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ABSTRACT

The federal government can undermine or support state water laws and programs by asserting its legislative power to manage domestic water resources. Predicting the future thrust of the federal government's legislative involvement in water resources can help states build flexibility into their plans and anticipate where they may be able to get federal funds to accomplish their water management plans. This paper applies the economic concept of technological externalities to predict that future federal involvement. The hypothesis of this paper has two parts: 1) that in addition to becoming involved in water resources management to provide public goods and promote the settlement of the West, the federal government also used its legislative power when externalities were present; and 2) that the externalities are non-excludable, non-rival, negative, and affect a large number of people.

To test this hypothesis, historical areas of federal water resources legislation are reviewed. They include: 1) changing or limiting surface water quantity, location, and use; 2) protection of surface water quantity; 3) protection of air quality; 4) ground water use; and 5) protection of ground water quality. The first part of the hypothesis is supported because externalities have been corrected. However, the second part of the hypothesis is rejected because the externalities associated with these areas are non-rival *or* rival, not just non-rival. The historical pattern of federal involvement is that it attempted to correct non-excludable, non-rival *or* rival, negative externalities that affect a large number of people. Applying this pattern to future areas highlights five potential areas of future involvement: instream flows, cloud seeding, wetlands, vegetation, and non-point source pollution. States should incorporate these areas into their management plans and identify other externalities to maximize their use of federal resources.

There is little in the existing structure or procedures which clearly defines the nature and extent of the federal interest in the nation's waters.

Task Committee on Federal Policies in Water Resources Planning, 1985, p. 1

INTRODUCTION

The federal government's exercise of legislative power over United States' (U.S.) domestic, navigable, freshwater, and inland water resources can cause difficulties for, or support, long-term water management by the states. The federal government exercises control by providing financial support, initiating infrastructure projects, and imposing federal regulations that constrict human action over water resources. For example, federal laws such as the Safe Drinking Water Act can require large financial burdens which must be absorbed into state budgets (Rogers, 1993). However, when the state and federal goals are similar, federal-state partnerships can help the states achieve their goal, especially when the federal government subsidizes the state's projects (Kenney and Rieke, 1997). The patterns of the past as seen through the theory of technological externalities provide insight as to the areas of the next major federal involvement in water issues and creates a test that can be used by the states to determine what water resource issues they should incorporate into their management plans.

The hypothesis of this paper has two parts: 1) that in addition to becoming involved in water resources management to provide public goods and promote the settlement of the West, the federal government also used its legislative power when externalities were present; and 2) that the externalities are non-excludable, non-rival, negative, and affect a large number of people. The federal government's first justification for its involvement in water resources was based on providing public goods (Task Committee on Federal Policies in Water Resources Planning (Task Committee),

1985; Rogers, 1993; Haveman, 1972). The second justification was to encourage the settlement and development of the arid western U.S. where large, reliable water supplies demanded large investments (Holmes, 1972; Conservation Foundation, 1984; Rogers, 1993; Reuss and Walker, 1983). The argument of this paper is that a third, unnamed justification was the correction of externalities.

This paper is structured according to the purpose of the federal historical legislative involvement (excluding its role as a proprietor of federal lands). The different purposes include: 1) changing or limiting surface water quantity, location, and use; 2) protection of surface water quality; 3) protection of air quality; 4) ground water use; and 5) protection of ground water quality. The underlying externalities of each area are identified and characterized. A historical pattern of federal action through legislation is then discerned, comparisons made, and future predictions of federal involvement are forecast.

The review shows that the federal government's historical involvement in building canals, improving navigation, providing flood protection in situations where there is no human action upstream that causes the flood, creating a water supply for irrigation and municipal uses, creating recreational opportunities for the public, and limiting a state's right to limit ground water exports are based on the public goods and economic development justifications. In addition, the third justification, externalities, is present where the federal government reactively began regulating construction in navigable rivers; the water use of bathroom appliances; development that destroyed wild and scenic rivers, species and the environment; surface water quality; air quality; and drinking water quality. The federal actions under scrutiny are reactive, not proactive,

because there is already a problem (the externality) which it attempts to correct. In addition, the federal government tried to counter the externality associated with upstream development and floods by building flood control structures. Therefore, the first part of the hypothesis is supported because the federal government has corrected externalities in addition to providing public goods and promoting economic development.

The second part of the hypothesis is rejected because the externalities associated with these areas are non-rival *or* rival, not just non-rival. All the externalities are non-excludable, negative, and affect and large number of people. The non-rival externalities include clearing navigation obstructions, limiting non-federal hydropower development which could impair navigation, destroying wild and scenic rivers, extirpating species, protecting the environment, and degrading the quality of surface water bodies used for recreation. The rival externalities include floods that threatened property and human life from upstream development, a shortage in irrigation and municipal water supply or higher costs, degradation of surface water quality used by people and industries, acid rain, climate modification, and threats to public health from polluted ground water. The rival characteristic is important where there are consumptive uses of water—the water is taken out of the river, aquifer, or atmosphere. The non-rival characteristic is present where there are non-consumptive uses of water—the water is used *in situ*.

The historical pattern is that the federal government attempted to correct non-excludable, non-rival *or* rival, negative externalities that affect a large number of people. Applying this pattern of externalities shows that maintaining instream flows, regulating cloud seeding, protecting wetlands, regulating vegetation planting and removal, and regulating non-point source pollution are all possible areas of future federal involvement

in water resources. The states can maximize their use of federal resources by incorporating these predictions into their management plans by creating state regulations or projects that would use future federal funding.

LITERATURE REVIEW

Definition of an Externality

This paper looks at technological externalities (what is meant by the use of the word "externality" throughout the paper) which are different from pecuniary externalities. Pecuniary externalities have been defined by Baumol and Oates (1988) as "…pseudo externalities…in which one individual's activity level affects the financial circumstances of another but which need not produce a misallocation of resources in a world of pure competition (p. 29)." Technological externalities, on the other hand, refer to the original misallocation of resources. It is possible for the original misallocation to result in subsequent pecuniary externalities when the affect to the original party affects the financial situation of other parties. Baumol and Oates (1988) provide a qualitative definition of a technological externality that is based on a mathematical relationship:

> An externality is present whenever some individual's (say *A*'s) *utility* or *production* relationships include real (that is, nonmonetary) variables, whose values are chosen by others (persons, corporations, governments) without particular attention to the effect's on *A*'s welfare (p. 17).

What this definition highlights is that an externality can be found when the actions of a person or entity (the "generator") affect another person or entity (the "victim") and the affected party has no control over the benefits or costs they receive. *Natural causes cannot create an externality*. For example, if a firm's actions cause harmful levels of arsenic in ground water that contaminates other people's wells then an externality is present. However, if that same arsenic naturally occurs in the environment,

there is *no* externality present, because the negative effects are the by-product of natural causes, not a *human* action. A second definition by Pigou (1932) highlights the fact that there is no exchange of money for the service or disservice provided by the externality. The source of an externality is ill-defined property rights that cause a misallocation of resources, which can possibly be remedied by government intervention to correct the market failure (Baumol and Oates, 1988; Head, 1974; Schotter, 2001).

Natural causes that do not create externalities include the movement of the water through the hydrologic cycle due to natural processes. This includes precipitation, evaporation, evapotranspiration, runoff, flowing rivers, ground water movement, and melting glaciers. Human actions that may create externalities include any physical or chemical alteration of the water's movement through the hydrologic cycle. These actions include adding pollutants to the water, diverting water from the river or lake, pumping ground water, etc. In addition, actions such as development and land use practices can alter the water's movement through the hydrologic cycle, thereby causing externalities. For example, increasing the area covered by impervious surfaces can increase the amount of runoff reaching the river and potentially cause floods downstream. Land use practices, such as applying pesticides and fertilizers, can also alter the chemical composition of the water when they become dissolved in the natural runoff. The externalities are identified by establishing the generators and victims of an action due to the importance of natural and human causes and affects in defining an externality.

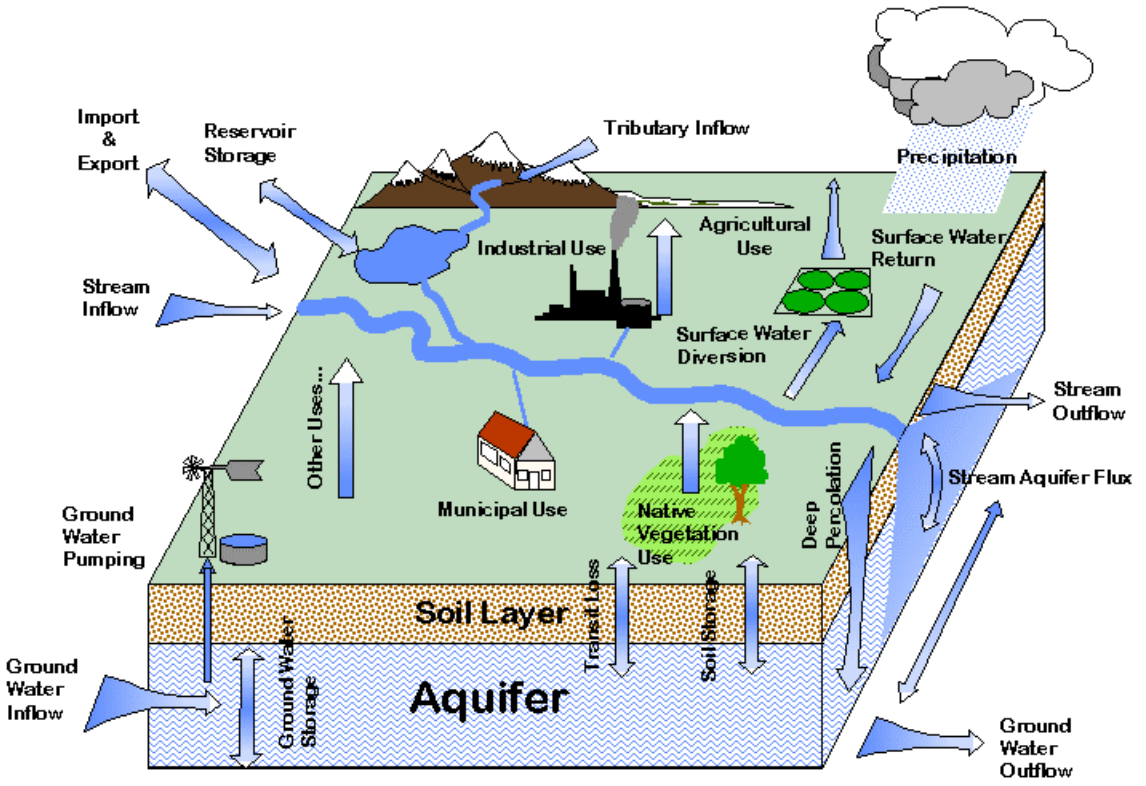
Identifying Generators and Victims

The movement of water through the hydrologic cycle and human perturbations to the quantity, quality, and location of the water provide the physical basis for the

qualitative review of the types of externalities present. In order to identify externalities, it is necessary to establish the generators and victims of the possible externality. According to the definition of an externality, if natural causes are either the generator or the victim, there is no externality. However, if humans are the generators and victims, then there could be an externality present. The federal government cannot be a generator or victim in this paper because this paper looks at externalities that are present *before* the federal government has provided support, built projects, or passed regulations. Furthermore, this issue of timing automatically eliminates any externalities created by the federal government's involvement in water resources.

Figure 1 shows the movement of water through the hydrologic cycle and the ways humans physically and chemically change the water (industrial use, agricultural use, return flows, municipal use, reservoir storage, and ground water pumping). Examples of natural processes that do not create externalities include the variables that change flows to and from the atmospheric water stock: precipitation, evapotranspiration (affected by the vegetation and surface water on the landscape and the moisture capacity of the air), temperature, and wind. As all of the arrows show, the change in the quantity of water in one of the stocks (atmospheric, surface (including glaciers), and ground water leads to an opposite change in the amount of water in another stock. This change in quantity can affect quality, especially if the change in quantity is the result of evaporation that removes pure water and leaves behind the impurities. The quality of the water vapor in the atmosphere is influenced by industries that emit pollutants into the air, which can cause acid precipitation. That is an example of a human action that can cause an externality.

Figure 1. Physical and chemical perturbations to the hydrologic cycle



Source: Colorado Division of Water Resources, Office of State Engineer

Surface water can be stored or flowing. Stored surface water includes liquid freshwater (lakes, wetlands, etc.) and frozen freshwater (glaciers). This diagram only shows the unnaturally stored surface water (reservoirs), but lakes, wetlands, and swamps can be added to the stored water category. Climate change also affects the amount of stored surface water through increased evaporation which has resulted in shrinking glaciers (Egan, 2005).

Ground water quantity is affected by decreased infiltration (building impervious surfaces), pumping, evapotranspiration (native vegetation use), and evaporation from the land surface and soil layer. The quality of the ground water is affected by a decrease in quantity (dilution effect) and return flows (especially from agricultural uses) that percolate to the ground water instead of running off into the surface water. If human

actions change the amount of infiltration, ground water level, amount of evapotranspiration, or quality of the ground water, then there could be an externality. However, if these changes are natural, then there is no externality, even if it affects people in the area.

Characteristics of Externalities

The nature of an externality is based upon its definitive characteristics as a good. These characteristics can be some combination of any of the following: excludable or non-excludable, rival or non-rival, positive benefits or negative benefits, and affecting a small number or a large number of people. A good that is excludable means that one person can exclude another from using it, and a good that is non-excludable is one where the use of that good is available to everyone (Cornes and Sandler, 1986). Externalities cannot be excludable because there can be no property rights assigned to them (Varian, 1990).

A good that is non-rival means that "…a *unit* of the good can be consumed by one individual without detracting, in the slightest, from the consumption opportunities still available to others from that *same* unit (p. 6)" [emphasis in original] (Cornes and Sandler, 1986). The rival or non-rival nature of an externality related to water resources usually depends on the use of the affected water. Non-consumptive uses of the water create non-rival externalities and consumptive uses of water create rival externalities. This is because if the water is left *in situ* (in place) and not consumptively used, then all the people that want to use the water are faced with the same situation. One person boating or swimming in polluted water does not affect the level of polluted water faced by other people who want to boat or swim. However, if the polluted water is used to supply a

municipality, then it is consumptively used because the municipality physically removes water from the source. Unless the water is perfectly mixed, the externality will be rival because it will change the amount of pollution (higher or lower) faced by the other users for consumptive or non-consumptive uses. If the water is perfectly mixed, then the externality would be non-rival. However, it is assumed that the water is not perfectly mixed in the pollution situations of this paper.

An externality can provide either positive or negative benefits to the affected party. An example of a positive benefit is increased precipitation in arid areas (assuming that it does not cause flooding). Negative benefits can be water pollution which can limit the suitability of water for specific uses or threaten public health, the destruction of property from flooding, and if navigation is impaired. It is also possible to have both positive and negative effects from one action, depending on the victim. For example, cloud seeding, a process by which people try to increase the amount of precipitation, can have both a positive or negative effect: positive if people who do not pay for the service receive needed rainfall and negative if people who do not pay for the service receive a hazardous amount of additional rainfall. Therefore, the benefit characteristic of externalities is dependent upon the generators and victims.

The number of people affected by an externality is another important characteristic and relates to ability of the affected parties to correct the externality without outside interference. For example, if an externality is limited to two parties, one generator and one victim, then negotiation may be more feasible than creating a nationwide tax to target that one generator (Baumol, 1972). On the other hand, for an externality that affects a large number of people, government interference in the form of a

nationwide tax would be able to target that large number of producers (Baumol, 1972). This is important to consider for federal involvement in water resources, because when a large number of people are affected, it indicates that federal involvement is appropriate. The federal government is not likely to be involved in externalities where a small number of people are affected. However, it is possible to have a small number of people affected in one area, but have the same problem in multiple areas. In this case, the externality would be considered to affect a large number of people.

The specific combination of these four characteristics determines the nature of the externality. However, it is possible for an externality to have the same characteristics of a public good if the externality is non-excludable and non-rival (Baumol and Oates, 1988). The externalities, therefore, may have been misnamed as public goods—a historical justification for federal involvement in water resources (Task Committee, 1985; Rogers, 1993; Haveman, 1972). One outcome of this review is that it will separate the externalities from the public goods.

Past Discussions of Federal Involvement in Water Resources

The federal-state relationship in managing water resources is based on the federal government's commerce, proprietary, general welfare, treaty making, judicial, compact, and war powers (Thompson, 1999). All of these powers preempt state laws that conflict with federal law and programs under the Supremacy Clause of the U.S. Constitution (Getches, 1997). The extent of the federal government's power over water resources is vast. As Getches (1997) explains, "The question is rarely whether power exists, but rather whether Congress intended to exercise its power to displace state law (p. 347)."

Therefore, although a discussion of federal power is important, it can be saved as an area for further study.

The actions undertaken by the federal government in its role as a proprietor—it owns about one third of the land in the United States—are excluded from this paper (Cunha, et al., 1977). We are looking at what is happening *before* there is a federal presence whose involvement can negatively or positively affect the *states'* abilities to manage their water resources. Although the federal government's land management practices affect water resources and humans, they do not always directly impose upon a state's power over its water resources. However, federal land grants to states to sell and raise money for water projects (1850 Swamp Act and 1894 Carey Act) are included because they provided support for state water projects (Thompson, 1999; Rogers, 1993; American Public Works Association (APWA), 1976).

There have been many publications that describe, explain, and analyze the history of the federal government's legislative involvement in water resources from 1800 to 2005; however, none have applied the theory of externalities to understand and predict future areas of federal involvement. Holmes (1972) and Holmes (1979) provide the factual history of the federal government's legislation, programs, and ideology/rationale concerning water resources from 1800 to 1970. Thompson (1999) and Kenney and Rieke (1997) also divide the history by time but attach descriptive names to the periods. Kenney and Rieke (1997) explain the rationale behind their six time-periods as highlighting "…important intergovernmental and bureaucratic trends that distinguish them from other periods in American history (p. A-11)." Organizing the history into time

periods allows people to understand the federal involvement at one period, but does not provide an indication of future involvement.

The economic justifications for federal involvement in water resources have also been thoroughly researched. Cost-benefit analysis has been used to justify federal participation in building dams, reservoirs, irrigation and municipal supply systems, and environmental programs (Holmes, 1972). Although Cunha, et al. (1977) mentioned externalities, the discussion was focused on explaining the economics behind internalizing externalities and did not characterize them. The difference between their analysis and this review is the timing issue: Cunha, et al. (1977) focus on what happens *after* the federal government is involved, and this paper focuses on what has happened before the government is involved. Therefore, this paper fills a gap in the literature by using the economic concept of externalities to review past federal involvement and predict future involvement.

The history has also been analyzed by looking at the balance between federal, state, and local involvement in projects or watersheds. The League of Women Voters (1966) looks at the history on a project basis, while Kenney and Rieke (1997) use a watershed basis. This paper uses a more general view: area of involvement. By not looking at specific projects or specific geographic areas, it is possible to generalize the specific problem that the federal government was attempting to address through providing financial and technical support or passing regulations.

There are also varying explanations for why the federal government uses its power to support states and national improvements and standards. Moreell (1956) gave a series of lectures wherein the main thrust was that the federal government had constantly

overstepped its power by involving itself in water resources (the early Presidents had held this viewpoint as expressed in their vetoes of certain bills). He went on to explain that the problem was that once the federal government had started it could not stop and in essence provided a socialistic service—the nation's taxes were being used to benefit local interests. Rogers (1993) explains that the federal government could not stop because new problems kept emerging such as water pollution and environmental protection. The League of Women Voters (1966) explains that the federal government has provided socialistic services because the projects are big (cross boundaries) and require large amounts of money. These ideas suggest that the federal government had multiple reasons for managing the nation's water resources, and that externalities could have had a role in continuing the federal government's involvement in water resources. Rogers' (1993) mention of water pollution and environmental protection could refer to human actions that are negatively affecting other water users—possible externalities. In addition, the League of Women Voters' (1966) mention of the size of the projects suggests that a large number of people were affected by those human actions, which would require a governmental solution, possibly at the federal level.

METHODOLOGY

The review is categorized according to the areas of federal involvement. The federal government was involved in canals, navigation improvement, flood control, recreation, municipal and irrigation supply (dams and reservoirs), and the protection of surface, atmospheric, and ground water quality. This type of review is in contrast to the typical chronological categorization used by Holmes (1972), Holmes (1979), Rogers (1993), Thompson (1999), and Kenney and Rieke (1997). The externalities, if present,

are then identified and characterized based on the four characteristics: excludability, rivalry, the benefit (positive or negative), and the population affected (small or large).

This information is organized in a table and qualitatively compared in order to identify the pattern. The first part of the hypothesis is answered by seeing if there are any externalities. If there are externalities, then part one is supported. If there are no externalities, then part one is rejected and part two is irrelevant. The second part of the hypothesis is answered by looking at the table and comparing the characteristics of the different externalities.

Other areas of water resources are then identified and assessed for the presence of externalities and the nature of that externality. The potential for these new areas to be pursued by the federal government is assessed using the previously determined historical externality pattern. If no externalities or trends were found in the historical review, then it would have been concluded that externalities were not an appropriate way in which to view the federal government's involvement in water resources.

REVIEW OF THE AREAS OF FEDERAL INVOLVEMENT

The federal government's involvement in water resources began with using its engineering expertise to conduct studies on how to improve the flowing surface water sources for human purposes. The United States Army Corps of Engineers (Corps) was the federal agency in charge after the passing of the 1824 General Survey Act and focused on creating plans for canals that would connect national trade routes (Rogers, 1993; Holmes, 1972). Subsequent Congressional enactments extended the Corps' responsibility to rivers and harbors, and the 1826 Rivers and Harbors Act solidified this area of involvement and expanded it to include not just surveys but also designing and

constructing improvement projects (Holmes, 1972). The natural constraints that prompted the federal government's involvement were the limitations imposed on trade from the natural waterway systems. The flowing surface water was not sufficiently interconnected or reliable which impeded the efficiency of national trade. The solution: control the water with human structures so that it served the purpose of commerce.

This federal interest in trade expanded from canals (constructing artificial channels) to navigation improvements and flood control (altering existing channels). Research and surveying were still major roles for the federal government, especially since the federal agencies were now determining what projects needed to be constructed, designing the projects, funding the projects, and managing the projects (Reuss and Walker, 1983; Rogers, 1993; Holmes, 1972). The history, timing, and limits concerning the federal government's exercise and recognition of power to construct navigation and flood works encompass entire books (Holmes, 1972; Homes 1979) and will be simplified to explaining how natural processes and human actions have influenced the level of federal involvement in providing public goods, promoting economic development, and correcting externalities.

This review covers surface, ground, and atmospheric water resources. The federal government has historically been most heavily involved in the surface water component of the hydrologic cycle, focusing more on the quantity than the quality of navigable surface waters. More recently, the federal interest has expanded into ground water, but only on a small level: limiting the states' rights to ban the export of ground water and providing resources for water quality improvements. Atmospheric water has not been directly addressed, but federal action (i.e., the passing of the Clean Air Act) has resulted

in decreasing the source of water quality issues—emissions of greenhouse gases. The areas of involvement under the purpose of changing or limiting surface water quantity, location, and use include canals, navigation improvement, obstructions in rivers, hydropower, flood control, irrigation and municipal supply, recreation, and the preservation of natural conditions and minimum flows.

Change or Limit Surface Water Quantity, Location, and Use

Canals

The federal government became involved in canals long after there had already been a significant amount of private and state investment (APWA, 1976). Federal interest began with providing resources in the form of surveys after the 1824 *Gibbons v. Ogden* court decision, and also involved land grants in the 1860s on which the canals could be built (APWA, 1976). The canal era ended before the federal government became heavily involved due to the growth of the railroads (APWA, 1976).

Building canals attempted to improve the natural impediments of the rivers for commercial traffic due to unreliable flows, impassible sections, and insufficient links to other rivers and cities. These problems negatively affected the people and companies (the victims) who wanted to use the water for commerce and the people who lived and worked in the cities that were isolated from the broader market. However, there was no externality present in this case, because there were no human actions (the generator was natural causes) within a market context that provided a service or disservice to other people. The federal government became involved to correct the negative qualities of the rivers and provide a private good that people could use when they paid a fee, not correct

problems due to a human action (Table 1). The federal government has been more involved in improving existing waterways than in constructing canals.

Navigation Improvement

The federal government's activities to improve navigation are limited to water that falls under the definition of "navigable." Navigable has been defined as "the waters of the United States (p. 95)," which is still a rather ambiguous definition (Rogers, 1993). Navigation improvement began with "[t]he Court's decision [in *Gibbons v. Ogden* that placed navigable waters under federal control] and the concurrent passage of legislation for improvement of the Ohio and Mississippi Rivers by channel clearing…(p. 3)" (Holmes, 1972). This led to federal removal of debris, widening of channels, and deepening of channels (Moreell, 1956; Thompson, 1999; Holmes, 1979). This case is similar to canals because nature, not a human action, is the generator. Trees would fall in and block the flow and sediment was deposited, making the water shallow and impassable. There was no externality present; however, the federal government provided a public good through its actions that affected a large number of people (Table 1). It provided a public good because they did not exclude people from using the improved river and the benefits were non-rival—boating is a non-consumptive use of the water.

Obstructions in Rivers

The 1899 Refuse Act restricted dumping garbage and materials, hydropower development, diverting water, and building dams, bridges, wharves, piers, channels and harbors without the authorization of the federal government (Holmes, 1972). "The Refuse Act prohibited the discharge of any nonliquid material into navigable waterways (p. 37)" (Thompson, 1999). "In 1890, Congress also adopted a general prohibition

Table 1. The externalities and their characteristics

Purpose	Area of Involvement	Generator	Victim	Externality	Characteristics			
					Excludability	*Rivalry*	*Benefit*	*Population Affected*
CHANGE OR LIMIT SURFACE WATER QUANTITY, LOCATION, AND USE	Canals	Natural causes	People isolated from the market	None	N/A	N/A	N/A	N/A
	Navigation Improvement	Natural causes	People who want to navigate the river	None	N/A	N/A	N/A	N/A
	Obstructions in Rivers	Human development of the river	People who want to navigate the river	Impair navigation and destroy property	Non-excludable	Non-rival	Negative	Large
	Hydropower	People and companies who built hydropower works	People who want to navigate the river	Impair navigation	Non-excludable	Non-rival	Negative	Large
	Flood Control	Natural causes	Downstream inhabitants	None	N/A	N/A	N/A	N/A
		Non-federal development upstream	Downstream inhabitants	Threaten property and human life	Non-excludable	Rival	Negative	Large
	Irrigation and Municipal Supply	Natural causes	People who live or farm in the area	None	N/A	N/A	N/A	N/A
		Large water users	Other users connected to the system	Shortage of supply or higher costs	Non-excludable	Rival	Negative	Large
	Desalination	None	N/A	None	N/A	N/A	N/A	N/A

Purpose	Area of Involvement	Generator	Victim	Externality	Characteristics			
					Excludability	*Rivalry*	*Benefit*	*Population Affected*
CHANGE OR LIMIT SURFACE WATER QUANTITY, LOCATION, AND USE	Recreation	Natural causes	People who want water-based recreation	None	N/A	N/A	N/A	N/A
	Preserving Natural Conditions and Minimum Flows	Development and human pollution	People who value the environment and recreation	Destroy wild and scenic rivers	Non-excludable	Non-rival	Negative	Large
		Development and human pollution	People who value the species	Extinction of species	Non-excludable	Non-rival	Negative	Large
		Development and human pollution	People that value the environment and its amenities	Destroy environment	Non-excludable	Non-rival	Negative	Large
PROTECTION OF SURFACE WATER QUALITY	Clean Surface Water	People and industries	Downstream users of the water	Degrade water quality	Non-excludable	Rival or Non-rival	Negative	Large
PROTECTION OF AIR QUALITY	Clean Air	Industries that emit pollutants	People who value fish & limestone artifacts	Acid rain	Non-excludable	Rival	Negative	Large
		Industries that emit pollutants	Everyone affected by the weather changes	Climate modification	Non-excludable	Rival	Negative	Large
GROUND WATER USE	Exportation	State banning ground water export	Residents in other states who want to import ground water	None	N/A	N/A	N/A	N/A
PROTECTION OF GROUND WATER QUALITY	Safe Drinking Water	Human land use practices	People who use the polluted ground water	Threat to public health	Non-excludable	Rival	Negative	Large

against the building of dams in navigable waters without permission of the Secretary of War (p. 5)" (Holmes, 1972). This action regulated private and public (state and local) development of navigable surface water for hydropower generation and placed it under the power of the federal government. The Refuse Act tried to limit human action (the generators) that could negatively affect people (the victims) who wanted to navigate the river. There was an externality present that was non-excludable, non-rival, negative, and it affected a large number of people (Table 1). The externality was non-excludable because the people impairing navigation could not control whom they affected. It was non-rival because the water was only used for navigation, a non-consumptive use, and so the same physical situation was facing everyone. In addition, it was negative because it constrained other people's actions on the river. Lastly, it affected the large number of people who wanted to navigate the river. In addition to this general regulation of water use, there were also specific regulations that addressed people's ability to use water for hydropower development.

Hydropower

Specific Congressional Acts also controlled the use of the rivers for hydropower generation. The 1920 Federal Water Power Act (1920 Act) regulated the use of power generation using federal projects, and the 1945 Flood Control Act loosened the 1920 Act's reach by allowing flood control reservoirs to be used to generate power (Rogers, 1993). In effect, the 1920 Act constrained the number of non-federal works and obstructions that would affect the navigability of the water. It addressed the same obstruction problem that was covered by the Refuse Act, but focused on dams that were built specifically for hydropower generation. The

generators of the externality were the people who built dams in the rivers, and the victims were the people who wanted to navigate the rivers. The externality present at that time was non-excludable, non-rival, negative, and affected a large number of people for the same reasons as stated in the obstructions in rivers section (Table 1).

Flood Control

The trade-based development focus of canals and navigation improvement evolved to protecting private property from harm due to devastating floods. The 1850 Swamp Act allowed the federal government to give swamplands to states so that they could drain the water and sell the land to pay for the construction of levees (Rogers, 1993; Holmes, 1972; Reuss and Walker, 1983). At this time, Congress limited the federal role to the provision of resources, not allowing federal agencies to construct the levees (Holmes, 1972). Therefore, land was used as a way to provide money for the states to fund structural solutions to prevent flooding.

The federal role in development was initiated by a series of destructive floods that highlighted the need for comprehensive and continuous protection. As Haveman (1965) explains,

> Until 1879, flood control was viewed by Congress as a purely local problem and, consequently, an area which the Federal government should refrain from entering. Because of the disastrous flood of 1874 in the Mississippi Valley, however, the opinion that local interests could no longer control the erratic force of the giant stream became widespread. In 1879, Congress, reacting to the growing pressure, put the Federal government into the field of flood control with the passage of a bill creating the Mississippi River Commission (p. 4-5).

The creation of the Commission did not result in an immediate involvement beyond resources and expertise. It was not until 1890 that Congress eliminated the restriction of using federal money to construct levees (Holmes, 1972). The direct authorization for

development came with the 1917 Flood Control Act, which was a response to destructive floods in 1915 and 1916 (Graves, 1995; Holmes, 1972; Rogers, 1993). The federal government was responding to the threat to human life and property posed by the floods.

The presence or absence of an externality present before federal flood control works depends on who caused the flooding (who is the generator): the river or people. There was no easy way to separate whether the river or people's development activities upstream caused the flooding that affected the downstream inhabitants. Therefore, it was necessary to theoretically separate the two actions and evaluate the presence of an externality in both situations. If the river caused the flooding (was the generator), then there was no externality present because there was no human action that caused the destructive flooding.

However, if human development caused the flooding (was the generator) then there would be an externality present because one upstream person's action threatened the property and lives of all the downstream inhabitants (the victims). This externality was non-excludable, rival, negative, and it affected a large number of people (Table 1). It was non-excludable because everyone downstream was affected, rival because one person's land being flooded meant that there was less water to flood another person's land, negative because it damaged property and posed a threat to people's lives, and it affected a large number of people as long as there were a large number of downstream inhabitants. In addition to having problems with too much water, there have been problems with supplying enough water for agriculture and urban areas.

Irrigation and Municipal Water Supply

The federal government has also supplied water to the public, especially in the arid West where any successful settlement hinged on having reliable water supplies (APWA, 1976). As with a number of the different types of water improvement projects, supplying water for irrigation began with the federal government using land to achieve its goals of development in the West (APWA, 1976). The APWA (1976) explains the situation:

> The ownership and distribution of water is the single greatest problem in western agriculture. The division of water supplies determines the pattern of settlement and the degree of success in farming. A need for construction of large-scale public works in the community interest was demonstrated early. As population increased and the readily available water supplies were tapped and distributed according to new laws and regulations, the natural flow of the streams during the growing season put a ceiling on development; and it became apparent that large reservoirs would be required (p. 309).

The federal government's purpose was to settle the land in the West, and it tried many different ways to provide incentives to settlers to accomplish this goal. However, it realized that people needed both land and water, not just land.

The federal government passed Acts such as the 1877 Desert Land Act and the 1862 Homestead Act which gave land to individual settlers (APWA, 1976; Rogers, 1993). In an attempt to provide water to these settlers through the states, the federal government also passed the 1894 Carey Act which gave land to states, not individuals, to sell and raise money to build water projects (APWA, 1976; Rogers, 1993). It was not until the 1902 Reclamation Act that the government became involved in the large-scale supply of irrigation water (APWA, 1976).

The problem with the first three Acts was that they supplied people with land but forced the people to find a reliable water supply. This meant that the land with "easy

diversions, short canals, and limited storage (p. 310)" was settled, leaving vast areas without settlement (APWA, 1976). The federal government then realized that it also needed to provide water to attract more settlers to the West and passed the aforementioned Reclamation Act to accomplish this goal. The federal government therefore went from providing the resources for individuals and the states to develop a water supply to developing the water supply itself.

The federal government also allowed their reservoirs to be used to supply municipalities under the 1944 Flood Control Act (APWA, 1976). Previously, the municipal use of federally stored water was not the primary purpose for constructing the reservoir, but a secondary use that went along with irrigation projects (APWA, 1976). These federal actions were not an attempt to correct an externality because there was no human action that was causing the irregular and scarce water supply—that was done by natural causes.

Another federal action related to municipal water supply was the passing of the Energy Policy Act in 1992. Section 325 set national water efficiency standards that companies manufacturing faucets (2.5 gallons per minute), shower heads, and flush toilets (1.6 gallons/flush) have to adopt for their new products after January 1, 1994 (Rogers, 1993). This legislation was aimed at conserving water supplies in the face of growing demand and low water prices. However, unless there was a human-created shortage of supply or higher costs due to large water users, there was no externality. It was only if people were using large amounts of water which resulted in a shortage or higher costs imposed on other users that an externality was created. The externality was non-excludable, rival, negative, and it affected a large number of people (Table 1). It was

non-excludable because it was imposed on everyone connected to the system, rival because the more water one person used the less there was available for everyone else, and negative because people did not receive the amount of water they wanted or needed. In addition, it affected a large number of people where the water supply system was large. There have also been other non-structural solutions to increase municipal water supplies.

Research into the process of desalination to augment municipal water supplies began in 1952 with the Saline Water Act (Rogers, 1993). Subsequent Acts have also been passed that concerned the desalination program's activities and funds. These Acts include the Saline Water Conversion Act of 1971, the Water Research and Conservation Act of 1977, the Water Research and Development Acts of 1978 and 1984 (Mielke, 2002). The most recent legislation was the 1996 Water Desalination Act which created the Water Desalination Research Development Program (Mielke, 2002). The federal government wanted to develop more efficient and inexpensive desalination methods. This research has been applied to non-federal desalination plants and federally subsidized desalination plants are currently under discussion within House Bill 1071 (Holtz-Eakin, 2005). If this bill passes, then it would be correcting an externality that is non-excludable, rival, negative, and affects a large number of people.

The generator of the externality created from the limited potable water supply that had to be augmented by desalinated water are the people who are diminishing the dilution capacity of the surface water by diverting water and returning lower quality water. The generators of the externality for brackish ground water are the people who are pumping all the potable water from the ground. The generators of salt water intrusion are the

people pumping ground water near the ocean and decreasing the amount of fresh water that is in the ground. The victims of all these externalities are the people who use the water—this can be the same people who cause the externality. The externality is non-excludable because the people who are pumping the ground water or decreasing the surface water quality cannot control who is affected by it. It is rival because if one person takes out potable water then there is less potable water left for others. In addition, it is negative because if there is a water shortage then people will have to pay more to get water or be faced with creating alternatives to their current water supply. The externality affects a large number of people because a large number of people live in coastal areas and the southern parts of the country that have the brackish water.

Recreation

Another area of federal involvement bestowed another public good on the general public—recreation—and allowed this use to be added to development projects. Recreation was first recognized along with municipal water supply from reservoirs in the 1944 Flood Control Act (Rogers, 1993). Subsequent Acts such as the 1954 Flood Control Act, the 1962 Rivers and Harbors Act, and the 1965 Water Project Recreation Act further legitimized recreation as a purpose and increased the number of reservoirs that could allow recreational activities (Rogers, 1993). The absence of recreational opportunities is not an externality because there was no service or disservice arising from a human action. The federal government was correcting a natural constraint to human leisure activities. It is possible that the federal government created externalities by providing these public goods, but since the externalities are not present *before* the federal involvement, they are outside the scope of this paper.

Preserving Natural Conditions and Minimum Flows

The federal government has used its power to protect the environment, which includes water resources. The most direct attempt to preserve the natural amenities of flowing water was the Wild and Scenic Rivers Act of 1968. This Act "…was designed to preserve, in a free-flowing condition, certain waters possessing outstanding scenic, recreational, fish and wildlife, geologic, historic, or other cultural characteristics (p. 61)" (Thompson, 1999). Rivers that received this designation were protected from development which would destroy the aforementioned features. An externality may or may not have been present depending on who or what was found to be the victim. If the river was protected from human action (the generator) that negatively affected people (the victims) who wanted to use it for recreational activities or valued the river itself or the ecosystem it sustained, then there was an externality. The externality in this case was non-excludable, non-rival, negative, and it affected a large number of people (Table 1). The externality was non-excludable because the people developing the river could not control whom they affected, non-rival because the victims used the river non-consumptively (natural beauty, recreation, environmental value), and negative because it provided a disservice to people who valued the river for its natural amenities. In addition, it affected the large number of people who valued the river. However, if the river was protected for environmental reasons that do not have a human victim then there was no externality.

The 1973 Endangered Species Act (ESA) indirectly affected water quantity aspects of surface water (Rogers, 1993; Thompson, 1999). The ESA has required minimum flows for endangered species, such as the silvery minnow in the Rio Grande, and tried to limit the human influence on the water resource—limit in the sense that water

must be left in the river (Defenders of Wildlife, 2000). In addition, it has halted development projects that have the potential to affect the habitat of an endangered species (Thompson, 1999). The ESA corrected an externality. The externality was the extinction of species through human action, namely development that destroyed the habitat or species itself, thereby affecting people according to their preference structure. Some people may have valued the existence of a species, and this value was negatively affected when the species died. This externality was non-excludable, non-rival, negative, and it affected a large number of people (Table 1). It was non-excludable because the generator of the externality could not control whom they affected and non-rival because affecting one person did not diminish the amount of the externality that others faced—the victims had non-consumptive uses for the water. It was negative because it provided a disservice and affected a large number of people because it was possible to affect anyone in the world who valued the species.

There are also many other environmental laws that have affected water resources (Table 2). For example, the National Environmental Policy Act (NEPA) of 1970 requires Environmental Impact Statements on activities that may affect the environment, which includes water resources (Thompson, 1999). The externality discussion for these laws is similar. If the law constrained human action (the generator) that negatively affected another human (the victim), not just the environment, then there was an externality present. These externalities would all be non-excludable, non-rival, negative, and affect a large number of people (Table 1). The reasoning for these characteristics follows the ESA externality, only instead of valuing a species, the environment is the value that is being destroyed. The externality is non-rival because we are looking at environmental

Table 2. Federal environmental laws

Name	Purpose
1934 Fish and Wildlife Coordination Act	Provisions must be made in federal projects for wildlife if economically practical (Rogers, 1993)
1954 Small Watershed Act	Established the Soil Conservation Service's small watershed program (Rogers, 1993)
1958 Fish and Wildlife Coordination Act	Wildlife preservation received equal consideration in water resources projects (Rogers, 1993)
1964 Wilderness Act	Preserved certain areas of national parks from any development (Rogers, 1993)
1964 Land and Water Conservation Fund Act	Financed of outdoor recreation by admission stickers (Rogers, 1993)
1965 Anadromous and Great Lakes Fish Act	Promoted preservation and development of fish resources (Rogers, 1993)
1970 National Environmental Policy Act (NEPA)	Required environmental impact statements for any significant federal action and set up the Council on Environmental Quality (CEQ) (Rogers, 1993)
1973 Endangered Species Act (ESA)	Created a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found (U.S. EPA, 2005b)
1976 Resource Conservation and Recovery Act	EPA given the authority to control hazardous waste from the "cradle-to-grave" (U.S. EPA, 2005d)
1976 Toxic Substances Control Act	Gave EPA the ability to track the 75,000 industrial chemicals currently produced or imported into the United States (U.S. EPA, 2005e)
1980 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund)	Created a tax on the chemical and petroleum industries and provided broad Federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment (U.S. EPA, 2005a)
1990 Pollution Prevention Act	Focused industry, government, and public attention on reducing the amount of pollution through cost-effective changes in production, operation, and raw materials use (U.S. EPA, 2005c)

amenities—a non-consumptive use of the environment.

Protection of Surface Water Quality

The Clean Water Act (CWA) of 1972 limited the degradation of the United State's liquid surface waters. It targeted point source pollution with the goal of improving the water quality by 1983 in order to make surface water safe for fishing and swimming (Thompson, 1999). In order to reach these goals, the federal government funded and constructed municipal wastewater treatment plants (Rogers, 1993; Thompson, 1999). In addition, the federal government required minimum water quality standards for all states, and allowed states to create more stringent standards (Rogers, 1993). Amendments to the Clean Water Act in 1987 targeted non-point source pollution, but the extent of the involvement was to provide resources (money) to accomplish this goal (Thompson, 1999). This Act attempted to decrease the human impact on the chemical composition of flowing and stored surface water.

By targeting human action, the Act was attempting to correct an externality that was non-excludable, rival or non-rival depending on the use, negative, and affected a large number of people (Table 1). The externality would be rival if the water was being taken out and used. This is because there was a limited amount of pollutants and one person taking out water that contains pollutants decreases the amount of pollutants left in the water for other users to consume. However, the externality would be non-rival if the water was being used for recreational or fishing purposes because people swimming or boating do not consume any of the pollution or water which forces everyone to be faced by the same level of pollution. In all cases, the externality would be non-excludable because the generator could not control who was affected, negative because it provided a

disservice (health problems or increased water purification costs), and it affected a large number of people as long as the water was used by a large number of people.

Protection of Air Quality

The federal government has not been very involved in controlling the quantity of atmospheric water and left the regulation of precipitation augmentation activities (cloud seeding) to the states (Davis, 1991). However, the federal government's actions to improve the quality of the air have resulted in a certain level of protection for atmospheric water. The 1990 Clean Air Act can be thought of as a Clean Water Act for the skies (Stanitski, et al., 2003).

The importance of the Clean Air Act for water quality is apparent at the atmosphere's interface of the surface and ground water sources. It is when the water falls from the sky as precipitation that the consequences of the water vapor picking up the pollutants that were released into the atmosphere from both point (big factories) and non-point sources (automobiles) are felt (Stanitski, et al., 2003). The precipitation's chemical composition changes and it becomes acid rain, because the chemicals that are in the atmosphere increase the acidity of the precipitation (Stanitski, et al., 2003). A particle or one of these chemicals is a necessary component for the accumulation of water vapor droplets into precipitation so that it becomes condensed enough to fall from the sky (Stanitski, et al., 2003). However, as with all water quality issues, the real problem is a matter of scale whereby the concentration of the pollutants results in the contamination of surface and ground water sources when the precipitation falls on the Earth (Stanitski, et al., 2003). In addition, the greenhouse gases emitted by industries can contribute to increased global temperatures that alter weather patterns, which increases precipitation in

some locations and decreases precipitation in others (Cech, 2005). The major catalyst for human involvement in this area is if the change affects humans or an environment that people value.

The externalities targeted by the Clean Air Act were acid rain and climate modification due to increases in greenhouse gases. Both of these externalities are non-excludable, rival, negative, and affected a large number of people (Table 1). They were non-excludable because the emitter could not control who was affected and rival because pollutants or precipitation falling in one location cannot fall elsewhere. The negative aspect comes from the destructive effects of acidic water and from making the weather even less consistent than it already was which, for example, can affect the livelihood of farmers. Everyone on the globe was and is affected in some way by these two externalities.

Ground Water Use

The federal government does not apportion or regulate ground water quantity. However, since ground water is considered to be an article of commerce, states cannot ban the export of ground water (*Sporhase v. Nebraska*, 1983). As Thompson (1999) describes,

> Prior to *Sporhase* it was assumed that states had absolute ownership and control of their groundwater, [which] the Court called…'legal fiction.' [This] is one more example of the continuing controversy over federal versus state ownership of water resources (p. 97).

There is the potential for the federal government to extend its power over ground water at the expense of the states.

The identification of an externality required a look at the situation if states could ban the export of ground water. The generator would be the state banning the export and

the victims would be all the residents in the states that wanted to import water. However, in this case, there were no ill-defined property rights, just a limitation of property rights, so there was no externality present. The federal action expanded the market for transferring water rights, and the state export ban limited the market. Within those market transactions, there could be externalities present such as increased pumping costs from a lower ground water table or a loss in return flows to downstream users (Nunn and Ingram, 1988). However, these problems are not the focus of the federal involvement; the focus is the size of the market for ground water.

Protection of Ground Water Quality

The extent of the federal government's involvement in protecting ground water quality has been by providing resources and encouraging regulations. This began with the 1986 Amendments to the Safe Drinking Water Act (SDWA) which gave grants to states to implement wellhead protection programs (WHPP) (Thompson, 1999). The 1974 Safe Drinking Water Act regulated water quality according to the potential negative health effects due to the concentrations of pollutants (Rogers, 1993). It attempted to correct the threats to public health (an externality) arising from land use practices that created non-point source pollution that entered the ground water via unprotected wellheads. The nature of this externality mirrors the ones covered by the Clean Air Act and was non-excludable, rival, negative, and it affected a large number of people (Table 1). The explanation is the same as for the protection of surface water quality except that it affected a large number of people because of the nationwide problem of non-point source pollution, especially in agricultural and urban areas (Rogers, 1993).

Predictions

The federal government's actions have attempted to provide public goods, promote economic development, and correct externalities, thus supporting part one of my hypothesis. The federal government provided public goods and promoted economic development in the East and West with the construction of canals, improving navigation, providing flood control, building dams and reservoirs to create reliable municipal and irrigation supplies, and creating recreational opportunities. The federal government also corrected externalities, which were non-excludable, rival or non-rival, negative, and affected a large number of people (Table 1). That is not to say that the federal government did not create externalities when it engaged the three types of activities; however, that topic is left for future research.

The non-rival externalities included clearing navigation obstructions, limiting non-federal hydropower development which could impair navigation, destroying wild and scenic rivers, eliminating species, protecting the environment, and degrading the quality of surface water bodies used for recreation (Table 1). The rival externalities included floods that threatened property and human life from upstream development, a shortage in irrigation and municipal water supply or higher costs, degrading the quality of surface water consumptively used by people and industries, acid rain, climate modification, and threats to public health from polluted ground water (Table 1). Therefore, the federal government has been involved in situations where externalities with two combinations of characteristics are present: 1) non-excludable, non-rival, negative, and it affected a large number of people; and 2) non-excludable, rival, negative, and it affected a large number of people. The federal government never interfered in a situation where a possible externality was excludable (it would not be an externality by

definition), positive, or affected a small number of people. The externalities' characteristics did not support part two of my hypothesis. I did not predict that the externalities would also be rival, a characteristic that became important in the situations where there were consumptive uses of water.

The patterns of the past based on the presence of externalities suggest that future federal involvement will focus on externalities with the two combinations of characteristics. In addition, the link between quality and quantity, the proposed legislation on desalination, and the agenda espoused by the Department of the Interior in Water 2025 suggest that the federal government will look towards improving the quality of existing supplies to combat quantity issues and not use structural, development solutions (U.S. DOI, 2003). Water 2025 explains that the federal government is focusing on non-structural changes such as demand management, improved efficiency, conservation, maintaining existing infrastructure, desalination, and economic markets to stretch available water quantities (U.S. DOI, 2003). Table 3 lists the different areas of potential federal involvement: instream flows, cloud seeding, wetlands, vegetation, and non-point source pollution. This analysis disregarded the political feasibility of undertaking the actions necessary to correct the externalities and focused entirely on the presence and type of externality.

Instream Flows

The first problem is that state water right systems and current river development do not always protect instream flows for fish and ecosystems (Rogers, 1993). "The instream values of the Colorado River include recreational use for whitewater rafting and fishing, channel maintenance related to the movement of sediment, and riparian and

Table 3. Predicted areas of federal involvement

Generator	Victim	Externality	Characteristics			
			Excludability	*Rivalry*	*Benefit*	*Population Affected*
State water rights systems	People who value the fish and ecosystems	Dry reaches of rivers	Non-excludable	Non-rival	Negative	Large
Humans engaged in cloud seeding	People who need the precipitation or are threatened by the large storm events	Decreased or increased precipitation in an area	Non-excludable	Rival	Negative	Large
Human destruction of wetlands	Downstream inhabitants	Threat to human life and property	Non-excludable	Rival	Negative	Large
Human destruction of wetlands	Downstream inhabitants	Increased surface water pollution	Non-excludable	Rival	Negative	Large
Human land use practices that change the types and amounts of vegetation	People who use the surface and ground water	Decreased available water supply	Non-excludable	Rival	Negative	Large
Human land use practices that change the types and amounts of vegetation	People who rely on the contaminated water for consumptive and non-consumptive uses	Increased surface and ground water pollution	Non-excludable	Rival or Non-rival	Negative	Large
Poor emission control technology and land use practices that increase non-point source pollutants	People who use the contaminated surface, ground, and atmospheric water	Degraded water quality	Non-excludable	Rival	Negative	Large

aquatic habitat (p. 257)" (Thompson, 1999). Externalities require ill-defined property rights and property rights usually define the use of water in water rights systems. There are problems with state water rights systems, but unless they affect interstate water apportionment issues, the federal government will have difficulty interfering on a national basis because it would be difficult to make each state's different water rights system uniform (U.S. DOI, 2003). The externality generated by the loss of instream flows follows the externality corrected by the ESA and is non-excludable, non-rival, negative, and it affects a large number of people (Table 3). The quantity issue to protect environmental values is indirectly addressed through the ESA, but direct involvement to correct the negative externality would follow past patterns (Table 3).

Cloud Seeding

If cloud seeding became more prevalent, then the externality generated by cloud seeding could be regulated by the federal government. That externality would be non-excludable, rival, negative, and affect a large number of people (Table 3). The nature of the externality follows the historical pattern of federal involvement. It is non-excludable because the cloud seeder cannot exclude people from feeling the effects of a decrease or hazardous (flooding and violent storms) increases in the amount of water in other locations. This quantity change in the amount of atmospheric water would be rival because if water is precipitated in one place, then there is less water available for people in another location. Although there could be a positive externality generated for some people who do not pay for the service but receive needed water, the federal government would not interfere to correct that externality, because it has a history of targeting negative externalities. It would also affect a large number of people because atmospheric

water affects a large spatial area. There are also a couple areas, wetlands and vegetation, which demonstrate both quantity and quality issues as well as the link between quality and quantity.

Wetlands

The destruction of wetlands can increase surface water runoff and impair the quality of surface water sources. The Clean Water Act has included provisions that limit the destruction and filling of wetlands without a permit (Rogers, 1993; Thompson, 1999). Throughout the history of the U.S., 60% of its 215 million acres of wetlands were destroyed to create land for agriculture and urban development (Rogers, 1993). The effects of this human destruction (the generator) on water quantity and quality are widespread, with increased flooding and polluted runoff reaching rivers (human victims). These two externalities from flooding and pollution follow the historical pattern because they are non-excludable, rival, negative, and affect a large number of people (Table 3). The reasoning behind the characteristics is the same as the flood control and protection of surface water quality examples. There is room for greater federal involvement beyond the use of the Clean Water Act to address these problems.

Vegetation

Changes in the types and amounts of vegetation are another pair of externalities that are widespread and have the potential to incite federal interest. Vegetation is usually overlooked outside of wetlands, but it plays a vital role in the flow of water among the three stocks of surface, atmospheric, and ground water. As discussed in the context of Figure 1, vegetation transpires both surface and ground water into the atmosphere. A human change in the types of vegetation alters the amount of water available to other

users because different plants use different amounts of water. In addition, changing the amount of water alters the dilution capacity of the resource, which can increase pollution levels. Both externalities created by this action are non-excludable, rival, negative, and affect a large number of people (Table 3). They are non-excludable and negative for the same reasons described in the protection of surface water example. They affect a large number of people because the land use practices that alter vegetation are prevalent in the entire country. They are rival when the victims use the water consumptively; however, if the polluted water is used for recreation or other non-consumptive purposes, the externality is non-rival. Either way, these two externalities follow the historical pattern. National vegetation requirements are rather far-fetched, but cities in the southwest including Albuquerque, New Mexico use incentives to promote planting vegetation that is suitable for the climate (City of Albuquerque, 2005).

Non-Point Source Pollution

Water quality issues arise due to ill-defined property rights. Any pollution discharged into the environment will eventually reach a water source and create an externality (Siebert, 2005). Although quality issues have been addressed, they are limited to point sources and point protection (wellhead). Wellhead protection tries to diminish the effects of non-point source pollution, not the amount of pollution itself. Regulating non-point source pollution would require regulations on the technology that is produced on an industry and consumer level. In addition, land use practices that add pollutants to runoff would need more widespread adoption and regulation (Rogers, 1993). Non-point source pollution creates an externality that is non-excludable, rival, negative, and affects

a large number of people (for the same reasons as in the previous discussions on water pollution) and follows the historical pattern (Table 3).

Suggestions

The five areas where there are current and potential externalities whose correction may spark the federal government's involvement in water resources follow the historical pattern of involvement. They all have externalities that are non-excludable, rival or non-rival, negative, and affect a large number of people. Although the political and legal feasibility of interference has not been analyzed, these are the areas the states should incorporate into their long-term water management plans including future federal funding and/or regulation in these areas. Possible ways to implement these suggestions include 1) creating state instream flow protection; 2) regulating cloud seeding; 3) protecting wetlands; 4) regulating or providing incentives for suitable vegetation cover; and 5) regulating non-point source pollution. To enhance the states' role in water resources management, each of these areas could use action that either regulates the harmful activities or plans on federal-state partnerships and federal financial support.

Creating state instream flow protection could include either regulating current water users or buying water rights. The focus for the state creating regulations should be to preempt future federal legislation that sets national standards for instream flows. However, if the state's plan includes buying water rights then it should plan on future federal funds to support that endeavor. State regulation of cloud seeding would need to regulate the actions to minimize the negative effects or just ban cloud seeding.

State protection of wetlands would require regulations that prevent wetland destruction or a large amount of funds dedicated to buying and preserving wetlands.

Based on the prediction analysis, federal financial support may be available to help states buy wetlands. State regulation and incentives to control land use practices that affect the type and amount of vegetation in a certain area would be directed at preventing national standards and receiving support to provide the incentives. States could expand current incentive programs and try to promote suitable vegetation for planting. In addition, it may be possible to allow a certain level of water consumption per property and allow the owner to choose what they want to plant as long as the vegetation's water usage does not exceed the set amount of water.

Lastly, states could create more stringent standards on non-point source pollution based on land use activities—not a measured amount of pollution that leaves a person's property. This means that if someone owns ten acres of farmland, uses a certain type of chemical, and landscapes their land in a certain way, the non-point sources pollution contribution of each property owner could be calculated. Then state personnel could work with property owners to decrease their non-point source pollution. That work could possibly be funded by future federal legislation and appropriations. If states incorporated some of these ideas into their management plans, then they could maximize the benefits of a federal presence in water resources management.

CONCLUSION

When the federal government asserts its power over water resources, it preempts any conflicting state law or interest. The ability for states to anticipate the future areas of federal involvement will allow it to build flexibility into its long-term management plans and maximize its use of federal resources. This paper has used the past to predict the future and give states guidance in where they should focus their efforts.

The areas where the federal government has been absent are the quantity, location, and use of atmospheric and ground water. The federal government has historically been most heavily involved in the surface water component of the hydrologic cycle, focusing more on quantity than quality. The most recent focus is on quality, especially in terms of how quantity and quality are inextricably linked: quantity affects quality and quality affects the quantity available for specific uses. The federal government has asserted its interest in navigable surface waters over both quantity and quality. More recently, the federal interest has expanded into ground water, but only on a small level—limiting the states rights to ban export of ground water and providing resources for water quality improvements. Atmospheric water has not been directly addressed, but federal action—the passing of the Clean Air Act—has resulted in decreasing the source of water quality issues.

In asserting its power, the federal government has historically attempted to provide public goods, promote economic development, and correct externalities, thereby supporting part one of my hypothesis that a third justification for federal legislative involvement is the correction of externalities. The federal government has been involved in situations where externalities with two combinations of characteristics are present: 1) non-excludable, non-rival, negative, and it affected a large number of people; and 2) non-excludable, rival, negative, and it affected a large number of people. This pattern resulted in the rejection of part two of my hypothesis that the externalities would be non-excludable, non-rival, negative, and affect a large number of people, because the externalities were also found to be rival.

This pattern was then used to predict future involvement by the federal government. Using past predictions and other possible areas, five potential areas of involvement were found to have externalities that exhibited the necessary characteristics of non-excludable, rival or non-rival, negative, and affected a large number of people. These areas are instream flows, cloud seeding, wetlands, vegetation, and non-point source pollution. States should therefore monitor these areas and build a future federal regulatory and financial presence into their long-term management plans of water resources. In addition, identifying externalities on a continuous basis will enable states to create a rough indication of future federal legislation concerning water resources.

GLOSSARY

Excludability: The ability to exclude those who do not pay for a good from consuming it (Hall and Lieberman, 2001:451).

Externality: A by-product of a good or activity that affects someone not immediately involved in the transaction (Hall and Lieberman, 2001:445).

Private good: A good that is rival and excludable, and is supplied by private firms in the marketplace (Hall and Lieberman, 2001:451).

Public good: A good that is non-rivalrous and non-excludable; the market cannot and should not provide such goods (Hall and Lieberman, 2001:451).

Rivalry: A situation in which one person's consumption of a good or service means that no one else can consume it (Hall and Lieberman, 2001:451).

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