculture in what is in many places effectively desert (National Research Council, 1992).

A fifth change is to improve the operation of water markets, so that water can be moved around quickly in response to changing needs and demands. However, markets only substitute one system of private control of water (the market) for another (the existing privately-held appropriative rights). There is no guarantee that market transfers would actually occur to the degree needed to respond to changing water demands, and that the market-driven redistributions would necessarily be either fair or responsive to ecosystem needs (Tarlock, 1992). Furthermore, it would be difficult to provide enough information and structure markets in ways that would properly reflect complex ecosystem interrelationships, both locally and regionally (Breckenridge, 1995). Encouraging the operation of water markets is therefore certainly not a panacea, but markets can introduce a much greater degree of flexibility, responsiveness, and feedback than the current system allows. Market enhancements must be done in the context of public policy choices if they are to advance societal goals as well as individual goals. If the market is going to help reallocate water to ecosystem management purposes, it is likely that government entities will need to become involved. Government may need to "buy back" some of the water supply that at this point is fully allocated in many places to consumptive uses. During a drought in California approximately ten years ago, the state set up a water bank in order to authorize and encourage the quick movement of water from lower-value users (senior irrigators) to higher-value uses (municipalities). Since the state established the bank, chose the buyers, handled the transactions, and even set the prices, it was hardly a true "market" (Dellapenna, 2000). However, it did accomplish the purpose of facilitating transfers more efficiently during a period of reduced water supply. Even if a government does not want to get into the business of actually running a market, other steps can be taken to enable private deals to occur. Such steps include ensuring that the law authorizes leasing of water between users and other temporary transactions, such as dry year options, and providing clearinghouse and information services.

Currently, in the western United States, market transfers of water rights can only occur when the proponent of the transfer can demonstrate that moving the water to a new place or type of use will not injure any third parties (generally downstream junior appropriators). This "no injury" requirement is often pointed to as a barrier to market transactions, because it spawns lengthy and expensive administrative and judicial review processes. The reason for the requirement, however, is to protect the investment and expectations of the junior appropriators who often depend on the return flow from upstream water users in order to get any water at all. Thus it would not necessarily make sense to change this requirement even though it certainly does serve as a market barrier. However, the more information available about individual users' actual water use, return flow, and streamflows, the easier and quicker it would be to assess the impact of market transactions. Therefore, the recommendation to require measurement of all water users, mentioned above, would contribute a great deal of "lubrication" to the market in the form of useful information. Another change that would help encourage use of the market would be to put the burden of proof to show injury on the party objecting to a transfer, instead of on the proponent of the transaction, where the burden usually is now. An additional possibility would be to change the "no injury" test to a compensation rule; in other words, instead of being able to block a transfer completely, an injured party could be awarded compensation in the form of damages, or even an alternate source of water provided or paid for by the successful applicant for the transfer. Although the latter method would not necessarily reduce water use overall, it still builds in more flexibility and resilience, and perhaps "optimizes" water use in an economic sense.

Finally, the water allocation system itself must be made more responsive to change. In a list of difficult tasks, this truly is one of the hardest. Water users who hold vested water rights in arid regions hold valid property rights, even though they are considerably different than ownership rights to a piece of land. How, indeed, could those rights be made more "flexible?" The market devices discussed above have the potential to inject some flexibility into the system as a whole, but they do not address individual water rights. Yet to truly incorporate adaptive management, there needs to be some "give" at the individual level as well. One way to achieve this goal is to "regulate" for it. To some degree, this is happening already. For example, the Endangered Species Act has been used to cut back on the amount of water a user can use, even though that person holds a legal water right to a stated amount of water. In a sense, this is adaptive management in action: the wildlife managers are trying to determine, on an ongoing basis, the struggling species' needs for water, and the rigid prior appropriative rights have been forced to give way, on a season-by-season basis. In a few instances, however, water users have been able to convince a court that any change in the amount of their water constitutes an unconstitutional taking that

cannot simply be required by regulation but instead must be compensated. Indeed, another way is to "buy" the desired results. This is really simply a question of risk allocation. Who should bear the risk of uncertainty injected into traditional water use by adaptive management, the water users or the managers (usually government agencies)? If the water users are increasingly successful in resisting regulation that challenges historical use methods and amounts, then government may need to pay for the desired flexibility.

CONCLUSION

Adaptive management principles will govern natural resource management in the future, including water and aquatic resource management programs. Incorporating the flexible "learning by doing" concepts of adaptive management into the rigid prior appropriation doctrine that governs water allocation in arid regions presents a significant challenge, however. Using adaptive management requires coping with a considerable amount of uncertainty, change, and experimentation, which are fundamentally incompatible with the prior appropriation system. The problem will be exacerbated as the western United States and other arid regions begin to feel the effects of global warming, which will likely bring changes in precipitation patterns resulting in more frequent and severe droughts in many places, but in increased flooding as well. In order to improve the responsiveness of the water management system generally, and reduce the vulnerability to expected climate changes, water law needs to change in several ways. From data gathering and use, to institutional configuration, to how water rights may be used, 21st century water law will need to stretch and give to accommodate adaptive management.

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