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AN ANALYSIS OF THE ECONOMIC AND IDEOLOGICAL FACTORS INVOLVED IN THE DEVELOPMENT OF RIGHTS TO WATER IN THE WEST, FOCUSING ON COLORADO

The University of Oklahoma PH.D. 1984

THE UNIVERSITY OF OKLAHOMA

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AN ANALYSIS OF THE ECONOMIC AND IDEOLOGICAL FACTORS INVOLVED IN THE DEVELOPMENT OF RIGHTS TO WATER IN THE WEST, FOCUSING ON COLORADO

A DISSERTATION

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in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

By

DAVID A. PENN

Norman, Oklahoma

1984

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APPROVED FOR THE DIVISION OF ECONOMICS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Chapter I

INTRODUCTION

Greater demands for water from agricultural, industrial, and domestic uses in the Western United States have spawned several investigations of alternative methods of alleviating the problem of water scarcity. Early studies concentrated on increasing the effective supply of water through the construction of storage reservoirs and diversion facilities.

Faced with rapidly increasing construction costs, however, recent studies have emphasized institutional rather than technological solutions. These studies conclude that the introduction of economic incentives through the institution of a market for water will help to alleviate water shortages.[1] In this way, water will be allocated to the highest valued use, shortages will be eliminated, and efficiency improved. Historical opposition to the market and the perspective that the allocation of water is somehow different from the allocation of other resources are viewed

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[1] Many examples exist in the literature. For a review, see Garret C. Oeltjen and Loyd K. Fisher, "Allocation of Water: Preferences, Priorities, and the Role of the Market," Nebraska Law Review, 57 (1978): 245-282.

as irrational by these studies.

But the persistence of seemingly less than efficient water rights institutions raises the question: How did this system of non-market water allocation come to be established in the West? Also, what role did economic incentives play in the development of rights to water? This study provides some preliminary observations and hypotheses regarding these questions. Since it was the first state in the West to establish a system of water rights based exclusively on the system of prior appropriations, the study focuses on the experience in Colorado. Many of the developments in water rights in the rest of the Arid West derive in one way or another from the Colorado system. Limiting most of the discussion to Colorado also serves to keep the study within manageable proportions.

The following material offers a discussion of water rights development in the West in three distinct but interrelated segments: theoretical, historical, and quantitative. Though many studies offer theoretical analysis of water rights, few have addressed the development of water rights and fewer have examined the historical context of property rights development. To my knowledge, no study has attempted to estimate a quantitative model of the evolution of water rights. Although important in their own right, an analysis of property rights evolution with only one or two

of these components would be similar to building a stool with only one or two legs; the result is an unbalanced structure. Adding the third leg or component, however, not only helps to add balance but also creates a study that is, perhaps, more than the sum of its parts.

In the first portion of the study, the theoretical basis of the development of property rights is examined, particularly rights to water. A review of the literature regarding the economic role of property rights and their development is presented in Chapter II. This chapter is important in that it gives an overview of the current applications of economic theory to property rights development. An important point developed in this chapter is that the treatment of property rights in terms of polarized exclusive or non-exclusive forms is not appropriate for study of the evolution of property rights. Thus, instead of being established in an completely exclusive form, it is more likely that property rights evolve gradually from less exclusive to more exclusive. The current level of exclusivity depends on the net benefits of exlcusion.

Chapter III develops an economic model of water rights evolution, building on the theory discussed in Chapter II. Based on the standard problem of non-exlusive resources, the model suggests that water claimants will more carefully define their rights to water when: 1) the derived demand

for water increases and 2) streamflow--the supply of diverted water--decreases.

The second portion of the study examines the historical experience of water rights development in the West, focusing on Colorado. This historical material provides an important context within which to consider the theoretical literature and the implications of the model of property rights evolution. Chapter IV discusses the beginnings of water rights in the West, briefly examining the experience in California and the early regulations of miners' districts and claims clubs. Conflicts regarding the right to water are found to arise particularly in periods of low streamflow. These conflicts create pressures for further specification of rights to water.

As the most easily irrigated lands were occupied by individual and cooperative irrigators, further development required new sources of investment capital. The implications of the development of the corporate canal are considered in Chapter V. It will be seen that much of the conflict concerning water rights occurred during this period. In addition, ideological factors take root during this period, causing a movement against monopolistic and speculative ownership of water. Ideology and the absence of highly competitive markets for water shape conflicts concerning rates charged for water deliveries and the quantity of water asso-

ciated with a water right. Included is a brief discussion of the origin of the Wyoming system of water rights administration.

The final portion of the study offers quantitative evidence regarding the influence of economic factors on the development of water rights, and some concluding observations. Models of water rights evolution in Colorado and the Arid West are estimated and discussed in Chapter VII. Chapter VIII provides a summary of the study, along with concluding observations.

Chapter II

THE FUNCTION AND DEVELOPMENT OF PROPERTY RIGHTS

The literature discussed in this chapter forms the cutting edge of the property rights paradigm. The material not only brings property rights and transactions costs into the discussion, but also offers explanations for change in property rights and institutions. Section one presents an overview of the literature regarding the economics of institutional change. The problem of efficiency and institutional change is examined in section two. The discussion provides a context for the analysis of the development of water law in subsequent chapters and lays the groundwork for the model of property rights change constructed in the following chapter.

2.1 THE ECONOMICS OF INSTITUTIONAL CHANGE

The economists who first attempted to explain the development of property rights were Marx and Engels.[1] According to Marx,

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[1] Svetozar Pejovich, "Towards An Economic Theory of the Creation and Specification of Property Rights," Review of Social Economy, 30 (September 1972): 316.

> political economy proceeds from the fact of private property, but it does not explain it to us. . . Private property is explained from external circumstances. As to how far these external circumstances are but the expression of a necessary course of human development, political economy teaches us nothing.[2]

Marx and Engels set out to develop their own theory of property rights evolution to fill the void left by mainstream economists.

Marx believed that institutions are a function of the level of development of the material powers of production. The material powers of production include the stock of natural resources, the size of markets, and the state of technological development. As any one of these factors change, the material powers of production will come into conflict with the relations of production--institutions and property rights--thus creating social pressures and incentives for change. Although the original specification of institutions and property rights may have encouraged social development when first established, the same property rights may hamper development as the material powers of production change. The conflict between the emerging set of property rights and the existing set will be resolved in the political/legal arena, resulting in a new specification of

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[2] Karl Marx, Economic and Philosophical Manuscripts of 1844, (Moscow: Foreign Laguages Publishing House, 1960), pp. 68-69, quoted in Ibid.

property rights and institutions.[3]

The relatively recent property rights and institutional change literature agrees with this much of Marx's analysis. The language, however, is couched in terms of the individual pursuing his or her self-interest. As Goldberg has put it,

> not only will people pursue their self-interest within the rules; they will also allocate resources toward changing the rules to their own benefit.[4]

Individuals maximize utility by allocating their resources among various activities so that the benefit or an additional dollar of resources expended on each activity is equated. And changing the rules of the game should be recognized as one of the activities possible. Pursuing their self-interest, individuals will allocate labor effort or resources to institution or rule changing activities as long as the prospective benefits exceed the costs. In terms of property rights, individuals will attempt to exclude others from access to a resource so long as the expected benefits exceed the costs of defining and policing the claim to

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[3] Karl Marx and Friedrich Engels, Critique of Political Economy, excerpt in Louis S. Feuer, ed. Marx and Engels: Basic Writings on Politics and Philosophy, (Garden City: Anchor Books, 1959), pp. 43-44.

[4] Victor P. Goldberg, "Institutional Change and the Quasi-invisible Hand," Journal of Law and Economics, 17 (October 1974): 461.

the resource.[5] To exclude potential users means to establish property rights.[6]

The subsequent discussion is divided into two sections: 1) the general models of institutional change, and 2) models and studies that relate to the development of property rights in natural resources.

2.1.1 General Models of Institutional Change

This section summarizes the work of Demsetz and of Davis and North.[7] Both studies offer general economic models for the development of property rights and institutions. The studies by Demsetz and by Davis and North have provided the foundation for much of the literature on the evolution of property rights.

The credit for pioneering the use of the tools of neoclassical economics to explain the development of property rights could probably be accorded to Harold Demsetz. The distinction awarded Demsetz is double-edged: some analysts have built on his work, while others have constructed their

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[5] Pejovich, "Specification of Property Rights," p. 312.

[6] Ibid.

[7] Harold Demsetz, "Toward A Theory of Property Rights," American Economic Review, 57 (May 1967): 347-359; Lance Davis and Douglass C. North, Institutional Change and American Economic Growth, (Cambridge: Cambridge University Press, 1971).

models in response to weaknesses in his work.[8]

Demsetz bases his analysis on the concept of externality. As discussed above, property rights define the cost and benefits associated with resource use. To the extent that these costs and benefits are not distributed to the decision-maker, externalities may result. Demsetz argues that a primary function of property rights consists of internalizing externalities.[9] The driving force in the evolution of property rights, according to Demsetz, is the emergence of new external costs and benefits. Opening of new markets, changes in technology and increased knowledge generate new cost-benefit incentives. New forms of property rights are constructed to internalize or capture new benefits or to avoid the costs of changing events. In other words, "property rights develop to internalize externalities when the gains of internalization become larger than the cost of internalization."[10]

Demsetz stresses that internalizing externalities through adjustments in property rights should not be interpreted as a deterministic process. Rather, the process of

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[8] As examples of the latter, see Carl J. Dahlman, The Open Field System and Beyond, (Cambridge: Cambridge University Press, 1980), and John R. Umbeck, A Theory of Property Rights, With Application to the California Gold Rush, (Ames: The Iowa State University Press, 1981).

[9] Demsetz, "Theory of Property Rights," p. 348.

[10] Ibid, p. 350.

property right change will likely be a sporadic, hit-or-miss process. The property rights that survive will be the ones that could best accomodate changes in technology and market conditions.[11] In a well-known example, Demsetz employs his theory to explain the origin of property rights to land among the Labrador Indians of Quebec. Up until the early eighteenth century, hunting for furbearing animals was largely for local consumption. The furs were not sold on the market, but were used by the hunter's family for clothing and shelter. Since the animals were hunted on common property, the usual type of externalities associated with free-access resources were generated. That is, free-access resources create little incentive to invest in maintaining the resource stock, since the gains from such effort would probably not be captured by the investor, but by other resource users. Thus, the incentive structure promotes overutilization of the resource. The externality generated in the case of the Indians, however, was not yet large enough to justify the trouble of establishing private property rights.

Increased demand for furs led to a greater fur trade with the Indians of Quebec. The result, as Demsetz provides, was that the Indians placed a higher value on furs and expanded the magnitude of their hunting operations. As

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[11] Ibid.

a result, the externality produced by free-access to the hunting lands greatly increased, thereby providing greater incentives for establishing exclusive property rights. Demestz documents that this in fact did occur: Indian families began to establish territorial hunting grounds. Thus the establishment of a greater degree of exclusivity of property rights was correlated with change in economic circumstances.

Relying on the work of Demsetz, Davis and North argue that new institutional arrangements are formed as the result of the pursuit of potential profits by individuals. The model attempts to predict the level--voluntary, cooperative, or governmental--of the new institutional arrangement and also the time lag between the initial perception of potential profits and the emergence of the new institutional arrangement.

Like Demsetz, the Davis-North model proposes that institutional change occurs when individuals perceive that the expected benefits of changing the rules of the game exceed the costs. As new sources of profit emerge, individuals or groups will take it upon themselves to change the rules of the game in order to capture these new benefits. New sources of profit are generated by many factors including economies of scale, externalities, transactions costs, and risk aversion. But new sources of profit don't just

materialize from thin air; they are the result of changes in one of the exogenous variables of the model. Exogenous variables include the level of technology, market size, relative prices, expectations of income, knowledge, and background economic and political institutions. A change in one or more of the exogenous variables generates a new source of profit. If these new profits cannot be captured in the existing incentive structure, pressures will build for institutional innovations that will permit profits to be captured.

Technological change, for example, often produces substantial economies of scale. Therefore, a business that utilizes the new technology would be able to cut unit costs by increasing the size or its operations. Suppose that the technological innovation required a large amount of capital investment. If firms could only be organized as sole proprietorships or as partnerships, the liability of stockholders may appear excessively risky. A new institutional innovation that would limit the liability of stockholders would result in a greater amount of funds available for investment. According to Davis and North, the corporation was just such an innovation. This institutional innovation enabled the firm to invest in the new technology, thereby generating new profits from economics of scale.[12]

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[12] Davis and North, Instutitional Change, p. 14.

2.1.2 Property Rights in Natural Resources

Other studies of change in institutions on a less grand scale include Anderson and Hill, Dahlman, Umbeck, and Libecap.[13] Each study examined the development of property rights in natural resources: Anderson and Hill analyzed property rights in land, livestock, and water in the American West; the enclosure of common lands in England was the focus of the study by Dahlman; Umbeck constructed a model of the choice of contracts for gold-bearing land during the California gold rush; and Libecap described the development of property rights to gold in Nevada's Comstock Lode.

The basic structure of each of these models is very similar. Individuals or groups are assumed to maximize some objective function such as utility, residual income, or profits. Generally, the problem faced by individuals consists of choosing the appropriate level of effort to apply to changing or defining the rules of the game in order to maximize the value of their objective function. Anderson and Hill call this effort property rights defining and enforcing activity. Umbeck characterizes the process as one of contracting between gold miners. Libecap refers to the defense

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[13] Terry L. Anderson and P. J. Hill, "The Evolution of Property Rights: A Study of the American West," Journal of Law and Economics, 18 (April 1975): 163-179; Dahlman, Open Field System Umbeck, Gold Rights and Gary Libecap, The Evolution of Private Mineral Rights: Nevada's Comstock Lode, (New York: Arno Press, 1978).

of mining claims, and Dahlman terms the activity as establishing and protecting ownership rights.

Also common throughout these studies is the proposition that individuals will use the same criterion for expanding resources on property rights defining and enforcing activity as for any other type of activity, namely, the expected benefits of the activity relative to the costs incurred. The problem of determining the equilibrium level of defining and enforcing activity then becomes one of characterizing the marginal cost and marginal benefit functions. As shown in Figure 1 taken from Anderson and Hill, the intersection of the marginal benefit and marginal cost schedules determines the equilibrium level of defining and enforcing activity. The benefit schedule, or the 'demand' for defining and enforcing activity, generally depends on the value of the asset and the probability that the gains generated by defining and enforcing activity will be captured by the owner of the asset. The 'supply' of defining and enforcing activity depends on the scale of operations and the assets of the property owner.[14]

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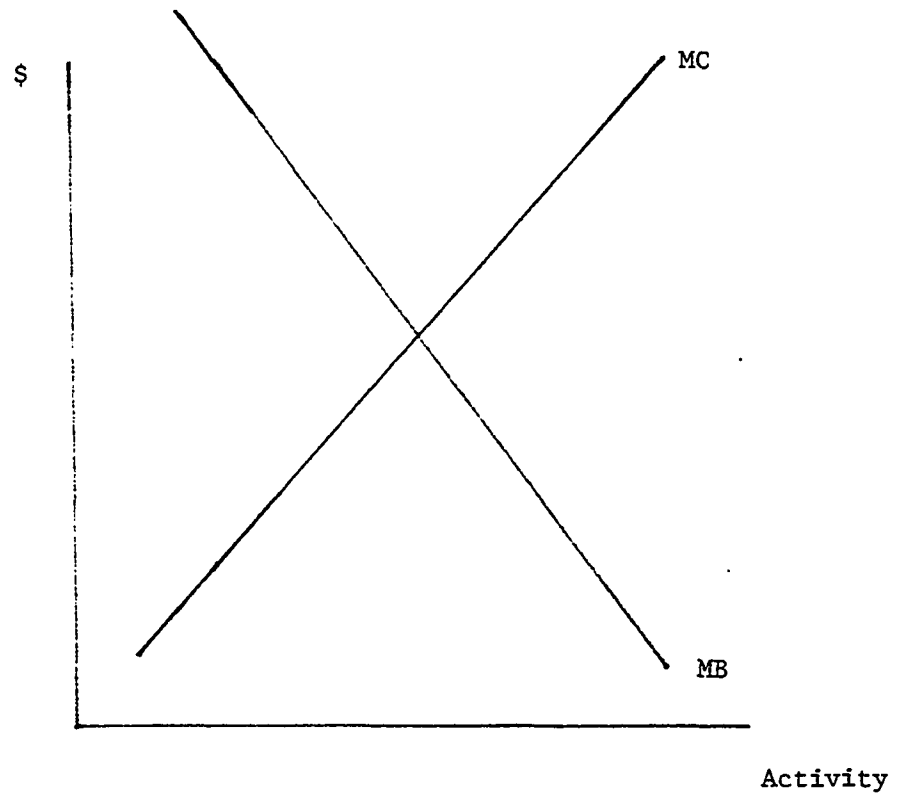
[14] Anderson and Hill, "Evolution of Property Rights," p. 167.

Figure 1: Costs and Benefits of Property Rights Defining Activity



Source: Adapted from Anderson and Hill, "Evolution of Property Rights," p. 166.

A brief summary of the analysis of the development of Western water rights discussed in Anderson and Hill will

illustrate the mechanics of the model. Early settlers in the West established the riparian rule of water rights generally because they had been familiar with the riparian system in the East. In addition, as Anderson points out, water was a relatively abundant resource. Thus the prospective additional benefits of further defining property rights to water did not justify the additional costs. With the discovery of gold and the subsequent increase in population, however, the benefits of defining and enforcing activity greatly increased. In particular, gold miners in California found that the riparian system was not suited to the technical circumstances of mining: water must be diverted from the watercourse to be used some distance from the stream. This the riparian rules would not allow, so the gold miners formed associations and molded their own system of water rights; one suited to the physical requirements of mining gold. Eventually, these new rules became recognized as the system of prior appropriation.

2.2 INSTITUTIONAL CHANGE AND EFFICIENCY

Some of the institutional change literature supports the proposition that the rules of the game tend to develop efficiently. In Demsetz's model, for example, change is efficient since it occurs when externalities are internalized. Similarly in the Davis-North model, institutional

change must result in social gains; otherwise, change would not have occurred.

One can also identify this propensity in the legal change literature. There, much of the work is based on Richard Posner's proposition that the common law exhibits a tendency to develop efficiently: "judge-made rules tend to be efficiency promoting, while those made by legislatures tend to be efficiency reducing."[15] Posner attributes this difference in institutional performance to the absence of incentives for self-serving behavior in the judiciary relative to the legislature. Judges are more detached from political pressures than are legislators; decisions based on the judge's self-interest would violate the norms of judicial behavior. Posner argues that a judge's decision will tend to be based on efficiency criteria if only due to the fact that self-interested decisions are all but ruled out. Hirshleifer calls this hypothesis 'Posner's Theorem': "market interactions tend toward economic efficiency, and the law will in fact tend to assist and supplment this tendency."[16]

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[15] Richard A. Posner, Economic Analysis of Law, 2d ed., (Boston: Little, Brown, and Company, 1977), p. 404.

[16] Jack Hirshleifer, "Evolutionary Models in Economics and Law," Richard O. Zerbe ed., Research in Law and Economics, 4 (1982): 3.

In related studies, Rubin and Priest build on Posner's Theorem.[17] In Rubin's model, the evolving efficiency in the common law depends on the actions of litigants, not on the discretion of the judge. He argues that inefficient rules are more likely to be challenged than rules that are efficient. If the rule is efficient, then the parties in the dispute will not litigate but will settle out of court. This process depends on the interest of both parties in developing legal precedents.

Priest follows basically the same argument, but generalizes the applicability of Rubin's model. He contends that inefficient rules will tend to be litigated because the costs imposed by inefficient rules are by definition greater than those imposed by efficient rules, whether or not the parties are concerned with developing precedents.[18]

Both models characterize the development of the common law as an evolution from less efficient to more efficient. If inefficient laws are more likely to be litigated, then even if court decisions are made at random, inefficient rules will tend to be overturned and efficient rules will tend to persist.

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[17] Paul H. Rubin, "Why is the Common Law Efficient?" Journal of Legal Studies, 6 (January 1977): 51-63; George L. Priest, "The Common Law Process and the Selection of Efficient Rules," Journal of Legal Studies, 6 (January 1977): 65-82.

[18] Priest, "Common Law," pp. 67-73.

A common thread of thought in these works is the notion that the efficient evolution of institutions takes place as a hit-or-miss process. Some recognize that inefficient insttitutions may crop up here and there, but that these sorts of aberrations are unstable and will not persist in the long run. Dahlman takes this argument one step further: since inefficient institutions are not expected to survive in the long-run, institutions that do in fact persist must somehow be efficient. Common property or free-access resources are widely regarded in the literature as being inefficient; they encourage a greater than optimal level of utilization.[19] But given this, how does Dahlman explain the longevity of an obviously inefficient institution such as the system of common lands in England? To answer this question, we must delve into the relationship between transactions cost and property rights.

2.2.1 Transactions Costs and Property Rights

The relationship between transactions costs and property rights was first explicitly examined in the seminal work of Coase.[20] According to Coase, voluntary exchange bet-

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[19] For example, see Richard James Sweeney, Robert C. Tollison, and Thomas D. Willett, "Market Failure, the Common-Pool Problem, and Ocean Resource Exploitation," Journal of Law and Economics, 17 (April 1974): 179-192.

[20] Ronald H. Coase, "The Problem of Social Cost," Journal of Law and Economics, 3 (October 1960): 1-44.

ween parties will result in efficient outcomes as long as property rights are assigned and transactions costs are zero. As long as property rights are well-defined, the allocative outcome will be the same regardless of the original specification of property rights.

The subsequent literature further examined the linkage between property rights and transactions costs. Specifications of property rights were compared on the basis of the level of transactions costs generated by each. Private or exclusive rights to resources were generally deemed superior to non-exclusive or unspecified rights since they lowered the cost of negotiating and enforcing exchange agreements or contracts. In other words, private property rights lower the costs of market exchange.[21] Fewer resources are expended in the exchange process, since the attributes of the resource, including ownership, physical dimensions, and quantity are already established in the property right. These results were confirmed in studies by Demsetz and Cheung.[22] Before further discussion, a digression on the definition of transactions costs is in order.

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[21] For further discussion of this point, see Carl J. Dahlman, The Open Field System, pp. 79-92.

[22] Harold Demsetz, "Theory of Property Rights," and Steven N. S. Cheung, "The Structure of A Contract and the Theory of a Non-Exclusive Resource," Journal of Law and Economics, 13 (April 1970): 49-70.

* * *

In this study, transactions costs are defined as the gains from exchange foregone due to the existence of non-exclusive property rights and restrictions on the transferability of property rights. A variety of definitions of transactions costs are found in the literature. In a relatively broad definition, Dahlman states that transactions costs include search and information cost, bargaining and decisions cost, and policing and enforcement costs.[23] The transaction cost concept is a useful tool when costs are carefully defined. But the term is used in so many different ways that one is really not sure what transactions costs really are. As Alchian has observed

> the conception of transactions remains sufficiently indefinite to permit superficial reference to transactions costs as the key to any paradox, externality, public goods provision, etc.[24]

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[23] Carl J. Dahlman, "The Problem of Externality," Journal of Law and Economics, 22 (April 1979): 148.

[24] Armen Alchian, "Some Implications of Recognition of Property Rights Transactions Costs," In Karl Brunner ed., Economics and Social Institutions, (Boston: Martinus Nijhoff Publishing, 1979), p. 234. Alchian describes no less than six types of transactions costs: 1) the costs of determining who holds what rights, 2) the cost of specifying the rights held by any individual, 3) the cost of assessing the attributes of a good, 4) the cost of determining available prices and estimating future prices, 5) the cost of ensuring that contract provisions are verifiable, and 6) the costs of verifying agreements and contracts. Ibid, pp. 234-236.

Matters really get confusing when transactions costs refer to both the cost of market exchange and the cost of establishing exclusive property rights. For this reason, the term will be used sparingly in the chapters to follow.

* * *

Later analyses raised some doubts about the universal superiority of private property rights. These studies pointed out that although private property rights will reduce transactions costs--the costs of negotiation and exchange--these gains will only be generated after exclusive property rights have been established. In order to establish exclusive rights, resources and effort must be allocated to the process of defining and enforcing property rights. In other words, establishing exclusive rights is a costly process. If the costs of establishing exclusive property rights are greater than the gains in terms of lower transactions costs, then exclusive rights would be inefficient and not worth the trouble constructing.

The cost of establishing exclusive property rights depends strongly on the physical nature of the resource. Some resources occur naturally in forms that are costly to measure and define. And as we have seen, the lower the level of definition of the characteristics of a resource, the higher the costs of exchange. Establishing and enforcing exclusive property rights in commercial fish in the oce-

ans, for example, would certainly cost more than their sale would generate.[25] Similarly, the definition and enforcement of exclusive rights to resources such as ground water and petroleum would be expensive, simply because they are difficult to isolate and measure.

Thus, the persistence of less than exclusive rights to a resource might be explained by the high cost of defining and enforcing property rights relative to the benefits. It is possible, then, that seemingly inefficient institutions may actually be efficient to the extent that the institution performs well relative to the actual constraints of the time and place. In other words, private property rights are not unambiguously superior to non-exclusive rights; one must consider the actual costs of increasing the exclusivity of the property right.

Using this argument, Dahlman contended that the open field system was actually an efficient institution in that it performed as well as could be expected given the actual constraints of the time, including technology, market size, relative prices, resource endowments, and the costs of establishing exclusive property rights.[26] The proposition that the definition of private property rights might actu-

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[25] Alan Randall, "The Problem of Market Failure," Natural Resources Journal, 23 (January 1983): 133.

[26] Carl J. Dahlman, The Open Field System, p. 204.

ally result in a net social loss is also argued by Anderson and Hill.[27]

2.2.2 Ideology and Institutional Change

In a recent study, Douglass North offers an alternative explanation for the longevity of seemingly inefficient institutions.[28] North believes that ideology may help to explain why inefficient institutions are established and why they may not evolve into more efficient forms. The recognition of the salience of ideological behavior by North constitutes a revision and important extension of the Davis-North model. In his work, North evaluates the propriety of the assertion of mainstream economics that all activities are the result of a solipsistic evaluation of relative costs and benefits:

> Something more than an individualistic calculus of cost/benefit is needed in order to account for change and stability. Individuals may ignore such a calculus, in an attempt to change the structure, because of deep-seated ideological convictions that the system is unjust. Individuals may also obey customs, rules, and laws because of an equally deep seated conviction that they are legitimate.[29]

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[27] Terry L. Anderson and P.J. Hill, "Privatizing the Commons: An Improvement?" Southern Economic Journal, 50 (October 1983): 450.

[28] Douglass C. North, Structure and Change in Economic History, (New York: W.W. Norton and Company, 1981).

[29] Douglass North, Structure and Change, p. 12.

The theory of institutions in North consists of three components: a theory of property rights, a theory of the state, and a theory of ideology. The state in this model is primarily concerned with the specification of property rights. The theory of property rights explains the relative impacts of particular specifications of property rights, and the resulting effects on economic efficiency. The theory of ideology explains the effects of social values on individual behavior.

North reviews two examples of theories of the state: contract theory and predatory theory. According to contract theory, the government specifies the set of property rights that maximizes social welfare or utility. Individuals are able to enter into contracts with one another that are well-specified, easily transferable, and enforced by the state. The purpose of the state consists of minimizing transactions costs in order to improve opportunities for market exchange of goods, services, and resources. As a result, gains from trade are generated and the economy experiences growth.

By constrast, the predatory theory holds that the state is essentially a tool of the group in power. Consequently, the state is more concerned with defining property rights so as to maximize the wealth or utility of the group in power. The effects on society and on economic growth are of secondary concern to the predatory state.

North generally adopts the predatory theory. Ruling groups will select the set of property rights that result in the maximization of their own welfare. But the choices made by ruling groups must take into account competitive pressures from potential ruling groups and the transactions costs associated with revenue collection. The ruling group will choose the set of property rights that maximizes revenue net of the costs of collection.

During particular periods in history, the power of potential groups relative to the established ruling group may diminish. In this event, the ruling group is likely to have their way in establishing property rights consistent with their interests. The result of diminished competition will be a higher probability of establishing property rights that are inefficient from the perspective of ensuring economic growth.

North's theory of property rights draws heavily from the property rights literature. According to this theory, resources will be transferred to their most valued use when property rights are privately held, carefully defined, and costlessly transferred and enforced. But as noted above, these activities are not without costs. The state, by specifying property rights, assigns exclusive authority over particular resources to individuals and uses its power to enforce this authority.

2.3 SYNTHESIS AND SUMMARY

Although a wide range of approaches and applications are found in the literature, a common theme emerges: institutions set the stage for economic activity, but in turn are molded by choices made in the economic system. A basic result of choice theory holds that persons maximize utility by allocating resources among various activities so that the benefits of an extra unit of resource used in each activity are equated: the process of specifying and altering the rules of the game should be recognized as one of the possible activities.

Assuming the people pursue their self-interest, resources will be allocated to property rights defining and enforcing activities when the benefits exceed the costs. A model of change in property rights could be constructed by specifying these cost and benefit functions. Such a model is constructed in Chapter II. The model predicts when changes in the specification of property rights are likely to occur, given a shift in a cost or benefit parameter. The model is designed to test the basic implication of the property rights school: if people act according to their self-interest, their actions become predictable.

The literature suggests that attempts to alter the structure of property rights are expected when the resource becomes more valuable or physically more scarce. Individu-

als will try to caputure residual income or internalize externalities by further defining property rights as the resource becomes more valuable. Increasing the level of exclusivity of the resource lowers transactions costs, and permits the capture of more gains from exchange. The literature also indicates that inefficient, non-exclusive rights to property are not likely to persist over time unless: 1) the costs of establishing exclusive property rights are higher than the benefits, or 2) the institution is preferred to more efficient forms due to ideological reasons.

Chapter III

A MODEL OF THE DEVELOPMENT OF PROPERTY RIGHTS TO WATER

This chapter develops a model of the evolution of property rights to water. The model takes a positive approach: its purpose is to explain the development of property rights rather than to evaluate their performance. The first section gives a cursory introduction to the problem of free-access resources. Section two describes how water users are motivated to establish some form of property rights to the resource, followed by a discussion of the benefits of water rights transfers and speculation. Exclusion costs and their determinants are discussed next. The fifth and sixth sections analyze the effects of increasing demand for water and variable resource flows on property rights development. Finally, the implications of the model are summarized.

3.1 THE PROBLEM OF FREE-ACCESS RESOURCES

The early property rights literature focused on the efficiency of exclusive vis-a-vis non-exclusive property rights.[1] The usual result held that externalities are generated when rights to property are non-exlusive. If the resource is valuable and access is unrestricted, then early resource claimants will earn positive profits from the use of the resource. But as we know from price theory, the existence of positive profits will cause more firms to enter and exploit the resource. Unless the influx of new resource claimants is limited, the resource will be exploited at a higher than optimal rate.

The solution in the Coasian tradition calls for the establishment of exclusive, or private, property rights to the resource. Exclusive property rights would allow resource claimants to internalize positive profits in the form of rent to the resource. Internalization could be accomplished by limiting the number of resource claimants. This prescription, however, implicitly assumes that the costs of establishing and maintaining exclusive property rights are zero.

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[1] See, for example, Harold Demsetz, "Toward a Theory of Property Rights," The American Economic Review, 57 (May 1967): 347-359.

According to Alchian, an important dimension of a property right is the extent to which the decisions of a person regarding the disposition of a good or resource dominate the decisions of all others for a particular set of uses, or the domain of the right.[2] If the probability is one that a person's decisions will determine the use of a resource for a given domain of usage possibilities, then the right may be considered 'absolute' for those uses. This quality is the strength of the right. For example, I may have the absolute right to drive my car, but the domain of my right does not include the right to run down pedestrians. Alchian notes that exclusive rights tend to be associated with an unlimited use domain and single person decision process. In other words, if the right is exclusive, then the probability is '1' that the resource claimant will determine the use of the resource over an unlimited domain of uses. On the other hand, one who holds a non-exclusive right may be characterized as posssessing a very low probability of determing the disposition of a resource over a limited domain of uses.

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[2] Armen A. Alchian, "Some Implications of Recognition of Property Rights Transactions Costs," in Karl Brunner, ed. Economics and Social Institutions, (Boston: Martinus Nijhoff Publishing, 1979), pp. 237-239.

We should emphasize that the use domain and 'strength' of a property right are not polar or discrete variables. The use domain, or the set of sanctioned uses of the resource, is continuous, ranging from few uses to an unlimited number of uses. Similarly, the probability that the resource claimant wil determine the disposition of the resource for a given domain also varies continuously between zero and one. Thus, we should treat property rights not as either exclusive or non-exclusive, but something in between; as semi-exclusive.

If rights to resources could be exclusively established at zero cost, then private property rights would be defined for all scarce resources. But since establishing and defining property rights requires the expenditure of resources, rights will be semi-exclusive. The particular level of exclusivity will depend on the benefits of exclusion relative to the costs.

In the sections below, a formal model of the evolution of property rights to natural resources is developed. We shall see that the level of development depends on the benefits relative to the costs of making the property right more exclusive.[3]

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[3] The analysis of the problem of non-exclusive property in this chapter has benefited from Robert H. Haveman's article, "Common Property, Congestion, and Environmental Pollution," Quarterly Journal of Economics, 87 (May 1973): 278-287.

3.2 A MODEL OF PROPERTY RIGHTS TO WATER

Assume that N' identical firms exploit a watercourse, with $1 \leq N' \leq N$. All firms possess a production function $q_i = f(a_i)$, where q_i is firm i's output of a single homogeneous product, say wheat, and a_i is the quantity of water diverted by firm i. Costs for each firm depend on the expense of diverting water and the costs of operating diversion capacity. Let C represent the annualized cost of constructing, operating, and maintaining a unit of diversion capacity for a given flow of water in the watercourse. Profit for each firm is the difference between revenue and cost:*

$$\pi_i = P\, f(a_i) - C\, a_i , \qquad (1)$$

where P is the price of wheat. Assume, for the moment, that the rate of flow of water in the stream is constant. Also assume that aggregate diversion capacity does not exceed streamflow.

Aggregate profit is the horizontal sum of the profit functions of the N' firms:

$$\sum_{i=1}^{N'} \pi_i = P \sum_{i=1}^{N'} f(a_i) - C \sum_{i=1}^{N'} a_i . \qquad (2)$$

The profit maximizing solution is shown in Figure 2, Panel A. The slope of the total revenue curve is the value of the marginal product of water, defined as the product of the

* A more realistic analysis would include other factors of production such as land and labor, and allow for subsitution. For simplicity, this possibility is omitted.

price of wheat and the marginal physical product of water. For simplicity, costs are assumed to increase at a constant rate, resulting in a linear cost schedule.

Aggregate water diversions are defined as A, where $A = \sum_{i=1}^{N'} a_i$. A' is the profit maximizing level of aggregate diversions. This level of production of the natural resource commodity equates the value of the aggregate marginal product of diverted water (the slope of the TR_a curve) with the aggregate marginal cost of production (the slope of TC_a). Since firms are identical, each firm diverts $\bar{a}$ units of water per period, so $\bar{a} = a_i$ for all i. Thus, total diversions may be expressed as the number of firms multiplied by $\bar{a}$.

Optimal production of diverted water is shown in Figure 2, Panel B.[5] The curve MC is the horizontal sum of the marginal cost curves of the N' firms. Marginal cost equals the value of the marginal product at A', generating profits equal to the distance ef in Panel A. In order to obtain the optimal level of aggregate diversions at A', the number of firms must be limited to N' and diversions per firm limited to $\bar{a}$.

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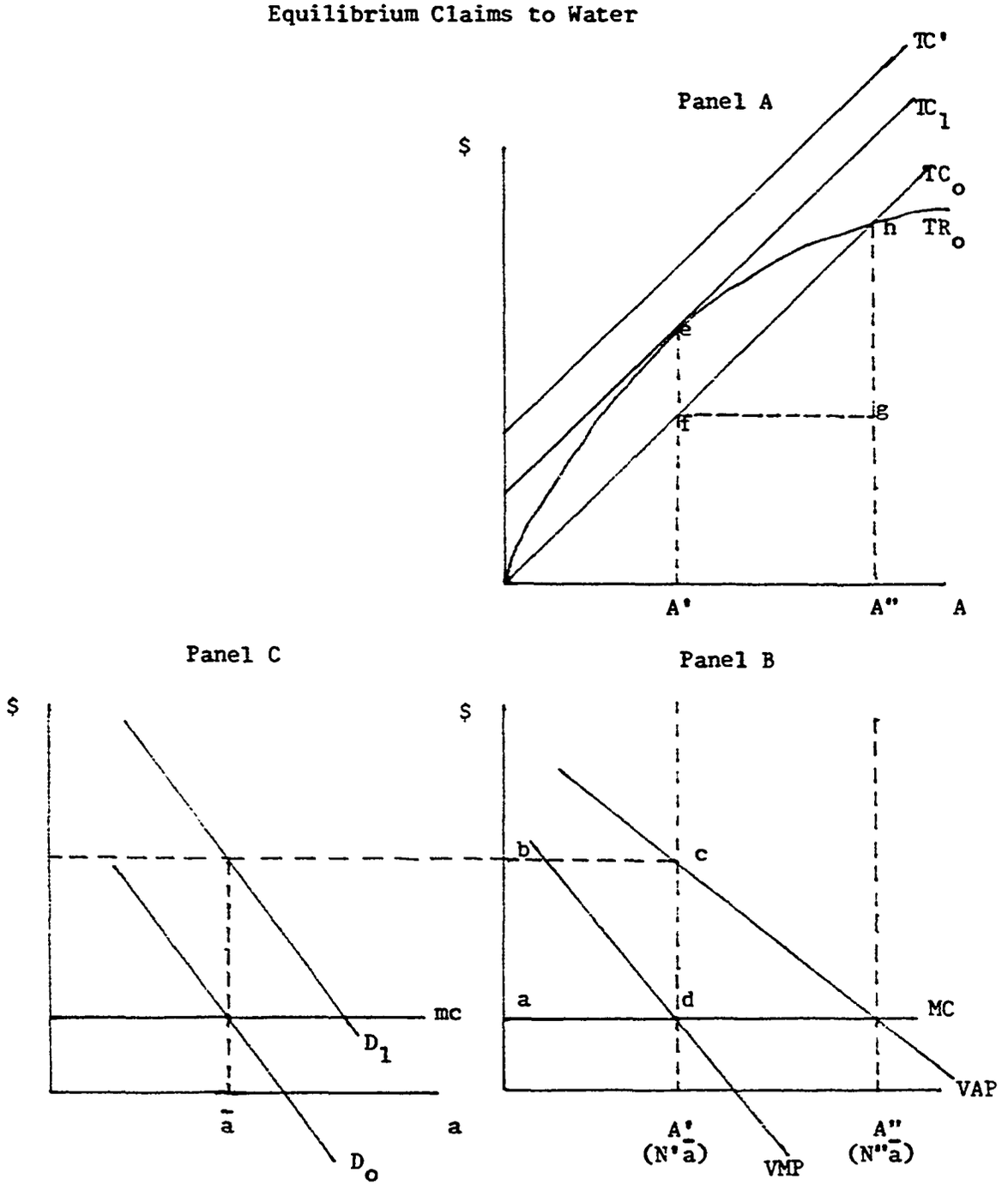
[5] This presentation owes much to the graphical analysis presented in Lee G. Anderson, "The Relationship Between Firm and Fishery in Common Property Fisheries," Land Economics, 52 (May 1976): 179-191.

Figure 2

Equilibrium Claims to Water



Source: Adapted from Anderson, "Relationship Between Firm and Fishery," pp. 182-184.

The existence of positive profits creates incentives for the entry of more firms. Unless access to the watercourse is restricted, the number of firms diverting water will increase as long as the benefits of production exceed the costs of entry. Eventually, the equilibrium level of production of the commodity will be established at A" where MC and VAP in Panel B are equal. This level of use corresponds with the intersection of the TR_0 and TC_0 schedules in Panel A. The entire economic surplus--the area abcd in Panel B-- has been dissipated at A"; in effect, it has been capitalized in the form of diversion facilities for the additional N"-N' firms. Since additional entrants would earn less than the market rate of return on their investment, the number of firms will not increase beyond N". At the equilibrium level of aggregate diversions A" (=N"a), excess resources valued at the distance gn are invested in diversion works.[6] The marginal cost of these resources is greater than the marginal benefit that is generated from the use of the water commodity.

The situation for the individual firm is shown in Panel C. The demand for diverted water, derived from the firm's revenue function, slopes downward due to diminishing marginal productivity of water. The level of diversions $\bar{a}$

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[6] Haveman points this out in Haveman, "Common Property," p. 280.

equates the value of the marginal product of water with the marginal cost of diversion. The position of the demand curve depends, ceteris paribus, on the level of exclusivity of the right to water. If rights are perfectly exclusive, for example, the appropriate demand curve is D_1 . D_1 includes the scarcity value, or rent, captured through the construction of exclusive rights to water by limiting the aggregate number of claimants to N' in Panel B. If on the other hand access was unrestricted, the derived demand curve would be D_0 , reflecting a zero rent, or return, to diverted water.

How could the aggregate level of diversion be limited to A'? One method consists of levying a tax on the diversion capacity proposed by each firm. This Pigouvian tax would absorb positive profits and raise costs from TC_0 to TC_1 as shown in Panel A.[7]

Alternatively, the optimum level of use could be attained by establishing private property rights to the resource. The literature attributes this prescription to Frank Knight in his response to Pigouvian taxes and subsidies.[8] The N' firms on the watercourse, for example, could

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[7] The use of a tax to correct negative externalities was apparently first proposed by A. C. Pigou in his work The Economics of Welfare, 1920.

[8] For example, see Herbert Mohring and J. Hayden Boyd, "Analyzing 'Externalities': 'Direct Interaction' vs 'Asset Utilization' Frameworks," Economica, 38 (November 1971):

capture the excess profits generated by the resource by organizing a club to share in exclusive access to the water.[9] Ideally, the club would limit membership (the number of firms) to N' and restrict the level of diversions by each firm to $\bar{a}$. The exclusion of supraoptimal claimants could be accomplished by increasing the total cost of entry from TC_0 to TC_1. Economic profit would be appropriated by the N' firms in the form of a factor payment to the resource, the rights to which are now exclusively held by the club. That is, TC_1 is the new cost curve inclusive of the rent generated by the water resource.

347-361. Knight's response to Pigou is contained in "Some Fallacies in the Interpretation of Social Cost," Quarterly Journal of Economics, 38 (August 1924): 582-606.

[9] Accoring to Timothy Tregarthen, club theory has not yet been applied to explain the organization of water rights groups. This study may be characterized as a preliminary step in that direction. See Timothy Tregarthen, "Water in Colorado: Fear and Loathing of the Marketplace," in Terry L. Anderson, ed., Water Rights: Scarce Resource Allocation, Bureacracy, and the Environment, (Cambridge, Mass.: Ballinger Publishing Company for the Pacific Institute for Public Policy Research, 1983), pp. 119-136.

3.3 THE BENEFITS OF WATER RIGHTS TRANSFERS AND SPECULATION

In the analysis above, firms were assumed to be identically productive in the use of water for the output of a single commodity, wheat. Transferability of water rights was in effect assumed away, since incentives for transfers were assumed not to exist. This section begins by allowing different production efficiencies and the use of water in the production of commodities other than wheat. Under these more general assumptions, incentives for water rights transfers are certain to exist.

The issue of transferability of water rights has attracted a good deal of attention in the literature. Meyers and Posner[10] provide what is regarded as the seminal work on the topic. For the purpose of this study, the relevant aspect of the literature is the discussion of the bene-

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[10] National Water Commission, Market Transfers of Water Rights: Toward an Improved Market in Water Resources, by Charles J. Meyers and Richard A. Posner, Legal Study No. 4, July 1971. Other notable contributions include L. M. Hartman and Don Seastone, Water Transfers: Economic Efficiency and Alternative Institutions, (Baltimore: The Johns Hopkins Press for Resources for the Future, Inc., 1970); H. Stuart Burness and James P. Quirk, "Water Law, Water Transfers, and Economic Efficiency: The Colorado River," The Journal of Law and Economics, 23 (April 1980): 111-134, and "Appropriatve Water Rights and the Efficient Allocation of Resources," The American Economic Review, 69 (March 1979): 25-37; Ronald N. Johnson, Micha Gisser, and Michael Werner, "The Definition of a Surface Water Right and Transferability," The Journal of Law and Economics, 24 (October 1981): 273-288; and Micha Gisser and Ronald N. Johnson, "Institutional Restrictions on the Transfer of Water Rights and the Survival of an Agency," in Terry L. Anderson, ed., Water Rights, pp. 137-165.

fits from water rights exchange. A well-known result from economic theory holds that economic efficiency can be improved by exchange of factors of production among firms when the value of the marginal products of inputs for the two firms are unequal. For example, assume that Firm A can produce $10 worth of crops with the marginal unit of water, but Firm B can produce only $5 worth from the marginal unit. Assuming that water is scarce and that there are many other buyers and sellers, Firm A will offer to buy water rights from Firm B at a price somewhere between $5 and $10 per unit of water. As a result, both firms may be made better off by the exchange.[11] Given this opportunity for capturing benefits through exchange, one would expect that firms would attempt to structure water law so as to minimize the cost of transferring water rights.

To phrase the argument in terms of the model presented earlier, let the VMP_D curve in Figure 3 represent the derived demand for water rights, assuming that the right is easily and inexpensively transferable.[12] The value of the marginal product of water is given for particular quantities

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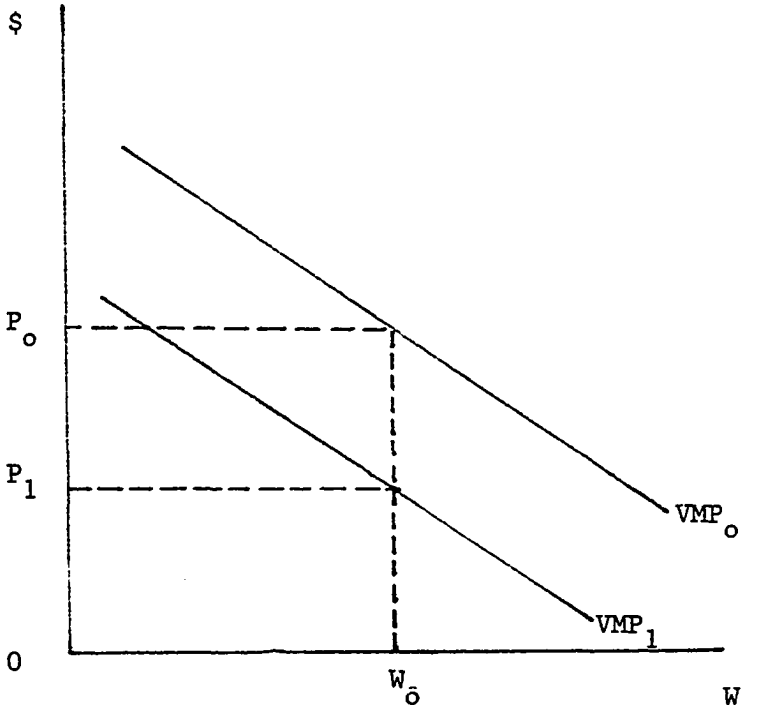
[11] All that is required for an efficient or Pareto optimal exchange is for one firm to be better off, leaving the other firm no worse off.

[12] This figure and discussion draw on the analysis in Richard Moss Alston, Commercial Irrigation Enterprise, the Fear of Water Monopoly, and the Genesis of Market Distortion in Nineteenth Century American West, (New York: Arno Press, 1978), pp. 42-46.

of water. For the quantity of water OW_o, the price per unit is OP_o. If transfers of water are legally impeded or constrained so as to increase the cost of transfers, the demand schedule will shift down from VMP_o to VMP_1. This shift results in a new price OP_1 that reflects the value of the marginal product of water to the firm, less the losses due to resrictions on water rights transfers.

Figure 3: Benefits of Water Rights Transfers



Source: Alston, Commercial Irrigation Enterprise, p. 45.

Efficiency is thus improved when water rights are easily transferred. One or more of the firms capture benefits from trade, with other firms no worse off. Consequently, we would expect that to the extent that firms are motivated primarily by profits, the club of users will construct rules or petition the courts and legislature for laws that minimize the costs of water rights transfers.

In addition to minimizing the costs of water rights transfers between users in the current time period, we would expect the coalition of firms to develop rules or lobby for laws that minimize the costs of speculation in water rights.[13] Speculators, by organizing futures markets, allow water-using firms to acquire water rights for use in the future at prices fixed in the current period. A firm anticipating future use of water or expanison in crop acreage faces a considerable amount of uncertainty regarding the future price of water rights. They must anticipate what they believe the price of a right to water will be in the future in order to determine the economic viability of the project. The firm's anticipated profits may be subject to a

[13] The role of the speculator in natural resource commodity and in situ markets is dissussed in Charles W. Howe, Natural Resource Economics, (New York: John Wiley and Sons, 1979), pp. 101-102. The implication of the beneficial use doctrine for efficient intertemporal water right allocation is analyzed by Stephen F. Williams, "The Requirement of Beneficial Use as a Cause of Waste in Water Resource Development," Natural Resource Journal, 23 (January 1983): pp. 7-23.

tremendous range of uncertainty due to fluctuating water prices. Thus, given the opportunity, the firm may choose to 'hedge' by purchasing water rights futures in order to reduce the risk of economic loss.

The implication of this discussion for our model of water rights development is this: we expect water users to place effort in minimizing the costs of speculative ownership of water rights.

3.4 THE COST OF EXCLUSION

Clear incentives exist for the exclusion of potential entrants to the watercourse. Aggregate profit equal to the distance ef in Panel A of Figure 2 could potentially be captured by the club of established users by raising the costs of entry for potential resource users. In effect, these net benefits would be generated by establishing and maintaining exclusive rights to the resource, and/or by allowing fully transferable water rights. But with these important incentives to establish exclusive and transferable property rights, why do we in fact observe seemingly scarce resources remain open to unrestricted use for long periods of time? In addition, why have transfers of rights to natural resources such as water been legally restricted or prohibited? Although this seemingly inefficient state of affairs is undoubtedly due to a combination of many factors, the recent lit-

erature suggests that relatively nonexclusive, immobile property rights are not likely to persist unless: 1) the costs of defining exclusive, transferable rights are higher than the benefits, and 2) the 'inefficient' form of property right is preferred on ideological grounds. The problem of high costs of establishing exclusive property rights is discussed next. The role of ideology wil be examined in Chapter V.

In the discussion above, the analysis focused singly on the benefits side of establishing exclusive rights to the resource. If firms are concerned only with the benefits of exclusion and not with the costs, then aggregate diversions will be established at A' with diversions of a per firm. With zero exclusion and enforcement costs, the benefits abcd under the VAP curve in Panel B would be the net benefits of exclusion and enforcement. On the other hand, if the costs of exclusion and enforcement were high relative to the benefits, then the net benefits of establishing and enforcing exclusive property rights could be zero or even negative.

Assume that the costs of establishing and enforcing property rights are viewed by the firm or club of firms as a fixed cost of production in the short-run, but variable in the long-run. Thus, the firm must take the specification of property rights as given for short-term decisions, but in the long-run the firm may be able to alter property rights

to its advantage. The firm's choice of property rights specification depends on the potential net benefits. If the costs of establishing exclusive property rights are greater than the benefits, then the rights to the resource will remain non-exclusive. For example, if the costs of diversion plus the costs of exclusion raised total costs to TC' in Panel A of Figure 2 then the club of firms would not bother to establish exclusive, transferable property rights since the net benefits would be negative. In other words, the value of the resources expended in the process of establishing private property rights would be greater than the value of the product of exclusive rights to water.[14]

A more realistic analysis would recognize the possibility that costs of exclusion and enforcement are actually somewhere between zero and prohibitive. This would make the level of exclusion in the property rights specification a continuous variable, ranging from fully exclusive and enforced to completely unrestricted and unenforced. Suppose that the costs of a particular means of excluding potential entrants and enforcing use equals E. The costs of producing the water commodity with the level of exclusion and enforce-

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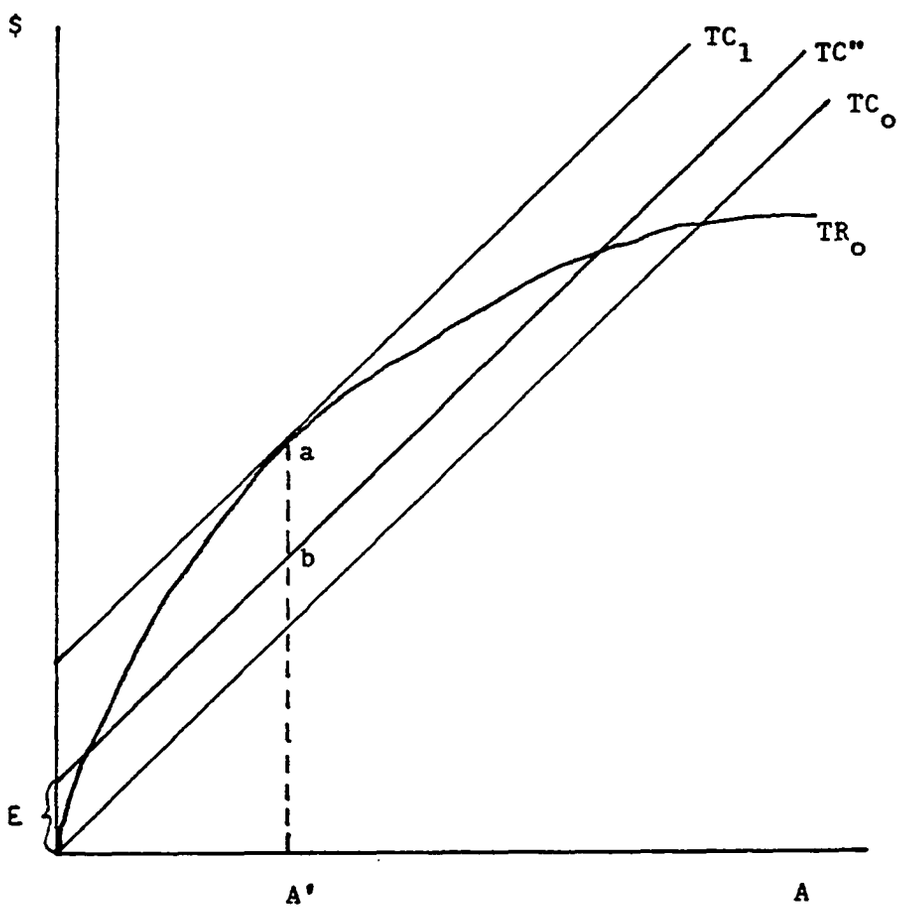
[14] In a recent article, Anderson and Hill emphasize that rent to the resource may be dissipated in the process of property rights definition as well as due to common property characteristics of the resource. See Terry L. Anderson and Peter J. Hill, "Privatizing the Commons: An Improvement?," Southern Economic Journal, 50 (October 1983): 438-450.

ment allowed by this method would raise total costs to the N' firms from TC_0 to TC" as indicated in Figure 4, resulting in net benefits ab. In effect, the costs of exclusion TC"-TC_0 are the expense of raising the costs of entry from TC_0 to TC_1. Although the net benefits of this exclusionary alternative are less than the total benefits possible with costless exclusion, they are certainly larger than the case of no exclusion at all. The group will choose to pay the cost of achieving less than perfect exclusion and enforcement, since the net benefits are larger than not excluding or enforcing at all. As we shall see, firms will select the method that minimizes the long-run costs of exclusion.

Figure 4: Effects of Positive Exclusion Costs



3.5 THE DETERMINANTS OF THE COST OF EXCLUSION

The costs of excluding potential users from access to the resource depend on factors such as the physical nature of the resource and the level of development of social institutions. In order to defend a claim to a particular resource, the claimant must be able to measure the dimensions of his/her claim in order to distinguish his/her claim from the claims of others. The costs of physically establishing or measuring the dimensions of a claim depend on the physical nature of the resource. For example, during the various Oklahoma land rushes in the 1890's, claims could be established simply by staking the four corners of the area. Later, when livestock were added to the land, the owner took more trouble to protect his or her property by constructing barbed-wire fences. This method of excluding potential land users and cattle rustlers did not eliminate losses altogether, but was reasonably effective.

The costs of establishing boundaries to claims of other types of resources are much higher. As Alan Randall observes, "fencing the open sea is technologically more demanding and thus vastly more expensive than fencing the open range."[15] Similarly, establishing exclusive claims to underground resources such as water and oil, and to fugitive

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[15] Alan Randall, "The Problem of Market Failure," Natural Resources Journal, 23 (January 1983): 133.

resources such as air and surface water may be prohibitively expensive.

The gains from exclusionary methods such as enclosing and measuring a claim by erecting fences, walls, and barriers will probably reach their limit fairly early on. With rapidly diminishing returns for the most simple methods, resource claimants will switch to other means of exclusion and enforcement; in particular, they may begin to use legal means of protecting their claims. The cost of developing legal rules to protect property claims, however, depends on the level of development of what might be called the 'collective alternative'. If some sort of court system or government has not yet been established, the cost of establishing a property right through the law would be very high indeed. Individual firms would not be able to afford this alternative.

Though each individual resource claimant may not be able to afford to define and protect their claims to the resource, a combination, club, or coalition of firms may be able to succeed. If economies of scale exist in enforcing claims to water, we expect groups or collectives of resource-using firms to be established. With economies of scale, the cost per claimant of exclusion will decline, permitting a more exclusively defined resource. Economies of scale will probably arise since once the rules of the group

are established and gain legitimacy, they can be enforced at a very low cost.[16]

The costs of methods of exclusion and enforcement are portrayed in Figure 5. The cost function E = E(A) is the long-run envelope of the short-run cost functions e_0, e_1, and e_2. The horizontal axis measures the level of diversion capacity that would exist if access were unrestricted. This indicates the pressure for entry from poential users. As the resource becomes more valuable, the number of potential entrants increases, raising the costs of defining and excluding.

The short-run cost functions are the exclusion cost of specific methods of exclusion. The function e_0, for example, represents the costs of physically measuring the claim to the resource through establishing physical boundaries around the resource claim or by measuring the resource flow. Note that the costs of this alternative increase rapidly beyond a'. The curve e_1 is the cost function of exclusion associated with cooperatives. An example of this method would be the associations of gold miners that developed in

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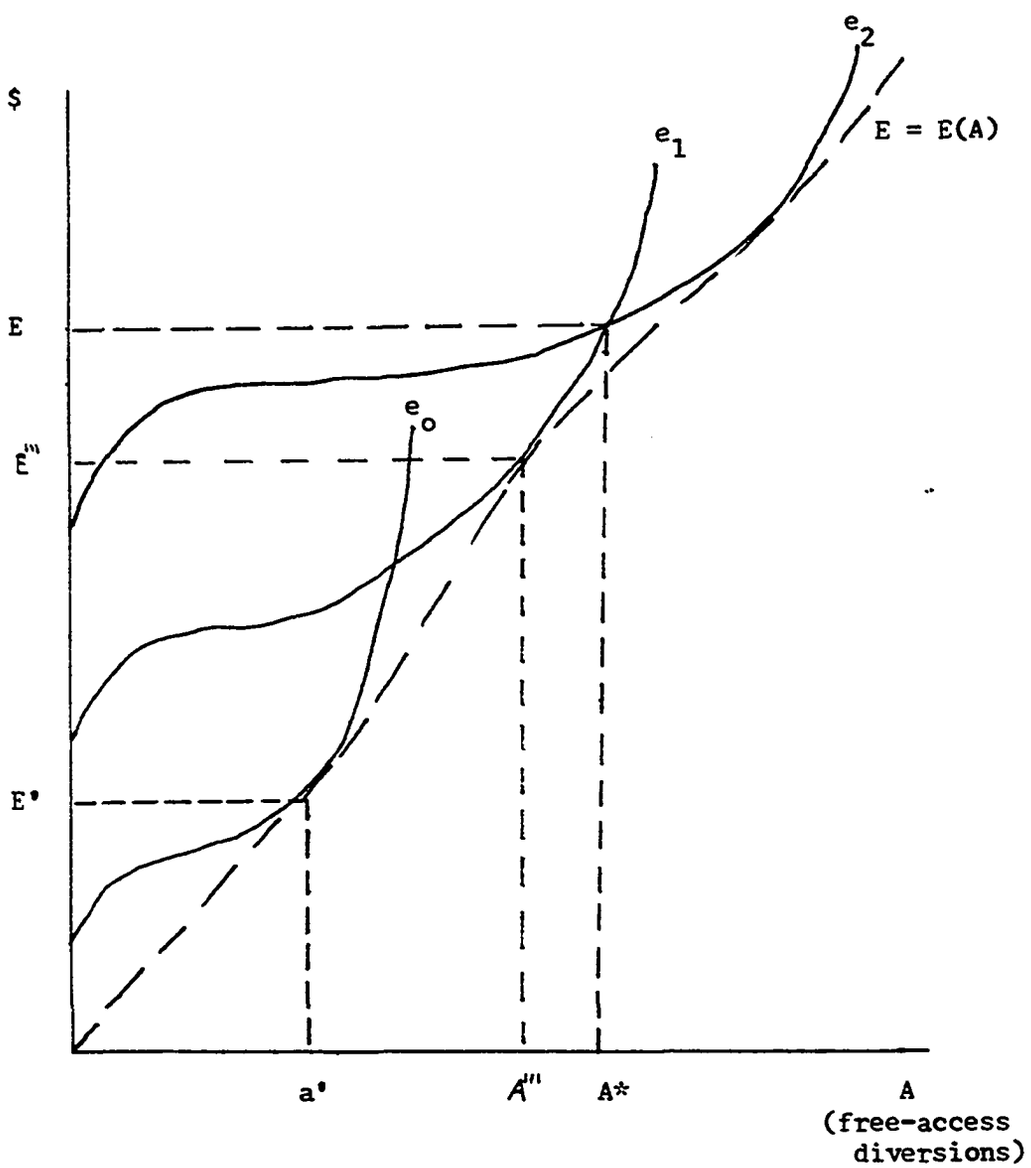
[16] In his thought-provoking work, Charles Lindblom contrasts methods of social control such as authority and voluntary exchange. He concludes that control through legitimate authority is much less costly than control through exchange. See Charles E. Lindblom, Politics and Markets, (New York: Basic Books, Inc., 1977). For an alternavtive perspective, see Ronald Coase, "The Problem of Social Cost."

FIGURE 5

Costs of Exclusion



the 19th century American West. These associations were formed in order to develop and enforce some level of exclusive rights to gold-bearing land and to the water necessary for gold mining. Finally, e_2 represents the costs of establishing rules and statutes through the courts and legislature. Costs are very high at low levels of water diversions, since at this level of development of the resource the courts and legislature did not exist. As the population in the area increased, the courts and legislature were established and concomitantly claims to water increased due to an influx of farmers and miners. Use of the courts and legislature became cost effective once the potential level of claims to the free-access resource in Figure 5 increased beyond A*.

Each of the cost functions are associated with a particular level of exclusion and enforcement of the property claim. The level of exclusivity increases as the average cost of exclusion decreases from e_0 to e_1 and e_2. The level of exclusion and enforcement associated with the cost curve e_0 may be rather low, but it represents the least-cost method of defining and enforcing the claims to water for a free-access equilibrium greater than zero but less than a'. At a', the cost of excluding all other users from the streamflow through erecting barriers or measuring the streamflow is E' per unit. If E' is greater than the benefits of

exclusion then the firm won't bother to measure or delineate the boundaries of its claim. Also at a', the costs of the other methods of enforcing more exclusive use of the resource are much higher and may generate negative net benefits.

3.6 INCREASING DEMAND FOR WATER

So far in the analysis the demand for water has been held constant. This section examines the implications of an increasing demand for water. Greater demand for water diversions may be caused by many factors, including increasing market size, technological changes in crop production technology, and higher output prices. The marginal product of water will increase over time as improved techniques of irrigation are developed, for example, or as yields improve due to better seed types or greater use of fertilizer. Any of these factors will increase the value of the marginal product of water by shifting the aggregate revenue function from TR_0 to TR_1 as Figure six shows. More revenue is generated for each unit input of water diverted. Suppose that the group had managed to raise the cost of entry in the previous period to TC_2, establishing the level of diversion capacity at A'. As the demand for water increases, the total revenue curve shifts up, generating positive profits for the current water-using firms. The existence of posi-

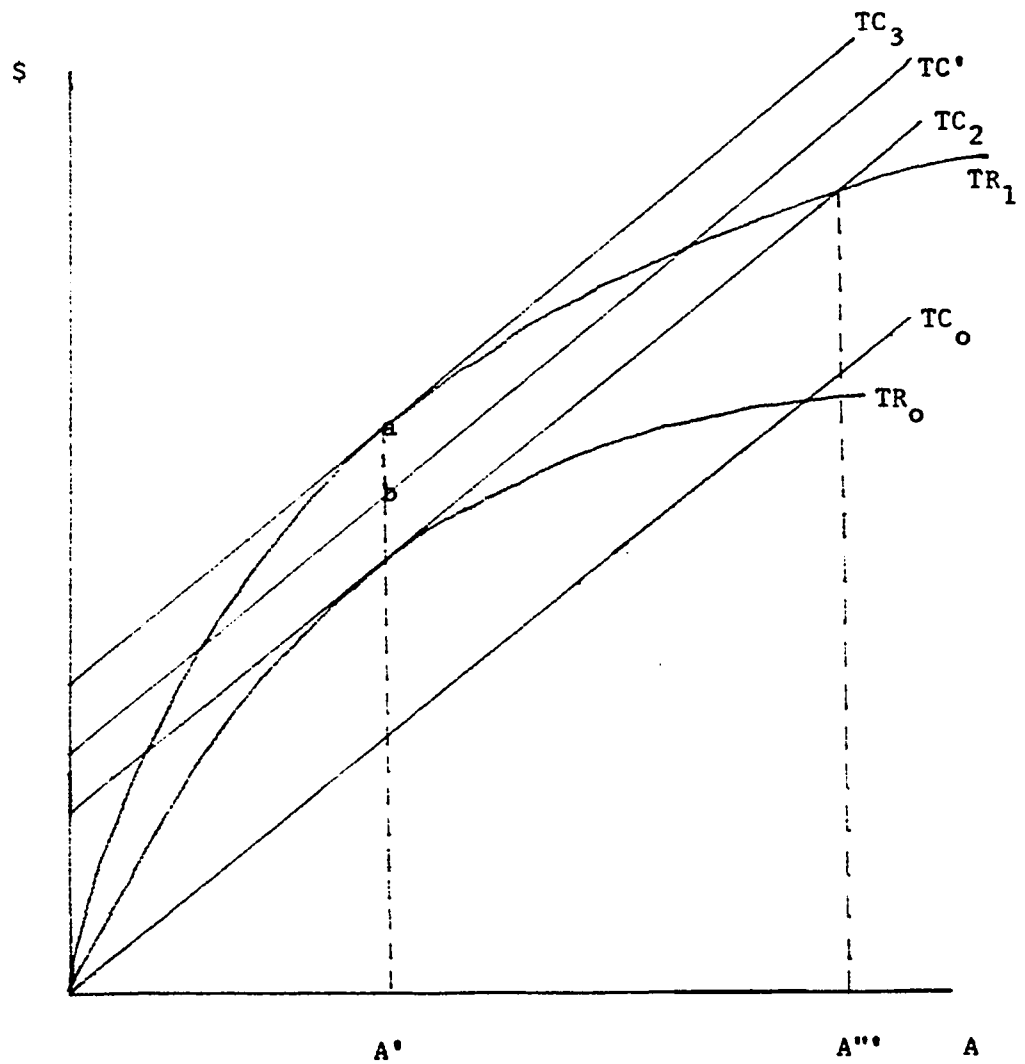
tive profits encourages the entry of more water-using firms, since now the benefits of entry more than compensate for the costs of entry reflected in TC_2 . Unless the group increases the level of exclusivity of the property right, equilibrium will be established at A"' and excess profits will be dissipated.

With the increased pressure from potential entrants, the club of N' firms will again determine the appropriate costs to be incurred in exclusionary and enforcing efforts. The appropriate costs of exclusion are found in Figure 5, where at the free-access equilibrium A"' the lowest costs of exclusion are given by the curve e_1 . The curve e_1 indicates a higher level of exclusivity for the rights to the resource. If the costs of diverting water including these exclusionary costs are less than the benefits, then the group will incur the cost of further defining and protecting their claims.

Suppose that the net benefits of the higher level of exclusion are positive. The group of firms are then able to raise the costs of entry from TC_0 to TC_3 , but must incur costs of TC' to do so. The net benefits from the added exclusion equals the distance ab. In general, more exclusionary and enforcing activity will occur over time as the demand for water increases.

Figure 6

Effects of Increased Demand for Water



3.7 VARIABLE FLOWS OF THE IN SITU RESOURCE

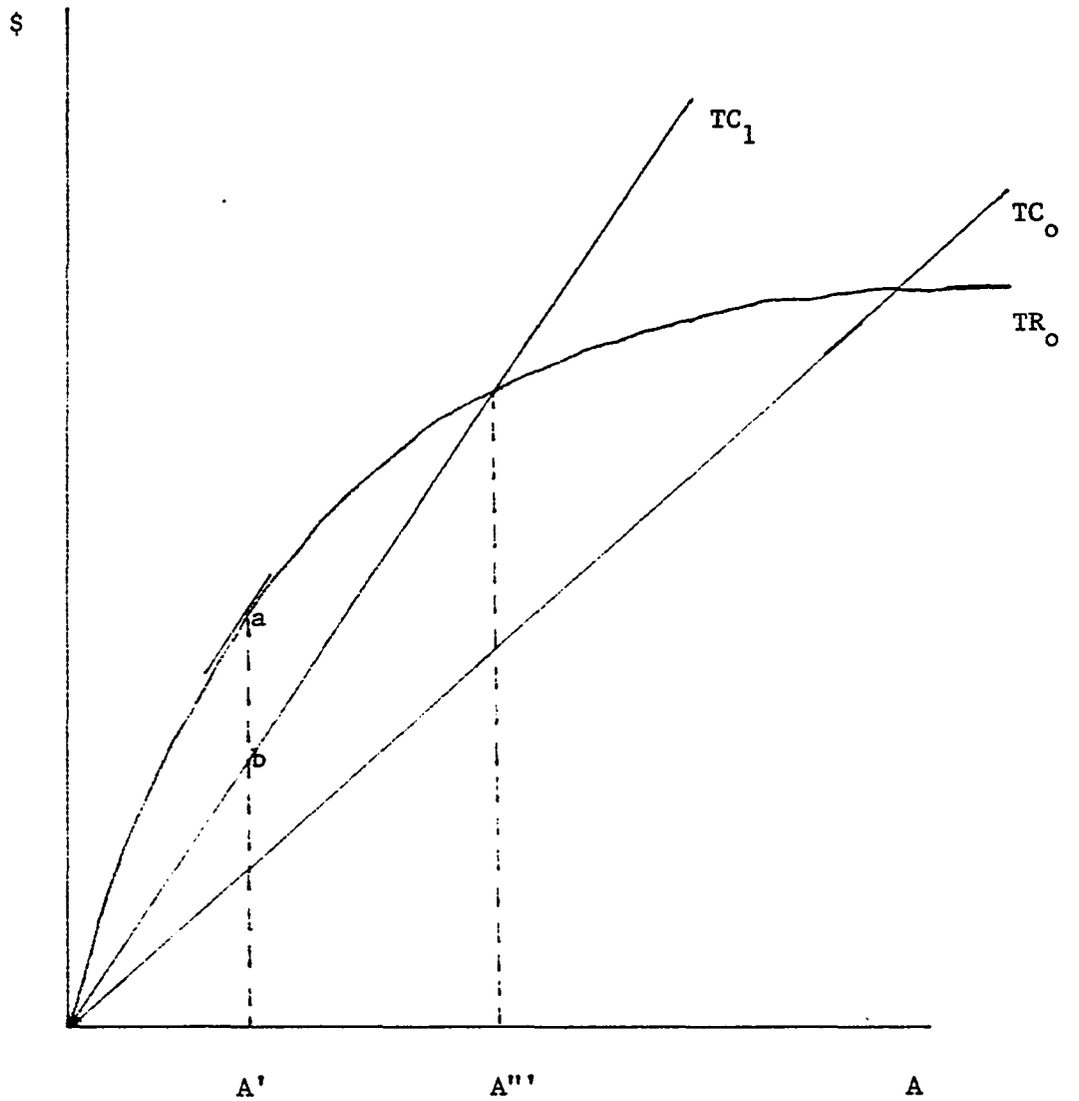
This section relaxes another of the assumptions made above, that the flow of water is fixed. No particular allocative problems arise when flow is greater than diversion capacity, so we shall focus on the situation in which total flow is less than the planned level of diversions.

Above we assumed that diversion costs were defined for a given flow of the in situ resource. If streamflow decreases, then the average costs of diverting water increase, since the sunk costs of diversion facilities are spread over fewer units of water diverted. As a result, the cost curve shifts from TC_0 to TC_1 as shown in Figure 7.

The higher costs of production result in a new optimal level of diversion capacity at A', where the slope of TC_1 equals the slope of the total revenue curve. The free-access equilibrium, however, would occur at A"' where profits are driven to zero. Thus the group of firms must establish and refine rules of allocating diversions of the water resource when streamflows are low. Once again, the net benefits generated from defining and enforcing these rules depend on the costs of enforcement relative to the benefits. The benefits of allocating the short-fall of water is potential profit, the distance ab in Figure 7. The

FIGURE 7

Effects of Variable Resource Flows



group of firms will choose the method of raising the costs of entry that minimizes the costs of enforcement.

3.8 IMPLICATIONS OF THE MODEL

Using a variation of the theory of clubs, this chapter constructs a simple model of the development of property rights to water. Assuming that water users are motivated by self-interest and that property rights defining costs are zero, resorce claimants will establish rules and laws that result in exclusive, transferable rights to water.

When positive definition costs are introduced into the model, the club of water-using firms must consider the benefits of establishing exclusive, mobile water rights net of the costs. Thus, if the net benefits are small, relatively nonexclusive rights to water may persist.

Increasing demand for water raises the net benefits of exclusion, resulting in increased defining and enforcing effort by resource claimants. In addition, periods of low in situ resource flow generate incentives for further development and definition of rights to water. We would expect, then, that water rights will evolve from relatively nonexclusive to exclusive forms due to increasing demand for water and recurrent periods of low resource flow.

The model constructed in this chapter generated two refutable hypotheses regarding water rights evolution.

Water rights defining and enforcing activity will tend to occur 1) during periods in which the demand for water increases, and)2 during periods of low streamflow.

Chapter IV

DEVELOPMENT OF WATER LAW IN COLORADO, 1858-1876

The previous chapters provided a theoretical framework for the evolution of property rights to water. Using the paradigm developed in the property rights/institutional change literature, Chapter III developed a model of the evolution of water rights in the West, and generated some refutable hypotheses. The next two chapters provide an historical context essential for the understanding of the economic and ideological motivations behind the evolution of water law in Colorado. Mixed in with the historical discussion will be observations and analysis intended to tie this contextual discussion with the theory presented above. Chapter IV first examines the origins of the system of prior appropriation in California. The rest of the chapter gives a brief overview of the early development of water law in Colorado up until 1876.

4.1 EXPERIENCE IN CALIFORNIA

The earliest example of the doctrine or prior appropriation in the West developed among the gold miners of California. The discovery of gold in January of 1848 brought to the Sierra Nevadas a tremendous influx of fortune seekers. At the time, the lands were legally still Mexican territory since the Treaty of Guadelupe Hidalgo, which ceded the area to the United States, was not signed until July of 1848.[1] The fact that they were trespassing on public lands made little impression on the gold miners. The commander of the U.S. Army unit in the area, Colonel Mason, resigned himself to the situation, as if he and his small garrison could do otherwise:

> This is public land and the gold is the property of the United States; all of you here are trespassers, but as the Government is benefited by your getting out the gold, I do not intend to interfere.[2]

As more and more prospectors flocked into the area, the increasing probability that one's claim might be jumped, or that one's water source may be over-appropriated created incentives for the establishment of some degree of legal title to mining claims. In the absence of an organized government, the miners developed their own law. The miners

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[1] Wells A. Hutchins, The California Law or Water Rights, (Sacramento: State of California, 1956), p. 41.

[2] S. C. Wiel, Water Rights in the Western States, 2d. ed., Vol. I, (San Francisco: Bancroft-Whitney, 1908, p. 72.

organized governing districts which developed rules and regulations outlining, among other things, the rules pertaining to the claiming of gold. Essentially, they codified established mining practices. One of the most common principles of mining law among the districts was the doctrine of 'first in time, first in right': the first to discover gold had the first opportunity to mine it. Soon afterward, the miners established a second principle that limited the size of individual claims. Subsequent mining laws required that claimants work and develop their claims as a condition for continued recognition of their rights by the mining district.[3]

Gradually, the diversion of water became indispensible for the process of mining gold. In the earliest period of the gold boom, prospectors generally used only a pan, shovel, and a pick. This technique required some water to wash sediment from the pan, but did not entail diverting water from the stream. As mining techniques became more efficient, they also became more water intensive. One device used by the miners --the cradle--was a sort of box set on rockers into which the prospector dumped 'pay dirt' containing gold particles. By pouring water into to the top of the box and rocking the cradle, one could wash the dirt and

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[3] John B. Clayberg, "The Genesis and Development of the Law of Waters in the Far West," Michigan Law Review, 1 (November 1902): 93.

debris out, leaving gold captured in the bottom. As the relatively acessible claims to gold played out, prospecting moved from streambeds to hillsides some distance from the nearest watercourse. Developing these areas required the diversion of water from the watercourse into ten to twenty foot 'long toms', and later into very long sluices.[4]

Thus, the principles of making claims to gold were adapted to establish rights to the use of water, an increasingly important input in the gold mining production process. Miners recognized water rights obtained by diversion from the stream and putting the water to use. As with gold, priority was applied to water; this meant that early claims were to be satisfied before later claims could legally divert water. These rules were to be enforced by the mining district.[5]

The provisions of the miners' code not only reflected the physical and technical requirements of water diversion for the mining of gold, but also illustrated the desire of the gold miners to protect their rights to increasingly valuable resources. The provision that gave the better right to the earliest prospectors and users of water could be interpreted as a method of rewarding the uncertainty and

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[4] Rupert Norval Richardson and Carl Coke Reister, The Greater Southwest, (Glendale, Calif.: Arthur H. Clarke Co., 1935), p. 193.

[5] Hutchins, California Law of Water Rights, p. 41.

potential losses that were associated with prospecting in new areas. Staking a claim in an unexplored area was more risky than prospecting in a well-worked valley, precisely because the probability of discovering a profitable quantity of gold was unknown. The 'first in time, first in right' requirement rewarded these early risk-takers by ensuring some sort of security to water as against subsequent claimants. It could be argued that the rule of priority encouraged exploration and risk-taking. It is not likely, for example, that miners would be willing to risk life and fortune to discover a profitable claim of gold, only to find that the supply of water needed to work the claim was being rapidly depleted due to the demands of subesquent prospectors. Under the riparian system, the early miner would have no superior claim to water: he/she would be forced to share with subequent users.

The diversion of water from the watercourse sanctioned by the miner's practice and mining law directly conflicted with the common law of riparian water rights, long established in the Eastern United States. Riparian law limits the use of water to lands adjacent to or contiguous with a water course. The right to water in this system cannot be lost through disuse, and priorities to the right to use water are not recognized. Riparian rights guarantee no specific quantity of water; they only provide for the reason-

able use of a proportionate share of the quantity of water available to all users.[6]

The State of California adpopted the common law, thus establishing riparian water law as the law of the land upon admission to the Union in 1850.[7] The laws of miners and the law of California seemed to be on a collision course. The next several years witnessed a continuing struggle between the established rules of the miners and the ostensible common law in California. In 1851, for example, with the backing of future Justice of the United States Supreme Court Stephen Field, the California legislature recognized the customs of the miners as binding in court, unless in conflict with the constitution and laws of the State.[8] Two years later the California Supreme Court reversed the decision of a trial judge to recognize the miners' law of water, declaring it to be "impracticable in its application" and preferring to "adhere to known principles of riparian and well-settled law."[9]

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[6] Ibid, p. 40.

[7] California Statutes, 1850, Ch. 95. sec. 219.

[8] Calif. Statutes, 1851, Ch. 5, Sec. 621. Cited in Wiel, Water Rights in Western States, Vol. I, p. 74.

[9] Eddy v. Simpson, (3 Cal. 249), p. 18.

But the supporters of prior rights persisted. In the case of Irwin v. Phillips the California Supreme Court in 1855 affirmed the prior rights of a canal company to divert water as against the rights to water of a subsequent water user on public land. In the opinion of the court, the rights to water of miners are fully recognized and vested, even without specitic legislation conferring this recognition. The common law was found to be inapplicable because there was no private land on the watercourse.[10]

In later cases, the California Supreme Court made clear that the right to prior appropriation could be exercised only on public lands, where no existing riparian users would be affected. In Crandall v. Woods,[11] for example, the court ruled that the owner of land riparian to a stream may assert a riparian claim to water, protected against future appropriators. The court later held, in a landmark case, that riparian rights were not dissolved by the law of prior appropriation, but that riparian rights to water become effective after the land becomes private, subject to the appropriations made previously. The riparian and appropriative systems have coexisted in California ever since; the appropriative system applying to public, or nonexclusive, land while riparian rights were observed for private

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[10] S. C. Wiel, Water Rights in Western States, pp. 77-80.

[11] 8 Cal. 136.

lands.[12]

4.2 HISTORY OF EARLY COLORADO WATER LAW

In Colorado between 1858 and 1859, according to Alvin Steinel,

> the mines were attracting their thousands of gold-hunters, and the valleys of the Platte and its upper tributaries were appealing to hundreds who believed that there might be as much gold for them in the crops that could be raised to feed the men and animals in the growing towns and mining camps.[13]

Prior to the organization of Colorado Territory, increasing demand for prime plots of land the the discovery of gold in the foothills led to the organization of local governing institutions on the public domain. Although the area east of the front range was ostensibly governed by the laws of Kansas Territory, the great distance to the capital at Topeka seriously muted the influence of Kansas law.[14] Once the local population reached a threshold level, notice was circulated for a meeting to organize a town company, claims club, or mining district. In October of 1858, for

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[12] Ibid, pp. 135-136.

[13] Alvin T. Steinel, History of Agriculture in Colorado, (Ft. Collins: Colorado State Agricultural College, 1926), p. 38.

[14] Hubert Howe Bancroft, The Works of Hubert Howe Bancroft, Vol. 25: History of Nevada, Colorado, and Wyoming. (San Francisco: The History Company, 1890), p. 389.

example, a meeting of citizens along the South Platte River was held for the purposes of organizing the Auraria Town Company. At the meeting, a constitution and by-laws were drafted and approved; these provided for the election of officers, surveying of the town site, and the issuance of stock. Article 10 of the by-laws required a prospective stock-holder to build a house within the city limits in order to obtain stock--or title--to the land.[15]

Other examples of what Bancroft termed "squatter sovereignty"[16] include the Arapahoe County Claim Club and the El Paso Claim Club. The regulations adopted by the Arapahoe County Claim Club required the claimant to build a house or plow land within sixty days of passage of the rule in order to receive recognized title to the land.[17] The El Paso Claim Club, also organized in 1859, established rules for holding land for the farmers of the Arkansas Valley.[18] McGowen notes that these clubs established three principles of American land policy: 1) free land may only be obtained by bona fide, continuous residents; 2) the claim must be improved and not left idle; and 3) club benefits applied only to a

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[15] Wilbur Fisk Stone, ed., History of Colorado, (Chicago: Clarke Publishing Co., 1918), p. 140.

[16] Bancroft, History of Colorado, p. 389.

[17] Rocky Mountain News, August 28, 1859. Cited in Steinel, History of Agriculture in Colorado, p. 39.

[18] Bancroft, History of Colorado, p. 389.

limited amount of land. The free price, of course, encouraged settlement, while the other provisions gave some security to club members against speculators or the government.[19]

The discovery of gold in Colorado occurred in early 1859. In an area approximately 35 miles west of Denver, miners found placer gold at the site of present day Idaho Springs on Clear Creek.[20] In May, a group led by George Jackson of California discovered a large quantity of gold on a tributary of Clear Creek. Soon after the announcement of the find at 'Jackson diggings', some 30,000 prospectors followed in his trail. Another discovery a short distance away was made by John Gregory. In order to protect their claims from the mass of miners certain to follow, the Gregory party organized a district with rules that would apply to all claimants.[21] The records of Gregory District show that in June 1859 a meeting of miners was held to establish the rules of mining. The resolutions passed demarcated the boundaries of the district and required that claims be staked off. The ninth resolution adopted called for the equal sharing of water by miners using water from the same

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[19] John D. McGowen, "The Development of Political Institutions on the Public Domain," Wyoming Law Journal, 11 (fall 1956): 8.

[20] Stone, History of Colorado, p. 238.

[21] Bancroft, History of Colorado, p. 378.

stream,[22] thus appearing to recognize the riparian water rights of common law. In 1860, however, a new district code established priority of claim as the rule of allocation when streamflow is not sufficient to meet all needs. All other matters would be settled by the provisions of the common law.[23]

The codes of other districts also reflected the conflict between the equal sharing of water provided by riparian rights and the security associated with a right to prior use. The Revised Laws of Spanish Bar District, for example, allowed that "all mill privileges, on either side of Clear Creek, shall be entitled to half the water in the creek." Conversely, the laws of Lincoln District, adopted in 1860, allowed the oldest claimant a priority of right in gulches or ravines where streamflow is inadequate for all uses.[24]

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[22] Thomas Maitland Marshall, "The Miners' Law of Colorado," American Historical Review, 25 (April 1920): 429.

[23] Ibid, p. 431.

[24] Colorado, Department of Natural Resources, Office of the Executive Director, The Colorado Water Study: Directions for the Future - Legal Studies, 1978, p. II-4.

4.2.1 Early Irrigation

The prospect for making a living by selling agricultural products in the mining camps was excellent in the early days of Colorado agriculture. Produce prices in Denver were high in 1860; even higher in the mining camps. In their first issue in 1859, the Rocky Mountain News pleaded with farmers to stay home:

> There will be enough to go to dig all the gold all the Union will need and those who raise stock and produce tor the mines will get their equal share of the gold in exchange for their produce. Everything must be high and will bring cash next fall; and those who live at nome will be perhaps best off.[25]

It was in the pursuit of potential profits that the earliest farmers built their water canals, largely in order to supply food to the mining camps. These early canals were built by individual efforts in the area drained by the South Platte River. In order to minimize the cost of transporting farm products, the first canals were built well upstream, not far from the markets of the mining camps.[26]

While irrigation in this period was limited to individually constructed ditches and canals, increasing concern with the legitimacy of claims to land and water prompted efforts to organize a form of government. It was hoped that

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[25] Rocky Mountain News, April 23, 1859. Quoted in Steinel, History of Agriculture, p. 53.

[26] Stone, History of Colorado, pp. 492-493.

a territorial or state government, by passing laws that recognized the validity of the prevailing water use customs, would pre-empt any attempt by the national government to enforce its title to public lands and associated water.[27] In April of 1859, a public meeting was held at Auraria, resulting in a call for a convention to consider the organization of a state or territory. Local elections were set in May for the convention to be held in June. Some 50 delegates met in Denver in June and organized committees to report back in August. Upon reconvening, the convention pieced together a constitution to be submitted for the approval of the people. The area included in the new government consisted of Arapahoe County, including the gold-mining region around Pike's Peak, and would be given the title "State of Jefferson."[28]

Since most of the delegates believed that the constitution would likely be rejected at the polls in September, they provided for the election in October of a delegate to Congress, representing the Territory of Jefferson. The constitution was rejected by an overwhelming margin: 649 votes in favor to 2,007 opposed. Soon after this defeat,

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[27] Steinel, History of Agriculture, p. 42.

[28] Stone, History of Colorado, p. 170; and Frank Hall, "State of Colorado," in The Province and the States, Vol. IV, ed. Weston Arthur Goodspeed, (Madison: Western Historical Association, 1904), pp. 380-381.

however, statehood forces organized a convention to establish a provisional territorial government. In October 1859, the territorial convention met and adopted a constitution called the "Organic Act or the Territory or Jefferson." In the same month, the territorial constitution was approved by a margin of some 2,000 votes, all without Congressional sanction.[29]

The provisional legislature wasted no time in convening. In November, the legislature established nine counties, authorized the appointment of county judges, and approved "An Act Concerning Irrigation." This statute was the first water law issued by an organization other than a mining district or a claim club in Colorado. The statute authorized the use of water for irrigation and the right or priority in use. Section three allowed the use of water on non-riparian land.[30]

At this point several different, sometimes competing, types or government were operating in Colorado. Miners courts and districts continued to operate and new organizations were established, as well as claims clubs. Arapahoe County officials drew their authority from the Territory or

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[29] Stone, History of Colorado, p. 170; and Hall, "State or Colorado," p.381.

[30] Robert G. Dunbar, "The Significance of the Colorado Agricultural Frontier," Agricultural History, 34 (July 1960):120-121.

Kansas, and now the new Jefferson Territory claimed jurisdiction over them all. An exasperated Rocky Mountain News thought the situation resembled "a regular triple-headed government machine."[31] As a result of this patch-work of governments, the provisional territorial government received less than full allegiance from its constituents. The miners of Gregory District, for example, rejected the new government by an overwhelming margin. Hundreds of miners refused to pay the $1 per head poll tax enacted by the provisional legislature.[32]

The lack of legitimacy accorded the provisional legislature was suggested by the very small turnout of voters at the second election in October of 1860. Earlier that year, a large meeting in Denver petitioned the President for the organization of a separate territory. As the provisional government withered away, Congress authorized the creation of Colorado Territory on February 28, 1861.[33]

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[31] Hall, "State of Colorado," p. 382.

[32] Hall, "State of Colorado," p. 383.

[33] Bancroft, History of Colorado, p. 410; and Hall, "State of Colorado," p. 384.

4.2.2 Colorado Territory

During their first session in September, the sanctioned territorial legislature approved a full set of criminal and civil law. Included among these statutes was a law that authorized the use of water for irrigation "when those claims are on the bank, margin, or neighborhood of any stream of water, creek or river"[34] The law also provided that the prior rights of mill owners shall not be impaired by any of the provisions of the act. An amendment authorized in 1868 added ditch owners to the protection allowed prior water claimants.

An important provision in the 1861 statute marked the beginning of the long history of administrative allocation of water in Colorado. Local justices of the peace were authorized to appoint three commissioners to apportion the waters among users in periods when streamflow was insufficient to meet all the demands in an area. Section five of the act allowed the condemnation of rights-of-way for ditches and canals. The amount of compensation paid for rights-of-way would also be determined by the commissioners. In addition, section eleven required that water not be use in a wasteful manner.[35]

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[34] Session Laws 1861, p. 67; from Harvey Huston, The Right of Appropriation and the Colorado System of Laws in Regard to Irrigation, reprint (Littleton, Colorado: Fred B. Rothman and Co., 1983), originally published 1893.

Although the legislation seemed to prepare the ground for the adoption of the system of prior rights, the legislature approved statutes that seemed to revive riparian rights. In 1861, for example, an act adopted the common law as the law of the land until specifically repealed by the legislature. The following year, the legislature prohibited the diversion of water from any stream

> line of said stream, and there shall be at all times left sufficient water in said stream for the use of miners and farmers along said stream.[36]

This deference to the use of water by miners should not be surprising, since miners accounted for a majority of the population in 1861.

Thus it appears that the experience of the evolution of water law in Colorado roughly resembled the early experience in California: a struggle between riparian rights and the system of prior rights. The increasing value of water for use in gold mining and irrigation, however, prompted the legislature to take the side of the system of prior rights. In 1864, the territorial legislature amended the 1862 statute, allowing some recognition of prior rights.[37]

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[35] Ibid, Sess. Laws 1861.

[36] Colorado, Department of Natural Resources, p. II-6.

[37] Colo. Terr. Laws 1864, sec. 32. p. 58, from Colorado, Department of Natural Resources, p. II-7.

The period 1858 to 1870 witnessed the beginnings of the development of social institutions that would define and protect rights to water and also provide for the distribution of water. Economic incentives generated higher values for the use of water in gold mining with more gold discoveries. High prospective profits had attracted some 22,000 miners to Colorado by 1860, accounting for almost two-thirds of the population.[38] The impetus or driving force behind the birth of these institutions revolved around the desire of miners to protect their investment of time and money from usurpation by subsequent prospectors. The value of the gold produced by the miners created the incentive for the protection of the rights to gold, as well as to the scarce inputs into the gold-producing production function; water was a most scarce input.

Early prospectors, fearing for the security of their water, promulgated rules that defined the rights of early users relative to later water claimants, and allowed diversion of streamflow due to the physical requirements of gold mining. Though fairly concrete rules were established at the local level through miners' courts and claims clubs, the development of water law on a more broad-based level was uneven. The territorial legislature seemed to indicate some

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[38] The estimated population of Colorado in 1860 was 34,277. U.S., Department of the Interior, Census Office, Eighth Census of the United States, 1860: Population: 547.

desire to legitimize the rule of priority, but the results were inconclusive. The early statutes did, however, clarify the rights of ditch owners relative to owners of land. The law of 1861 gave ditch owners the right to obtain land for building canals through condemnation when necessary, upon compensating the owner of the land. This law was the first to limit the domain of the right to own land in deference to the right to build and maintain irrigation ditches. Other than this provision for rights of way for ditches, the early water use institutions left many matters regarding allocation and relative rights murky and unspecified.

Large canal projects were constructed in the next period in the development of water law in Colorado. Population grew nearly five-fold from approximately 40,000 in 1870 to 194,000 in 1880.[39] The number and size of farms grew by similar proportions. The number of farms increased from 1,738 in 1870 to 4,506 in 1880. The number of farms between 100 and 500 acres in size increased from 258 in 1870 to 3,022 in 1880.[40] Relatively high prices for agricultural goods sold in the mining camps attracted greater numbers of

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[39] U.S., Department of Commerce, Bureau of the Census. Historical Statistics of the United States, p. 25.

[40] U.S., Department of the Interior, Census Office, Tenth Census of the United States, 1880: Report on the Statistics of Agriculture, pp. 26-27.

farmers.

But long-run sucessful farming in Colorado required irrigation and the construction of canals and ditches. With an average rainfall of only 13 -14 inches, irrigation was a necessity. In the earliest period in the history of irrigation in Colorado, farming was relatively profitable, but markets were limited to the mining camps. Irrigation works generally consisted of small, individually owned ditches. According to the Cherry Creek Pioneer,

> irrigation doubtless will be necessary in some places but it will be some time before such a thing will be necessary, as there is sufficient bottom land to accomodate all who follow agricultural pursuits for some time to come.[41]

In the next historical phase, however, irrigation extended from the bottom lands to areas farther from the streams and rivers. Claims to water usage equalled and even exceeded the flow of water available. Agricultural revenues increased, creating greater incentives for bringing more acreage under the ditch. Conflicts over rights to water and administration of water distribution followed closely the increasing value of water. These conflicts became particularly acute during drought years, when water became more valuable due to greater physical scarcity.[42]

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[41] April 23, 1859, quoted in Steinel, History of Agriculture, p. 53.

[42] Robert G. Dunbar, "Water Conflicts and Controls in Colorado," Agricultural History, 22 (July 1948):181.

4.2.3 Cooperative Canals

The phase in Colorado history characterized by the building of the great irrigation canals and ditches began in 1870. In that year, two cooperative organizations or colonies were organized in Colorado Territory. The most famous of these was the Union Colony, founded by Nathan C. Meeker and associates. Meeker, agricultural editor of the New York Tribune, issued a call through the paper for the organization of an agricultural colony in Colorado. The colony was to be situated at the confluence of the Cache la Poudre and South Platte Rivers. The new settlement was named for the owner of the New York Tribune, Horace Greeley, who had been impressed with the Mormon Colony in Salt Lake City.[43] Meeker and the other founders of Union Colony intended to mold a new idealistic community, based on the principles of temperance, diligence, and cooperation. The wealthy were invited to invest their capital in the project, to serve as a home for less wealthy members of high ideals. It was expected that the colony would be the locus of a future colonization movement, with each member holding an equally valuable share of farm land.[44]

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[43] Stone, History of Colorado, p. 159; and Robert G. Dunbar, Forging New Rights in Western Waters, (Lincoln: University of Nebraska Press, 1983), pp. 21-22.

[44] George Lofstrom Strebel, "Irrigation as a Factor in Western History" (PhD thesis, University of California, 1966), p. 323.

The Union Colony quickly developed plans for building four large irrigation canals. Individual irrigators were to own the land, but the community would own the ditch. It was estimated that the four canals would cost $20,000 to build. Work on ditch No. 2 began in the fall of 1870; it stretched 26 miles from the Cache la Poudre to lands north of Greeley. The first large ditch, No. 2, cost $27,000 to build and partially irrigated only 2,000 acres.[45]

Faced with the failure of No. 2 ditch to irrigate lands properly, the settlers had to decide whether to abandon the colony or to attempt to salvage the canal by correcting engineering problems and expanding its capacity. The colonists preferred to rebuild the canal, but the cooperative treasury was empty. The officers of the colony, however, in an ingenious interpretation of the contract with the colonists, determined that the needed extension of the canal could be interpreted as canal repairs, which by the agreement were to be paid by the settlers. The funds required were raised by levies on the lands under the ditch.[46] This enabled expansion of the canal in 1872 and 1877 to a capacity of 320 cubic feet per second. The result

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[45] U.S., Congress, Senate, Irrigation in the United States, by Richard J Hinton. Senate Misc. Doc. 15, 49th Cong., 2nd sess., 1887, pp. 135-139. Senate Exec. Doc. No. 41, 52nd Congress, 1st Session, 1892, pp. 135-139.

[46] Strebel, "Irrigation," p. 327.

was a 36 mile poorly engineered canal. The very quick fall of the canal created substantial erosion problems in the canal walls and caused the loss of large quantities of water due to seepage. Hinton reports that 6% of the total acreage served by the canal was rendered unusable due to canal seepage. The seepage, however, was eventually captured in ditches and applied to other lands.[47]

With the completion of the canal expansions, ownership of the canal was transferred from the community at large to the individual farmers in 1878. The canal was now organized as the Cache la Poudre Irrigation Company. One share of stock in the company was issued for every ten acres of land, amounting to 2600 shares of stock.[48] Each water right in the No. 2 canal claimed 1/320 part of the flow in the ditch.[49]

Perhaps the most salient aspect of the cooperative Union Colony was the relatively low cost of service and the prevalence of cooperation between irrigators. Although the design of the canal left much to be desired, the cost of delivering water per unit was much lower than the costs incurred by a large private canal company in the same area. In twenty years of use, for example, the costs of water delivery for irrigation including construction, enlargement,

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[47] U.S., Senate, Report on Irrigation, pp. 139-140.

[48] Ibid.

[49] Ibid, p. 141.

and maintenance costs were estimated to be $4.95 an acre, or 24.5¢ per acre per year. With twenty years of use, the costs of water delivery per acre for the privately constructed and owned Larimer and Weld Canal was $20, or more than $1.00 per acre per year.[50]

In addition, cooperation between irrigators helped to mitigate the effects of drought and water shortage. In times of low flow, 2 or 3 users would combine their water flows and rotate applications, thus saving water from the greater evaporation and seepage that would have occurred with three separate water applications.[51] Hinton remarks that this cooperative attitude among Colony irrigators resulted in almost no litigation between users concerning water rights.[52]

Concurrent with the ongoing expansion of the Union Colony's No. 2 ditch, a group headed by Gen. R. A. Cameron established the Agricultural Colony at Ft. Collins, approximately 25 miles up the Cache la Poudre from the Union Colony. The new colony constructed two canals, with total capacity roughly equivalent to the canal capacity of the Union Colony.

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[50] Ibid.

[51] Ibid.

[52] Ibid, p. 135.

The increased demand for water from the Cache la Poudre caused little problem until the dry summer of 1874. The absence of rain in the early summer found the Poudre at its lowest level since 1863.[53] Irrigators in Greeley (Union Colony) were forced to close the headgates of No. 2 ditch so that water would reach ditch No. 3 downstream.[54] Concerned with the diminished streamflow, some of the Union colony settlers proceeded upstream to the Agricultural Colony to inspect the canals there. They found that the Ft. Collins canals were diverting much of the flow of the Poudre, even though the canal was junior in time to the Union Colony canals. Believing that their rights to property were being damaged, the Union colonists petitioned the courts for an order to close the headgates of the Agricultural Colony ditches.[55]

Meeker, as editor of the Greeley Tribune, published four demands by the Union Colony. First, he argued that the principle of first in time, first in right should be recognized as binding in Colorado. As discussed above, this notion -- the basis of miners' law in Colorado -- had been eluded to in an 1864 statute. He believed that this doct-

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[53] Ft. Collins Standard, July 15, 1874, from Dunbar, "Water Conflicts," p. 182.

[54] Dunbar, "Water Conflicts," p. 182.

[55] Ibid.

rine would help to secure the investment made in irrigation works by the Union Colony and that this protection was justified since the Greeley settlers had earlier claim to the water than did the Ft. Collins group. In his second demand, Meeker argued that the river itself should be divided as are irrigation canals: that a superintendent should be in charge of the equitable distribution of water. Third, he called for the construction of a reservoir to hold the waters of the spring floods, and lastly he demanded that further diversion of the Poudre be stopped and violators be 'knocked in the head.'[56] Meeker's demands presaged the development of institutions to administer water allocation in Colorado, as well as the development and regulation of reservoirs for water storage.

In an attempt to settle the dispute out of court, representatives from the Greeley and Ft. Collins groups conferred at a compromise location. The upshot of this conference was that the Ft. Collins irrigators agreed to let more water flow down the river, in exchange for the dropping of litigation by the Greeley group.[57] Although the agreement was not upheld, the conflict was defused when the rains returned in late July. But the Greeley settlers had little

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[56] Greeley Tribune, July 8 and July 15, 1874, quoted in Dunbar, "Water Conflicts," p. 182.

[57] Dunbar, "Water Conflicts," p. 183.

inclination to forget how their water supply had been interrupted by the Ft. Collins irrigators.[58]

4.2.4 Constitutional Convention

Soon after the Ft. Collins-Greeley dispute, Congress authorized the drafting of a constitution for the proposed state of Colorado. The resulting constitutional convention in 1875 provided an excellent opportunity for water users to construct a more carefully defined and exclusive right to water. Upon convening in December 1875, the constitutional convention took up the problem of water law in five categories: 1) ownership of water, 2) prior appropriation, 3) use preferences, 4) rights-of-way, and 5) rate-setting for water delivery.[59]

Only three days prior to the constitutional convention, the Colorado Grange held their own convention. The populist farmers' organization approved resolutions that called for the state control of the waters of Colorado.[60] In the previous year, a speech by Governor Elbert gave evidence of the ideological frame of mind of many irrigators. In his

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[58] Ibid.

[59] Colorado, Department of Natural Resources, p. II-9.

[60] Hensel, "A History of the Colorado Constitution in the 19th Century" PhD thesis, (Boulder: University of Colorado, 1957), cited in Colorado, Department of Natural Resources, p. II-9.

message to the Territorial Legislature in 1874, Governor Elbert outlined what he considered to be the important principles of both ownership of water and water management. First, water should belong to the state, he argued, but the control of water distribution should be the province of canal owners. In addition, prior rights are superior: no one should be permitted to divert water at the expense of users with previously acquired, or vested, rights. Second, Elbert believed that "each considerable stream should be a management district". Local control of canals and ditches would reside in these districts in the form of an elected board of canal commissioners. The board would have the power to arbitrate disputes over rights to water, thereby avoiding the costly process of settling the dispute through litigation.[61]

The Grange and many farmers in general believed that corporations, in a speculative binge, would surely snatch up all the valuable lands and waters of the state if given the opportunity. The Grange apparently agreed with Governor Elbert's suggestions for the control of state waters: they resolved that corporate control of water be prohibited except in the case of actual settlers on the land to be irrigated[62]

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[61] Steinel, History of Agriculture, pp. 193-194.

[62] Wayne E. Fuller, "The Grange in Colorado," Colorado Maga-

Given this expression of opinion by the Grange in the background, the Convention set about contructing the basic law of ownership of waters in Colorado. The issue of water ownership split the convention between those in favor of state ownership in order to forestall corporate water monopolies and those opposed to legislative control of water. The first report of the irrigation committee stated the compromise:

> the water of every natural stream within the State of Colorado is hereby declared to be the property of the people of said state and the same is dedicated to their use forever.[63]

According to the committee chairman S. J. Plumb, this statement was simply a declaration of existing law, which recognized private rights to the use of water. Delegates concerned with protecting their interests from a perceived threat to their vested rights insisted that the declaration be limited to unappropriated water[64]

Some delegates believed that this declaration was meaningless and redundant, since the rights to divert and use water were already well established by custom. Appa-

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zine, 36 (July 1959):259; and Denver Daily Times, December 20, 1875, cited in Colorado, Department of Natural Resources, p. II-9.

[63] Proceedings of the Colorado Constitutional Convention, p. 44. Quoted in Colorado, Department of Natural Resources, p. II-11.

[64] Ibid, p. 344.

rently, the farmers desired to clearly establish in the constitution that the water belonged to the people, as opposed to the state.[65]

The constitutional provision that adopted priority of rights was resolved with little dispute. What discussion there was centered on the definition of the term 'appropriation'.

The section that established preferences in water use, however, generated heated debate. The report of the irrigation committee gave prior appropriators the superior rights to water, except from June first until September first, when agricultural uses will have the preferred use. The convention at large amended this provision to give first preference to domestic uses of water. Some delegates attempted to elevate farming uses above others by granting irrigation water rights a preference at all times. Another group proposed an amendment that would have granted preference to lands lying within a natural watershed to use of the streams to those lying outside the watershed. This proposal would have had the effect granting superior rights to riparian landowners when streamflow was low. The sentiment of the convention was, however, that economic development of the state required that cultivation be encouraged regardless of whether the water is used on riparian or nonriparian lands.

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[65] Denver Daily Tribune, February 19, 1876. Quoted in Ibid.

Recognition of riparian rights to water, they argued, would only encourage a wait-and-see attitude among landowners. Many had purchased land along streams but delayed investing in irrigation works and cultivation until it was clear that the economy of the territory would do well enough to make the investment viable. The final version adopted in the constitution gives preference to domestic uses.

The convention approved the right-of-way section of the constitution with little conflict. This provision merely stated the existing law, since rights-of-way for ditches and canals had long been recognized in customs and reconfirmed in Yunker v. Nichols. Article II, section 14 of the constitution authorized condemnation of rights-of-way upon payment of compensation.

Finally, a provision allowing local boards of commissioners to set water delivery rates was adopted. Since this section virtually duplicated a territorial statute, there was little opposition.

The final version of the section that establishes ownership of waters reads:

> The water of every natural stream not heretofore appropriated, within the State of Colorado, is hereby declared to be the property of the public, and is dedicated to the use of the people of the state, subject to appropriation as hereinafter provided.[66]

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[66] Colorado Constitution, Article XVI, Section 5.

Priority of rights is established by section six:

> The right to divert unappropriated waters of every natural stream for beneficial uses shall never be denied. Priority of appropriation shall give the better right, as between those using the water for the same purpose; but when the waters of any natural stream are not sufficient for the service of all those desiring the use of the same, those using the water for domestic purposes shall have the preference over those claiming for any other purpose, and those using the water for agricultural purposes shall have the preference over those using the same for manufacturing purposes.[67]

4.3 SUMMARY

The discovery of gold in California in California in the 1840's and in Colorado in the 1850's increased the economic incentives for protection of inputs into the gold mining process; namely water. Supplying the mining camps with agricultural goods was a lucrative business. Since the dry climate virtually necessitated irrigation, farmers began to develop rules governing the use of scarce water.

As increasing population put greater pressure on water supplies, water became more scarce and conflicts over water more intense and frequent. Early statutes provided ambiguous recognition of prior rights and allowed irrigation ditches rights-of-way. The development of large, cooperative irrigation ditches created more potential for conflict over rights to water, especially during periods of low flow.

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[67] Ibid., section 6.

Partially in response to past conflicts over water and partly due to ideological factors, the constitutional convention adopted the system of prior rights, along with the administration of water rates and preferencesfor domestic water users.

Chapter V

THE ERA OF THE CORPORATE CANAL

The organization of the first of the large corporate canal organizations in 1879--the Larimer and Weld Irrigation Company--marks a transitional period in the development of Colorado water law. It will be recalled that early water use in the area was generally governed by the rules of the miners' organizations and claims clubs. Irrigation in this period was confined to small plots of land not far from the streams and rivers. Irrigation ditches were built by individual effort: pioneer irrigators diverted water directly from the streams into individual canals and ditches. Water was not yet so valuable to justify the establishment of more exclusive rights to water. According to Elwood Mead:

> The first generation of irrigators gave no thought at the outset to their right to divert or to use a creek or river. They found water running to waste and put it to use, just as they breathed the pure air or enjoyed the abundant sunshine. They saw no more need of making an official record of this use than of keeping a record of the elk and antelope they shot for food. . . So long as streams carried a surplus, water was diverted and used without restraint and with lavish prodigality. Irrigators gave scant heed to their respective rights because, so long as each had all he needed, one right was good as another.[1]

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[1] Elwood Mead, "The Growth of Property Rights in Water,"

Eventually, the lands that could be profitably irrigated by an individual or partnership were all taken up. Lands remaining were farther removed from the rivers and streams, and subsequent irrigators could less afford the costs of building individual ditches to these lands. Consequently, irrigators pooled their resources in order to expand the capacity of existing ditches and to build larger canals to the benchlands. These community ditches were owned and operated by the owners of the lands irrigated. Each owner was obliged to contribute resources or labor effort to the construction and maintenance of the ditch, the assessments arrived at through mutual agreement.[2]

International Quarterly, (September-December, 1902):2-3. Additional evidence is provided by John E. Field:

> At first water was taken from the river and used without thought of its ever becoming scarce or of there being a conflict for its possession. The lands then considered farming lands were so limited that there was apparently more water than ever would be used.

John E. Field, Irrigation from Big Thompson River, U.S. Department of Agriculture, Office of Experiment Stations, Bulletin No. 118 (Washington: Government Printing Office, 1902), p. 52. Cited hereafter as Field, Irrigation from Big Thompson River.

[2] U.S., Department of Agriculture, Office of Experiment Stations, Irrigation in the Rocky Mountain States, by J. C. Ulrich. Bulletin No. 73 (Washington, D.C.: Government Printing Office, 1899), p. 19. Cited hereafter as Ulrich, Irrigation in the Rocky Mountain States.

Some of these mutual ditches were incorporated in order to expedite construction and to simplify assessments. The quantity of stock issued to each irrigator depended on the acreage irrigated; generally, 5 shares for 80 acres of land. Since these mutual organizations were not in business to sell water, the stock represented a claim to a share of water, not to a share of profit. Organization by-laws usually permitted rotation of water and rental of shares for an irrigation season.[3] The business of the companies was generally managed by a board of directors, elected by the stockholders. Day to day operations were the responsibility of a superintendent, who divided water among the stock-holders. The rules of operation and assessments for maintenance and operating costs were devised at the stockholders' annual meeting.[4]

Thus, mutual ditches were managed and owned by the irrigators. Since irrigators could acquire stock by contributing their labor time in building the canal, the amount of cash required to construct and maintain the system was reduced. Some have called this system the ideal form of organization for irrigation.[5] Problems may arise, however,

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[3] Raphael J. Moses, "Irrigation Corporations," Rocky Mountain Law Review, 32 (1960): 528.

[4] Ray Palmer Teele, "The Organization of Irrigation Companies," Journal of Political Economy, 12 (March 1904): 169-170.

when shares are sold to outsiders, i.e., persons not owning land under the canal. These problems revolve around the definition of the extent of a right to water, and the question of whether water rights should be considered appurtenant, or attached, to land. These problems came to a head in the subsequent era in Colorado water law, that of the corporate canals.

5.1 CORPORATE CANALS

An advantage of the community ditch, as discussed above, was that lands could be brought under irrigation without a large capital outlay. Irrigators invested their labor efforts in lieu of investment capital. As long as lands could be relatively cheaply irrigated by cooperative efforts, the community ditch organization performed well. Eventually, however, the sites most suited to cooperative irrigation were all claimed. Although much land of superior quality remained, it was frequently located in the high plateaus at long distances from the nearest source of water, or it was separated from water sources by hills and mountains. Most of these more productive lands were beyond the ability of cooperative efforts to irrigate, since considerable engineering talent and expensive routing through canyons, along

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[5] Ibid, p. 170.

cliffs--even some tunneling--were often required.[6]

The development of ditch companies in the 1880's funded by investment capital--as opposed to user-owned individual and cooperative ditches-- generated continuing political and legal conflicts regarding: 1) the definition of the right to water, and 2) the rates charged by ditch companies. Much of the discussion of regulation of canal corporations focused on the monopolistic nature of the enterprise: once the farmer purchased land, he or she was dependent on the canal corporation for a supply of water. The canal building boom was seen by some as a binge of speculative investments by Eastern and foreign capital. In 1884, for example, four hundred miles of corporate canal were built in Colorado, largely funded by speculative capital.[7] Mead attributed the tremendous increase in canal building to the companies' belief that they could exercise secure and absolute property rights to the water in their canals. Between 1880 and 1885,

> the state was gridironed with canals built in advance of their need, simply and solely because of the belief that by thus securing possession of water supply they controlled the values of all the land tributary to their ditch.[8]

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[6] Ulrich, Irrigation in the Rocky Mountain States, p. 23.

[7] Leonard P. Fox, "State Regulation of the Canal Corporation in Colorado," Michigan Law Review, 16 (January 1918): 159.

[8] Mead, Irrigation Institutions, p. 211. Quoted in the Colorado Farmer, February 2, 1888.

In order to curb the market power of corporate canals, many states placed limits on rates charged for water deliveries. Since the supply of water in the watercourse varied with the level of snowfall and precipitation, unregulated water rates would have been subject to large fluctuations. In dry seasons unregulated rates would increase to levels perhaps too high for many farmers to afford. But when the streams swelled with flood water, rates would likely plunge so low that the company may suffer a loss.[9] The administration of water rates could in principle benefit both buyer and seller by providing stable prices and revenue in the long-run.

The first of the corporate canals to be built was the Larimer and Weld Canal, constructed in 1878 with capital from the Colorado Mortgage and Investment Company of London, Limited, locally known as the 'English' company.[10] The canal eventually irrigated 50,000 acres, stretching 53 miles long.[11] Its capacity was 720 cubic feet per second: easily the largest in the Cache la Poudre Valley.[12] The same com-

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[9] This account of the problems arising from unregulated water rates was based on the experience in Spain. See Katharine Conan, "Some Unsettled Problems of Irrigation," American Economic Review, 1 (March 1911):1-19.

[10] Dunbar, "Colorado System," p. 253.

[11] Ibid, p. 244.

[12] Dunbar, "Agricultural Frontier," p. 122.

pany later built the High Line Canal, the Loveland and Greeley Canal, and the Platte Valley Canal, with a combined capacity sufficient to irrigate well over 100,000 acres.[13]

Publication of the plans to build the Larimer and Weld Canal caused concern among irrigators in Greeley and in Ft. Collins. Fearing for the security of their claims to water, they felt that the time had come for a more formal method of securing title to the use of water.

Up until this time, there was no procedure in the law allowing for the filing of claims to water or any systematic process of establishing ownership or title to water use.[14] Faced with increasing demands for water diversions, the farmers of the South Platte Valley considered three proposals: 1) the measurement of streams and rivers, 2) the division of the state into hydrologic districts, and 3) the creation of a state commissioner of irrigation. The second and third proposal became the basis of the Colorado system of water rights administration.[15]

These proposals were introduced into the Colorado legislature in 1879 as House Bill No. 22. The original bill defined priority in right in terms of the farmer's use of water rather than ditch capacity. The bill also provided

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[13] Fox, "State Regulation," p. 159.

[14] Field, Irrigation from Big Thompson River, p. 184.

[15] Dunbar, "Water Conflicts," p. 184.

for the division of the state into water districts, creating water commissioners for each district who would settle disputes regarding rights to water. Thus, the bill favored administrative settlement of disputes, and clearly favored irrigators over ditch owners for the purpose of defining water rights.[16]

In committee, however, the bill was rewritten to attach prior rights to the ditch instead of to land, favoring the corporate interests. The final statute approved by the General Assembly created ten water districts, all but one in the South Platte Valley. In each district, a water commissioner would apportion water according to the relative priority of ditches. District courts were authorized to determine relative rights to water. The courts appointed a referee who would take testimony regarding the date of construction and enlargement of ditches and their carrying capacity. Reviewing the findings of the referee, the court then issued a decree which established the relative priorities of the ditches in the district, along with the quantity of water allowed to each user. In effect, water rights were quantified in terms of the carrying capacity of the ditch or canal.[17] Notably, the statute mandated that consumers along

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[16] Ibid, p.252.

[17] Dunbar, "Colorado System," pp. 253-254; Leonard P. Fox, "State Regulation of the Canal Corporation in Colorado," Michigan Law Review, 16 (January 1918):161. Fox argues

a ditch share water pro rata in times of shortage of flow. In other words, priorities for users along a ditch were not recognized. Commissioners supervised the diversion of water into the headgates of the ditch with regard to priority, but beyond the headgate distribution of water was the province of the canal corporation.[18]

The procedure for adjudicating rights to water constructed in the 1879 legislation was soon put into motion. Scant precipitation in 1879 and 1880 prompted increased demand for water diversions and caused concern among irrigators for the protection of their rights to water. Under pressure from irrigators, several referees were appointed by district judges in the South Platte Valley during the summer of 1879. The referees, as outlined in the 1879 statute, issued notices and began to take testimony regarding priorities and ditch capacities within the several districts.[19]

The next April, when one of the referees filed testimony with the court in Denver and sought a decree of rights, Judge Elliott refused. He claimed that the procedure of adjudication was unconstitutional since it did not provide

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that the statute, by defining rights to water in terms of ditch capacity, ignored the constitutional requirement that rights be recognized only when water has been put to a beneficial use.

[18] Fox, "Canal Corporation," p. 161.

[19] Dunbar, "Colorado System," p. 255.

the usual cause of action and procedures normally associated with a lawsuit. Distressed by this decision, the Union Colony appealed to the Colorado Supreme Court. The court, however, sided with Judge Elliott and declared the 1879 law unconstitutional.[20]

The Union Colony, less than enthusiastic with the court's decision and concerned with the loss of water to Ft. Collins irrigators downstream, prevailed upon the governor to appoint a water commissioner to allocate water in the area. Although the new commissioner had no official records to rely on, he nevertheless was somewhat successful in allocating the water.[21]

Reform of the irrigation law quickly became an issue in the upcoming elections. With support from the Greeley irrigators, from newspapers, and from the State Board of Agriculture, irrigation bills were introduced into the third legislature. As Dunbar notes, the proliferation of giant corporate canals under the umbrella of the Colorado Mortgage and Investment Company "made imperative some legal registry of their the farmer's stream rights."[22]

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[20] Ibid, and Union Colony v. Victor A. Elliott 5 Colo. 380 (1880).

[21] Dunbar, "Colorado System," p. 257.

[22] Ibid, p. 258.

In 1881, the legislature approved legislation that amended the 1879 water rights adjudication act. In the new legislation, adjudication of water rights could be requested by petitioning the court, thus meeting the lawyers' demands for proper procedure.[23] The legislature also approved legislation affecting rights of way, ditch construction, and the operation of headgates. One statute required that persons contructing or enlarging a ditch file a notice with the county clerk.[24] Other statutes required ditch owners to keep headgates in good repair and provided penalties for disturbing headgates and ditch banks.[25]

5.1.1 A New Water Right

The legislation of 1879 and consequent court cases led to the recognition of a new sort of water right. Up until this time, most farmers diverted their water directly from natural streams. Title to the water was perfected by beneficial use, usually irrigation. Obtaining and using the water was regulated directly by the state. Fox calls this type of water right a 'primary appropriation.'[26]

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[23] Ibid, p. 259 and Session Laws, 1881, p. 144.

[24] Session Laws, 1881, p. 161, sec. 2.

[25] Session Laws, 1881, p. 163 and p. 165.

[26] Fox, "Canal Corporation," pp. 161-162.

Farmers obtaining water from corporations possessed a 'secondary appropriation.' Unlike primary appropriations, their rights did not flow directly from the authority of the state. The particular rights to water of these farmers depended on the terms in the contracts with the canal corporations. This secondary appropriation gave the two-step process heretofore necessary for a valid appropriation or water right--diversion from the natural stream flow and putting the water to beneficial use--a new twist. Previously, both steps had been taken by the irrigator-ditch owner. With the emergence of corporate canals, the process of appropriation was split between the ditch owner and the irrigator: the corporation diverts the water, but the farmer puts the water to beneficial use. As one might imagine, the ambiguous nature of the rights of the canal company vis-a-vis the irrigator generated a substantial amount of litigation as demand for water continued to increase. Fox believed that this state of affairs had dangerous aspects:

> It interposed the canal corporation as a middleman between one class of irrigators and the public waters dedicated by the constitution to the use of the people of the state. To a large extent the state abdicated legislative and administrative control over secondary appropriators in favor of contractual control of the canal corporation. Thus the prosperity of the secondary appropriator depended largely upon the terms and execution of his contract with the water corporation. The measure of state interference to guarantee equitable water contracts becomes the criterion of fair and

effective regulation of the ditch corporations.[27] Canal corporations acquired land usually from the government or from the railroad, constructed irrigation ditches, and then sold water rights contracts along with the land.

Canal corporations provided water under two kinds of contracts: one consisted of the sale of the right to water in perpetuity, the other amounted to an annual rental of water. In both cases, unlike the mutual ditches described above, the canal owners or stockholders were not the farmers using water from the ditch. Rather, the canal owners typically were individuals and corporations from the East or Europe, looking for a handsome rate of return on their investments.

Contracts offering perpetual water rights were generally much more popular with the farmers, but less profitable for the canal corporations. In these contracts, the company agreed to keep canals and headgates in good repair, and to deliver water to the lands specified. Contracts specified the quantity of water to be delivered, but with the qualification that when water is scarce and largely claimed by senior appropriators, the water diverted will be divided pro rata among users on the ditch. The company assumed no liability for losses due to this type of shortage.[28]

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[27] Ibid, p. 162.

[28] Ulrich, Irrigation in the Rocky Mountain States, pp.

The price of a perpetual water right in the typical contract usually covered the costs of construction. Operations and maintenance costs were recovered in yearly assessments.[29] The quantity of water was generally measured in terms of acres irrigated, although some contracts specified measures such as the 'miner's inch' or the second-foot.[30] Prices varied depending on location: in the San Luis Valley, perpetual water rights sold for $400, while the North Poudre Ditch Company charged $1200 for perpetual rights.[31]

5.1.2 Irrigation and Ideology

Just as the plentiful rainfall of the mid 1880's had fostered optimism and a cooperative spirit, drought in the early 1890's supplied pessimism and conflict. Deteriorating growing conditions and economic uncertainty,[32] combined with the perceived threat of outside monopoly capital, generated incentives for political organization and activism. Chief

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[29] Mead, Irrigation Institutions, p. 93.

[30] Ulrich, Irrigation in the Rocky Mountain States, p. 53.

[31] Leonard Peter Fox, "Origins and Early Development of Populism in Colorado," PhD dissertation, University of Pennsylvania, 1916, pp. I 28-29.

[32] One writer argued that the financial panic of 1893 was largely due to the over-investment of speculative capital in various enterprises in the West. See Leon W. Fuller, "Colorado's Revolt Against Capitalism," Mississippi Valley Historical Review, 21 (December 1934): 348.

targets for farmers included the excessive rates charged by railroads and monopoly control of water by canal corporations, as well as abuses by grain dealers, beer combines, and loan companies.[33] In the election year of 1888, for example, both Republican and Democratic parties called for the state regulation of the railroads.[34] Regarding control of the canal corporations, Democrats favored state regulation, while Republicans believed that a federal reclamation program would solve the problems of the irrigators.[35]

Dissatisfaction with the inability or unwillingness of the two major parties to address the problems faced by farmers and irrigators led to the emergence of third-party and agricultural lobbying groups. For example, the Grange was organized in the 1870's as a farmer's cooperative organization. The purpose of the organization was to provide a mechanism to buy goods and sell produce directly in the markets, thereby avoiding the cost of middlemen. The Grange fought against the control of water by the canal corporations, and protested the practice of charging higher prices for water delivery that reflected the increased value of the

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[33] Fox, "Populism in Colorado," p. III-19, and Wright, Origins of Populism, p. 42.

[34] James Edward Wright, The Politics of Populism: Dissent in Colorado, (New Haven: Yale University Press, 1974), p. 69.

[35] Ibid, p. 70.

land. The organization advocated a system of state supervision of water rights. In this system, the state would be divided into districts following hydrologic boundaries, with each district managed by a water commissioner.[36]

In their state convention of 1888, the Grange adopted resolutions that advocated outright state ownership of ditches and canals, and federal assistance in the construction of reservoirs. The convention believed that new reservoirs were essential for future growth, and that their provision was "too vast an undertaking for private capital and too precious to be trusted to corporations."[37]

The reluctance of the Grange to engage in overt politics contributed to its decline, and fostered the growth of the more political National Farmer's Alliance. The demands of the Alliance included rail regulation, bimetallism, secure water rights, and the attachment of water rights to land upon putting the water to beneficial use. Other broad-based political organizations that emerged to deal with these types of issues were the Independent Party and the People's Party. Motivated by the drought of 1890, irrigators took leadership positions in the Indpendent Party

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[36] Wayne E. Fuller, "The Grange in Colorado," Colorado Magazine, 36 (July 1959): 255-259.

[37] Steinel, History of Agriculture, p. 208.

campaign for water reform and the attempt to capture the governorship. Although the Independents lost in the 1890 election, the Populists won in the governor's race of 1892 on a platform of free coinage of silver and redress of agricultural grievances.[38]

In 1891, the Colorado Farmer's Protective Union was assembled from several organizations seeking water reform. The Union lobbied the legislature to require the accurate measurement of water deliveries from ditch companies to irrigators.[39] A second proposal would have required that the ditch company post a bond with the county treasurer, to be refunded when evidence that water was actually delivered to farmers was submitted. The Union also called for the dissolution of any ditch company that sold more water rights than it could deliver.[40]

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[38] Fox, "Origins of Populism," p. IV-37.

[39] Measurement of the quantity of diverted was relatively crude in this early period. Irrigators knew approximately the number of acres they irrigated, but had little concern with determining the actual quantity of water used. In the mining districts, however the relative scarcity of water spawned the use of a measure called the 'miner's inch', defined as the "volume of water which will flow through an inch-square orifice under a uniform and designated pressure." See Elwood Mead, Irrigation Institutions, (London: Macmillan, 1910), p. 102.

[40] Fox, "Regulation of Canal Corporation," p. 170.

The report of the Colorado Irrigation Commission in 1890 confirmed many abuses in the sale of water rights.[41] A member of the commission, former state engineer J. S. Greene, argued that the power of the canal corporations must be curbed, that speculation in water be discouraged, and that the users of water should be recognized as the true owner of the rights to use water. These goals would be accomplished by: 1) attaching water rights to land, and 2) putting the State in charge of the distribution of water to irrigators.[42]

Hearings sponsored by the U. S. Senate Special Committee on Irrigation in 1890 provide numerous statements of the plight of the irrigators, and where they laid the blame for their troubles. The gist of the farmers' testimony was that the deck of legal cards appeared to be stacked in favor of the canal corporations. They complained that the list of statutory penalties for violating the rights of the ditch companies grew longer every session, but that the irrigator had little recourse when his/her rights were violated.[43] Many advocated state ownership of canals and ditches,

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[41] Ibid.

[42] U.S., Department of Agriculture, Acquirement of Water Rights in the Arkansas Valley in Colorado, by J.S. Greene. Bulletin No. 140 (Washington, D.C.: Government Printing Office, 1903), p. 68. Cited hereafter as Greene, Acquirement of Water Rights.

[43] Report of the Special Committee, p.

believing that water would be more fairly distributed, since "the companies are not governed by the desire to be right; they are only governed by that which pays the most money that is possible."[44]

5.2 WATER RIGHTS, EFFICIENCY, AND IDEOLOGY

Increases in the demand for water due to greater claims by corporate canals led to legal conflicts among canal companies, and between canal companies and irrigators. Regarding the latter, two aspects of the conflict were particularly important: 1) the measurement of a right to water, and 2) rates charge for water delivery. These conflicts deserve close examination, since they demonstrate elements of both ideological and economic behavior.

5.2.1 Water Rentals and Water Rates

The Supreme Court of Colorado and the Court of Appeals decided several cases in this period dealing with the selling of water rights by canal corporations. Some of this water was provided by rental contracts. Many of the provisions of the contracts were similar to the provisions of perpetual contracts. The corporation assumed no liability

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[44] Levi Booth, quoted in Ibid, p. 348. Booth argued that the State should prevent ditch companies from building more canals once the water supply had been totally claimed. Ibid, p. 350.

for water shortages, and the consumer forfeited his/her rights to water for non-payment of fees.[45] Water was delivered to the farmer in exchange for a charge per unit of water carried. Rental contracts generally must be renewed at the beginning of the irrigation season each year.[46]

Some companies offering rental contracts took notice of the increased value of the farmer's land due to the availability of irrigation water. They felt that since the value of the land had increased essentially due to the water they provided, the corporation should capture this increased productivity. The High Line Canal, for example, charged $1.50 per acre for the delivery of water plus a bonus fee of $10 per acre, payable in advance, for the right to buy water.[47] Thus, in addition to the per acre rental charge for water delivery, corporations tacked on an additional per acre charge or royalty, on the basis that the water was theirs to sell.[48]

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[45] Fox, "Regulation of Canal Corporation," p. 164.

[46] Ulrich, Irrigation in the Rocky Mountain States, p. 52.

[47] Fox, "Regulation of Canal Corporation," p. 164.

[48] According to the Denver Republican, July 11, 1890, the value of an acre of land under the High Line Ditch incresed from $9 per acre in 1884 to more than $26 per acre in 1887. Cited in Roger V. Clements, "British-Controlled Enterprise in the West Between 1870 and 1900, and some Agrarian Reactions," Agricultural History, 27 (October 1953):139 fn. Clements notes that the owner of a system of canals in the San Luis Valley, the Travelers' Insurance Company, also charged the extra fee. Ibid, p.

Many farmers felt that this added charge for water was an illegal circumvention of the legally established rates for water set by the county commissioners. The failure of an early court challenge to the additional charge on water led to the organization of the Farmers' Irrigation and Protective Association in 1887, which promptly introduced an 'anti-royalty' bill in the legislature. The irrigationists' lobbying effort focused on the fact that the High Line Canal -- which levied the extra fee -- was owned by the 'English company.'[49] The farmers effectively played on local prejudice against foreign capital in the legislature. Legislators were heard to say that "the idea of a royalty upon water was un-American. It was not the idea of an American brain or American heart." One senator asked his colleagues

> Gentlemen of the Senate, are you for English royalties or for the rights of American farmers?[50]

In the case of Wheeler v. Northern Colorado Irrigating Company,[51] the Colorado Supreme Court made its earliest important statement regarding the status of canal corporations. The corporation argued in effect that it was the owner or proprietor of the water, and thus had the right to

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[49] Clements, "British Controlled Enterprise," p.139.

[50] Rocky Mountain News, March 3, 1887 and March 30, 1887. Quoted in Ibid.

[51] 10 Colo. 582, 17 Pac. 487 (1888).

charge for their property what they wished. The court, however, adopted much of the argument of the plaintiff. Noting that a valid appropriation required both the diversion of water and beneficial use and that the waters of the state belong to the public, the court found that the corporation was a quasi-public carrier of water, not the proprietor. The corporation could charge a rate for providing the water for farmers, but could not sell water as if it were private property. Thus, the royalty was declared unconstitutional.[52]

In their decision, the court remarked that the canal corporation, by the nature of irrigation, tends to take on the characteristics of a monopoly. As a monopoly facilitating the irrigation of farms with the public's water, the activities of the canal corporation affect the public interest and are consequently subject to judicial review.

Earlier in 1887, the farmers succeeded in their lobbying efforts in the legislature. The governor signed an "Act to define, prohibit, punish and restrain extortion and other abuses in the management of ditches, canals, and reservoirs" on April 4.[53] Section one of the act prohibited royalties and required the delivery of water upon payment of charges

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[52] Fox, "Regulation of Canal Corporation," p. 139, and Wheeler v. Irrigation Company, 17 Pac. 489-490 (1888).

[53] Colo. Session Laws, 1887, p. 308.

set by the county commissioners: anyone charging more than this rate would be guilty of a misdemeanor.[54]

The success of the efforts of the Farmers' Irrigation and Protective Association in outlawing royalty charges showed

> for the first time in the state's history . . . that farmers were good crusaders and worthy foes in a fight involving their rights.[55]

5.2.2 Quantity and Measurement of the Right to Water

The early court cases in Colorado measured water rights by the capacity of the ditch, not the amount of water actually used in irrigation.[56] These water rights were generally not attached to any particular tract of land. Measurement of water based on capacity rather than use was certainly easier to accomplish. The watermaster for each canal would regulate the flow in each ditch by altering the height of the headgate. Presuming a steady flow of water in the canal, the watermaster could measure the flow of water and determine the corresponding volume by referring to a 'rating

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[54] Ibid, Section one. Penalties for violating Section One consisted of a fine of from $100 to $5000 and/or 5 months to 1 year in jail. Section 2, Ibid.

[55] Steinel, History of Agriculture in Colorado, p. 208.

[56] Fort Morgan Land & Canal Company v. South Platte Ditch Company 18 Colo. 1, 30 Pac. 1032 (1892). This was generally the case throughout the arid West. See Hutchins, Water Rights Laws, Vol. I, p. 492.

table' developed for each ditch.[57]

Regulating the quantity of water based on actual use would be much more difficult.[58] The amount of water associated with a water right would vary, depending on the actual need of the land at the time. This would require a periodic calculation of the quantity of water consumed by the crops, which varies depending on the weather, soil fertility, and the type of crop.

In addition to the practicability of associating the measure of a water right with ditch capacity as opposed to actual use, the choice of the method of measuring the right to water also resulted from the power of the canal corporation. Since the relative priority of a water right was already defined in terms of the beginning of the ditch, rather than the earliest time of use, "it was but a step from making the ditch control the date of the right to having its size govern the amount of the right."[59] Mead suggests that the canal corporation regarded the water as their property, and expended resources in order that legislation and court cases reflect this belief. Farmers had little time or resources to battle the corporations in the courts

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[57] Elwood Mead, "The Growth of Property Rights in Water," International Quarterly, (September-December 1902): 6.

[58] Ibid.

[59] Ibid, p. 6.

or in the legislature. According to Mead,

> The owners of large irrigation enterprises . . . employ attorneys to prepare their incorporation papers, to frame their water rights contracts and to look after their interests in the courts. . . it has gradually come about that much of the ablest legal talent of the West is retained or enlisted in favor of giving those rights to the ditch owners, separating them entirely from the land, and ignoring the claims of actual settlers.[60]

As more and more corporate ditches were built, the canal companies sold greater quantities of water rights. But often times, however, the ditch would have a very low priority on the stream so that it would not be legally able to carry water to its capacity over the entire irrigation season. Thus, the farmer did not purchase the right to a definite quantity of water, but purchased the right to a share of whatever the company delivered, up to the contractual maximum. The opportunities for abuse by less than scrupulous water corporations are obvious. A company could build a ditch on a stream already over-appropriated, sell water rights to unwary farmers up to the capacity of the ditch, and claim to be released from liability when little or no water was delivered.[61] In effect, the risk of sporadic streamflows was transferred from the ditchowner to the water

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[60] Ibid, p. 7

[61] Ray Palmer Teele, "The Organization of Irrigation Companies," Journal of Political Economy, 12 (March 1904): 164.

user.[62]

This abuse also sometimes occurred when canals were extended. According to Byron Wheeler, a Colorado farmer,

> The water supply is sure to be decreased, not alone from natural causes, but from the cupidity of the company controlling the ditch, in continually extending its area and selling water that it can not deliver, even though there should be a flood in the stream. So that 20,000, or 40,000, or 100,000 acres are added to the area which a given ditch is supposed to irrigate at first and the others must then prorate. The result is that every man under the ditch is put to his strumps to get what he pays for.[63]

To the early water users, it mattered little whether water rights were established as owner of the ditch or owner of the land, since they owned both.[64] With the emergence of the corporate canal, however, the ownership of ditches and the land were divorced, raising the issue of the ownership and measurement of rights to water.

The problem of establishing the quantity of water associated with a water right generated conflict in the courts. Basically, the dispute involved whether the right to use water should be defined in terms of a definite quantity of water flowing through the ditch, or as the quantity

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[62] Fox, "Origins of Populism," p. II-27.

[63] U.S. Congress, Senate, Report of the Special Committee of the U.S. Senate on the Irrigation and Reclamation of Arid Lands, Senate Report 928, 51st Cong., 1st sess., 1890, pt 1, p. 347.

[64] Mead, "Property Rights in Water," p. 5.

necessary to irrigate a particular tract of land. The first method of definition gave the owner the right to use a particular quantity of water where he or she choose on any land; the second method attached the water right to a particular tract of land, with a limit set on the quantity of water that could be applied.[65]

The more efficient method, and therefore the method we would expect to be adopted, consisted of defining water rights in definite quantities, unattached -- or non-appurtenant -- to the land. Water defined in this way will ultimatley be allocated so that the value or the marginal product of water is equalized across lands. For example, the irrigator will apply water to his/her lands up to the limit of his/her water right as long as the net revenue generated by the marginal unit applied is as least as large as the revenue that would be receieved by selling the water to another user. In other words, as long as the value or the marginal product of water is less than the market price of water, then irrigate; sell when the value of the marginal unit of water drops below the market price.

Alternatively, when the right to water is attached to a particular piece of land, the irrigator does not have the option to sell or lease water to other users. The irriga-

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[65] Henry C. Taylor, "Economic Problems in Agriculture by Irrigation," Journal of Political Economy, 15 (April 1907):225.

tor, with rights to water defined in terms of land, cares nothing about the marginal product of water, but applies water to the land as land as average product is positive; i.e., as long as total revenue increases. The well-known result is that water will be used inefficiently, since the opportunity cost of water is in effect ignored.[66]

5.2.3 Origins of the Wyoming System

Although in theory the Colorado method of defining water rights appeared to be relatively efficient, the practice of water rights adjudication left much to be desired. The adjudication process, for example, did not allow testimony by the state engineer regarding the actual quantity of water supplied for the various ditches or the streamflow available. Thus, expert testimony from the state was excluded from adjudication proceedings; determining the quantity of water allowed by a right was left to judges and referees who were unfamiliar with stream measurements and the duty of water. The only information the state engineer was permitted to provide was the names of water claimants and the owners of the ditces and canals.[67]

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[66] Ibid, pp. 226-227.

[67] Robert G. Dunbar, Forging New Rights in Western Waters, (Lincoln: University of Nebraska Press, 1983), p. 98, and U.S. Departmen t of Agriculture, Economic Research Service, Natural Resource Economics Division, Water Rights

One result of this system was that decreed amounts often exceeded the quantity of water available in the stream. According to Frederick Newell,

> decrees have been made to various ditches entitling them to two, three, or even five times as much water as could possibly be carried, the aggregate amount mentioned in decrees being perhaps ten or twenty times as much as the river from which the water is taken carries even in times of flood.[68]

A committee of the Granger organization drafted proposed legislation to address this problem in 1887. Chaired by Elwood Mead, the committee submitted three bills to the legislature. House Bill No. 294 created a state board which would make rules concerning the use of the streams of the state. Water diversions would not be allowed unless the permission of the board was first obtained. House Bill No. 271 would have tied water rights to land, or made water appurtenant to land. House Bill No. 119 outlawed royalty payments for water deliveries. Mead believed that these bills would reign in the monopoly power of the corporate canals. However, only the anti-royalty bill was approved by

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Laws in the Nineteen Western States, by Wells A. Hutchins. Misc. Pub. No. 1206, Vol. II (Washington, D.C.: Government Printing Office, 1971), p. 239. Cited hereafter as Hutchins, Water Rights Laws.

[68] U.S., Department of the Interior, Census Office, Eleventh Census of the United States, 1890: Report on Agriculture by Irrigation in the Western Part of the United States, by Frederick H. Newell, p. 94.

the Colorado legislature.[69] Not until the overhaul of water law in 1969 did the Colorado legislature require filing with a state agency in order to obtain the right to water.[70]

Mead, however, found more success in implementing his proposals in Wyoming. Taking office as the territorial state engineer in 1888, Mead found a system fraught with the same difficulties as in Colorado: many streams were overappropriated, and no central registry of claims existed. Under the influence of Mead, the Wyoming constitution adopted in 1890 established a board of control. The Board was vested with the power to define water rights as to priority and quantity. In contrast with the practice in Colorado, the state engineer and division superintendents provided expert hydological testimony regarding irrigation requirements and streamflows.[71] Implemented by the statute of December 22, 1890, the Wyoming system required that irrigators apply to the board for a permit to appropriate water: applications were approved if the board found no conflict with the public welfare. The statute also implied that water rights are attached, or appurtenant, to land.[72]

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[69] Dunbar, Forging New Rights, pp. 102-105.

[70] Hutchins, Vol. II, p. 217.

[71] Ray Palmer Teele, "Relation of the State to Irrigation," p. 243, and Dunbar, Forging New Rights, pp. 105-109.

[72] Ibid, pp. 109-110, and Taylor, "Economic Problems in Agriculture," p. 226.

Mead apparently realized that water would be used more economically when defined in a transferable form, but believed that

> there were other questions which were of more immediate importance than the highest degree of economy in water use. . . he had learned that where water rights were granted in cubic feet per second, without regard to the area of land on which it is used, no administrative system had been developed to keep the earlier appropriators from establishing rights to much more water than they were actually using.[73]

The injustice of this system to later appropriators who would find their water claimed by the inflated claims of earlier appropriators motivated the Wyoming system. Taylor argues that this system appears to be desirable in the early stages of water rights development, but may not be appropriate when the streamflow is fully claimed and water is highly valued.[74] In other words, the increasing value of water may call for modification of the original system of water rights specification.

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[73] Taylor, "Economic Problems in Agriculture," p. 227.

[74] Ibid.

5.3 SUMMARY

The irrigation of lands farther removed from the streams and rivers required larger capital outlays in diversion works and canals. The emergence of the corporate canal brought with it the needed capital, but also greater conflicts over rights to water. Increased demand for water, coupled with the difficulty of defining and protecting property rights on an individual basis, fostered the development of state administration of water rights.

Conflict between canal corporations and irrigators over water focused on two factors: 1) the quantity of water associated with a water right, and 2) the price of water delivery. Irrigation lobbying groups were organized to battle the corporate canal companies in the courts and in the legislature. The ideology of these groups set the stage for much of the water law to follow.

Chapter VI

WATER RIGHTS LEGISLATION AND LITIGATION IN COLORADO

This chapter provides a more detailed analysis of the development of Colorado water rights in the courts and in the legislature from 1850 to 1920. Most of the major changes in water law are reviewed, with particular attention given to the evolution of the law regarding the basis of the system of prior rights, the status of the canal corporation, and the development of procedures for appropriating new sources of water.

6.1 WATER RIGHTS LEGISLATION

A great deal of legislative activity regarding irrigation took place between 1879 and 1903. Table 1 summarizes the most significant statutes approved during this period. Important legislation during this period can be assigned to one of four categories: 1) regulation and administration of water diversions, 2) control and measurement of diversions, 3) permitted sources of water for appropriations, and 4) measurement and filing requirements. After laying the foundation of the Colorado system of water rights administration

in 1879 and 1881, the legislature refined and amended the system in practically every term between 1879 and 1903.

TABLE 1

Water Rights Legislation in Colorado: 1861-1919

Year	Legislation
1861	owners of land adjacent to streams may use water for irrigation; distribution of water by appointed commissioners when flow is low; condemnation of right of way for ditch; prior rights protected
1862	prohibits diversion of water to the detriment of any user along the stream
1877	ditches must be kept in good repair; during summer, may divert only water necessary for domestic, stock, or irrigation purposes
1879	pro rata sharing when flow low; water districts established; system of adjudicating water rights established
1881	water districts organized into water divisions; state engineer created; ditch owners required to measure flow of water; amendments to 1879 adjudication procedure; procedure for extending ditch right of way; punishment for disturbing headgates
1887	procedure for fixing water delivery rates; superintendents of irrigation for water divisions created; ditch owners required to appoint superintendent to measure flows; required to keep ditch in good repair; royalties for water delivery prohibited; penalties for diverting more water than entitled; filing with state engineer required for ditch right of way
1889	penalties for bribing water district officials; headgates with locks required; priority of right to water from other than natural streams; water commissioner given police powers

TABLE 1

Continued

Year	Legislation
1891	water appropriated for domestic use shall not be used for irrigation
1895	provides for accepting the benefits of the Desert Land Act; water commissioners given power to shut down headgates if water used wastefully
1897	authorizes transfers from one stream or reservoir to another; must maintain measuring devices
1899	decree required for changing the point of diversion; maps and statements required; temporary intra-ditch loans of water permitted
1901	requires construction of headgates and measuring weir as condition of water delivery; raises penalties for interference with headgates; irrigation districts authorized
1903	state provides engineering assistance for building reservoirs; amendments to 1899 statute regulating change in point of diversion maps and statements required when constructing or enlarging ditches or reservoirs
1911	further refines the duties of the state engineer; self-regulating measuring devices required
1915	authorizes state control of headgates and weirs
1917	prohibits diversion of water for use outside of state; priority of rights to spring water defined
1919	procedure for settling outstanding claims to water; priorities conditional on future beneficial use of water authorized

Some statutes authorized changes in the state administrative system. For example, in 1887 a new layer of management was created between the state engineer and individual water commissioners. A superintendent of irrigation was appointed for each water division.[1] One of the primary duties of the superintendent was to prepare a 'register of priorities': a list of ditches, arranged in time of priority, compiled from the adjudication decrees of the courts. The function of the register was to help protect priorities. If a ditch owner failed to receive water, he/she would report to the district commissioner who would in turn report to the division superintendent. Upon examining the register of priorities, if indeed the ditch owner was not receiving water entitled, the superintendent could order that the headgates of upstream water users be closed.[2] In later sessions, the legislature extended the police power to water commissioners,[3] and made bribery of water district officials a crime.[4]

Other important statutes regulated the delivery of water. In 1887, two such statutes were approved: one described a procedure for the fixing of water rates by

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[1] Sess. Laws 1887, p. 295.

[2] Sess. Laws 1887, p. 299, sec. 10.

[3] Sess. Laws 1889, p. 469, sec. 1.

[4] Sess. Laws 1889, p. 39, sec. 1.

county commissioners, as provided by the constitution, and the other prohibited the payment of royalties for water, as discussed above.

The problem of control and measurement of water diversions was addressed several times by the legislature during this period. In 1881, for example, legislation required ditch owners to install measuring weirs or measuring devices. The data generated by the device were to be collected by the state engineer.[5] The provisions of an 1887 act required ditch owners to maintain their ditches in good repair and to appoint a superintendent to measure water diversions along the ditch.[6] In 1889, headgates were required on all ditches. Measuring devices were required to be used when diverting water from one stream to another in an 1897 act.[7] Four years later, legislation was approved that prohibited the delivery of water to any ditch until the owner built a headgate permitting control of the rate or diversion.[8] Locks on headgates were mandated in 1911, along with self-registering measuring devices.[9] Finally, the state assumed control over headgates and weirs in 1915, making

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[5] Sess. Laws 1881, p.121, sec. 12.

[6] Sess. Laws 1887, p. 305, secs. 2-3.

[7] Sess. Laws 1897, p. 176, sec 2.

[8] Sess. Laws 1901, p. 193, sec. 1.

[9] Sess. Laws 1911, p. 463, secs. 1-2.

unauthorized operation of headgates a crime.[10]

In addition to increasing the specificity of measurement and diversion requirements, legislation expanded the sources of water diversions subject to priority of appropriation. For example, due to the increased value of water, lawmakers in 1889 mandated that the laws of priority applied not only to water taken from natural streams, but also to waste, seepage, and spring waters.[11] The legislature later extended the process of adjudication to include spring water.[12]

Though the law appeared to increase the specificity and exclusivity of water rights, presumably in response to the increasing value of water, some legislation appeared to result in a reduction of efficiency. There is little doubt that the 1917 statute[13] prohibiting the diversion of water for use outside the borders of the state was inefficient, since it restricted the use of water in potentially higher valued uses.

The efficiency reducing aspects of two other statutes, however, are less than clear cut. One of these acts required that parties desiring to change the point of diver-

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[10] Sess. Laws 1915, p. 290.

[11] Sess. Laws 1889, p. 215, sec. 1.

[12] Sess. Laws 1917, p. 541, sec. 1.

[13] Sess. Laws 1917, p. 539.

sion of water obtain judicial approval, or a decree, beforehand. The person desiring to change the point of diversion was required to notify all other water users who may be affected by the change, and offer proof to the court that the proposed change would not affect the vested rights of these other users. The district court was authorized to issue the decree only if the change would not harm other users.

Obviously, the act was designed to require that the party wishing the change in point of diversion does not impose detrimental externalities on other water users. Thus, from one perspective, the act increased efficiency by avoiding possible negative externalities. However, in doing so the statute discouraged fewer changes in the point of diversion, since it would now be harder to prove non-injury. Assuming that the changes were usually desired in order to take advantage of a profitable new land, the act made such changes more difficult, thus potentially reducing efficiency. The net reduction or gain in efficiency from this act is thus indeterminate.

6.2 LITIGATION

Similar to the development of legislation, case law evolved from general statements outlining the parameters of the water rights system to fairly specific pronouncements over a wide range of water rights categories. Table 2 demonstrates that the types and quantities of cases decided by the Colorado Supreme Court and the Court of Appeals vary dramatically during the period 1870-1919. Early cases---before 1890--established most of the basic rules of water use.

At about the same time as the Greeley-Ft. Collins dispute over water, for example, the Colorado Supreme Court issued its first opinion regarding water rights.[14] In this case, the court gave unambiguous approval to the diversion of water from streams for use in irrigation. It also upheld the restrictions placed on the domain of the rights of landowners vis-a-vis the rights of ditch owners created by the grant of right-of-way to ditch owners. The roots of the conflict went back to 1871 when Yunker and Nichols agreed to jointly build an irrigation ditch across Nichols' land, the water to be shared. After the ditch was built, Nichols proceeded to divert all the water in ditch, leaving none to reach the lower lands of Yunkers. The trial court jury found for the defendant Nichols, apparently based on the

[14] Yunker v. Nichols, 1 Colo. 551, (1872).

TABLE 2

Water Rights Litigation in Colorado: 1870 - 1919

Category	Number of Cases				
	1870-1879	1880-1889	1890-1899	1900-1909	1910-1919
Appropriations					
system of prior rights	1	3	0	3	0
rights of way, easements	1	0	8	4	8
diligence	0	2	5	3	0
definitions, duties of officials, procedures, and jurisdiction	0	0	7	11	6
Corporations					
status	0	1	10	7	6
damages due to lack of water	0	0	7	2	4
rates for water delivery	0	1	1	0	3
abandonment	0	1	3	8	9
Transferability					
change in point of diversion	0	1	1	13	11
conveyance of rights to water	0	1	3	3	6
appurtenance	0	0	6	4	0
Other					
rights to seepage, waste, and ground water	0	0	5	9	7
reservoirs and storage	0	1	4	5	9

theory that his right to control resources on his land was paramount.

The Colorado Supreme Court, however, took a different view of the dispute. In the opinion of Chief Justice Hallett:

> In a dry and thirsty land it is necessary to divert the water of streams from their natural channels, in order to obtain the fruits of the soil. The value and usefulness of agricultural lands, in this territory, depend on the supply of water for irrigation, and this can only be obtained by constructing artificial channels through which it may flow over adjacent lands.[15]

In other parts of the country, where rainfall is greater, the court noted, there is no need to enter someone else's land in order to build ditches. But in response to the dry climate, Colorado law[16] allowed rights-of-way to ditch owners

> by withholding from the land-owner the absolute dominion of his estate, which would enable him to deny the right of others to enter upon it for the purpose of obtaining needed supplies of water.[17]

Thus the decision of the trial court was reversed. Justice Wells felt motivated in his opinion to note that the rights of the ditch owner would be valid even without the 1861 statute, since they "arise from the necessities brought on by

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[15] Ibid, p. 552.

[16] Session Laws 1861, p. 67.

[17] Yunker v. Nichols 1 Colo. 553 (1872).

the local peculiarities of climate."[18]

The decision of the supreme court in the Yunker case, recognizing the right to divert and convey water from the stream across the land of others, laid the basis for the Colorado system of water rights.[19] Although the Colorado constitution had specifically recognized priority of rights to water as early as 1876, the question of the rights of riparian relative to non-riparian water users was not resolved by the courts until the late 1870's and early 1880's. The first case that addressed the problem was decided in 1878,[20] but the most important case was heard four years later. In Coffin v. Left Hand Ditch, Justice Helm explicitly recognized the economic value of enforced water rights:

> It has always been the policy of the national, as well as the territorial and state governments, to encourage the diversion and use of water in this county for agriculture; and vast expenditures of time and money have been made in reclaiming and fertilizing by irrigation portions of our unproductive territory. Houses have been built, and permanent improvements made; the soil has been cultivated, and thousands of acres have been rendered immensely valuable, with the understanding that appropriations of water would be protected. Deny the doctrine of priority or superiority of right by priority of appropriation, and a great part of the value of all this property is at once

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[18] Ibid., p. 570.

[19] Ralph Henry Hess, "The Colorado Water Right," Columbia Law Review, 16 (December 1916): 651-652.

[20] Schilling v. Rominger 4 Colo. 100 (1878).

> destroyed. . . it would be an ungenerous and inequitable rule that would deprive one of its benefit simply because he has, by large expenditure of time and money, carried the water from one stream over an intervening watershed and cultivated land in another.[21]

The court ruled that the common law doctrine of riparian water rights was inapplicable in Colorado; that necessity of climate required the diversion of water from the streams. Also, the first person to appropriate the water and put to beneficial use has the prior rights, whether or not the water is used on lands adjacent to the stream.[22]

In later cases, the courts articulated the general attributes of a water right, and distinguished between the ownership of water and ownership of the right to use water.

> water of every natural stream is the property of the public. Private ownership of water in the natural stream is not recognized.[23]

But the right to divert water is guaranteed; the right to use water is a property right, available for sale or transfer. In order to claim a valid right to water, there must be diversion and application to a beneficial use.

> This may now be considered as one of the fundamental principles underlying our system of irrigation. It is too well established to be open to controversy.[24]

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[21] Ibid., p. 443 and p. 449.

[22] Ibid.

[23] Ft. Morgan Land & Canal Company v. South Platte Ditch Company (1892) 18 Colo. 1, 30 Pac. 1032.

Even though the language in Coffin constituted a fairly definite repudiation of riparian rights and recognition of priority, some water users were not made believers; they continued to challenge prior rights. The court was compelled to rule against assertions of riparian rights in five cases between 1882 and 1909.[25] An exasperated court in 1909 noted that to recognize a riparian water right "would require the reversal of decisions of the court, tearing up the statute laws, and nullification of provisions of the constitution".[26]

In addition to establishing and reaffirming priority of rights, the supreme court pronounced the doctrines of relation back and diligence. Borrowing from California and Nevada, the court ruled that although an appropriation is not complete until water is actually diverted, if work on the diversion facility proceeds with diligence the priority of right will relate back to the time the work began. However, if the appropriator procrastinates in finishing the diversion works, then the priority will be recognized only when water is diverted and actually put to beneficial use.[27]

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[24] Ibid, p. 1033.

[25] Thomas v. Guiraud 6 Colo. 530 (1883); Hammond v. Rose 11 Colo. 524 (1888); Crippen v. White 28 Colo. 298 (1901); Wellington v. Beck 43 Colo. 70 (1908); and Sternberger v. Seaton 45 Colo. 401 (1909).

[26] Sternberger v. Seaton 45 Colo. 401 (1909).

The question of abandonment of water rights was first considered by the supreme court in 1883. In this case, farmer Hammond had not diverted water into his fields for many seasons. The court ruled that Hammond's right to the water depended on putting it to use. Since Hammond had no intention of resuming use, the court decided that he had abandoned his right to water, and that it was available for appropriation by other users.[28]

Recall that the codes of the early mining organizations and claims clubs had required water to be used as a basis for claiming rights to the water. This requirement was generally thought to inhibit speculative ownership of water. Speculation, or making a profit from merely owning but not necessarily using property, was held in very low regard by the irrigators and miners of the era. Consequently, they erected institutional barriers that required resources be put to use in order to make a profit. However, the theoretical discussion in Chapter III indicates that to the extent that natural resource property rights develop in an efficient manner, one would expect to observe the development of a competitive resource futures market. The requirement of actual use of the resource as a condition of

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[27] Sieber v. Frink 7 Colo. 148 (1884), and Highland Ditch v. Mumford 5 Colo 325 (1880).

[28] Dorr v. Hammond 7 Colo. 79 (1883).

claiming rights is clearly inconsistent with the implications of the model in this regard; i.e, the model cannot explain restrictions on speculative ownership of water. Perhaps the 'use or lose' requirement could be explained by the values and ethical nature of irrigators; that is, by their ideology.

Lastly, the steadily rising value of water led to nascent recognition of transfers of water rights and of rights attained other than by diversion. When water was relatively abundant there was little need for the clarification of the rights to store water in reservoirs or the rights to change the point of water diversion. But as rising profits in irrigation encouraged more farmers to venture from the East to the 'Great American Desert', water became more and more scarce from the increasing demand and also from the occasional drought. The increasing value of water created the incentive for storage of waters in the late spring, when melting snow swelled the rivers. Thus, the water that would have been waste as far as the irrigator was concerned could be used to irrigate crops in the late summer when streamflows were typically low. Storage reservoirs began to appear in the mid 1880's; the first case involving reservoirs was decided by the supreme court in 1886.[29]

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[29] Larimer County Reservoir Co. v. People 8 Colo. 614 (1886).

Increased demand for water combined with recurrent droughts created the incentive for irrigators to ensure that each drop of water was used in its most productive fashion. In order to improve the efficiency of transmission of water through irrigation ditches and to exploit more productive lands, irrigators began to change the point at which water was diverted from the stream. Early court cases permitted such changes with no loss in priority, provided that the quantity of water diverted was not changed and that the rights of other users were not injured.[30]

As Table 2 demonstrates, cases involving changes and transfers of water rights were much more numerous after 1890, reflecting reallocation of the all but claimed surface water supplies. Rising demand for water raised the value of water for use in irrigation. Given that the domain of the right to water was anything but well-specified, increasing water values generated incentives for a more exclusive right to water. Perhaps due to the inability or unwillingness of legislators to address these problems, the increased demand for greater exclusivity of water rights found an outlet in the courts. During this period, the costs of protecting water rights through litigation began to approach or even exceed the benefits. The increased cost of litigation

[30] For example, Sieber v. Frink 7 Colo. 148 (1884) and Fuller v. Swan River Placer Mining Co. 12 Colo. 12 (1888).

threatened the value of investments in ditches and canals. As Mead notes,

> In ten years the water-right litigation of one State is estimated to have cost over a million dollars. In many sections it has exceeded the money expended in constructing the ditches in which it has its origin.[31]

6.2.1 Status of the Canal Corporation

A significant number of cases during this period dealt with the litigation involving the canal corporation.[32] As shown in Table 2, court cases regarding the status of the canal corporation and damages due to lack of delivered water accounted for a substantial proportion of water rights litigation in the 1880's and 1890's. As noted by Fox,

> neither in the nineties nor subsequently did the legislature enact any fundamental changes in the laws of 1879 and 1887 regulating ditch corporations.[33]

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[31] U.S., Department of Agriculture, Office of Experiment Stations, Water Rights of the Missouri and Its Tributaries, by Elwood Mead. Bulletin No. 58 (Washington, D.C.: Government Printing Office, 1899), p. 10. One estimate placed the cost of legal and court fees incurred in defending water rights of 73 ditch owners in California at $125,000. See U.S.G.S., "The Legal Status of Irrigation," Proceedings of the First Conference of Engineers of the Reclamation Service, Water Supply Paper No. 93, (Washington, D.C.: Government Printing Office, 1904), p. 296.

[32] This section draws heavily from the excellent discussion of water rights litigation in Leonard P. Fox, "State Regulation of the Canal Corporation," Michigan Law Review, 3 (January 1918): 158-178.

[33] Ibid, p. 171.

The courts, however, decided many of the the problems of water rights definition and the rights of ditch companies relative to those of irrigators; problems that the legislature could have, but chose not, to solve. The court cases included the general status of the canal corporation, damages from non-delivery of water, and the fixing of equitable water rates. The important litigation regarding water rates was discussed in Chapter 5, and will not be repeated here.

As for defining the right to priority, the supreme court ruled in Combs v. Agricultural Ditch Company that the water carrier had no priority independent from the actual use of the water, and that any rights claimed by the ditch company depended fundamentally on the continued use of the water. In other words, ownership of a share of the company did not automatically result in ownership of the water right, since the latter could only be acquired by actually putting the water to beneficial use.[34]

> If the law were to be declared otherwise--if ditch companies were at liberty to divert water without limit, and at the same time make ownership of stock an absolute condition precedent to the right to procure water from their irrigating canals---water-rights would soon become a matter of speculation and monopoly, and tillers of the soil would have to pay exhorbitant rates for the use of water, or our arid lands would become unproductive. The constitution provides that the water of natural streams may be diverted to beneficical use; but the privilege of diversion is granted only for uses truly beneficial, and not for

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[34] Ibid, p. 172.

purposes of speculation.[35]

The Combs decision required ditch owners not applying water diversions to beneficial use within a 'reasonable' amount of time to relinquish the water to irrigators who need and would use the water. In a later case, the court decided that the non-use of water for nine years was unreasonable, and therefore the right to priority was voided.[36]

Disputes between ditch owners and irrigators arose regarding the application of the 1879 act that required pro rating of water among irrigators along a ditch during periods of low streamflow. In one case, for example, the ditch company pro-rated scarce water among the users of the original ditch and users of an extension to the ditch. The prior ditchowners argued that the constitutional provision for priority of right was being violated by the ditch company; that when the ditch was extended, a new right with a later priority was created for the additional irrigators. The court agreed, and ruled that since the users of the extended portion of the ditch actually made a new appropriation, that the irrgators served by the original ditch would receive all of their water rights before those served by the exten-

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[35] Combs v. Agricultural Ditch Company (1892) 17 Colo. 146, 28 Pac. 968.

[36] New Mercer Ditch Company v. Armstrong (1895) 21 Colo. 357, 40 Pac. 989.

sion.[37]

Other court cases examined the obligation of ditch owners to provide water to irrigators, and the definition of the 'estimated capacity' of a canal. The court of appeals, in Pawnee Land and Canal Company v. Jenkins, found that the company may be liable for economic losses due to low streamflow.[38] If through proper maintenance of the ditch the water could have been delivered, then the ditch company is liable for damages suffered. The court ruled against the canal company and awarded Jenkins $500 in damages.[39]

As discussed above, most canal companies sold rights to water based on the capacity for diversion. In many cases, however, the quantity of water actually diverted rarely approached the physical capacity of the ditch, due to the demands of prior appropriators and to drought. Usually, what water that was available was pro-rated among the water users with each user's share of the water growing smaller as the ditch company continued to sell water rights. In a case heard in 1892, the appellant Wyatt argued that the Larimer and Weld Irrigation Company had no right to sell more water rights, since the canal could not actually furnish the addi-

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[37] Farmers' Highline Canal & Reservoir Company v. Southworth (1889) 13 Colo. 111. This decision was confirmed in Nichols v. McIntosh (1893) 19 Colo. 582.

[38] (1892) 1 Colo. App. 425, 29 Pac. 381.

[39] Ibid, and Fox, "Regulation of Canal Corporation," p. 173.

tional greater quantity of water.[40] The ditch company, on the other hand, contended that it could issue additional water rights up to the estimated capacity of the canal, as stated in the water rights contract. The court ruled that the 'furnishing capacity' of the ditch rather than the 'carrying capacity' was the appropriate measure of capacity, and ruled that the sale of water rights greater than the ability of the canal to furnish water was unfair and illegal.

6.2.2 Water Rights Transferability

In numerous cases during the period 1900-1919, the courts ruled that a change in the point of diversion was permitted as long as the rights of others were not injured.[41] The supreme court recognized the economic importance of transferability in this 1891 opinion:

> The authorities seem to concur in the conclusion that the priority to the use of water is a property right. To limit its transfer. . . would in many instances destroy much of its value. . . This right may be transferred by sale so long as the rights of others. . . are not injuriously affected thereby.[42]

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[40] Wyatt v. Larimer and Weld Irrigation Company 33 Pac. 144. Ibid, p. 174.

[41] Recall that as of 1899, statutes required that a decree be obtained for any proposed change in the point of diversion.

[42] Strickler v. City of Colorado Springs 26 Pac. 316.

In other words, the right to change the point of diversion is not absolute; the proposed change cannot harm the rights of others.[43] The same condition was applied to loans of wate from one irrigator along a ditch to another.[44]

Another issue related to water rights transfers was the matter of whether water rights were attached, or appurtenant, to the land. As discussed above, some believed that appurtenance requirements were necessary to prevent speculative ownership of water. The Colorado Supreme Court first ruled that water rights could be transferred apart from the land in 1891.[45] Justice Elliott in 1892 wrote that water rights were not necessarily tied to the land on which the water was used; that these rights "cannot be inseparably annexed to the land." This principle applied to water diverted from natural streams as well as from ditches, and to rights acquired by stock as well as primary appropriations.[46] The general principle came to be that the transfer of water rights with the land depended on the intention of the parties to the transfer; water rights were not necessarily appurtenant to land. The court confirmed and reconfirmed this principle on several occasions in the 1890's and

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[43] Handy Ditch v. Louden Irr. Canal 27 Colo. 515 (1900).

[44] Ft. Lyon Canal Co. v. Chew 33 Colo. 392 (1905).

[45] Strickler v. City of Colorado Springs 26 Pac. 316 .

[46] Oppenlander v. Left-Hand Ditch Co. 31 Pac. 857.

1900's.[47]

6.2.3 Other Water Rights Litigation

Increased scarcity of unclaimed water created incentives for the utilization of new and different sources of water in the early 1890's.[48] Some the more important sources of water that heretofore had been underutilized included water storage, seepage and waste water, and ground water. As is usually the case, the development of new practices of resource use resulted in conflicts over the proper use of the resource. The emergence of storage and seepage rights was no exception. Table 2 shows that only one case in this category was decided before 1890, but with increasingly scarce water supplies, the number of cases grew dramatically from 1890 to 1919.

The earliest case regarding ground water was considered by the court of appeals in 1893.[49] In this case, the plaintiff was an appropriator of stream water fed by an underground source. The defendants were accused of lowering the flow of the stream by the operation of their ground water pumps. The court ruled that the appropriator had

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[47] For example, Arnett v. Linhart 21 Colo. 188 (1895), and Travelers' Ins. Co. v. Childs 25 Colo. 360 (1898).

[48] Hinton, p. 132.

[49] McClellan v. Hurdle 3 Colo. App. 430, 33 Pac. 280.

established a property right in the percolating water.[50]

The first case concerning storage rights was heard by the supreme court in 1886.[51] In this case, the court ruled that diversion of water was not necessarily required to obtain a water right, or appropriation; the true test is application to a beneficial use. Thus, reservoirs may be situated on a streambed, instead of away from the streambed.

The definition of rights for water storage relative to direct flow rights took some odd twists and turns. In the earlier cases, the court ruled that water could be diverted for storage only when none of the irrigators along the stream required the water, regardless of the priority of the reservoir.[52] In 1907, however, the supreme court ruled that a direct irrigator may store water temporarily for use later in the season, as long as the quantity stored does not exceed the quantity of the direct flow right.[53] The court reversed their decision in a similar case in 1915. Finally, in 1936 the court gave storage rights the same legal protec-

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[50] Ibid., p. 282.

[51] Larimer County Reservoir Coompany v. People 8 Colo. 614, 9 Pac. 794.

[52] Wayne D. Williams, "Irrigation Law in Colorado: Part II," Rocky Mountain Law Review, 10 (April 1938): 187.

[53] Seven Lakes Reservoir Company v. The New Loveland & Greeley Irrigation and Land Company 40 Colo. 382, 93 Pac. 485, and Ibid.

tion as direct flow or irrigation rights.[54]

6.3 SUMMARY AND CONCLUSIONS

The development of legislation and litigation in Colorado demonstrated an evolution from less exclusive to more exlcusive forms of water rights. Legislation in the period 1861 to 1919 called for greater regulation of water diversions, more careful measurement of the quantity of water diverted, and the application of prior rights to sources of water such as seepage, waste, and ground water.

Similarly, litigation in the higher courts evolved a more specific set of rules governing the use of water. The system of prior rights was recognized and affirmed early in this period; rights-of-way for ditches were also recognized. In addition, the courts applied the rule of priority to seepage and ground water.

The evolution to more exclusive forms of rights to water was constrained, however, by ideological influences generated by the struggle between irrigators and the canal corporations. Concern with monopoly control of water supplies, water delivery rates, and externalities in water rights transfers caused the promulgation of seemingly inefficient rules such as the regulation of water rates and the requirement of judicial approval of water rights transfers.

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[54] Williams, "Irrigation Law in Colorado," pp. 188-189.

Chapter VII

ESTIMATION OF A MODEL OF WATER RIGHTS EVOLUTION

Earlier chapters constructed a theoretical framework for water rights development and examined the qualitative historical evidence of water rights eveolution in Colorado. This chapter examines the quantitative evidence of water rights evolution. In order to test the hypotheses generated in Chapter III, a model of water rights evolution is constructed. But first, the chapter briefly reviews the selection of appropriate measures, or indicators, of the model variables. The collection of data is discussed next, followed with the estimation of equations for both Colorado and the Arid West. A final section summarizes the results of the chapter.

7.1 A REVIEW OF THE EVIDENCE

In the previous chapter, water rights litigation showed a marked increase in the late 1880's and early 1890's. A combination of factors account for this increase in legal activity. The most important of these include adverse weather conditions, diminished streamflow, and increased value of irrigated crops. First of all, precipi-

tation during the period was below average in several years, reaching a low of 6.4 inches in 1893. Low precipitation would probably increase the value of water diversions, since more water would be needed to irrigate the parched soil. Other unusually dry seasons include 1888 with 9.8 inches of precipitation, and 1890 with 8.8 inches.[1]

Secondly, streamflow also diminished significantly in several years during the period. Reduced streamflow would result in a lower volume of water diversions and reduced profits for irrigators. The increased physical scarcity of water generates economic incentives for the exclusion of supra-optimal claimants. Exclusion of claims to water could be accomplished several ways, but the method most likely consists of more carefully defining the right to water through litigation.

Of course, if the rights to water were exclusive, i.e., very well-defined and specified, then periods of low streamflow will not necessarily lead to greater litigation. With exclusive water rights, low flow would present no problem of the definition of water rights; water would continue to be allocated efficiently. But water rights, due to the

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[1] Precipitation is measured as the mean of precipitation recorded at Ft. Collins, Greeley, Denver, and Las Animas County. Compiled from U.S. Department of Agriculture, Weather Bureau, Summaries of Climatological Data by Sections, 2d ed., Vol. I.; reprint ed., (Washington, D.C.: Weather Bureau, 1926).

nature of the resource, are semi-exclusive and imperfectly specified. As water becomes more valuable or more scarce, water claimants will attempt to protect, or more carefully specify, their claims to water.

The third and perhaps most important factor contributing to litigation and legal change in water rights is the increasing value of the product of water. The analysis in Chapter 3 showed that an increase in the demand for water causes an upward shift in the revenue schedule, creating an economic surplus partially attributable to the scarce water resource. This surplus may be dissipated or it may be claimed, depending on the nature of the property rights to the resources. If rights are relatively non-exclusive, the economic surplus will be dissipated by the entrance of new claimants attracted by positive levels of profit. If relatively exclusive, however, at least part of the surplus will be claimed by the current resource users. Thus, if the net benefits of making the rights to the resource more exclusive are positive, then established resource claimants will take measures to exclude further claims and to protect against encroachment on their water rights.

Since data regarding the price of water rights over time are not available, we are forced to use a proxy for the value of water. The value of irrigated crops per acre would be a good proxy since it indicates the productivity of land

which in turn is fundamentally linked to the availability of water.[2] Land in the arid states was practically worthless without water, but land provided with water for irrigation increased rapidly in value. The linkage between land and water also resulted in the measurement of water in terms of the quantity necessary to irrigate 80 acre tracts for a given period of time.

Given this strong association between the value of water and the value of land, we would expect that it it were known, the average value product of water would be highly correlated with the value of crops per acre irrigated. Table 3 presents a summary of crop values by decade for the arid West and for Colorado.[3] These data were calculated by summing the values of the major crops and dividing by the total number of acres. Crop values grew little from the 1880's top the 1890's, probably due to the depression and deflationary pressures during the mid 1890's. In Colorado, crop values actually declined. During the period 1900-1909, however, crop values soared, proabably reflecting the impact of the Reclamation Act. Crop value per acre in Colorado

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[2] Recall that some canal corporations exploited this linkage by requiring a surplus payment or royalty for water deliveries in order to claim a portion of the increased value of the newly irrigated crop land.

[3] For the purposes of this study, the arid West includes the states of Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming.

jumped 27% from the level of 1882-1889. In the arid West region, crop value per acre increased by 77% for the same period. The rate of increase, however, decreased substantially from 1900-1909 to 1910-1919. The general trend of increasing crop values per acre from 1882 to 1919 implies an increasing value of water. By far, the largest proportion of the output of these crops were grown on irrigated farms. For example, Table 4 shows that 95% of Colorado's wheat output in 1899 was irrigated, as was 99.4% of the alfalfa hay crop. In value terms, according to the 1890 census, irrigated crops accounted for 89% of the value of all crops grown in Colorado.[4]

TABLE 3

Value of Crops per Acre for the Arid West and Colorado

Period	Colorado	Arid West
1882-1889	$16.20	$11.17
1890-1899	13.51	13.36
1900-1909	20.52	19.75
1910-1919	23.04	25.42

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[4] U.S., Department of the Interior, Census Office, Eleventh Census of the United States, 1890: Report on Agriculture by Irrigation in the Western United States, by F.H. Newell, p. 90. Wheat cultivation dominated early irrigation in Colorado until the early 1880's. Falling relative wheat prices encouraged diversification into corn, oats, and alfalfa. But alfalfa required three to four time more water than wheat, thereby exacerbating water shortages in the late 1880's. Fox, "Origins of Populism," pp. I-33-34.

TABLE 4

Acreage and Production of Irrigated Crops, 1899

Crop	Acreage		Production	
	Total (x 1000)	Percent Irrigated	Total (x 1000)	Percent Irrigated
corn	85	48	1276 bu	68
wheat	295	84	5588 bu	95
oats	121	83	3080 bu	90
barley	22	92	531 bu	96
hay	455	99	1107 tn	99
potatoes	44	82	4466 bu	92

7.2 DATA COLLECTION

It would be useful to examine the appropriateness of the data selected to measure the independent variables. The number of cases filed in district courts dealing with the protection of water rights would be the best measure of legal activity. The collection of these data, however, is far beyond the resources of this study. The number of water rights cases reported by the appellate and supreme courts of each state was chosen as a reasonable proxy. One would expect that the level of activity at the trial court level would determine the level of activity at the higher court levels. Court cases dealing with water rights were collected from several editions of the American Digest, a publication which lists court cases with headnotes by legal

categories for the entire nation.[5] Cases were selected from the category 'Water and Water Courses' from four editions of the digest. Case headnotes were scanned to ensure that the case was related, in general, to the protection or definition of the right to water. Some cases and categories of cases were excluded. Cases involving damages to land due to water seepage from canals, for example, did not involve the value of water and so were not included. Subcategories such as 'Bed and Banks' were also excluded. The type of cases included range from rights of way to damages due to loss of flow, and from appurtenance to the validity of the system of prior rights.[6]

Data were also collected for streamflow and crop value. Streamflow data were collected from U.S. Geological Survey publications.[7] Criteria for selection of rivers and

[5] The following editions of the publication were used: American Digest 1658 to 1896, Century Edition, Vol. 48: Vendor and Purshaser to Willful Injuries (St. Paul: West Publishing, 1904); American Digest 1897 to 1906, Decennial Edition Vol. 20: Vendor and Purshaser to Zinc (St. Paul: West Publishing, 1910); American Digest, 2d Decennial Edition 1907 to 1916, Vol. 23: War to Zoological Societies, (St. Paul: West Publishing, 1922); Third Decennial Digest, 1916 to 1926, American Digest System, Vol. 27: Trover and Conversion to Wharves (St. Paul: West Publishing, 1929).

[6] An example of the categories or cases included appears in Chapter V, Table 2.

[7] U.S., Geological Survey, Compilation of Records of Surface Waters of the United States through September 1950, Part 6-A: Missouri River Basin above Sioux City, Iowa, Water Supply Paper No. 1309 (Washington, D.C.: Government Print-

recording stations included the completeness of early records and the location of the river and recording station. Based on these criteria, four rivers were selected: 1) the Cache la Poudre River recorded at Ft. Collins, Colorado, 2) the Arkansas River recorded at Canyon City, Colorado, 3) the Missouri River recorded at Ft. Benton, Montana, and 4) the Bear River recorded at Collinston, Utah. Data for the Poudre river begins in 1884, for the Arkansas in 1888, and for the Missouri and Bear rivers in 1891. Figure 8 shows the approximate locations of these recording stations and also the distribution of irrigated acreage. Much of the irrigated farmland in the study area depends on the flow of these four rivers.

Two streamflow indexes were calculated: one for Colorado, and the other for the entire arid West region. Indexes were used since they reflect variations of flow around a base level without regard to the annual quantity of flow. The Colorado flow index was constructed from the mean of the nominal flows of the Cache la Poudre and Arkansas rivers, with the base set at the mean level of the combined flows. Similarly, the other index combines the annual flows

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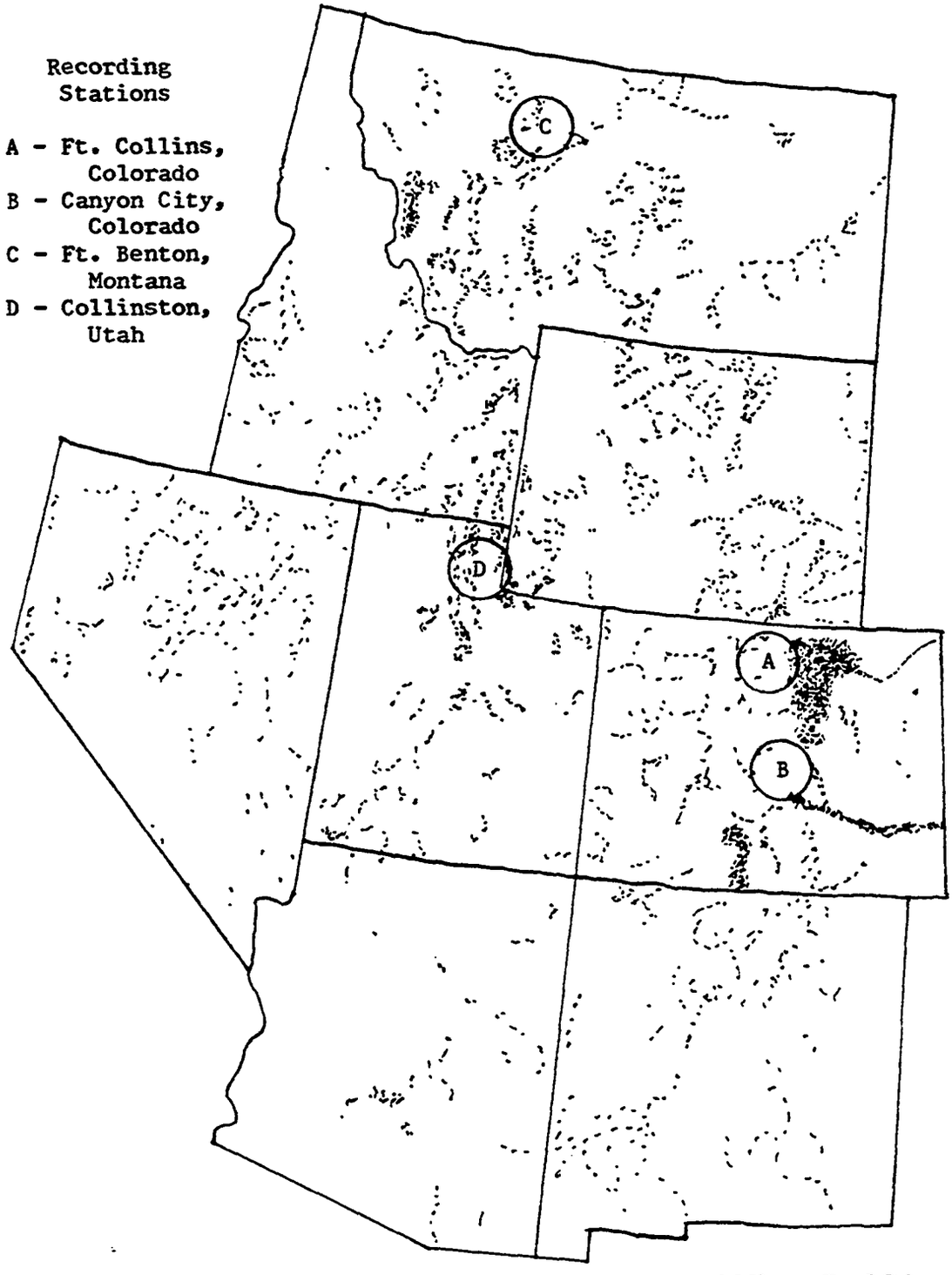
ing Office, 1959); Part 6-B: Missouri River Basin below Sioux City, Iowa, Water Supply Paper No. 1310 (Washington, D.C.: Government Printing Office, 1958); Part 9: Colorado River Basin, Water Supply Paper No. 1313 (Washington, D.C.: Government Printing Office, 1954); and Part 10: The Great Basin, Water Supply Paper No. 1314 (Washington, D.C.: Government Printing Office, 1960).

FIGURE 8: Irrigated Areas in 1899



Source: U.S. Department of the Interior, Census Office, Twelfth Census of the United States, 1900: Agriculture, Part II, Crops and Irrigation, p. 802.

of the Bear and Missouri rivers. For the entire arid West region, the streamflow index is the mean of the Colorado flow index and the Bear-Missouri flow index.

In addition to streamflow, crop values and crop value per acre data were collected for the seven state region for the six crops mentioned above from Department of Agriculture publications.[8] On theoretical grounds, the value of irrigated crops per acre is the preferred indicator of the value of water. Unfortunately, the only data available include both irrigated and non-irrigated crops. The problem is to choose which measure most closely resembles the variation of the value of irrigated crops per acre: the value of crops, or the value of crops per acre. Table 5 presents a comparison of the two measures with the value of irrigated crops per acre as reported by the census. The left-hand column shows the combined values of cereal grains, hay and forage, and vegetables per acre irrigated. According to calculations based on census reports, the value of irrigated crops per acre in Colorado increased from $11.25 in 1899 to $49.12

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[8] U.S., Department of Agriculture, Bureau of Statistics, Corn Crops of the United States, 1866-1906, Bulletin No. 56 (Washington, D.C.: Government Printing Office, 1907); Hay Crops of the United States, 1866-1906, Bulletin No. 63 (Washington, D.C.: Government Printing Office, 1908); Potato Crops of the United States, 1866-1906, Bulletin No. 58 (Washington, D.C.: Government Printing Office, 1908); Wheat Crops of the United States, 1866-1906, Bulletin No. 57 (Washington, D.C.: Government Printing Office, 1907); and Yearbook of Agriculture, volumes 1907 to 1922.

in 1919. We know that the measure that most closely resembles the variation in the value of irrigated crops per acre will be the best proxy. Percentage change calculations are supplied in order to allow comparison of the proportionate changes in the data. The evidence offers little clear cut basis for choosing between the two proxies. Between 1899 and 1909, for example, the proportionate change in crop value of 88 per cent is very close to the 83 percent change in the value of irrigated crops per acre. The percentage change in the value per acre estimate of 50 percent is much lower than for the census figure. Beyond 1909, the rate of growth of the census figures probably lies somewhere between the rates of growth of the two proxies. In the section that follows, equations are estimated using both estimates. The true significance of the value of irrigated crops per acre in explaining the variation in legal activity is likely to be between the two estimates. The association between the two independent variables and legal activity is illustrated in Table 6 and Figures 9 and 10 for Colorado.

TABLE 5

Comparison of Measures of Irrigated Crop Value in Colorado

	Census	Estimates	
	Irrigated Value/Acre	Value ($ x 1000)	Value/Acre
1899	$11.28	$20125	$14.46
1909	20.67	37747	21.71
(1899-1909)	(83)	(88)	(50)
1919	49.12	129187	38.34
(1909-1919)	(138)	(242)	(77)
(1899-1919)	(336)	(542)	(165)
	(% change)		

TABLE 6

Regression Data for Colorado

Year	Cases	Crop Value (x $1000)	Crop Value per Acre	Streamflow Index
1884	2	4015	$14.82	218
1885	1	4813	16.15	160
1886	1	4383	13.28	103
1887	2	5707	15.55	101
1888	4	8918	17.25	89
1889	2	11035	14.64	57
1890	3	11772	14.44	97
1891	4	14257	15.18	112
1892	8	15682	13.46	95
1893	12	11510	9.54	95
1894	5	18740	15.99	104
1895	13	16967	13.49	109
1896	13	15393	12.43	70
1897	8	17429	13.35	101
1898	9	17327	12.74	74
1899	7	20125	14.46	119
1900	13	22427	15.65	121
1901	9	25413	20.55	111
1902	10	20962	17.35	49
1903	6	24755	20.27	92
1904	6	20857	16.55	87
1905	12	27177	21.85	108
1906	16	27854	22.78	102
1907	14	33887	25.91	185
1908	14	30419	22.55	85
1909	10	37747	21.71	149
1910	16	35828	19.63	76
1911	7	33644	17.06	99
1912	12	38458	17.53	108
1913	11	42887	19.02	72
1914	13	45856	19.04	115
1915	13	44416	17.82	89
1916	10	65577	25.77	100
1917	12	101566	26.33	126
1918	8	98994	29.91	101
1919	12	129187	38.34	83
1920	6	98897	43.36	100
1921	9	58714	12.91	103

FIGURE 9

Water Rights Litigation and Streamflow in Colorado, 1888-1921

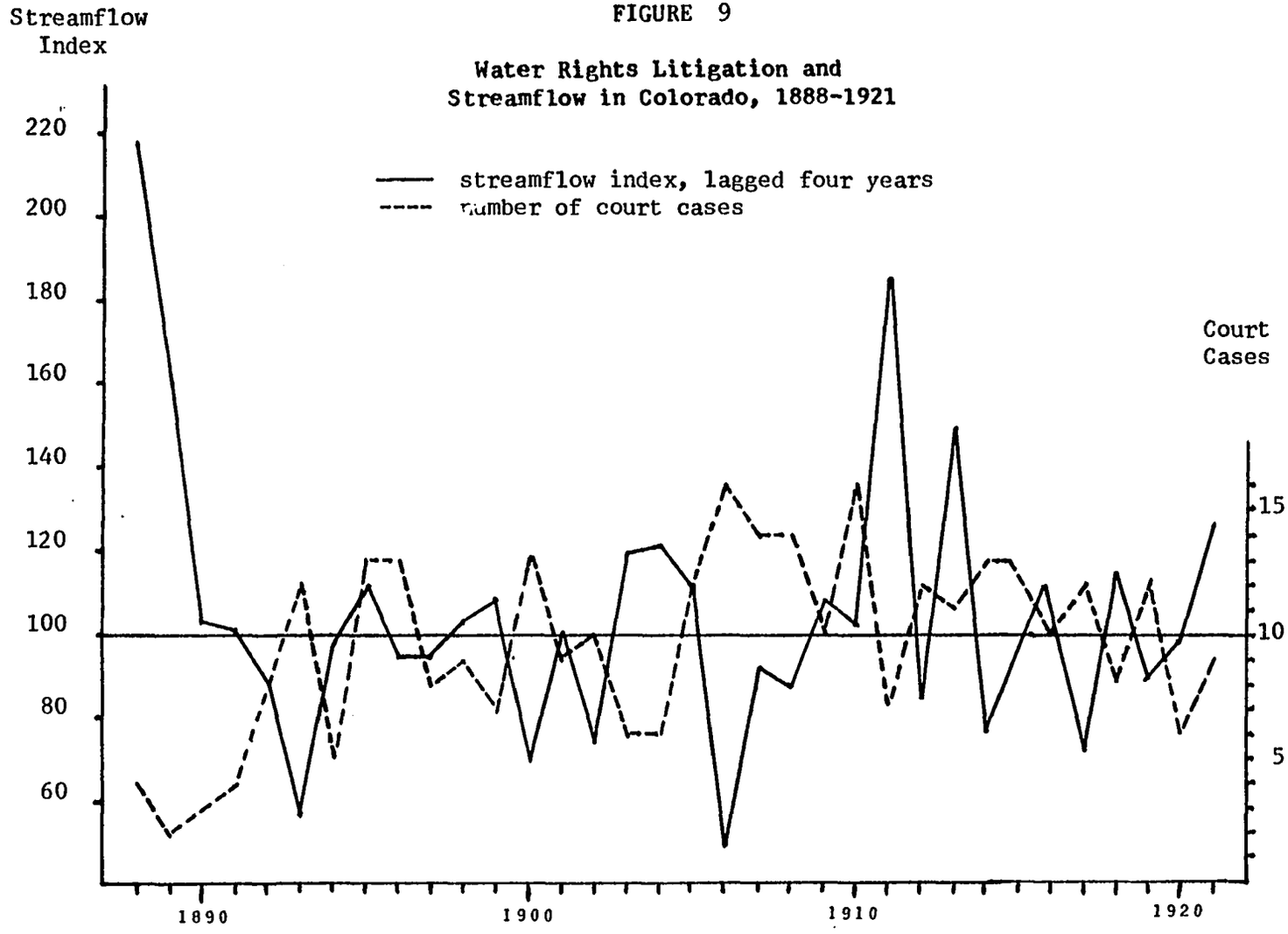
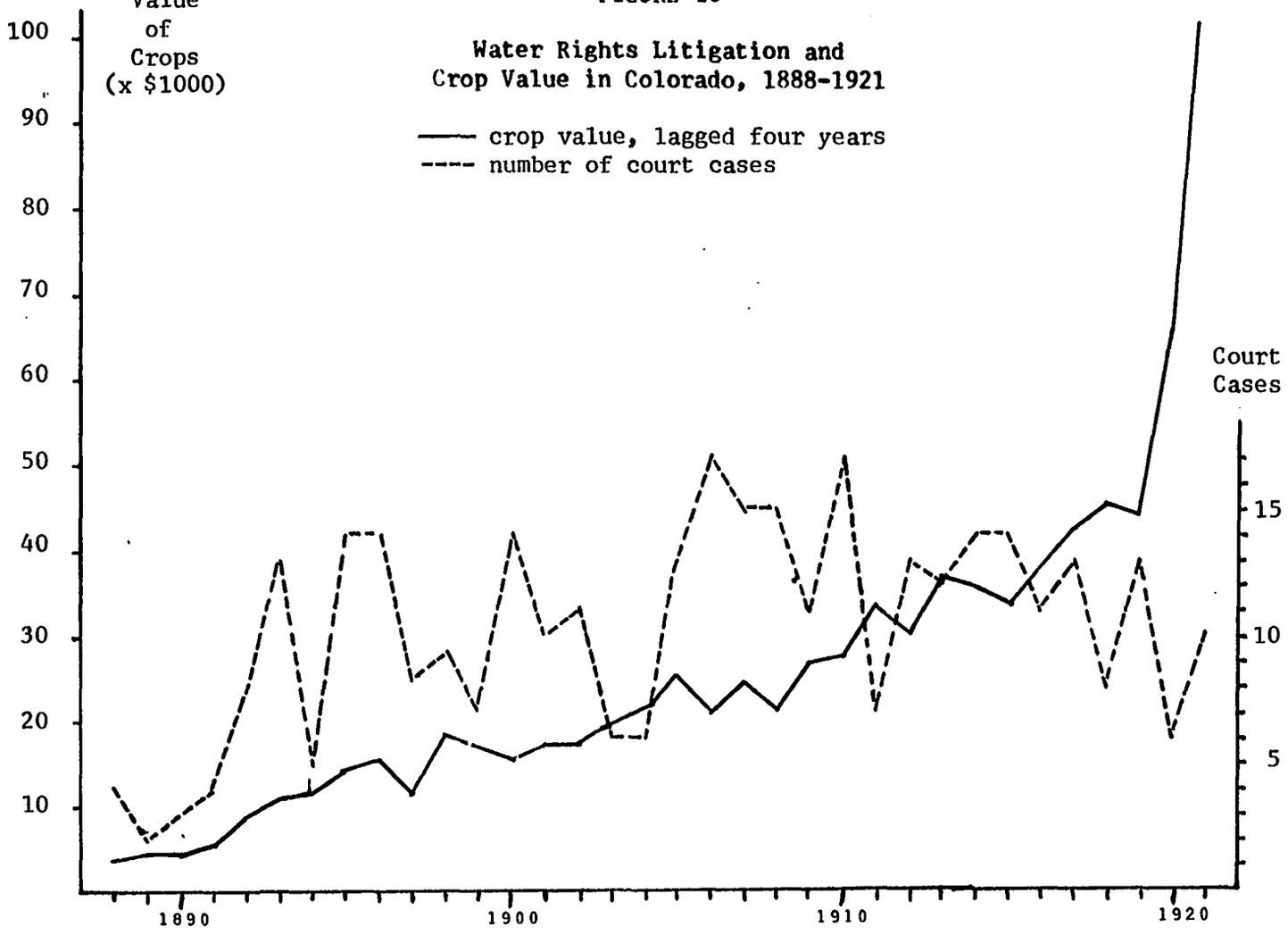


FIGURE 10

Water Rights Litigation and Crop Value in Colorado, 1888-1921



7.3 ESTIMATION OF EQUATIONS

This section performs formal tests of the principle hypotheses mentioned above. To restate, the theory examined the major economic factors that could cause an increase in the level of legal activity related to water rights: 1) the increasing value of water, as indicated by the increasing value of irrrigated crops per acre, and 2) physical scarcity of water, as measured by an index of streamflow. The value of the average product of water is hypothesized to be positively related to the level of legal activity, while streamflow is thought to be negatively related. Since the demand for water diversions is inversely related to precipitation, we may also hypothesize an inverse relationship between precipitation and the level of legal activity.

7.3.1 Colorado

Several different equations were estimated. Table 7 presents the results of some of the estimates for Colorado. Since legal activity takes much time to run the course from the moment of the original incident to the hearing of the case in court, we expect a lag before the effects of the independent variables are fully reflected in the level of litigation. After experimenting with several different lag

periods, the best fit resulted from a four year lag for crop value, crop value per acre, and streamflow. The dependent variable in all the equations is the number of court cases involving water rights in Colorado. The independent variables are the index of streamflow (FLOW(-4)) lagged four years, and average precipitation (PRECIP(-4)) also lagged four years. Equations one, two, and three were estimated using crop value lagged four years (CROP VALUE(-4)) as the proxy for the value of water, while eugations four through seven use crop value per acre (VAL/ACRE(-4)), lagged four years.

In equation one, the coefficient for crop value is positive and the coefficient for streamflow is negative, consistent with the hypotheses. The sign of the precipitation coefficient is positive, however. In addition, the t-ratios for both the crop value and precipitation coefficients are low: the associated p-values indicate that the null hypothesis cannot be rejected at the .05 level of significance.[9] The coefficient for streamflow is highly signi-

[9] The P-value indicates the level of significance that would be required to accept the null hypothesis that the coefficient equals zero. In other words, if the P-value is less than a given level of significance, then the null hypothesis must be rejected. The value shown is the total area of rejection. That is, the value is appropriate for a one-tailed test; for a two-tailed alternate hypothesis, the P-value must be halved. For a further discussion, see A. A. Afifi and S. P. Azen, Statistical Analysis: A Computer Oriented Approach, (New York: Academic Press, 1979), pp. 397-400.

TABLE 7

Estimated Equations for Colorado

Equation (years)	Dependent Variable	Independent Variable	Coefficient	t-ratio	P-value	R^2	F	DW
1 (1888-1921)	CASES	Constant	11.526	4.12	.0003	.402	6.7	1.06
		CROP VALUE(-4)	3.38×10^{-5}	1.24	.2238			
		FLOW(-4)	-.0659	-4.13	.0003			
		PRECIP(-4)	.3004	1.73	.0938			
2 (1888-1921)	CASES* $\hat{\rho} = .463$	Constant	10.111	3.64	.0011	.470	6.4	
		CROP VALUE(-4)*	3.5×10^{-5}	1.01	.3229			
		FLOW(-4)*	-.062	-4.45	.0001			
		PRECIP(-4)*	.368	2.52	.0176			
3 (1888-1921)	CASES	[1]Constant	14.967	4.53	.0001	.607	8.7	1.72
		[1]DUM	-7.614	-3.09	.0045			
		CROP VALUE(-4)	-3.73×10^{-5}	-.95	.3521			
		DUMxCROP VALUE(-4)	3.39×10^{-4}	3.83	.0007			
		FLOW(-4)	-.0501	-3.57	.0013			
		PRECIP(-4)	.1721	1.14	.2661			
4 (1888-1921)	CASES	Constant	8.924	2.90	.0069	.448	8.1	1.21
		VAL/ACRE(-4)	.2578	2.05	.0494			
		FLOW(-4)	-.0722	-4.62	.0001			
		PRECIP(-4)	.2743	1.64	.1119			

[1]DUM = 1 for the years 1888 to 1910 and DUM = 0 for the years 1911 to 1921

TABLE 7

Continued

Equation (years)	Dependent Variable	Independent Variable	Coefficient	t-ratio	P-value	R^2	F	DW
5 (1888-1921)	CASES* $\hat{\rho} = .381$	Constant	8.194	2.36	.0251	.470	6.4	
		VAL/ACRE(-4)*	.196	1.31	.2008			
		FLOW(-4)*	-.066	-4.58	.0001			
		PRECIP(-4)*	.359	2.41	.0222			
6 (1888-1921)	CASES	[1]Constant	20.113	2.86	.0079	.531	6.3	1.35
		[1]DUM	-12.525	-1.86	.0730			
		VAL/ACRE(-4)	-.2429	-.82	.4197			
		DUMxVAL/ACRE(-4)	.6911	2.06	.0492			
		FLOW(-4)	-.0744	-4.85	.0001			
		PRECIP(-4)	.1721	1.01	.3199			
7 (1888-1921)	CASES* $\hat{\rho} = .285$	[1]Constant	18.354	2.45	.0210	.519	5.8	
		[1]DUM	-11.388	-1.55	.1321			
		VAL/ACRE(-4)*	-.2311	-.73	.4726			
		DUMxVAL/ACRE(-4)*	.6202	1.70	.1008			
		FLOW(-4)*	-.0705	-4.74	.0001			
		PRECIP(-4)*	.2615	1.66	.1093			

[1]DUM = 1 for the years 1888 to 1913 and DUM = 0 for the years 1914 to 1921

ficant with a P-value of less than .0003.

As for the overall ability of equation 1 to explain variation in legal activity, the value of R-squared indicates that the independent variables account for approximately 40 percent of the variation in the number of cases. The F statistic value of 6.7 allows the rejection of the null hypothesis of no linear relationship at the 99.5th percentile. The DW statistic, however, indicates the presence of positive serial cor relation, since it is less than the critical value of 1.21 at the 5% level of significance. The existence of positve serial correlation results in estimates of R-squared and the t-ratios that over-estimate the statistical significance.

The SAS AUTOREG procedure was used to estimate equation one, corrected for serial correlation. The results are shown in equation 2. Similar to other methods of correcting serial correlation, the SAS routine transforms the variables into weighted first-difference equations, where the weight is an estimate of first order auto-correlation indicated Table 7 as . In the absence of other statistical problems, the correction results in lower t-ratios and a lower R-squared. In equation 2, t-ratios for the constant term and CROP VALUE(-4) terms are lower, but the other two coefficients show higher t-ratios. The coefficient of determination is also higher. Significantly, the estimated coerfi-

cient and t-ratio for the PRECIP(-4) variable is much higher. The instability of the PRECIP(-4) coefficient suggests the presence of multicollinearity between PRECIP(-4) and the other independent variables, thus making interpretation of the PRECIP(-4) coefficient difficult.

A review of the crop value data in Figure 10 suggests a break in the relationship between crop value and court cases in the period 1911 to 1914. Before 1911, crop value and court cases exhibit a reasonable positive relationship. But after 1914, the relationship disappears, or perhaps even becomes negative. The streamflow data shows no similar break. Equation 3 introduces dummy variables to account for the changing relationship between crop value and litigation. The dummy is set equal to one for the period 1888 - 1910 and set equal to zero for the period 1911-1921, inclusive. The results in equation 3 show that the dummy variables for the intercept term and the crop value term are significant at the .05 level. The equation offers a much better overall fit--R-squared equals .607--and the DW statistic indicates that the hypothesis of no auto-correlation cannot be rejected at the 1% level.

In Table 8, model estimates based on equation 3 are given as equations 3a and 3b. Equation 3a represents the model in the period 1888-1910 in which the dummy was set equal to one. Of course, the intercept term in 3a is the

sum of the 'Constant' and 'DUM' terms in equation three, and the CROP VALUE coefficient is the sum of CROP VALUE(-4) and DUM*CROP VALUE(-4). The streamflow and precipitation variables are unchanged. Since the dummy variable was set equal to zero for the period 1911-1921, the intercept and CROP VALUE coefficients are identical with the estimates in equation 3.

From equations 3a and 3b it is clear that crop value is important in explaining the variation in litigation; the t-ratio for the coefficient is significant at the .0005 level.[10] The significance of crop value diminishes in the subsequent period, however. The t-ratio of -.95 is not significantly different from zero at the .1 level. The intercept term also changes significantly from the earlier period.

The significance of the DUM and DUMxCROP VALUE(-4) coefficients indicates that a very definite change took place in the relationship between crop value and water rights litigation, beginning in approximately 1911.[11] Crop value is significant in explaining litigation before 1911,

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[10] The standard error of the coefficient was calculated from the variance-covariance matrix.

[11] The test of the hypothesis that DUM = 0 is equivalent to a test of the hypothesis that the intercept has not changed from the period 1888-1910 to the period 1911-1921, or that Constant + DUM = Constant. A similar result holds for the slope coefficent.

TABLE 8

Model Estimates for Colorado

Equation Number	Period	Equation
3a	1888-1910	CASES = 7.352 + 3.02×10^{-4} CROP VALUE(-4) (2.75) (3.88) − .0501 FLOW(-4) + .1721 PRECIP(-4) (-3.57) (1.14)
3b	1911-1921	CASES = 14.967 − 3.73×10^{-5} CROP VALUE(-4) (4.53) (-.95) − .0501 FLOW(-4) + .1721 PRECIP(-4) (-3.57) (1.14)
7a	1888-1913	CASES = 6.966 + .3891 VAL/ACRE(-4) (2.07) (2.24) − .0705 FLOW(-4) + .2615 PRECIP(-4) (-4.74) (1.66)
7b	1914-1921	CASES = 18.35 − .2311 VAL/ACRE(-4) (2.45) (-.73) − .0705 FLOW(-4) + .2615 PRECIP(-4) (-4.74) (1.66)

NOTE: t-statistics in parentheses

Models:

3a CASES = $(\alpha_1+\alpha_2)$ + $(\beta_1+\beta_2)$ CROP VALUE(-4) β_3FLOW(-4) + β_4PRECIP(-4)

3b CASES = α_1 + β_1CROP VALUE(-4) − β_3FLOW(-4) + β_4PRECIP(-4)

7a CASES = $(\alpha_1+\alpha_2)$ + $(\beta_1+\beta_2)$ VAL/ACRE(-4) − β_3FLOW(-4) + β_4PRECIP(-4)

7b CASES = α_1 + β_1 VAL/ACRE(-4) − β_3FLOW(-4) + β_4PRECIP(-4)

but not after. Streamflow, however, is an important determinant of litigation throughout the period.

Estimates using crop value per acre as the proxy for the value of water are given in equations 4 through 7 of Table 7. The signs of the coefficients for crop value per acre and streamflow in equation 3 are positive and negative, respectively. All but the precipitation coefficient are significant at the .05 level. The estimate as a whole explains approximately 45 percent of the variation in water rights litigation, but this figure is probably inflated by serial correlation since the DW statistic is less than the critical value of 1.27 at the 5% level of significance. Equation 5 was estimated using the procedure for correcting serial correlation mentioned earlier. Once again, the PRECIP(-4) coefficient increases, suggesting multicollinearity.

A dummy variable procedure was used in equation 6, except that a better overall fit was obtained with the break point located at 1913. The overall fit of the equation is somewhat improved from equation 4, but the DW statistic lies in the indeterminate range. Equation 7 was estimated to correct for possible positive serial correlation. Model estimates based on equation 7 for the periods 1888-1913 and 1914-1921 are shown as equations 7a and 7b of Table 8. As with the earlier equations, both intercept and crop value

per acre terms are quite different from one period to the next: the crop value per acre coefficient is significant in the early period, but not significantly different from zero in the latter period. Referring to the DUM and DUMxVAL/ACRE(-4) coefficients in equation 7, th e evidence of a shift in the relationship between litigation and the independent variables is less conclusive than in equation 3. The null hypothesis of no change in the relationship can be rejected, but with a level of significance of only 85%. As in equation 3, the streamflow coefficient is negative and highly significant.

To summarize this section, a model of water rights litigation in Colorado was constructed for the period 1888 to 1921. First, the level of water rights litigation appears to be responsive to streamflow and the value of water, as measured by the proxies crop value and crop value per acre: approximately 50 to 55% of the variation in the dependent variable is explained. The significance of precipitation was muddled due to multicollinearity. Secondly, the relationship between the value of water proxies and the number of cases significantly changed during the period; the variable ceased to be an important after approximately 1912. This result suggests the occurrence of some sort of structural or institutional change that altered the water value/litigation relationship. Some speculation concerning the

nature of this stimulus is offered at the conclusion of this chapter.

7.3.2 Arid West

A similar set of estimations were derived for the region of the arid West.[12] Data collected for the region are presented in Table 9 and equation estimates are shown in Table 10. In all of the equations, the best fit was obtained with a lag of only two years, compared with the four year lag used in the Colorado estimates. This result implies that the legal process appears to have been less time consuming in the region than it was in Colorado.

Another interesting difference from the Colorado estimates is that the fit of the 'standard' equations one and four is poor: only about 20% of the variation in litigation is explained. Also, the coefficients of the proxies for the value of water--crop value and crop value per acre--are significant, but the streamflow coefficients are not.[13] The DW statistic in equations 1 and 4 indicate that the hypothesis of no serial correlation must be rejected at the 1% level.

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[12] This region is defined to include all the states that rely primarily on the system of prior appropriations. States included are Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming.

[13] Since data for the Bear river and Missouri river recording stations did not begin until 1891, the streamflow data for the period 1884 to 1890 were treated as missing observations and set equal to the mean streamflow.

TABLE 9

Regression Data for the Arid West

Year	Cases	Crop Value (x $1000)	Crop Value per Acre	Streamflow Index
1884	4	20821	$13.74	100
1885	3	21319	13.09	100
1886	3	21496	13.15	100
1887	4	26808	13.64	100
1888	10	29085	13.31	100
1889	4	33212	13.02	100
1890	7	35459	13.36	100
1891	19	35657	12.56	103
1892	16	34139	12.06	103
1893	13	34099	11.68	98
1894	12	44650	15.28	119
1895	23	39656	13.45	98
1896	24	38406	13.04	85
1897	19	45473	13.96	103
1898	30	46774	14.40	91
1899	17	48943	13.81	121
1900	30	57124	15.66	105
1901	21	71040	18.88	95
1902	19	68207	17.78	60
1903	19	80078	20.44	84
1904	27	79422	19.57	92
1905	34	85519	20.33	82
1906	24	92702	17.90	87
1907	20	105545	22.22	157
1908	33	112897	21.87	105
1909	26	140633	22.88	139
1910	27	148727	22.11	87
1911	29	166451	22.51	93
1912	41	160719	19.16	107
1913	30	173294	20.02	94
1914	36	191675	20.68	109
1915	28	209877	20.06	92
1916	24	310613	29.10	110
1917	28	394206	35.24	128
1918	22	468782	36.79	94
1919	28	406936	28.57	71
1920	22	356603	24.32	93
1921	36	237139	15.76	99

TABLE 10

Estimated Equations for the Arid West

Equation (years)	Dependent Variable	Independent Variable	Coefficient	t-ratio	P-value	R^2	F	DW
1 (1886-1921)	CASES	Constant	25.564	2.98	.0053	.219	4.6	.84
		CROP VALUE(-2)	3.6×10^{-5}	2.92	.0062			
		FLOW(-2)	-.0733	-.88	.3845			
2 (1886-1921)	CASES*	Constant	28.806	4.03	.0003	.142	1.8	
		CROP VALUE(-2)*	3.08×10^{-5}	1.62	.1145			
	$\hat{\rho} = .527$	FLOW(-2)*	-.1034	-1.63	.1132			
3 (1886-1921)	CASES	[1]Constant	44.943	5.79	.0001	.618	12.6	1.54
		[1]DUM	-27.638	-5.54	.0001			
		CROP VALUE(-2)	-1.67×10^{-5}	-1.08	.2878			
		DUMxCROP VALUE(-2)	2.76×10^{-4}	5.02	.0001			
		FLOW(-2)	-.1141	-1.88	.0692			
4 (1886-1921)	CASES	Constant	18.206	2.05	.0485	.264	5.9	.99
		VAL/ACRE(-2)	.753	3.33	.0022			
		FLOW(-2)	-.097	-1.20	.2392			
5 (1886-1921)	CASES*	Constant	24.247	2.88	.0071	.141	1.8	
		VAL/ACRE(-2)*	.538	1.72	.0953			
	$\hat{\rho} = .447$	FLOW(-2)*	-.1206	-1.78	.0845			

[1]DUM = 1 for the years 1886 to 1909 and DUM = 0 for the years 1910 to 1921

TABLE 10

Continued

Equation (years)	Dependent Variable	Independent Variable	Coefficient	t-ratio	P-value	R^2	F	DW
6 (1886-1921)	CASES	[1]Constant	47.059	4.15	.0002	.485	7.3	1.26
		[1]DUM	-42.015	-3.54	.0013			
		VAL/ACRE(-2)	-.313	-.86	.3881			
		DUMxVAL/ACRE(-2)	1.857	3.07	.0044			
		FLOW(-2)	-.098	-1.40	.1731			
7 (1886-1921)	CASES* $\hat{\rho} = .305$	[1]Constant	49.512	4.06	.0003	.368	3.5	
		[1]DUM	-41.252	-2.82	.0084			
		VAL/ACRE(-2)*	-.356	-.83	.0218			
		DUMxVAL/ACRE(-2)*	1.784	2.42	.4117			
		FLOW(-2)*	.113	-1.67	.1017			

[1]DUM = 1 for the years 1886 to 1909 and DUM = 0 for the years 1910 to 1921

The significance of DW in equation 6 is indeterminate. Equations 2, 5, and 7 are adjusted for serial correlation.

Equations 3 and 7 indicate that a much better fit is obtained by allowing for a structural shift in the intercept and in the crop value per acre variable. The dummy intercept and the dummy crop value per acre variable are significant at the .005 level, allowing a rejection of the hypothesis of no change in the slope and intercept terms. The resulting model estimates are shown in Table 11: equations 3a and 7a estimate the period 1886-1909, while equations 3b and 7b examine the period 1910-1921. Once again, the intercept term increases greatly, while the proxy for water value reduces to a level not significantly different from zero in the 1910-1921 period.

TABLE 11

Model Estimates for the Arid West

Equation Number	Period	Equation
3a	1886-1909	$CASES = 17.305 + 2.593\times10^{-4}$ CROP VALUE(-2) (2.62) (4.92) $- .1141$ FLOW(-2) (-1.88)
3b	1910-1921	$CASES = 44.94 - 1.67\times10^{-5}$ CROP VALUE(-2) (5.79) (-1.08) $- .1141$ FLOW(-2) (-1.88)
7a	1886-1909	$CASES = 8.26 + 1.428$ VAL/ACRE(-2) (.79) (2.39) $- .1129$ FLOW(-2) (-1.67)
7b	1910-1921	$CASES = 49.512 - .356$ VAL/ACRE(-2) (4.06) (-.83) $- .1129$ FLOW(-2) (-1.67)

NOTE: t-statistics in parentheses

Models:

3a $CASES = (\alpha_1+\alpha_2) + (\beta_1+\beta_2)$ CROP VALUE(-2) $- \beta_3$FLOW(-2)
3b $CASES = \alpha_1 + \beta_1$CROP VALUE(-2) $- \beta_3$ FLOW(-2)
7a $CASES = (\alpha_1+\alpha_2) + (\beta_1+\beta_2)$ VAL/ACRE(-2) $- \beta_3$FLOW(-2)
7b $CASES = \alpha_1 + \beta_1$ VAL/ACRE(-2) $- \beta_3$ FLOW(-2)

7.3.3 The Decline of Water Rights Litigation

Though the reasons for the decline in litigation in the post-1910 period are not well-established, there is some evidence that the decrease in legal activity was linked to the relationship between the irrigator and the canal corporation. It appears that the dependence of irrigators on the canal corporations during this period was reduced, thus resulting in fewer causes for litigation. The factors that reduced the dependence of irrigators on canal corporations include an increase in the availability of stored water supplies through construction of reservoirs, and the 'mutualization of canal corporations.[14] The effect of the first factor is obvious: since the supply of water for irrigation is increased by storage in reservoirs, there is less incentive for the protection of the rights to water.

The second factor refers to a provision in many water rights contracts that required the transfer of the corporate stock to the irrigators served by the canal once water rights equal to the capacity of the canal were sold. For example, article IX of a published water contract states:

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[14] Fox, "Regulation of Canal Corporation," p. 177. Fox also includes an increase in farm prices as a mitigating factor, but gives no explanation.

> The said company agrees that when it shall have sold and have outstanding and in force a number of water rights equal to the estimated capacity of the company's canal. . . it will transfer to the holder of each water right. . . such a proportion of the number of shares of the capital stock of the said. . . company as the number of water rights held by the irrigator bears to the whole number of water rights held or outstanding in the canal of the company.[15]

7.4 CONCLUSION

The principle hypotheses of the study regarding the relationship of the value of water and the quantity of streamflow to the level of water rights litigation were tested in this chapter. Measures of streamflow and the value of water were developed from the data, and a model of water rights litigation was constructed. Model coefficients for the variables streamflow and the proxies for the value of water were generally highly significant. Precipitation was not a significant explanatory variable in the Colorado model. Overall, the explanatory variables accounted for 50 to 55% of the variation in the number of court cases regarding water rights in both Colorado and in the arid West.

The relationship between water rights litigation and the proxies for the value of water appears to be strong up until the period 1910-1913, after which the relationship dissipates. The decline in litigation post-1910 is probably

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[15] U.S. Congress, Senate, Report of the Special Committee, p. 331.

due to the increased availability of water for irrigation through storage and the mutualization of the canal corporation.

Chapter VIII

SUMMARY AND CONCLUSIONS

This study has examined the economic and ideological factors involved in the development of rights to water in the West, particularly in Colorado. The method of the investigation relied on three elements: theoretical, historical, and quantitative. The problem of the evolution of property rights in natural resources is important, for an improved understanding of the past is essential for understanding current problems and predicting future conflicts over resource use.

The theoretical portion of the study provided a discussion of the effects of differing property rights structures on the allocation of resources, and how resource users may be motivated to change the property rights structure. In this section, property rights were seen as the socially sanctioned rules that govern the use of resources. The operation of market systems depends fundamentally on the existence of exclusively defined, or private, property rights. Neoclassical economics has begun to recognize the importance of property rights as the basis of an economic system. Much ink has been spilled regarding the relative

erficiency of private property and common property resources.

But much of the literature has regarded the form of property rights as a given. In these models, economic actors maximize utility or profit with the form of property rights already determined for them. That is, the form of property right was not usually considered an endogenous variable in the model. But property rights do not fall from the sky; they evolve in response to changing material and economic circumstances. According to the literature surveyed in Chapter II, factors such as technological change and the development of new markets generate incentives for the specification of a more exclusive form of property rights in resources. Changes in economic conditions may increase the value of the resource for which no property right had previously been established. Without the specification of some level of exclusive property rights, it is well-known that rents attributable to the resource will be dissipated, resulting in inefficient resource allocation. These rents can only be captured by establishing some form of resource ownership, thereby excluding other users from access to the resource.

The level of exclusivity of a property right depends, however, not only on the profits to be captured but also on the cost of defining and enforcing greater exclusion. In

fact, the persistence of free-access to a valuable resource may be due to the high costs of establishing property rights. These costs vary, depending partly on the physical nature of the resource and partly on the means of exclusion. Resource claimants will choose to implement the level of exclusivity that minimizes total costs for a given level of revenue. It may well be that the cost of the least exclusive form of property rights specification may be too large, meaning that any effort expended in defining the rights to the resource will lower net revenue. Thus, access to the resource may remain unrestricted for extended periods of time.

The model of water rights evolution constructed above generated two principle hypotheses. Water rights defining and enforcing activity will increase when: 1) the derived demand for water increases, and 2) when streamflow is low. Parametric changes in the water supply and demand schedules will generate incentives for increasing the level of exclusivity. An increase in the price or the marginal product of water--or both--will shift up the revenue schedule; the resource becomes more valuable and more effort will be placed in maintaining control of the resource, particularly in terms of the more careful specification and enforcement of rights to the resource. Also, the supply of water diversions, or streamflow, is subject to stochastic variations.

Lower streamflows result in a lower equilibrium level of water diversion. The problem of who will suffer a loss of flow and who does not creates conflict over the right to the resource, especially in periods when water is physically more scarce.

The second portion of the study reviewed the historical record of water rights development in Colorado. The evidence revealed that water rights evolved from relatively general, unspecified froms to more complex and delineated specifications. The greatest change in water rights appears to have occurred during periods in which the demand for water increased and also during periods characterized by low streamflow. The development of water rights in Colorado was divided into three periods: 1) the gold-mining period, 2) the period of individual and cooperative irrigation efforts, and 3) the coroporate canal period. In the earliest period, water rights evolved along with the rights to gold-mining claims. The doctrines of 'first in right' and 'use or lose' orginally were developed in the gold mining districts. The first in time aspect had the effect of rewarding the earliest miners for the risks incurred in discovering important gold-producing lands. Without such safeguards against encroachment by later prospectors, the mining economy would have developed at a much slower pace.

Early agricultural enterprises in Colorado grew in response to increasing markets in the mining camps. Concerned with the absence of recognized title to land and to water, the early irrigators organized local governments. Statutes governing the use of water were among the first laws adopted by the provisional and territorial legislatures. Most other subjects concerning the right to water were, however, left undecided in this early period.

The next period of water rights development was characterized by the growth of irrigation through the development of cooperative irrigation companies. Since many of the lands easily irrigated had been claimed, further development required greater capital investment. This was achieved through cooperative enterprises such as the Union Colony in Greeley.

The combination of greater demand for water and a period of low streamflow in the early 1870's created conflicts between irrigation organizations and led to changes in water law. In 1872, for example, the Colorado Supreme Court issued the opinion that firmly established the system of prior rights in Colorado. Other court cases in this period provided the initial rules of the game regarding transfers of water rights, the status of the canal corporation, and the right to store water for use in later time periods. Also, the constitional convention resulted in rules that

among other things outlined the system of priority and established a means of setting water delivery rates.

The third period in the development of Colorado water rights surveyed in this study begins with the emergence of the corporate canal. As discussed above, much like the transition from early irrigation to the period of the cooperative canals, the great corporate canals grew in response to the need for ever greater capital investments in order to provide water to lands farther removed from the rivers and streams. Both types of enterprise were privately owned and operated; the real difference between the two was that the owners and users of the water were one in the same with the cooperative or mutual canals, while in the corporate canals irrigators were the water users but ownership resided with Eastern or foreign capitalists. The divorce of use and ownership found in the corporate canals may have contributed to the increase in water rights litigation that occurred in the late 1890's and continued into the 1900's. Legal conflicts focused on the status of the canal corporation, the equity of water delivery charges, and the definition of the right to water. One result of this litigation was that water rights were defined in terms of the furnishing capacity of the ditch or canal. Also, the courts ruled that the payment of fees above the legal charge for water deliveries was unlawful.

Many other developments regarding the specification of water rights occurred in the period 1890-1920. Legislation required more careful measurement of water diversions and gave more power to water commissioners. In addition, laws were passed regulating the transfer of water rights and allowing intra-ditch water loans. Much litigation during this period involved water rights transfers, appurtenance, and rights to new sources of water such as seepage and ground water.

The third portion of the study estimated a model of water rights evolution. The discussion in Chapter VII provided evidence of a statistical association between the demand for water diversions, the supply of water, and the level of water rights litigation. The estimated equations confirmed the principle hypotheses: 1) streamflow or the supply of water diversions is negatively related to the level of legal activity, and 2) the demand for water, as indicated by proxy measures, is positively related to the level of water rights litigation. These variables accounted for at least half of the variation in the level of water rights litigation. The streamflow variable appeared to be statistically significant throughout the period 1884-1921; the crop value and crop value per acre variables, however, were not statistically significant after approximately 1911. The decline in the importance of the demand for water on

litigation was probably due to the increased mutualization of corporate canals and the increase in the effective supply of water for irrigation by the construction of storage reservoirs.

The quantitative evidence and much of the historical evidence support the proposition that water rights institutions tend to evolve in response to changing economic incentives. Some developments, however, appear to be uneconomic, or inefficient, to contemporary scholars. Restrictions of water rights transfers and the regulation of the corporate canal, for example, have been roundly criticized in recent studies largely because they result in a greater degree of public control over the allocation of water.[1] But greater public control may be justified when negative externalities are generated in the transfer of water rights, or when mon-

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[1] For example, Alston claims that the

> potential development of water monopoly led the early enthusiasts to disregard economic principles in their unyielding attempt to prevent such an occurrence.

Alston, Commercial Irrigation Enterprise, p. 146. Also, Terry Anderson argues that

> the fear of monopoly. . .has little empirical basis. . . many of those companies were not financially profitable, suggesting that their so-called monopoly power was not all that great.

Terry L. Anderson, Water Crisis: Ending the Policy Drought, (Baltimore: Johns Hopkins Press for the Cato Institute, 1983), p. 39.

opolistic water companies control local water supplies. So-called irrational behavior based on ideology may well have emerged as a social response to monopolistic control of water by the canal corporations and to externalities generated by the transfer of less than exclusive rights to water.

To conclude, this study primarily addresses two weaknesses in the literature regarding the development of rights to natural resources. First, most studies present only one or two aspects of the evolution of property rights. This study examines the development of the rights to water through three perspectives: theoretical, historical, and quantitative. Second, many studies make ex post judgments regarding the efficiency of water rights without having examined the actual historical constraints on the definition of more exclusive rights to water. The benefits of increasing exclusivity, for example, may well have exceeded the costs at a particular point in time. In addition, the possibility that irrigators--due to potential or perceived market power or perhaps to ideological considerations--may actually prefer a seemingly inefficient set of rules governing water use is not widely recognized in the literature.

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