Water Allocation Under Stress: Institutional Comparison of the Snake and Klamath Rivers

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Abstract

A key question in climate change research is the extent to which socioeconomic systems may be either resistant to climate change or able to adapt to its effects. Institutional development on the Snake and Klamath Rivers in Idaho and Oregon is examined in the context of stresses placed on water allocation and management by drought, growth, and social policy change. Of key concern is the ability of existing institutions to re-allocate water between users and uses under stress. The case studies are then used in a theoretical examination of elements required for a successful water marketing, or re-allocation structure.

Key Terms

Climate Change
Economics
Irrigation
Institutional Adaptation
Water Law
Water Policy/Regulation/Decision Making

Introduction

A fundamental issue in climate change is the adaptive capacity of human systems. Housing, transportation, recreation, and land use are all heavily influenced by climate, and entail sizeable infrastructure costs. Shifting from an infrastructure optimized for one climate to one optimized for another could entail significant, potentially prohibitive, cost. A key question in climate change research is thus the extent to which socioeconomic systems may be either resistant to climate change or able to adapt to its effects.

These questions arise in many arenas, but particularly in the utilization of natural resources. Within the resource category, water availability and use is key to the economic structure of many regions, perhaps nowhere more so than the Western United States. This study examines two large water resource systems, the Snake River in Idaho and the Klamath River in Oregon and Northern California. In each system the primary water use over the past century has been irrigated agriculture, now under pressure from climate variability, changing social policy, and new uses. The two systems are compared in terms of their respective institutional development and their responses to climate, demand, and policy-induced stress. The measurement criterion is the ability of existing institutions, when stressed, to re-allocate water from lower to higher value uses, and to distribute the costs of the any externality in a way that minimizes those costs.

Central to both river systems is the Bureau of Reclamation (BoR), and its water storage programs authorized under the Reclamation Act of 1902. The Klamath Project is a single, centrally administered BoR project, begun in 1904; the Snake is home to several inter-related BoR projects, and to private development prior to, and contemporaneous with, BoR storage construction.

Stresses are defined as external to the systems under study. The study finds that the two systems differ considerably in their adaptability to stress, particularly that stemming from climate variability, in conjunction with changing social policy. In 2001, under pressure from changing social policy and allocation decisions to protect fish, BoR withheld water delivery to farmers in the Klamath Project, resulting in large scale farming losses and significant political controversy. On the Snake, similar, though perhaps not as relatively momentous stresses over the past century have yielded a continuing series of institutional innovations, including emerging water markets. This paper examines the reasons for this difference in outcomes between the two systems and the import of that difference for developing water markets or other mechanisms to facilitate movement of water between uses and users.

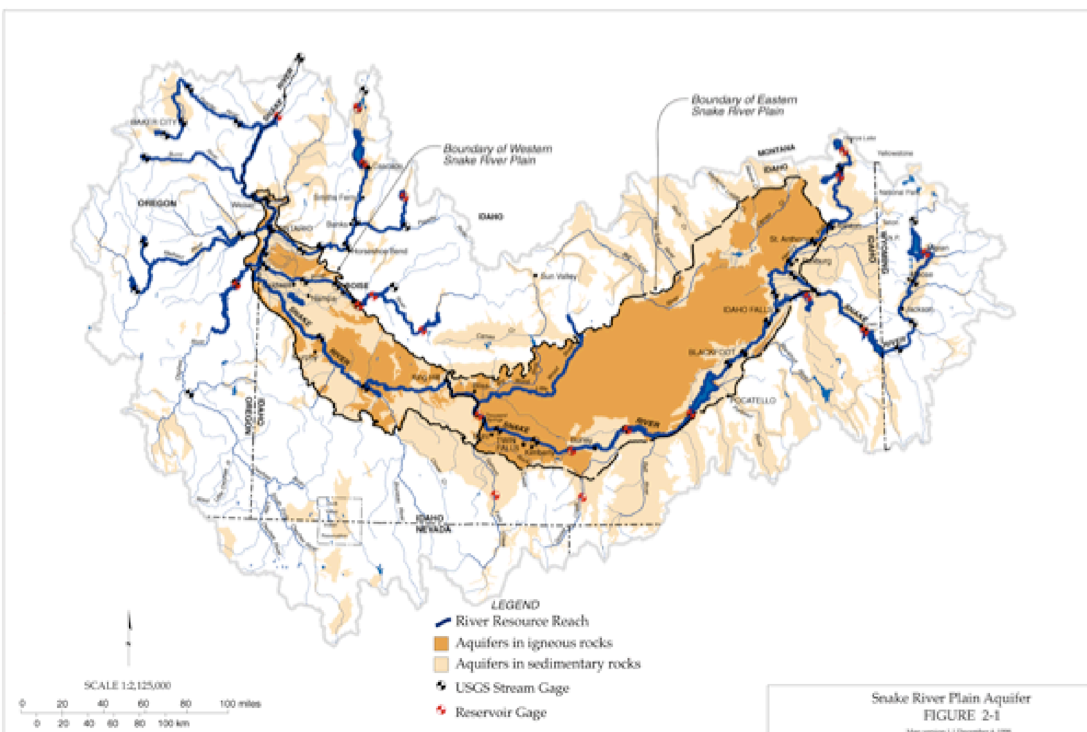
Following the case study, the paper sets up a conceptual model to examine the qualities of an adaptive system, centered on the nature of the contract involved. It hypothesizes that the primary explanatory variable in the two histories is their institutional structure: the matrix of constraints and incentives facing individual stakeholders and users of the two systems. It then further examines the possible bases of resource contracts, for the purpose of suggesting the likely characteristics of successful water marketing arrangements.

Physical Presence: Snake River

The Snake River rises in western Wyoming: a northern fork in Yellowstone National Park, and a southern fork in Grand Teton National Park. The river then flows into southern Idaho and crosses the state from east to west before flowing north along the Idaho-Oregon border and thence westward into Washington State where it meets the Columbia. Tributaries rise in Wyoming, Idaho, Oregon, and Washington. With the exception of the Bear Lake basin in far southeastern Idaho and portions of northern Idaho that drain into the Spokane River before reaching the Columbia, virtually the entire state is drained by the Snake River.

The first BoR dam built on the Snake is in Grand Teton Park, in Wyoming: the Jackson Lake dam, built in 1911 and raised in 1916. Further dams were built for irrigation storage through 1956, when Palisades dam, in southeastern Idaho, was completed. One other dam, the Teton Dam on a tributary of the Henry's (north) fork, was built in the mid 1970s, but failed as it was being filled for the first time.

Figure 1. Upper and Middle Snake



Source: Bureau of Reclamation, 1999

Three sub-basins can be distinguished on the Snake. First, the reach across southern Idaho, which contains the Minidoka and Palisades projects, supports the majority of irrigated agriculture in Idaho, and interacts with the Eastern Snake River Aquifer (ESRA, Figure 1). Second, the Boise and Payette rivers are home to the Boise Project, several dams built for irrigation and flood control purposes. The Western Snake River Aquifer underlies this area. Finally, tributaries flowing through southeast Oregon support the Owyhee Project, on the Idaho-Oregon border. The Owyhee project is a single, centrally administered, integrated BoR project.

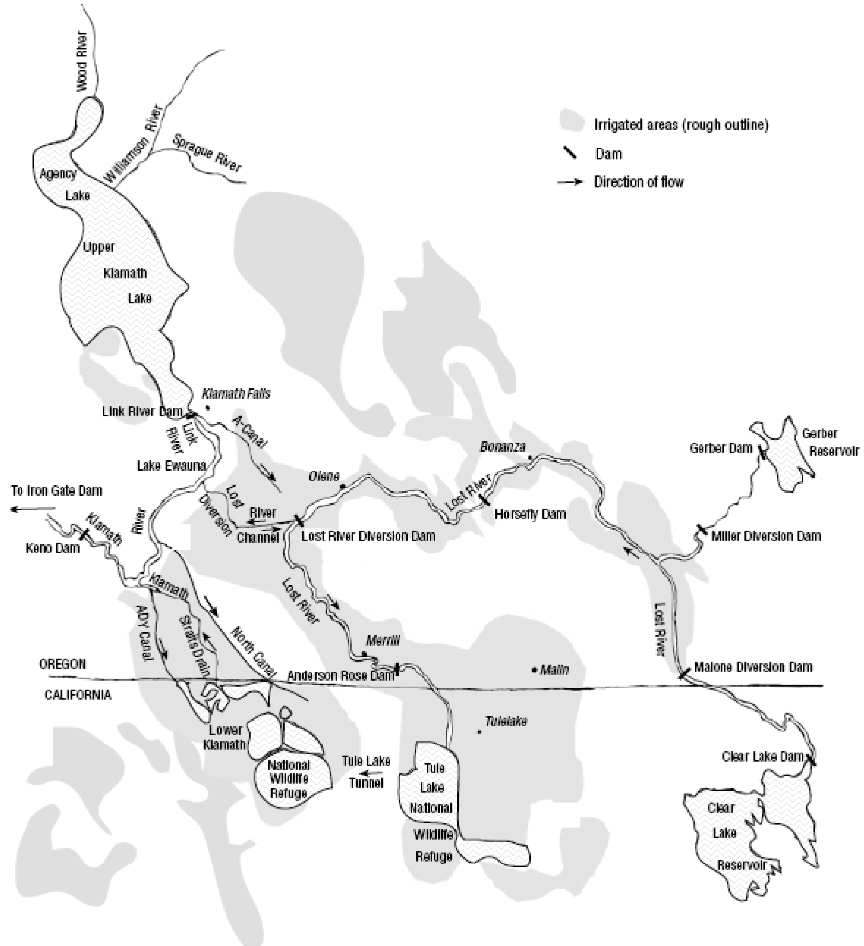
This analysis deals primarily with development on the Eastern Snake River Aquifer (ERSA).

Physical Presence: Klamath Basin

The Klamath River originates in Upper Klamath Lake in southwestern Oregon, fed by rivers from mountains east of the Cascades, and generally south of Crater Lake. The basin is located in SW Oregon and in northern California. The Klamath Project consists of irrigated lands, wildlife refuges, reservoirs, pumping stations, and diversions, all under the administration of the Bureau of Reclamation. The overall basin contains 500,000 acres of irrigated land, of which 240,000 are inside the Project (Figure 2).

Upper Klamath Lake is a large but shallow reservoir, with a surface area ranging from 60,000 to 90,000 acres; the historic high is estimated to have been 105,000 acres (Braunworth, et al., p. 47). The BoR estimate is 77,593 acres at an elevation of 4143 feet, and 44,200 acres at an elevation of 4136 feet (dead pool). The average depth during the summer is only 7.0 feet.

Figure 2. Klamath Reclamation Project



Source: Braunworth, et al., p. 36.

Physical comparisons

Tables 1 - 3 show metrics of the Snake and Klamath systems. The Snake system is approximately 3.5 times as large as the Klamath in terms of reservoir storage, ten times in terms of diversions, and irrigates seven times the Klamath basin as a whole and fourteen times the Klamath Project.

Table 1. Reservoir Storage (acre feet)

Snake River			Klamath River	
Upper Snake	4,173,695		Upper Klamath	520,000
Boise River	1,917,425		Clear Lake	527,000
SE Oregon	1,107,407		Gerber	94,270
			Link River	873,000
Total	7,198,527			2,014,270

Source: Bureau of Reclamation (BoR) website, Pacific Northwest region Teacup Diagrams

Several differences emerge from these data. First, the Snake has nominally far less storage in relation to irrigated land than does the Klamath: storage on the Klamath totals 133% of annual irrigation, and provides each year approximately 86% of irrigation diversions. Storage on the Snake contains only 43% of an average year's use, and provides about the same percentage of diversions. However, because the overall Klamath system is small, it has extremely limited capacity to withstand multi-year droughts. Such droughts have occurred six times in the Project's history, the latest prior to 2000 being 1991-94. During the 1991-94 period, reduced deliveries were made to the two wildlife refuges.

Environmental policy changes exacerbate the vulnerability. At 4136 feet elevation, the Klamath has zero storage; at 4139 feet it stores 174,000 acre feet (AF); and at 4143.3 feet, maximum storage of 486,828 AF. In 1994, the lake fell to 4136.8 feet elevation, only nine inches above dead pool. The 2001 operating plan, required by the final 2001 Biological Opinion (BiOp), required a minimum elevation of 4142.5 feet on June 1, falling to 4140 feet on October 15 (Braunworth, 2002, Ch. 2), simultaneously with a requirement for Coho salmon of increased flow requirements at Iron Gate Dam. With those requirements, the lake can provide almost no irrigation support in a critically dry year.

Table 2. Water Diversions (Million acre feet)

	Snake	Klamath
Gravity, main river	9.5	1.5
Gravity, tributaries	6.0	
Pumping from river	1.0	
Total	16.5	1.5
Of which, storage	7.0	1.3
Groundwater	3.5	

Source: Snake: Idaho Water Resource Board web site; BoR 1999, Ch. 2; Klamath: Braunworth, p. 46

A second, and major, difference is that the Snake combines BoR projects with substantial private irrigation based on natural flow rights, developed before and independently of the Bureau. Most of this irrigation, while not subject to Bureau policy, remains vulnerable to the Bureau's actions because the Bureau controls all large storage on the river. The major natural flow exceptions are 19th century development on the upper Snake, and the Twin Falls project, a Carey Act project near Twin Falls, Idaho, for which privately-constructed Milner Dam has a 3,000 cfs natural flow water right.

The presence of the Eastern Snake Aquifer introduces a large conjunctive component that is not evident in Klamath management. The aquifer runs NE to SW across southern Idaho. It is recharged by surface irrigation as well as by rainfall, the Snake, and its tributaries; pumping in many locales supplants surface waters during dry years. While the aquifer thus serves in part as a drought buffer, there has been no net drawdown in the past twenty years.

Table 3. Irrigated Acreage

Snake River	3,400,000
Twin Falls Canal Co. (natural flow, private): 1903-05*	260,000
Other private	1,540,000
Minidoka and Palisades Projects (BoR): 1907 - 57	1,111,178
Other BoR (includes land supplemented with BoR water)	490,000
Klamath Basin, total	509,000
Klamath Project: 1904	240,000

*Water right: 3,000 cfs, about 900,000 AF over 5 months
Source: BoR website; Braunworth

The combination of natural flow and storage diversion rights contributes to a management complexity not present on the Klamath, and may explain some of the innovative capacity that has been evident on the Snake. As an example, the droughts of 1916 and 1919, when natural flow rights owners saw their headgates shut off while there was still flow in the channel (from Jackson Lake storage), gave rise to the Committee of Nine, an extra-legal governing body that has allocated water between natural flow and storage water users since 1919.

Development Histories

The Snake River

Irrigation in the Snake River began about 1850, when farmers in what is called the Upper Valley in Eastern Idaho built temporary structures out into the river to divert water onto their land. Each spring the river would wash out the dams, and each summer they would be rebuilt. Later, increased pressure resulted from hydro production, recreation, fishing, and navigation. Hydraulic mining occurred on the Boise, a Snake tributary, but posed problems more of sediment than competition for water.

Major development on the Snake began with the Carey Act, which, by scaling projects up from the individual level to the incorporated irrigation district, led to private dam and canal construction, with flows and participation sufficient to ensure success. Later, under the 1902 Reclamation Act the BoR built large-scale storage dams on the river that largely eliminated private risk and led to even larger-scale irrigation.

Snake development took place in four distinct phases: the early private, small scale development; larger private projects (e.g., Twin Falls project) under the Carey Act; storage-based projects made possible by large BoR dams; and groundwater. The policy basis of groundwater development was the Desert Land Act of 1877; the technical basis was the perfection of pumps in the 1950s that could raise water from several hundred feet.

While government involvement increased across these phases, bringing greater scale economies with each phase, a diverse ownership pattern was established early, reinforced with development under the Carey Act. The upper Snake and the Twin Falls Project feature private, natural flow diversions. The Minidoka and Palisades projects feature BoR storage. The Reclamation Act brought major expansion, but did not result in the centralized, administrative structure known in the Klamath Basin. Groundwater began to be a factor after 1950, resulting in large-scale water use not related to Bureau control.

Beginning with droughts in the early 20th century, Snake irrigators and the State have been active institutional innovators. The first innovation of significance was a 1913 contract whereby an irrigation interest in what later became the Minidoka Project paid to raise Jackson Lake dam by 17 feet, and BoR contracted to provide water not just from Jackson Lake, but from any federal reservoir, including the one closest to the project. This provision later came to be of enormous value to Upper Valley natural flow irrigators, because it allowed joint management of the entire reach, including legal provision of water to irrigators upstream from the reservoir in which they owned storage (Gertsch, pp. 136-8). It also merged federal and private ownership interests, of enormous importance in later decision dynamics.

The next innovation, foreshadowed by joint reservoir management, was creation of the Committee of Nine, in the aftermath of the severe 1919 drought. The Committee was formed by some thirty water districts on the upper and middle Snake, which have since merged into the world's largest; created ad hoc in 1919, it has been elected since 1923. Its initial task was collaborative private/public financing of new storage at American Falls; it also undertook determination of natural flow/storage right allocations for the entire river above Milner (Fiege, 1999, p. 90-112). The Committee still serves as the advisory group for that district, though it has no other formal legal authority (Gertsch, pp. 208-213; IDWR).

The key feature of the post-1919 activity – later dam construction, and responses to drought, public policy shifts, and economic change – has been a high level of collaboration between private rights holders, BoR, the State, and the Idaho Power Company. Recent innovations and agreements have effectively subordinated hydro rights at an early dam built to provide power for a mining community; altered the definition of "beneficial use" to allow the clock to be suspended for any water assigned to a rental pool or water bank; provided for transfers from agricultural to industrial use; and created a virtual water lease for hydro purposes through an innovative power buyback program.

In the early 1980s a moratorium was placed on further diversions pending completion of a basin-wide adjudication. In 1994, all new pumping in the aquifer was prohibited.

Most policy changes and institutional innovations since 1970 have not been due to drought, but to underlying changes in social priorities and emerging conflict between surface and groundwater users. The rental pools and water bank have been used not only to move the point of diversion, but also to temporarily change the nature of use, primarily for hydro and fish. And since 1990, the Idaho Department of Water Resources (IDWR) has collaborated with the University of Idaho to develop procedures and modeling tools to support conjunctive management of surface and ground water in the Eastern Aquifer. These tools also support more efficient permanent transfers between uses and users.

The Klamath Project

The Klamath Project was authorized in 1905 by the Bureau of Reclamation, and opened to homesteaders in 1917. Most of the Project's institutional history has flowed from agency and congressional policy, including the rights of Indian and former-Indian lands (1975, 2002); establishment of the wildlife refuges; the Klamath River Basin Compact (1957); ESA designations; US Fish and Wildlife Service (USFWS) BiOp on suckers (1992); and National Marine Fisheries Service (NMFS) BiOp on coho salmon (1999) (Braunworth, Chapters 1,3).

All land in the project below Upper Klamath Lake is administered by BoR with regard to water supply (Braunworth). Though individual water rights exist, and droughts occurred to foreshadow the 2001 crisis, there were no shortages prior to 2001 sufficient to create an institutional crisis. As a result, there was no reason to create alternative structures. Droughts in the 1990s resulted in loss of water for fish and wildlife rather than irrigators.

Biological Opinions, the approved scientific basis for management decisions, were issued in 1992 and 1999. In January 2001, on the basis of predictions for the lowest inflow on record into Upper Klamath Lake, USFS and NMFS issued new biological opinions that resulted in a higher minimum level in Upper Klamath Lake, and simultaneously a higher flow at Iron Gate Dam. Following the BiOp, BoR informed Project irrigators that no water from the Upper Lake would be available for either irrigation or the wildlife refuges during the 2001 irrigation season. In July, on the basis of higher than expected precipitation, BoR released 40,000 AF for irrigation, and 26,000 AF for the refuges.

Water law

Idaho

In Idaho the prior appropriation doctrine is found in the constitution. This may be because mining was the state's first economic base, and miners had long memories of their California and Colorado experience (Interview May 12, 2003 with Hal N. Anderson Administrator, Planning and Technical Services, Idaho Department of Water Resources). Because of private development prior to the BoR projects, there is a rich body of case law supporting water use in Idaho. Also, because the basic law is in the Constitution, the Legislature has tended to address issues through definition of terms (e.g., "beneficial use") rather than change the basis of allocation.

The system has dealt throughout its history primarily with irrigation. Over 95% of diversions are for irrigation, and environmental pressures only began to develop in the 1970s. Conflicts between agricultural and municipal uses are only now becoming evident. While domestic uses have a constitutional preference, there is no preference for lawn watering or industrial use within cities. In 1996 the legislature provided that municipalities could acquire water rights for a reasonable future period, defined as up to 50 years, instead of the normal five years plus one five year extension, the allowable period of non-use before loss of the right. Most Idaho cities have historically derived their water from groundwater pumping, and have not been concerned about their water rights.

Oregon

In Oregon, prior appropriation was adopted by statute in 1909. Prior to that time the state had effectively followed the riparian doctrine, which was well suited to conditions in the Cascades. Water was abundant in Western Oregon, and there was little need to transport water from a source to a place of use; individuals looked to themselves or local courts for rights enforcement (OWRD). All new appropriations have been subject to a permitting process since 1909, and an adjudication is currently underway in the Klamath Basin for rights that pre-date 1909.

Innovations have dealt largely with improving in-stream use. Transfers for non-irrigation uses other than in-stream are generally prohibited, there is no rental pool or water bank as in Idaho, and permanent transfers are difficult. New legislation in 2001 makes temporary transfers (one irrigation season) easier, but neither partial season transfers nor partial rights transfers are allowed (OWRD, 2001).

Oregon does not recognize the interaction between ground and surface water, though work has begun on means whereby the injurious effects of a water transfer can be mitigated by those undertaking the transfer. Several provisions of the law, including some exercised during the 2001 crisis, encourage substitution of groundwater for surface water, if the surface water is moved in-stream. These provisions would appear to allow for enlargement of the water right through the use of groundwater.

The Oregon Water Trust (OWT) cites one example of a transfer that enlarges the right:

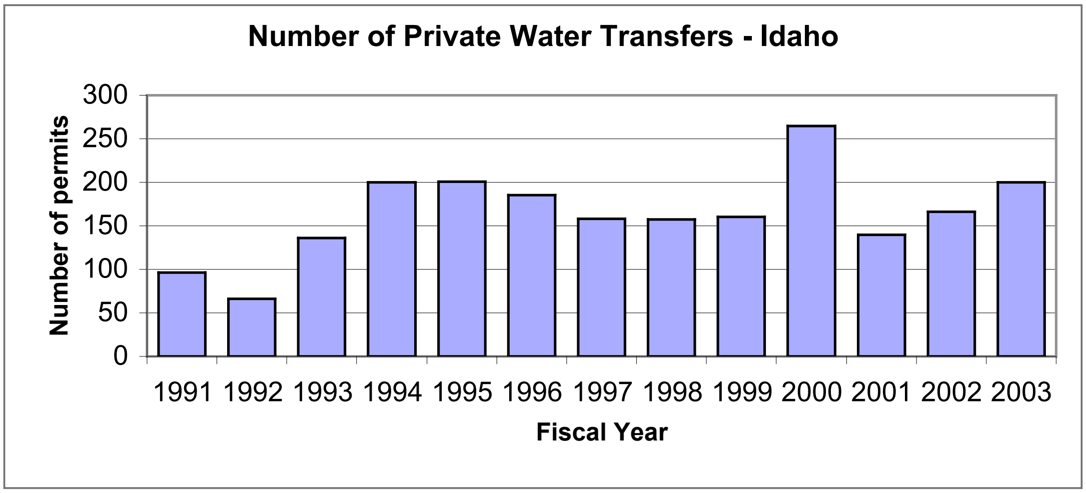
> "…three … water right holders sold their … ditch rights to OWT … in exchange for $1,000 to $1,500 an acre. **One of the landowners has converted to a groundwater source, and OWT helped to facilitate this process**. The application to transfer these water rights to an in-stream right has been approved by the Oregon Water Resources Department. Deschutes County, the Deschutes Resources Conservancy and OWT funded the purchase of these rights." [emphasis added] (http://www.owt.org)

Changes in Use

Idaho

Interest in, and support for changes in use, between uses and users, and changed point of diversion, have increased substantially since 1980. Interest has grown since the Snake River became fully appropriated in the 1970s, a moratorium was placed on new diversions in the 1980s, and a prohibition on new consumptive appropriation from the ESRA in 1992. Transfer applications since 1992, when the prohibition went into effect, are roughly double the number filed prior to that year (Figure 3). A high percentage of the change-in-use transfers along the middle Snake and on the Boise River near Oregon are for dairies.

Figure 3: Permits for Permanent Transfers



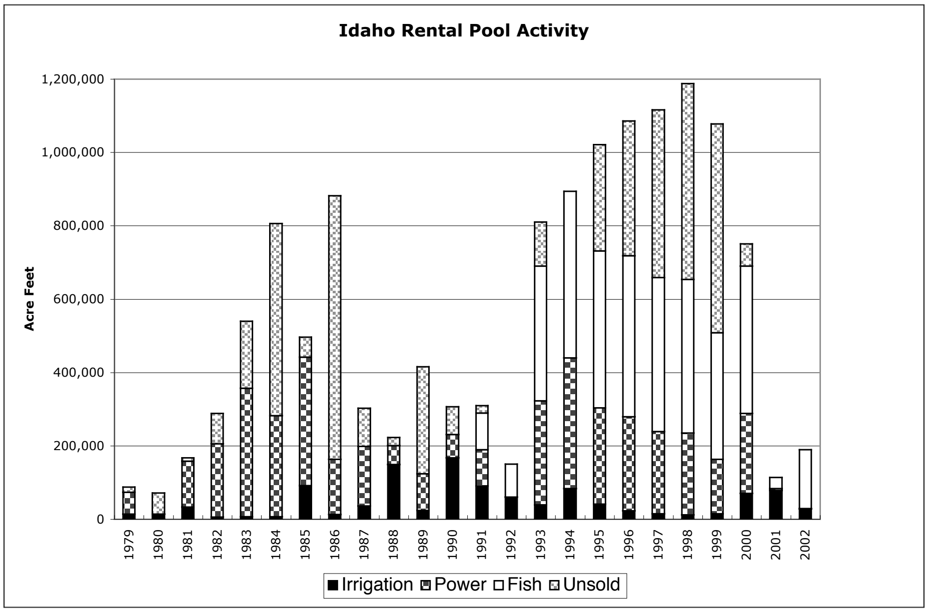
Source: IDWR

Structural support for temporary transfers takes two forms. First, changes in prior appropriation definitions were made to provide that water banking was a beneficial use. This change allows a rights holder to bank water for an indefinite period of time without losing the right. Second, legal support for a water bank (statewide, primarily natural flow) and rental pools (stored water, in specific watersheds) was enacted and regulations promulgated by the Idaho Water Resource Board in the late 1970s. Using the rental pools and the water bank, water has been increasingly moved between users and uses over the past decade, since a prohibition on new consumptive appropriation was placed on the aquifer in 1992 (Figure 4).

Permanent water rights transfers are now getting much more attention. Only the consumptive use can be transferred, because water diverted but not consumed – used by plants or evaporated – returns to the system. This is what leads to the potential for rights enlargement through the Oregon conservation statutes. Conservation does not normally create "new" water, although it may put water into a reach above the point where it would otherwise re-appear.

IDWR has responsibility for determining potential third party injury, but in their toolkit is a procedure for determining the extent of potential injury and any required mitigation. Backing up that policy process is a hydrologic modeling system developed in conjunction with the Idaho Water Resources Research Institute, of the University of Idaho. A revision of December 2003 makes possible the calculation of 100-year mitigation requirements for transfers from any of 1100 grid cells in the ESRA to any other. The model calculates the resulting increase or decrease in response function, the gain to the river, for six reaches on the Snake River, with all changes adding to 1.0 (IDWR, 2002; IWRRI, 2003).

Figure 4: Idaho Rental Pool Activity (acre feet)



Source: Idaho Department of Water Resources

Other mitigation projects range from a purchase by the City of Pocatello of storage in Palisades Reservoir, to Micron Technology's active storage facility, an underground basin into which Micron injects filtered water through an 1100 foot well. Water may now be stored underground (aquifer recharge), a beneficial use, to change the timing of delivery within or between water years.

The State operates a water bank, primarily for natural flow rights except on the Lemhi River, where storage rights may also be banked. In addition, several water districts operate rental pools, for privately held storage in BoR reservoirs. These are managed by local committees under authority of the state Water Resource Board. Table 4 shows recent sale prices for water in various Idaho markets.

In 2003 Water District #1, on the upper and middle Snake (the combined district formed in the 1920's by the Committee of Nine), formed an experimental "Global Rental Pool," which would automatically include all unused water, thus increasing the percentage of stored water available during drought. In 2003, the third year of the driest period on record on the Snake, the global pool succeeded in preventing any delivery reductions, even though water consumption was at record levels. This innovation promises substantial benefit, because it removes the disincentive to placing unused water in the pool: the "last to fill" rule, under which if you place water in the pool and the reservoir then does not refill, you might not have that water available in a succeeding year. On the other hand, in 2003 several "free riders" refused to participate, but were able to acquire water anyway. The innovation will fail if those practices continue.

Table 4: Idaho Water Markets – Recent Values

	Location	Date Start	Length of Term	Water Source	Administration	Recent Price - Posted Price or Minimum (acre foot)	Activity (acre feet per year)	Purchaser
Rent or Lease								
Rental Pools:								
District 1	Upper Snake	1930's	Up to 20 years	Stored	Committee of 9	$2.95 - $10.50	250,000	Irrigation/Power/ In Stream
District 63	Boise River	1988	Annual	Stored	Local Dist. 63 Board	$6.50 - $6.93	3,000	Irrigation/Power
District 65	Payette River	1990	Annual	Stored	Local Dist. 65 Board	$3.20 - /$8.50	150,000	Irrigation/Power/ In Stream
Shoshone-Bannock	Upper Snake	1990	Up to 5 years	Stored	Tribe			
In-Stream Flows:								
Lemhi River	Lemhi River	2000	Part Year to Annual	Surface	Local Committee	based on net economic benefit ($75-$100)	300	In Stream (BoR)
District 65K	Payette - Lake Fork Creek	2001	Annual	Surface	Local Committee	$2.70	2	Conservation
Water Bank:								
State	State	1979	1 year lease to permanent transfer	Surface/ Ground	Water Resource Board	$11+	5,000	Irrigation/Power
	Snake River	2001	Annual	In Stream (NMFS)	Water Resource Board	$50	40,000	In Stream (BoR)
Permanent Transfer								
State	State	1900's	Permanent	Surface/ Ground	Water Resource Director	Various		All

Source: IDWR

Oregon

In Oregon, approval for a transfer of use requires that the Department find no third party injury. For transfers other than to provide in-stream flows, restrictions include prohibition of partial rights transfers, and prohibition of partial season transfers. Rental pools and water banks such as have developed in Idaho do not yet exist. No state effort has yet been undertaken to provide for, or determine the required extent of, mitigation for injury. The state of the law, together with Oregon not having yet declared a prohibition on new appropriations, tends to discourage transfers.

Conjunctive Management

The Eastern Snake River Aquifer lies just north of the Snake River across most of southern Idaho. It contains an estimated 250 million acre-feet of water in the top 500 feet, and interacts extensively with the river (BoR 1999, p. 2-8). During the past century the aquifer's level rose until the mid-1950s as surface irrigation increased. It then fell for some years due to groundwater pumping and application efficiencies (The 1 m AF savings from application technologies, referred to earlier, reduced recharge, and thus outflow, by a similar amount).

Today, the aquifer level is relatively stable, except for impacts caused by drought and seasonal impacts, at a level higher in most locations than the pre-irrigation level of 1911. Because of this interaction, conjunctive management has become a necessity for the ESRA. Following a suit over a water "call" in 1990, the Department was directed by the court to institute conjunctive management, despite a claim by the Director that it could not be done. A "call" is a formal request to the Director, by a water rights holder, the water right be fulfilled by curtailing junior appropriators.

Since that time, tools have been developed that now enable at least rudimentary conjunctive management (*supra*). Integrated conjunctive management, including irrigators, cities, and industrial users, both surface and groundwater, is scheduled to be in place in the 2005-10 period, or after the adjudication is completed, whichever comes first (Gary Spackman, IDWR, September 9, 2003).

In Oregon, there is no conjunctive water management. While it is generally understood that pumping of groundwater will reduce return flows to surface streams, Oregon law and practice during 2001 actively encouraged replacement of surface flows with new groundwater sources, and in some instances subsidizes groundwater pumping to increase in-stream flow (See Oregon Water Trust example, above).

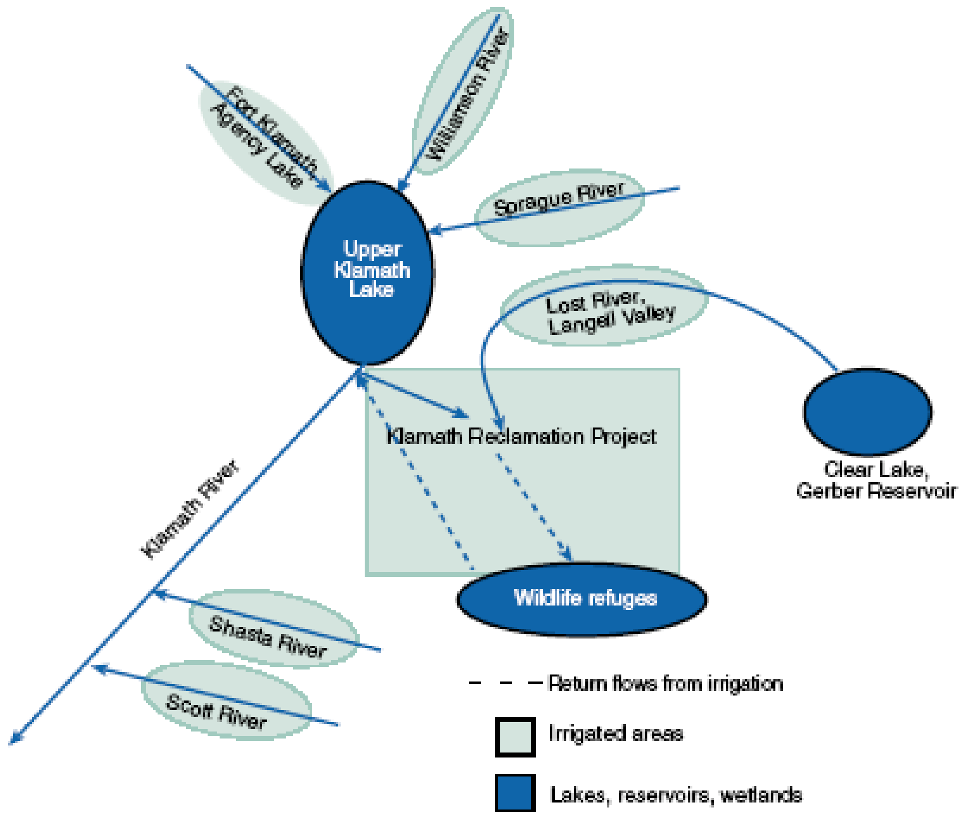
Klamath 2001

In 2001, BoR adopted a revised management plan, combining requirements for minimum flow at Iron Gate Dam, below the Project, determined by the National Marine Fisheries Service (NMFS), for coho salmon; and water depths in Upper Klamath Lake, agreeable with the US Fish and Wildlife Service (USFWS), for shortnose suckers. The agreed plan required minimum flows at Iron Gate Dam of approximately 1700 cfs, in contrast to the BoR's proposed minimum flow in a critically dry year of 398 cfs in August, and approximately 500 cfs the remainder of the summer. Because flows had to be met while the lake level was maintained (*supra*), the Bureau curtailed water from a large portion of the Project during the 2001 irrigation season (Braunworth, Ch. 2).

The economic loss resulting from that decision included an estimated $74 million gross loss to farmers in the Project, not including secondary losses to communities in the area. That estimate is net of groundwater substitution, estimated to have been worth $13 million. Because the basin has the potential for substitution of UKL water with water from upstream sources, the presence of a water market would have enabled farmers with upstream rights to sell, or lease, water to Project farmers.

Figure 5 illustrates the unrealized market potential. The BoR controls flows out of Upper Klamath Lake, for use in the Project and wildlife refuges below the lake. The management plan codified in a BiOp impacts only BoR decisions. Thus, the decision structure in place provides no avenue for moving resources not under BoR control from lower to higher-valued uses.

Figure 5: Key Features and Irrigated Areas in the Upper Klamath Basin and Klamath River System



Source: Braunworth, et al., p. 366

Table 5 shows the values that could be accessed by a market. Class IV and V land (low productivity) constitutes some 87% of the acreage above UKL and 78% of all non-project lands, with an average marginal return on water of about $12 per acre foot. In contrast, land inside the Project, subject to BoR regulation, is 81% Class II and III (higher productivity), and returns an average of about $50 per acre foot. Clearly, a market structure that would allow rights holders above the lake to sell water for use below the lake would benefit all parties. Jaeger estimates that a market would have reduced the gross primary impact from $74 million to $6 million (Jaeger 2002).

The Bureau of Reclamation conducted a bid auction for water to meet part of the BiOp requirements in 2002. Through the bid process, BoR obtained water from 16,525 Project acres at an average of $167 per acre, or about $83 per acre foot, well above the marginal return on water (Table 6). The Bureau also paid for groundwater substitution at an average $33 per acre foot, for 67,000 AF of groundwater. The BoR used market mechanisms to obtain water, but paid substantially more than would have been expected to result from a more robust market, in which Project farmers would not have paid more for water than they expected to realize from its use.

Table 5: Marginal Value of Water in Klamath Basin

	Acres	% of total	Marginal Water Value ($/AF)
Above Upper Klamath Lake			
Class II	2,710	2.1%	$39.00
Class III	14,325	10.8%	$19.43
Class IV	86,225	65.3%	$15.97
Class V	28,830	21.8%	$5.67
Total	132,090	100.0%	
E and S of Upper Klamath Lake			
Class II	13,288	15.0%	$60.99
Class III	35,705	40.3%	$34.16
Class IV	38,947	43.9%	$4.34
Class V	740	0.8%	$4.34
Total	88,680	100.0%	
Total Non-Project			
Class II	15,998	7.2%	
Class III	50,030	22.7%	
Class IV	125,172	56.7%	
Class V	29,570	13.4%	
Total	220,770	100.0%	
Klamath Project			
Class II	35,105	17.2%	$66.77
Class III	110,490	54.2%	$39.85
Class IV	57,748	28.3%	$21.15
Class V	620	0.3%	$4.87
Total	203,963	100.0%	

Source: Jaeger (2002), tables 1 and 3

In contrast, Table 4 indicates that temporary water transfers in the Snake basin have sold for from $10 to $50 per acre foot during the recent drought period. There is anecdotal evidence that additional payments have been made "under the table" for water, but no substantiated records of those transactions exist. The $10.50 is an administered price set by the Committee of Nine, so sales reported at that level are likely to understate the value of the full transaction.

The Theoretical Framework of Water Markets

The Snake and Klamath histories are different, and their responses to both climate variability and policy-induced stresses appear to be different. What explains these differences, and how can that knowledge be applied to other situations?

The private use of a natural resource, theoretically owned by the state, presents a class of contracting problems, and can best be analyzed as such. The transactions-cost literature provides a model for contract problems that fits the current case. In Idaho, water users, particularly those diverting water for irrigation, industrial, or municipal uses, are engaged in a contract with other users, the terms being governed by the doctrine of prior appropriation (A water right is a usufructory right, or right to use but not own, an asset. From a practical standpoint, in most cases the right is sufficient to support investment because it confers control of the returns on its use). Over time, they have modified the terms of their contract, *ex post*, as circumstances have changed and new stresses arisen. At times, these modifications have altered the prior appropriation doctrine itself, such as the broadening of "beneficial use" to include water banking and underground storage for recharge. In Williamson's terms, such modifications are in the nature of private ordering, wherein the parties to a contract resolve disputes and alter contract terms without recourse to a judicial venue. In this discussion, "private" does not necessarily mean exclusion of public entities, but that alterations are the result of negotiation, however carried out, among parties with property rights in the contract. Revisions to an original contract may involve sanction by a public entity, and be codified through revisions of the law, e.g., the definition of beneficial use.

In the Klamath Basin, the contract exists primarily between the irrigators and BoR. Because BoR rules must apply equally to all contracts throughout the country, private ordering of the nature seen on the Snake is not possible. Further, until 2001 the Klamath system did not experience the stress levels known on the Snake since about 1916. As a result, even to the extent that private ordering may have been possible, there has been no reason to create such capability in Oregon.

The property rights literature indicates that ownership matters: rights to use, to appropriate returns, and to change the form and/or substance of an asset. The concept is clear; few people will invest in an asset whose returns are controlled by an external third party. Applying this concept to water institutions, the rights allocation must be such that parties have an ownership stake, have investment at risk, and have contract rights sufficient to significantly impact allocation decisions.

The property rights literature assumes that judicial enforcement of contract rights is efficient. The transactions cost literature disputes that presumption. Instead, most dispute settlement takes place through "private ordering," or non-judicial means involving the parties; hence, bargaining is pervasive, and *ex post* support institutions matter (Williamson, 1985, p. 29). The Snake experience fully supports that conclusion.

A Transactions Cost Approach to Institutional Design

Transactions costs are the costs associated with contracting: obtaining information, and enforcing the provisions of the contract. They are not trivial, but are frequently absent from standard economic analysis, in which the focus is the nature and direction of relationships. Ronald Coase has shown (1937, 1962, 1971) that in the absence of transactions costs firms would be unnecessary because workers, suppliers, and customers could negotiate prices and roles continuously and instantaneously as needed, without benefit of management. Because in the real world such negotiation would be prohibitively expensive in terms of human time, management is able to return far more in value than it costs. The same case can be made for the existence of government, i.e., that in the absence of transactions costs all members of society could continuously negotiate and pursue their collective goals. Thus, the meaningful question with regard to government is not whether, but how much and for what objectives, in the context of cost savings, given current technology, to be achieved through having governance instead of continuous negotiation.

For the present case, allocation of scarce water, information as to water availability and price, and enforcement of rights are critical. If we think of resource allocation as a contract problem, there are four possible decision models that apply, the choice depending on the characteristics of the market and the assets in question (Table 6). The characteristics are 1) the nature of rationality ascribed to participants, 2) the extent to which opportunism is a problem, and 3) whether asset specificity is non-trivial (Williamson, 1985, p. 31).

Table 6: Resource Allocation Models

	Behavioral Assumption (process can handle)		
Contracting Process	Bounded Rationality	Opportunism	Asset Specificity
Planning	No	Yes	Yes
Trust	Yes	No	Yes
Competition	Yes	Yes	No
Governance	Yes	Yes	Yes

A planning model assumes unbounded rationality, the absence of constraints on relevant information, i.e., that all future events of significance are knowable. This is a heroic assumption. For the Klamath, where the contract provided that BoR would deliver water when available, except in cases of *force majeure*, it would have meant anticipating public policy change and future demands for water at the time the original contract was drawn. To the extent these risks were not anticipated, the planning model assumes that the judicial system can resolve ensuing conflicts in an efficient and timely manner. When the courts determined that ESA constituted a *force majeure* event, the irrigation customers, having not anticipated that risk, moved immediately to the political arena.

On the other hand, a planning model, because obligations are prescribed and an efficient public judicial process is assumed, handles both opportunism and asset specificity well as long as the assumptions hold. Water is a very specific asset in this context, because its very character depends on being available in a particular place at a particular time. A planning-based contract, unlike a competitive market, takes those characteristics into account.

Opportunism is the very human tendency to go beyond simple interest-seeking on the basis of known information, to taking advantage of asymmetrical information, including incomplete or distorted disclosure. It can also include more odious forms of behavior, and may be active or passive, before or after the contract. The courts are usually a reasonably efficient means of resolving difficulties arising from the more egregious forms of opportunistic behavior.

A trust model does not require comprehensive knowledge *ex ante* because of the nature of the underlying relationship. Participants can depend on others not to take advantage of changed circumstances, but to work things out on the basis of known self-interest. The model works best in small social groups, where reputation is important, or in larger groups bound by an effective social code. On the other hand, cultures where trust is the primary basis of business intercourse tend not to grow beyond the boundaries of persons known to each other (e.g., southern Italy, tribal cultures).

Arrow notes that the "efficacy of alternative modes of contracting [varies] among cultures because of differences in trust" (Arrow, 1969, p. 62, cited in Williamson, 1985, p. 9). To some extent, a trust model can be found in Snake River irrigation, where most irrigators are members of the Mormon church, and bound by a fairly comprehensive social code. The common cultural link makes it possible to deal collaboratively with a highly specific asset, as when some irrigators have shared their water with less fortunate neighbors in a location where the river commonly submerges for a several mile stretch. The Committee of Nine may owe part of its success over the century to informal authority flowing from a tacit sanction by the Mormon Church. There are limits, however: many irrigators have tended their ditch banks with both shovel and rifle, as a matter or course. The presence of opportunism is frequently fatal to trust-based arrangements.

A competitive market, on the neoclassical model, handles both bounded rationality and opportunism well, provided that the asset in question is reasonably homogeneous and traded in a broad market. Changes in conditions lead to price adjustments, which lead directly to adaptation. Opportunism is automatically constrained, because all parties have access to the same or similar products from multiple vendors. Thus no customer must take the price of any one vendor, and no vendor must yield on price to a single customer.

Asset specificity is not handled well by competitive markets, because the very uniqueness of the asset to be traded (e.g., water in a given location or quality) violates the requirement for competing buyers and sellers. Market transactions may be confined to an insufficient number of either buyers or sellers. When BoR took bids on water from Project farmers in 2001, the resulting prices appear to have substantially exceeded what would have been expected from a market arrangement. This could be expected because there was only one buyer, no market history, and insufficient supply as the auction was limited to Project farmers.

The combination of asset specificity, bounded rationality, and opportunism normally requires some level of governance. The presumption of bounded rationality, however, excludes governance of a planning nature, and the property rights literature reminds us that ownership matters. Thus, an efficient solution in the presence of asset specificity must incorporate a large measure of ownership on the part of participants, coupled with a governing presence to enforce the rules. Such an institutional arrangement will be characterized by a large measure of private ordering, *post hoc*, through which the participants continuously innovate to deal with stress on the original contract.

It can be seen that institutions governing a competitive model, or a governance model wherein private ordering is possible and experienced, are capable of autonomous adaptation to changed circumstances. And while not all adaptations are necessarily successful, those that are unsuccessful will tend to be discarded or adjusted over time.

Water exhibits bounded rationality, opportunism, and asset specificity. Because of climate variability, demand growth, demand from new uses, and potential public policy change, comprehensive contracting *ex ante* is not possible. Thus, planning models are unlikely to be successful, and the BoR contracts found in the Klamath Basin would be severely tested at some point.

Because of the opportunism that is necessarily present with an asset-specific resource, a trust model will have limited, though sometimes beneficial, application. A neoclassical market is not possible, if only because water diversion must be very specific in place and time for surface users, and only slightly less so for groundwater users.

Thus, a "water market" is not a solution, if by "water market" one has a neoclassical arrangement in mind, with multiple buyers and sellers of a homogeneous product. Nor is a planning solution likely to succeed, because of its simultaneous assumptions that 1) all contingencies can be known in advance, and 2) judicial ordering is efficient. A governance solution, on the general model of utility regulation, may be possible, wherein the regulator serves to enforce the ground rules and mediate ongoing negotiation (private ordering) rather than allocate the resource directly.

Such a model is close to that developed in Idaho over the past century. The Idaho Department of Water Resources, successor to the State Engineer, enforces prior appropriation rules, oversees rights registration, measures flows, and approves transfers. The Committee of Nine was created in 1919-24 by the Upper Snake water districts to find additional storage and to allocate water between natural flow and storage users. It has no official status other than being the designated operating committee for the Upper Snake rental pool, but provides a semi-formal and non-judicial means of adjusting the contract and meeting new circumstances. Surface and groundwater users, irrigators, industrials, and municipalities are currently in on-going negotiation to resolve conjunctive management issues in the middle Snake. The institutions that have resulted exhibit a very high degree of *ex post* private ordering, albeit sometimes under the pressure of formal sanction.

Fundamental public policy shifts, of course, can undo any institutional structure. An ESA action of the nature that set off the Klamath crisis is threatened on the Snake: legal action is threatened to void a BiOp under which four lower Snake River dams in Washington State (for slackwater navigation to Lewiston, Idaho), irrigation, and fish are expected to co-exist. The worst case is the end of irrigation in southern Idaho ($3.5

billion annual primary impact). Other possibilities are removal of the slackwater dams or continuation of the current arrangement, presumably until the fish disappear, thereby making the issue moot.

The fundamental public policy caveat aside, a properly designed market arrangement can greatly reduce the adaptive cost of climate variability and change. Such a market is likely to feature process governance and a central umpire, but with individual users and associations, each with an at-risk stake, engaged in private ordering of the issues that result from changed circumstances.

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