Rights-Based Management of Tuna Fisheries: Lessons from the Assignment of Property Rights on the Western US Frontier

Gary D. Libecap

University of California, Santa Barbara
National Bureau of Economic Research
Hoover Institution

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I. Introduction.

Rights-based arrangements increasingly are under consideration for adoption in fisheries to mitigate the losses of the "Tragedy of the Commons" or open access.[1] Grafton, Squires, and Fox (2000) demonstrate the gains from individual transferable quotas (ITQs) in the Pacific Northwest halibut fishery. Hannesson (2004) describes a general pattern of moving from uncontrolled entry to centralized governmental regulation (command and control) to adoption of property rights of some type. Arnason (2002) summarizes international experiences with ITQs. These institutional innovations have taken place as fisheries have become more valuable, as they have faced greater depletion threats, and as dissatisfaction has increased with existing regulatory policies.[2]

The advantages of property rights arrangements include better alignment of incentives for investment in the resource, provision of collateral for accessing capital for investment, more flexible exchange, greater information generation, and improved cost savings in meeting conservation or environmental objectives.[3] The more complete are property rights, the more the private and social net benefits of resource use coincide, reducing externalities and the associated losses of the common pool.[4]

By contrast, centralized (command and control) regulation, which typically relies upon uniform standards, arbitrary controls on access, constraints on timing of use, and/or limits on technology or production capital, suffers from a variety of well-known problems including high cost, inflexibility, ineffectiveness, and industry capture. Further, regulatory decisions take place in the absence of information about alternative uses that market trades generate. Finally, centralized rules may or may not align with the

incentives of actual users of the resource. Generally, no party involved, including direct participants, regulators, or politicians, is a residual claimant to the economic gains from investment or trade.[5] Accordingly, extraction, production, investment, and allocation decisions are based on other factors that are apt not to be consistent with maximizing the economic value of the resource or of conserving it.

Despite the attractions of property rights, they remain controversial, limiting or slowing their adoption. They often are adopted only late, after conditions have deteriorated for many regulated resources. By that time, political conflict over the assignment of the costs and benefits of a new property regime is swamped by the overall costs of not taking action. Unfortunately, many of the resource rents have been dissipated. Moreover, as shown below, there are path dependencies from past regulations or inappropriate property assignments that raise the costs of adopting new rights regimes.

The allocation of property rights is most controversial because of the distributional implications involved in moving from open-access or central regulation to a property regime. In many cases, at least some constituencies, including regulators, who benefited from the previous regulatory arrangement, will be disadvantaged under a new rights system. Hence, these parties will resist the arrangement until there are few options.

Any property right that has meaning involves exclusion, so that some parties that previously used the resource will be denied access. Production under a property rights regime has a different composition of inputs and timing than what occurs under open-access or regulation, with negative impacts on certain groups of labor, input sellers, service organizations, and processors. These production changes are inherent in the efficiency gains of privatization, but not all parties directly benefit from them. Further, as

the resource rebounds and becomes more valuable, new owners have wealth, status, and political influence not available to those without access privileges. These distributional factors, along with the costs of bounding, measurement, and enforcement constrain the extent, timing, and effectiveness of the assignment of property rights to address the common pool.[6] As emphasized by Coase (1960), allocation rules are always important for distribution and they affect production opportunities in the presence of transaction costs.

For example, disputes over the types and distribution of ITQs to be granted in U.S. fisheries resulted in a four-year moratorium on their expansion in 1996.[7] Five U.S. marine fisheries operate under ITQ regimes (as compared to over 40 in Canada): the Mid-Atlantic surf clam and ocean quahog fishery, the Alaskan halibut fishery, Alaska sablefish fishery, the South Atlantic wreckfish fishery, and Alaska crab fisheries. These ITQs are more limited and are a weaker property right than found in many other major fishing countries.[8] Some U.S. ITQs are reserved for community development quotas, and there are limits on quota size held by any party and on transferability. In the Alaska halibut fishery, for example, only transfers from larger to smaller vessel classes are permitted, and no individual is allowed to own more than 0.5 percent of the total quota. There are other controls on share consolidation to limit holdings and to maintain a targeted number of vessels in the halibut fleet.[9] As described below, these restrictions are understandable from a short-term distributional viewpoint, but they are likely to have long-term negative consequences for fisheries and the ability of ITQs to protect resource rents and the welfare of the fishers who depend on them.

In this paper, I examine these issues across a variety of resources and develop generalizations for application of ITQs in fisheries. I examine the assignment of private property rights during the 19th and early 20th centuries to five natural resources, mineral land, timberland, grazing and farm land, and water on federal government lands in the Far West. The region was richly endowed with natural resources, but assigning property rights to them required adaptation from established, eastern practices as defined by the federal land laws, and this adaptation provides a laboratory for examining current questions of institutional design in fishery regulation.

As we will see, western property institutions encountered many of the same information, political, and design problems that are encountered today. Some were successful, whereas others were not. Property rights allocations based on local conditions and unconstrained by outside government mandates were most effective in addressing both the immediate threat of open-access and in providing a longer-term basis for production, investment, and trade. Western mineral rights stand out in this regard. In contrast, federal government limits on farm land allotment size, use, and exchange through the Homestead uniform distribution in 160-acre plots had long-term negative consequences.

Indeed, a major lesson is how hard it is to repair initial faulty property allocations. Whereas Coase emphasized transaction costs in private negotiations, political transaction costs are especially important in the assignment and subsequent modification of property rights.[10] Once an allocation rule is established, it becomes very difficult politically to modify. Many constituencies develop a stake in the *status quo* and the distributional implications of any change in it can be both large and uncertain. These factors complicate

the development of bargaining positions in negotiations for institutional change. Moreover, these same problems raise the transaction costs of private efforts to make property rights structures more efficient.[11]

II. Allocation Rules.

There are a number of ways to assign property rights as outlined in Table 1.

Table 1
Summary of Allocation Rules

Allocation Rule	Allocation Scheme	Benefits	Costs
First-Possession.	First-come, first-served. Grandfather claims. Market determines size and nature of property right, rather than exogenous political and bureaucratic constraints.	Recognizes incumbents and specific, non-deployable investments. Rewards first movers, innovators, risk-takers. Economizes on Transaction Costs.	Fairness concerns. Dissipation from Rush.
Uniform Allocation.	Equal distribution. Equal access (Lottery).	Minimizes equity concerns. Works best when no incumbents.	Non-optimal allocations. High transaction costs of subsequent trade.
Auction.	Competitive bidding places asset with highest-valued users.	Revenue to state. Reduces equity concerns. Generates information about resource value. Works best when no incumbents.	Design and administration costs.

First-possession.

First-possession assigns ownership on a first-come, first-served basis or first-in-time, first-in-right. First-possession rules are attractive because they recognize incumbent parties, who have experience in exploiting the resource and hence, may be the low-cost, high-valued users.[12] Incumbents also have a direct stake in access to the resource and will be important constituents in a property rights distribution. These parties are concerned about any past investments in specific, non-deployable assets. By recognizing such investments first-possession rules encourage future outlays. Allocations that do not

consider the position of incumbents will face opposition, raising the costs of rights assignment and enforcement. Grandfathering in initial allocation often has been a necessary ingredient in building the political support for property rights allocations.[13]

There are other reasons why first-possession rules can be efficient. They recognize first-movers, innovators, entrepreneurs, who initially experiment with and use a resource. Society benefits from innovative, risk-taking activities. Further, under first-possession the market can determine optimal claim size, whereas under other allocation arrangements bureaucratic or political objectives may define the assignments. If these are not consistent with optimal production size, then further trade is required, and if transaction costs are high, such exchange might be limited. Hence, first-possession can economize on transaction costs.

First-possession has been criticized on fairness grounds because it discriminates against new entrants, and existing holdings may be large. There are wide-standing views that "people should get what they deserve and deserve what they get." If first-possession ownership is viewed as rewarding those who by luck and connections got early access, then it may be opposed politically.[14]

The rule-of-capture that applies in fishing, oil and groundwater extraction is a type of first-possession rule. Ownership is granted to the party that invests in extraction. But the rule-of-capture grants ownership to the flow and not generally to the resource stock, and hence in the presence of open-access conditions, it can exacerbate competitive extraction incentives.[15] If the competing parties are homogeneous and ownership is short-term, then full dissipation is possible as parties rush to "capture" the asset. If, on the other

hand, the parties are heterogeneous and use rights are long-term, then first-possession assignments to a flow mitigates rent dissipation, as is the case with fishery ITQs.[16]

The same criticism of first-possession rules and rent dissipation applies if homogeneous claimants race to establish property rights to the stock.[17] But as before, if the parties are heterogeneous and the resulting rights are secure and permanent, then full dissipation will not occur. Moreover, the "winners" of such a race may be the most efficient producers. There also are costs of measuring and verifying past use claims, and other potential rent-seeking actions to secure the most favorable baseline period and criteria for allocating property rights. There are, however, costs with any rights allocation rule and there is no reason to believe that first-possession is more costly than other assignments. Generally, if the transaction costs of subsequent exchange are high, then it makes sense to assign rights to low-cost users with histories of past involvement in the resource.

Uniform Allocation.

Uniform sharing rules meet egalitarian goals by providing equal-sized allotments or equal opportunities. If there are no restrictions on subsequent exchange of property rights and transaction costs are low, there are few efficiency implications. The resource still migrates to high-valued users and to optimal production sizes. But if exchange costs are high, then inefficiently small (or large) distributions can persist. Uniform allocations, however, avoid the measurement costs of verifying claims of past production or of documenting precedence claims that are part of first-possession assignments. They also can circumvent the costly pursuit of or rush for property rights when first-possession is

known to be the allocation rule. They work best when there are no incumbent users whose informal claims may not be consistent with more equal distributions.

Auction.

A third allocation mechanism is auction, and there are various types.[18] It can directly place the asset into the hands of those who have the highest value for the asset. It thereby avoids the transaction costs of re-allocation. Auctions also transfer rents to the state (as the seller). And auctions generate information about the value of the resource. As with uniform allocations, auctions work best for unallocated resources where there are no existing claimants and where resource values are high. By granting more of the rents to the state, auctions reduce the distributional implications of first-possession. The amounts and distribution of rents, however, depend upon auction design, which can be complex. There are other costs to auctions. The state must be able to measure and enforce resource boundaries and the individual allocations that are auctioned off. The terms of the auction may also be influenced by competing claimants who lobby for rules that provide them with specific advantages.[19] It is often argued that auctions can transfer rents to the state without important distortions or incentive effects for resource users. But caution is in order. The effect depends on meeting restrictive conditions in auction design that may not be feasible. In a similar setting, Johnson (1995) has shown that the imposition of taxes on quota rents in ITQ (individual transferable quota) fisheries could lead to reduced incentives of fishers to conserve (invest in) the fish stock. For these reasons auctions are not used as often as economists have predicted.[20]

III. Mineral land.

Western mineral rights developed abruptly with the discovery of gold in 1848 at

Sutter's Mill in California.[21] The prospectors had no official sanction to claim mineral land because minerals were not addressed in federal land law which was directed solely on agriculture. Further, there was no civilian government to provide a legal framework for assigning property rights. As a result, miners devised local, private property arrangements within mining camp rules.

Since private mineral rights were based on local negotiations with virtually no outside constraint, the market determined the allotment mechanism, individual claim size, as well as conditions for exchange, maintenance, and enforcement of property rights. For this reason, western mineral rights provide a baseline for comparison with the other property rights arrangements described below.

A first-possession grant to a single, specific location of mineral land was the allocation rule.[22] The first prospector to arrive at a location thought to have deposits of valuable ore was granted private claiming rights. Each party had, at least in principle, an equal chance at first choice of a spot. Accordingly, first-possession encouraged socially valuable search and exploration. And those who discovered a new district typically were granted two mineral claims, whereas all others were allowed a single claim. Each mining claim had to be marked and worked according to local mining camp rules. Abandoned claims could be occupied by others. In the meantime, others were prohibited from entry until the claim was deemed to be abandoned.

Claim sizes were determined by local factors, not outside government requirements. Smaller claims were allowed in potentially richer stream beds where gold was thought to concentrate and water for extraction was nearby, whereas larger claims were allowed on drier hill sides that offered lower prospects. Enforcement costs were

likely higher for the more valuable stream claims necessitating smaller individual holdings, than for the less attractive hillside claims. Mining camp rules were flexible, so that as ore played out, claim sizes were extended.

In general there were no restrictions on the private sale of mineral claims. Sales were routine, first to allow entry to those without any land in the district and then, to consolidate claims for more capital intensive production. Some claims sold for a great deal and mining companies incorporated and sold shares on the San Francisco Stock Exchange and other western financial markets to raise capital.[23]

Camp rules initially were informal and gradually were given more structure as mining values rose, the number of claimants and congestion increased, and as the technology of mining and the nature of the ore and extraction changed.[24] They were incorporated into territorial, state, and federal law, and the Mining Law of 1872 remains the basis for obtaining title to mineral lands on federal property today.

The legal rights structure has been successful in promoting the development of the industry. Mining involves high risks and costs in finding and developing ore deposits. Most sites turn out either to have no ore or not to be profitable. Moreover, there are significant fixed-capital investments with long lead times for extraction, transport, and refining that are vulnerable to unanticipated changes in prices and costs and to expropriation through high tax rates or government seizure. The American hard-rock mining law that developed out of the mining camps, however, provided secure ownership. The structure has been flexible, and there has been no history of high taxation, significant payments for receipt of title, or threatened nationalization. The accompanying security of property rights encouraged exploration and production.

Overall, U.S. industry became more mineral intensive in production than the country's physical resource endowments would have otherwise suggested.

IV. Range Land.

Another group that settled the West early, faced new conditions, and had to institutionally innovate was ranchers. In the 1870s and 1880s, cattle herds were driven onto the western Great Plains by ranchers to take advantage of rich pasture lands. There was no specific provision in federal land policy for formal ranch claims. Accordingly, to avoid the losses of competitive overgrazing and to reduce conflict over land, ranchers, as with miners, divided the land on the basis of first-possession.

The size and nature of rancher allocations were determined by the market through collective action within livestock associations. Because of the broken terrain and limited precipitation, livestock carrying capacities of the western range were low. With 25 acres or more required to sustain a single cow for a year, upwards of 10,000 acres were commonly required to support enough animals to achieve economies-of-scale in grazing. These allotments certainly were beyond anything possible formally under the Homestead Act.

Initially, the lack of ability to obtain formal fee simple title to federal range land did not matter. Individual ranches were made up of a combination of fee simple holdings obtained under the land laws, as well as land purchases from railroads and state school land sections and much larger informal claims.[25] Local grazing rights included occupancy or beneficial use requirements. There were no restrictions on transfer. Patented ranch properties could be bought and sold and these included memberships in livestock associations.[26]

The open range in the 1870s had few other recognized claimants, and it was far from established government.[27] By the late 1880s, however, with the entry of homesteaders, ranchers began facing new competitors who wanted to place the land into crops. Conflicts over land began. There were opportunities to change the land laws to allow for larger allocations more in keeping with the requirements for successful ranching operations in the Far West. But nothing came of them because they were politically unattractive. Federal politicians were reluctant to make major modifications in the land laws.[28] Their position was hardened after 1890s when the U.S. Census declared the frontier closed, indicating that there was less and less land available for new claimants. Larger land allocations would only exacerbate the problem. Libecap and Hansen (2002) point out that there was no clear scientific understanding of the area's climate or of the type of agriculture that would be effective there. The belief persisted that small Midwestern farms could take hold and that ranchers were blocking this process. A strong current of anti-monopoly bias in the distribution of property and a desire to maintain the homestead allotment at 160 acres prevailed.

The quasi-legal practices of ranchers were attacked and their fences removed by the General Land Office. As the ability of the livestock associations to control entry declined, the incentives of members to violate internal rules increased, and the groups, along with their informal land allocations began to break down.[29] In the absence of fencing, the only way that ranchers could maintain their informal claims to land was to reduce the incentive to enter it by overgrazing. But overgrazing to mark and protect rangeland claims was costly. It made cattle herds more vulnerable to drought since grass stands were driven to low levels with little reserve when precipitation was scanty. The

costs of overgrazing to define and enforce land claims against other potential users were reflected in lower calf crops, higher death losses, smaller cattle weights, and diminished animal values (Libecap, 1981, 23-28).

Because ranchers could not obtain title to semi-arid rangelands and because these lands ultimately also were inhospitable to homesteaders, approximately 80,000,000 acres in western states (excluding Alaska) were retained under permanent federal ownership with enactment of the Taylor Grazing Act of 1934.[30] Most of the lands were placed in grazing districts and grazing permits or leases were distributed and managed by the Bureau of Land Management (BLM). Currently, the BLM administers some 177,053,843 acres of range land in the continental United States, almost a quarter of the acreage in 11 western states, including nearly 70 percent of Nevada, over 40 percent of Utah, and over 20 percent of Wyoming, Oregon, and Idaho.[31] Political constituencies, ranging from ranchers to mining companies to conservation and recreation groups, compete to influence agency policy over access and use of the public domain. Private grazing leases that had been transferable with ranch properties have become more insecure as limits were placed on them and as lands were dedicated to other uses. The resulting tenure uncertainty affects grazing practices, investments, and rangeland values.[32]

There is no attempt here to measure the losses of bureaucratic management, but they may be substantial. The vast majority of BLM lands have no important amenity values or other critical externalities associated with their use that would justify government ownership and oversight.[33] They remain as a legacy of a federal land policy

that held private distributions inappropriately small, limiting fee simple titling and the establishment of viable ranches based on it.

V. Farm land.

Unlike miners and ranchers, homesteaders could claim federal land using existing land policy. Individual ownership of a single plot of farm land was allocated under the Homestead Act and similar land laws through a combination of first-possession and uniform allocation. 160-acre distributions that had worked well in the Midwest and were applied in the West.

The Great Plains and Far West were semi-arid, with annual rainfall of 20 inches or (much) less and erratic distribution. By contrast the Midwest was characterized by less variable precipitation of 30 inches or more. Nevertheless, migrants brought with them the cultivation practices, crops, and farm sizes that were familiar and successful in their areas of origin and so long as there was no drought, these actions worked well.

Because homesteaders did not understand the climate and the eventual need for larger farms, they typically did not seek larger allocations nor did they lobby for major changes in the land laws. Folk theories, such as "rain follows the plow," where precipitation was believed to increase with cultivation, and pseudo-scientific farming prescriptions, such as "dryfarming doctrine," where proper tillage was believed to overcome drought, were thought to make small farms viable despite the region's dry climate (Libecap and Hansen, 2002).

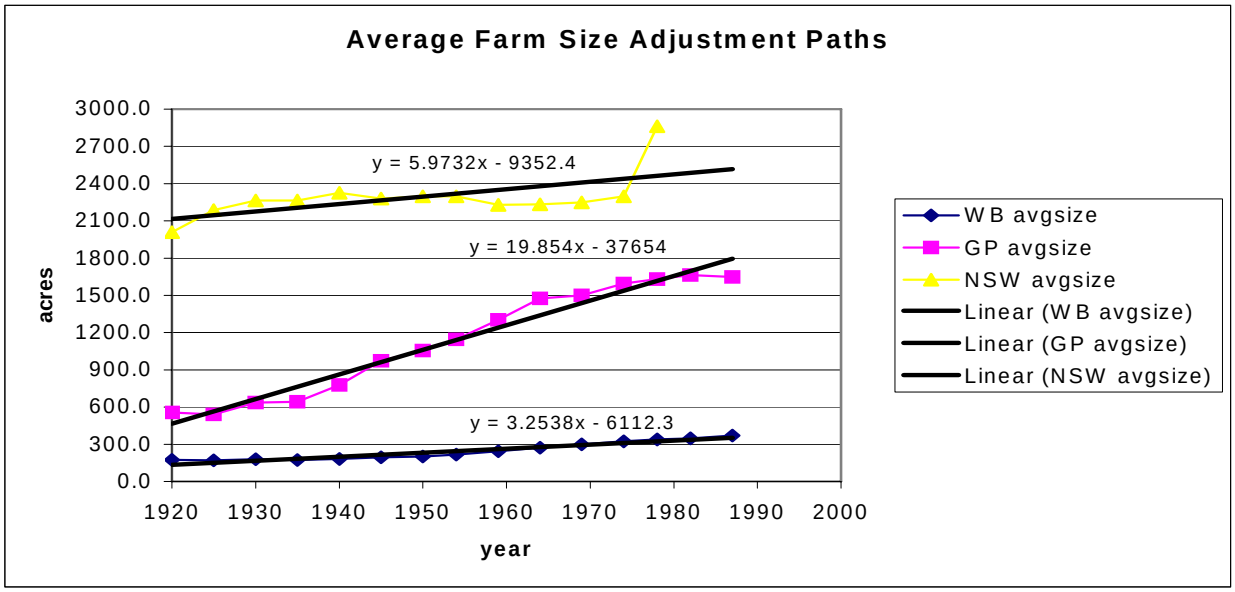
One consequence of these small-farm allocations was extensive farm failure.[34] The region west of the 98th meridian became known for periodic "homestead busts" when drought caused wheat yields (the most common crop) to collapse along with farm

incomes. Homesteads did not have enough wheat in cultivation to offset the drop in yields and maintain a minimum family income. Small farms also typically did not have cropland in fallow, a practice that could mitigate the effect of drought by collecting moisture and nutrients while the land was left idle.

Hansen and Libecap (2004a, 115-17) analyze the effect of drought on small homestead farms in three eastern Montana counties, Cascade, Carbon, and Fergus using county directories, dating from 1916 through 1930. Over 7,000 farms are in the data set. The analysis reveals that by the end of the period, the number of farms had fallen by 43 percent and farm size had doubled as properties were abandoned and consolidated. In Cascade and Fergus Counties an average-sized farm in 1916 had a 2/3's probability of failure during the drought years and chances were 4 out of 5 that they would not survive from 1916 through 1930. By contrast larger farms tended to endure drought more successfully.

The adjustment process toward larger farm sizes, however, took over 60 years because of a lack of alternative economic options for small farm owners. Hansen and Libecap compared farm size change in the American Great Plains, the Midwest, and New South Wales, Australia, which is a major wheat producing area and has a climate similar to that found in the Great Plains. The paths are illustrated in Figure 1.

Figure 1



Source: Hansen and Libecap (2004a, 126).

As illustrated, in the Midwest, farm sizes only gradually changed. Between 1920 and 1987 mean farm size approximately doubled from 175 acres to 371 acres, with the estimated annual adjustment of 3.3 acres. However, the experience of the Great Plains was quite different. Mean farm size in 1920 was 557 acres, and it tripled to 1,648 acres by 1987, with the estimated annual increase of 19.9 acres in farm size. For New South Wales, farm size was 2,010 acres in 1920 and rose to 2,862 acres by 1978, the last year for which we have data. The per-census period farm size growth rate is 9.2 percent in the Great Plains, but 6.3 and 1.2 percent in the Midwest and New South Wales, respectively. The 160-acre limit of the Homestead Act was not a problem in the Midwest. As late as 1920, a 160-acre farm was close to optimal in the region. From that time forward, only moderate farm-size adjustments took place in response to changes in the relative factor prices. Similarly, in New South Wales wheat farms started out large in 1920 and only

gradually grew. The homestead limit, however, was binding in the Great Plains, and the figure illustrates the property rights adjustment necessitated by starting with farms that were too small in the Great Plains. Meanwhile, there was dramatic out-migration unmatched elsewhere in the country. The population of many of the 363 Great Plains counties peaked in 1910 and two-thirds had their largest populations in 1930 or earlier.[35]

A second consequence of small farm allocations was over cultivation and lack of investment in erosion control that had serious environmental effects with the Dust Bowl of the 1930s. Small homestead farmers cultivated more of their land to meet income targets, leaving it exposed to damaging wind erosion. They were less likely to adopt strip fallowing practices that could slow the flow of wind. Their farms were too small to internalize the benefits of downwind erosion control, and they bore high opportunity costs because strip fallow required between a third and a half of a farm to be left idle, a cost they could not bear. The optimal size of holding to address wind erosion externalities was 50,000 acres or more, meaning that coordination was necessary to address the problem, but the large number of homesteaders also raised the costs of collective action.

Hansen and Libecap (2004b, 679-82) analyzed the relationship between farm size and fallowing using census data for 285 Great Plains counties between 1930 and 1964. They found that over the 35-year period mean farm size grew by 74 percent and the fallow share of crop land rose by almost a factor of 4. Later droughts in the 1950s and 1970s were not accompanied by the severe wind erosion that occurred in the 1930s. The larger farmers that predominated by those years could internalize more of the returns from investing in erosion control through strip fallow investments, and they did so.

Counties with less fallowing (higher cultivation shares of total farmland) had more serious erosion, controlling for other natural factors. If the cultivation share had fallen by one standard deviation below the mean share (fallow had increased), the predicted probabilities of "no" or "light" wind erosion would have risen by 33 percent. Alternatively, if the cultivation share were raised to 100 percent (no fallowing), as was the case with many small homesteads, the predicted probability of "severe" wind erosion jumped by 123 percent and the predicted probability of "no" wind erosion practically disappeared.

VI. Timberland.

Those who claimed timberland in the West also had to innovate around the formal land laws. They did so by making first-possession "farm" entries to multiple 160-acre plots under the Homestead Act, Pre-emption Act, or the 1878 Timber and Stone Act. Lumbering involved fixed capital investments in sawmills and spur railroad lines and other forms of transportation to move the logs to mills and lumber to markets. These investments needed a ready and continuous supply of saw timber. There also were economies-of-scale in cruising timber for the best stands and in harvest.

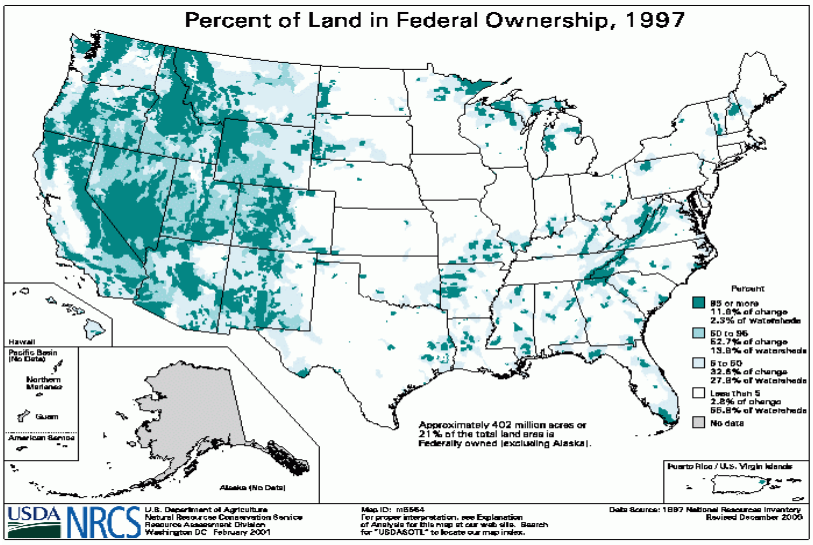
To assemble enough forest land, lumber company officials negotiated with land agents who hired entrymen to occupy and "farm" the land until title could be obtained from the General Land Office. Once title was received, it was transferred to the land agent, who in turn sold the property to the timber company for a pre-negotiated price, usually $6 to $7 per acre. Libecap and Johnson (1979, 136-8) analyze the costs of having to circumvent the land laws through fraud. They conjecture that fraud may have increased land acquisition costs by an additional $17 million in the Pacific Northwest and thereby

delayed titling by up to 6 years. During that time the land would have been vulnerable to open entry and the illegal harvest of concern to early conservationists such as Gifford Pinchot, who became the first Chief Forester of the U.S. Forest Service in 1905.

Technically "unclaimed" federal timber lands were placed under permanent federal management by the General Revision Act (Forest Reserve Act) of March 3, 1891 which created the National Forest Reserves.[36] By 1900 over 46,000,000 acres were placed in the new reserves, and today, the National Forests and grass lands encompass 193,000,000 acres, about the size of Texas.[37] As with BLM lands, the management of the National Forests by the Forest Service has been criticized for being excessively costly and dominated by constituent group politics.[38] Also, as with BLM lands, most National Forests have neither important amenity values nor significant externalities from land use that would merit government ownership. They too were retained by the government because of an inflexible land allocation policy.

Figure 2 details the extent of federal lands in the continental United States. Some are sensitive ecological areas, national parks and monuments, and Indian Reservations. Most are none of these. They instead represent the long-run results of a uniform land allocation system that turned out to be unsuitable, but could not be easily modified. The figure illustrates again the path dependencies that can occur from a faulty property rights distribution policy.

Figure 2



Source: http://www.nrcs.usda.gov/TECHNICAL/land/meta/m5554.html

VII. Surface Water.

In the Far West, surface water is allocated through first-possession under the appropriative rights system. This arrangement allows individuals to claim, move, and use water based on priority of claim.[39] Those with the earliest water claims have the highest priority and those with subsequent claims have lower-priority or junior claims. No two parties on a waterway have the same priority, so that there is a ladder of rights, ranging from lowest to highest in ranking. Water is not tied to the land, and therefore can be sold or leased separately from it.

Under the appropriative rights system, individuals were granted usufructory or possessory rights to water, rather than fee simple title.[40] The sizes of their claims were based on the market. There were no outside restrictions on individual claims, except that each party could own only what could be placed into beneficial use. Because beneficial

uses were difficult to measure, the basic test of meeting the requirement has been physical diversion.

There are no restraints on transfer so long as no harm is inflicted on other diverters, who sequentially use some of the same water. An upstream farmer who diverts water for irrigation consumes only part of it, with the remainder percolating through the ground back to aquifers, streams, or to ditches for repeated access by other downstream parties. Small water exchanges among miners or farmers within a watershed are therefore unlikely to have much impact on others. But larger trades that involve changes in the location, timing, or nature of use, are likely to have some external effects on others. Removal of significant amounts of water out of a watershed can reduce downstream flows and therefore decrease the water available for lower-priority claimants. As a result, all western states have regulated such transfers. To mitigate adverse third-party effects, state water agencies typically allow changes in diversion and location for only historical consumptive uses.[41]

The appropriative rights system is quite different from that which exists in the eastern U.S., where surface water rights are based on riparian land ownership.[42]These rights are appurtenant to the land and are transferable only with it. The arrangement works well where precipitation and streams are plentiful and more-or-less uniformly spread. In the semi-arid Far West, however, where there is a general absence of water and what exists is irregularly located, there was a need for institutional innovation that would allow water to be claimed and transferred to settlement locations, often out of the watershed. Appropriative property rights were developed through local contracting unencumbered by outside constraints, in much the same way as western mineral rights or

livestock associations were formed.[43] Appropriative water rights were often incorporated into mining claims and codes and into mutual ditch companies or irrigation districts organized by irrigators to bring water to their properties. These local rules were recognized subsequently by the states.

Appropriative water rights have supported the development of mining and agriculture in the semi-arid West. They provided security for investment in mining and agricultural water infrastructure, including elaborate irrigation networks provided by mutual ditch companies, irrigation districts and the Reclamation Service (later, the Bureau of Reclamation) to promote the region's flourishing agriculture.

The prior appropriation system also forms the basis for trading water as values change. Between 1987 and 2005, there were at least 3,267 trades for 31,417,629 acre feet of water between farmers, urban areas, and environmental uses.[44] This is a substantial amount of water, since an acre foot supplies the consumptive demands of between 4 and 6 people annually.[45]

VIII. Conclusion.

Table 2 summarizes the experience of different allocation rules for western resources.

Table 2
Summary of Allocation Mechanisms and Strength of Property Right for Five Natural Resources

Resource	Allocation Rule	Nature of the Property Right	Current Property Rights	Long-Term Results
Mineral Lands.	First-Possession.	Full, Legal Property Right.	Recognized in State and Federal Law.	Basis for Exploration and Development of U.S. Hard-Rock Mining Industry.
Range Lands.	First-Possession. Rejected.	Informal Use Rights.	Uncertain Grazing Permits. Constituent Group Politics and Bureaucratic	Informal Claims Not Recognized by U.S. Land Laws. Overgrazing.

			Objectives Determine Access and Use.	Range Land Reserved as "Public Domain" under BLM Management.
Farm Lands.	First-Possession and Uniform Allocation.	Full, Legal Property Right.	Title. Failed Farm Lands Often Reverted to Federal Ownership and Management.	Uniform Allocations Too Small. Farm Failure. Stranded Investment. Out-migration. Excessive Cultivation. Wind Erosion (Dust Bowl). Consolidation to More Optimally-Sized Farms Took 60 Years.
Timber Lands.	Uniform, "Farm" Allocations. Fraud.	Full, Legal Property Right if "Farm Claims" Successful. Trespass Otherwise.	Timber Harvest Permits.	Timber Lands Placed Under Federal Management (Forest Service)
Water Rights.	First Possession.	Use rights. Tradable Separate From Land.	Recognized in State Law.	Basis for Development of Mining and Irrigated Agriculture. Water Markets.

Overall, the development of property rights to natural resources in the western U.S. in the 19th century provides a number of conclusions about the design and allocation of property rights for consideration in fishery ITQs. One is that first-possession or recognition of existing resource use practices and allowing local conditions to determine property size is likely to be the most effective allocative mechanism in established fisheries. Its empirical regularity on the frontier suggests that first-possession has had important efficiency attributes beyond political expediency. The most successful allocations, mineral rights, membership in livestock associations, and appropriative water rights were all determined locally.

Outside government constraints on who could obtain property rights and mandates for uniform (small) allocations to meet distributional objectives had negative results for timber, range, and farm land. Small homesteads failed, stranding farm

investments and necessitating out-migration. In their desperation to earn an income on farms that were too small, homesteaders over-cultivated and under-invested in erosion control with serious environmental effects. Ranchers and timber companies could not obtain title to sufficient range and timberland. By default much of the current federal holdings of 391,340,229 acres in the continental U.S. (21 percent of the total area) were left to long-term political and bureaucratic management as the "public lands." Allocations and uses of those lands have shifted as the political influence of various interest groups has waxed and waned.[46]Agency capture has encouraged subsidies and inefficient use, and uncertainty of control has reduced resource values and incentives to invest in the resource stock.

A second conclusion drawn from the Far Western frontier is how long property rights allocations endure, even in the face of accumulating evidence that some are *ex post* inappropriate. The private transaction costs of adjustment to new arrangements and the political transaction costs of changing property assignment rules can be very high. Hence, there is opposition to change and pressure to maintain the *status quo*, resulting in path-dependencies in property distribution patterns and use.

A related, third conclusion is that substantial resource rent dissipation is tolerated because of the distributional implications of changing property rights allocations. Only late in resource use, after many of the rents have been lost are institutional changes typically enacted, and even then, they will be incrementally and incompletely adopted to mitigate political opposition.

Finally, the experience of property rights on the Far Western frontier reveals their critical importance in directing resource use, trade and investment. These benefits were

recognized by the region's early settlers who had to devise their own arrangements to meet new conditions and to avoid the potential losses of open access. In the most successful cases they were free to do so and in the other cases they were constrained by formal land policy with less positive long-term results.

In terms of implications for future ITQs in fisheries, first-possession or historical catch is likely to govern where there are incumbent fishers. Uniform allocations could be granted in new fisheries if the transaction costs of subsequent exchange are low. This is important because uniform allocations are unlikely to be of optimal size. Auctions could be used in new fisheries where there are high-valued species and limited information about the value of the fishery. Preferential assignments to certain groups of fishers (small, community) and accompanying restrictions on exchange lower the value of the property rights and the value of the fishery. They may be important for political support of the rights arrangement, but they come at a cost. Finally, the stronger the right, the better the arrangement will protect the long-term value of the fishery and the well being of fishers who are part of it.

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[1] This paper draws from Libecap (2006a, 2006b). Open-access losses are described in Garrett Hardin's 1968 *Science* article (Hardin (1968). See Stavins (2003) for discussion of the movement toward market-based instruments. Among fisheries, wild ocean and straddling stocks seem especially vulnerable. For straddling stocks, see Stokke (2000).

[2] More generally, see Stavins (1998).

[3] For example, consider success under the Clean Air Act Amendments of 1990 in designing air pollution emission permits for lowering the cost of meeting air quality targets (Tietenberg 2003, 12; Stavins 2003, 4; 1998, 6-13). Alston, Libecap, and Schneider (1996) describe the importance of title for land use and long-term investment on the Amazon frontier.

[4] Libecap (1989), Dahlman (1979).

[5] Johnson and Libecap (1994, 156-71)

[6] See Libecap (1989, 10-28).

[7] Sustainable Fisheries Act, 16 USC 1801.

[8] Arnason (2002, 12, 52-7), Leal (2005).

[9] Doyle, Singh, and Weninger (2005).

[10] I am not referring to the exchange of property, but changes in the property allocation rule: who can own, in what amounts, and what can be done with the property.

[11] For spill over between private and political transaction costs as revealed in efforts to regulate oil production in U.S. states, see Libecap and Wiggins (1984, 1985).

[12] See discussion of first possession in Epstein (1979), Rose (1985), and Lueck (1995, 1998). Alston, Libecap, and Schneider (1995) find that the original settlers on the more remote Amazon frontier in Brazil had lower opportunity costs than those who came later and who often purchased land from the initial claimants after roads were built and transportation costs to market had declined. The early settlers were younger and had less wealth and education.

[13] On the American frontier, "squatters" moved ahead of the federal land survey. When the land was subsequently surveyed and opened for claiming, "claims clubs" formed to prevent outsiders from encroaching on pre-existing holdings. See Gates (1979, 152).

[14] Alesina and Angeletos (2005, 960-80).

[15] The property right is granted to the flow, rather than to the stock, because stock ownership may be too costly to define and enforce due to the nature of the resource or to political constraints. For discussion of reasons to limit alienation in these cases, see Johnson and Libecap (1982) and Epstein (1985).
[16] Johnson and Libecap (1982) show that heterogeneity among fishers limits rent dissipation even under open-access and the rule of capture.
[17] Anderson and Hill (1990). Stavins (1995) refers to grandfathering as a give away. See also Haddock (1986) for criticism of rent dissipation when the parties are homogeneous.
[18] For summary of auction issues, complications, and applications, see McAfee and McMillan (1987, Milgrom (1989), and Klemperer (2002).
[19] See discussion by McMillan (1994) regarding the experimentation and costs of designing auctions for the spectrum.
[20] Tietenberg (2003, 10) notes that auctions were used extensively in just one ITQ in Chile. Historical catch was the dominant allocation mechanism. Lueck (1998, 136) points to the costs of auctions.
[21] Morriss, et al (2004, 748).
[22]Umbeck (1977, 436), Morriss (1998, 601), Zerbe and Anderson (2001, 133).
[23] Morriss (1998, 602).
[24] Morriss (1998, 604), Libecap (1978).
[25] Libecap (1994, 270)
[26] Dennen (1976, 433-34).
[27] Native Indian tribes of course competed with ranchers for the land which was grazed by buffalo and other wildlife, but their claims generally were not recognized. For discussion of the effects on buffalo herds as the commons emerged with the decline in Indian enforcement, see Lueck (2002).
[28] Peffer (1951, 8-62, 135-68) describes the political controversy over homestead farm size, the claims of ranchers, and efforts to adjust the federal land laws.
[29] Osgood (1929, 186) discusses the break down of local groups as outside competition for land rose, Libecap (1981, 31-7) describes the actions of the General Land Office to counter the large claims of ranchers and to remove their fences, and Morriss (1998, 666-75) discusses the Johnson County war in Wyoming as ranchers attempted to police their land claims and cattle ownership against intruders.
[30] June 28, 1934, 48 Stat 1269.
[31] Libecap (1981, 2). See also *Public Lands Statistics*, fiscal year 1998 for range land totals in the US and Alaska, and fiscal year 1996, Table 1-3 for more detailed breakdowns of federal land ownership by state, including that administered by the USDA Forest Service, and Department of Interior, National Park Service, http://www.blm.gov/natacq/pls98/98PL1-4.PDF.
[32] Libecap (1981, 65-102).
[33] Rangelands of valuable heritage and character are another matter and have been placed in National Parks and Monuments.
[34]In general, early farm settlement was more successful in the Midwest. See Ferrie (1994) and Stewart (2006) for discussion of the benefits of the capital gains in land values as a source of wealth accumulation.
[35] Hansen and Libecap (2004a, 125-8).
[36] 26 Stat.1096-97. Gates (1979, 399-400), Libecap (1994, 272). The Forest Reserves were transferred from the Department of the Interior to the Department of Agriculture in 1906.
[37] Gates (1979, 580) and U.S. Forest Service, http://www.fs.fed.us/aboutus/.
[38] See for example, Sedjo (2000).
[39] Burness and Quirk (1979). See also Kanazawa (1998) and Morriss (2001, 865, 867-91).
[40] Getches (1997, 83).
[41] Anderson and Johnson (1986) and Johnson, Gisser, and Warner (1981) describe how specifying a property right in water in terms of consumptive use with options for third party grievances can be an effective method for promoting transfers.
[42] Morriss (2001, 868). Rose (1990) discusses the evolution of property rights and experimentation with riparian rights.
[43] Glennon (2002, 14-21); Getches (1997, 74-189). Anderson and Snyder (1997, 37-44) provide a summary of irrigation institutions that developed to transport and allocate water for agriculture.
[44] Brewer, Glennon, Ker, and Libecap (2006).

[45]An acre foot is 326,000 gallons of water. http://www.cabq.gov/progress/pdf/per-capita-water.pdf reveals that an acre foot of water will supply between 4 and 8 people annually with water in the Southwest. See also http://www.santacruzsentinel.com/extra/newcentury/10/index.html for discussion of urban water use.
[46] Fiscal Year 1996 Public Lands Statistics, http://www.blm.gov/natacq/pls98/98PL1-3.PDF, continental states only.