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Misalignment of watershed and jurisdictional boundaries: the importance of scale

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Abstract

The misalignment of the boundaries of watersheds and jurisdictions is cited often as a barrier to effective water governance, but the validity of the assertion depends on watershed scale and the decisions or processes involved. The paper probes these decision processes and their alignment with scales of natural watersheds and with governance processes. Two examples from the USA provide context and data to inform the discussion, one from the humid eastern part and one from the drier western part. Ultimately, the spatial and governance scales determine the complexity of decisions. The major issue is the level and nature of negotiations and how stakeholders communicate and work with each other to resolve issues in a form of pragmatic federalism, where the concept merges into decentralization to the subwatershed level. At smaller scales, negotiations can be worked out in person-to-person venues but at larger scales institutions have their own trajectories and inertia. Ultimately, watershed boundaries can be effective for joint planning and assessment, but decisions follow governance patterns. Basin boundaries do provide venues for coordination mechanisms to mediate conflicts.

Keywords: Assessment; Case studies; Conflict resolution; Coordination; Governance; Jurisdictions; Negotiations; Planning; Scales; Watersheds

1. Introduction

The mismatch between watershed boundaries and water resources management jurisdictions is viewed by some as a fundamental barrier to integration in water decisions, but others discount its importance. Whether it is or is not an important issue was probed by Cohen (2012), who explained that water managers '… may lament the fact that water resources are not confined to the political boundaries within which management decisions are made …'. Drawing from examples from Canada she asserted that governance processes and not physical spaces define the extent to which integration and participation can occur. In a counter view, Kauffman (2002) drew from US examples to conclude that watersheds form the best hydrologic planning units.

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Such debates about the mismatch of governance and water management have been underway for a long time. Wolman (1980), a 20th-century water leader, wrote about basins: 'Viewed by themselves, they represent artificial spheres of action irrelevant to society's needs. The engineer-planner finds them convenient, because he sees them as continuous hydrologic worlds.' More recently, ecologists have studied a broader issue known as the problem of fit, where the mismatch between watersheds and jurisdictions is only one of many challenges of adapting socio-cultural systems to sustainable ecosystems (Folke *et al*., 2007).

As water conflicts and needs developed, a diverse collection of basin organizations has emerged around the world. Many of the issues focus on river basins with typical problems being to resolve conflicts among sovereign governance authorities, both within national borders and among them. A survey and explanation of these unique institutions was presented by Delli Priscoli (2008), who provided many examples of scenarios across the world. Kenney & Lord (1994) also discussed different types of basin organizations with a focus on the USA, to include compacts, treaty organizations, river basin commissions and boundary organizations.

While many of the published reports focus on river basin examples, the importance of the mismatch depends on the scales of natural systems, governance authorities and the complexities of contextual situations. The focus of this paper is on how these scales and the management complexity they measure determine whether alignment of watersheds and jurisdictions is important or not. For evidence, two examples from the USA are used to examine how types of water decisions unfold at different scales and shed light on how governance occurs. Although the US examples may not apply everywhere, the theories about watershed scale and water management functions are common across governance systems. By focusing on different scales, down to the sub-urban level, the contribution here should add to ongoing discussions about governance issues that have focused mostly at the river basin level.

2. Defining concepts

In the natural sciences, metrics such as stream order and watershed scale are recognized as important measures of scale. These lead to watershed scale being recognized as a convenient spatial variable and, while several classification systems have been developed for it, there is no globally-accepted system. In the USA, a system developed under interagency cooperation enjoys wide acceptance (Natural Resources Conservation Service (NRCS), 2014). In it, the nation is divided into 21 major regions (Table 1).

Table 1. Hydrologic unit descriptions for the USA.

Name	Level	Number of units	Average area in square miles*	Description
Region	1	21	177,580	Geographic areas of major river basins or several river basins
Subregion	2	222	16,800	Normally a river basin
Basin	3	352	10,596	Smaller river basins
Subbasin	4	2,149	700	Larger watersheds
Watershed	5	22,000	227	Smaller watersheds
Subwatershed	6	160,000	40	Much smaller watersheds*

*From United States Geological Survey (USGS) *et al*. (2009).

The smallest scale of the subwatershed still averages 40 square miles (1 square mile = 2.6 square kilometers), which is about the size of a typical US city of 150,000 in population. For purposes of this discussion, it is convenient to consider even smaller basins down to about one square mile to be called, for example, a 'sewershed' to denote an area where a major project involving stakeholders might be implemented.

There is a natural correlation between watershed scale and the related concept from the geosciences of stream order. The smallest streams are first order and the order increases as streams take on more tributaries. Large rivers corresponding to major basins will have the highest stream orders (Horton, 1945).

In terms of governance, scale is associated with degrees of government authority as in local-state-federal levels and by their scope, both in spatial area and number of functions. Given its many issues, a discussion of governance scale becomes complex quickly. In general, the three levels of government provide a measure of vertical scale, while horizontal scale measures scope of activity and authority. For example, the federal government covers the greatest area and has the broadest range of activities, whereas a small single-purpose special district, a form of local government, might have a limited scope of authorities over a small area.

Given the many functions of governance across sectors of society, it is not unexpected that many problems of mismatch between lines of authority and problem spheres occur. This is a central topic of planning and public administration and has been addressed extensively by researchers. Regional planners focus on issues such as best scales for investment and economic efficiencies, where the local scale usually emerges as the best because decisions are made there and economic interactions favor zones where transportation and business relationships work best (Dawkins, 2003). Infrastructure planners seek economic scales for public facilities such as water supply services, where excessive land use sprawl creates diseconomies of scale (Clark *et al*., 1977).

The federal system in the USA establishes the context for state-federal relationships. Actually, the US federal system is the world's oldest and began with autonomous states, which became part of a federal union after a fractious organizational period that featured strong contests over contending philosophies about the balance between state and federal power. In the past few decades, federal initiatives have come to dominate water policy, especially in the realms of clean water, safe drinking water, and environmental protection. Local governments operate under authority of state governments, and they include both county or sub-regional forms and municipalities in the form of towns and cities. To bridge the gaps of authorities for various governmental functions, the USA has a large number of special purpose districts, many of which exercise water management functions such as water supply, irrigation, and flood control.

These districts are mainly organized along jurisdictional lines, but some align with watershed boundaries and have combinations of planning, regulatory, and service activities. Tampa Bay Water (Florida) is an example of an authority organized on the basis of jurisdictions. As a regional wholesale water provider, it was created to end conflicts among six city and county governments and foster an integrated approach. An example of an authority organized along basin lines is the Trinity River Authority in Texas, which serves a 715-mile long river corridor that passes through the major population centers of Dallas/Fort Worth and Houston and ends at the Galveston Bay and estuary system. As a political subdivision of the state, it has three functions: basin master planning, serving as local sponsor for federal water projects, and providing area-wide services for wastewater treatment, water treatment, recreation and reservoir facilities (Grigg, 2010).

How scale affects the governance of ecosystems has become a popular topic, and research literature about it has expanded rapidly since the work of Folke *et al*. (2007). Recent research has focused on issues such as the conflicts between land use decisions at larger scales to favor conservation and the need for sociological approaches at the individual or local community scales to recognize ownership and incentives (Wyborn & Bixler, 2013). Inquiries continue to seek insight into the best scales for different governance activities and how nested governance and policy networks can support collaborative conservation.

The many overlapping governmental authorities with different scopes create a polycentric form of water governance. This term means the co-existence of many independent centers of decision-making (Ostrom *et al*., 1961). For example, in a given watershed you might have concurrent activities by a city government, a county government, and an electric power authority.

Within systems of governance, the term water resources management usually means the decision process for control of natural and infrastructure systems to handle water in the best interests of society. To achieve this, water managers understand the need to recognize natural systems. For example, a group from the American Water Works Association affirmed that water management: '… encourages planning and management on a natural water systems basis' (Grigg, 2008). In water decisions, natural water systems are viewed as sources for water to be managed and sustained, which is often a contentious issue. Typical decisions involve water uses that require capital investments to construct infrastructure and operational control of systems to meet water demands and comply with regulations. The infrastructure facilities are used for reservoir storage, conveyance of water, treatment of water, and distribution of water for diverse purposes.

Complexity in water resources management derives from natural and governance scale factors, as in population served and range of services. Referring to water resources management as multiple-purpose and multiple-means, White (1969) explained its multi-dimensionality and when multi-level polycentrism of governance is added, it is easy to see how complexity increases. This has given rise to the use of the term 'Integrated Water Resources Management (IWRM)', which has been defined as '… a process which promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the environment' (Global Water Partnership, 2014). In effect, this concept adds to the complexity of management itself the added burden of coordination with 'land and related resources'.

IWRM, is seen as increasingly needed and achieving success in it challenges federal systems of governance in special ways because effective management is not the mandate of one level of governance, but all levels have key roles (Garrick *et al*., 2014). This idea stems from a workshop held to discuss how water governance is working out in nations with federal systems of governance. Most of its focus was on larger river basins, but in discussing the US situation, Gerlak (2014) explained that its system reflects 'pragmatic federalism with collaborative partnerships and coordination across and within state and federal levels in response to integrated water management problems and processes such as watershed planning'. This provides a workable explanation of how issues are sorted out in situations such as the cases explained in this paper. They show cases in a federal system, but down to the micro-watershed level, as compared to the national-state level focus of most discussions of federalism.

3. Case examples

Case studies show a broad range of water resources management scenarios across variables of scale and contextual arrangements. No attempt is made here to include this broad range in the discussion, but two US examples are explained to illustrate important aspects of basin versus jurisdictional approaches to water resources management and down to the local level and even to the finer grain view of areas within cities.

Figure 1 shows the locations of the cases. In the East, the linked Apalachicola-Chattahoochee-Flint and Alabama-Coosa-Tallapoosa (ACF-ACT) basins drain toward the Gulf of Mexico. While these appear small on the continental scale, they are the major rivers of an important urban-agricultural region of the US Southeast, including the Atlanta region with over four million people. Many publications are available to explain several decades of water conflicts in these basins (Hunton & Williams Water Policy Institute, 2009).

In the West, the Missouri–Mississippi river system drains a major portion of the center of the nation. It involves a drier climate, larger areas and longer rivers, while the eastern case involves a humid region, smaller areas, shorter rivers and denser population. The focus of the discussion here will be on the headwaters region of the Platte River, a major tributary of the Missouri River.

3.1. Eastern case: ACF-ACT system

The basins comprising the ACF-ACT systems are linked by interbasin transfers and boundary issues. Conflicts about their management resulted in an interstate compact and federally sponsored comprehensive study, which was followed by a series of lawsuits. Water issues on both rivers include urban and industrial demands, hydropower, navigation, and fisheries. The focus of this discussion is on the ACT, beginning with the watershed of the Conasauga River at Dalton, Georgia (Figure 2).

Fig. 1. Location of case study river basins.

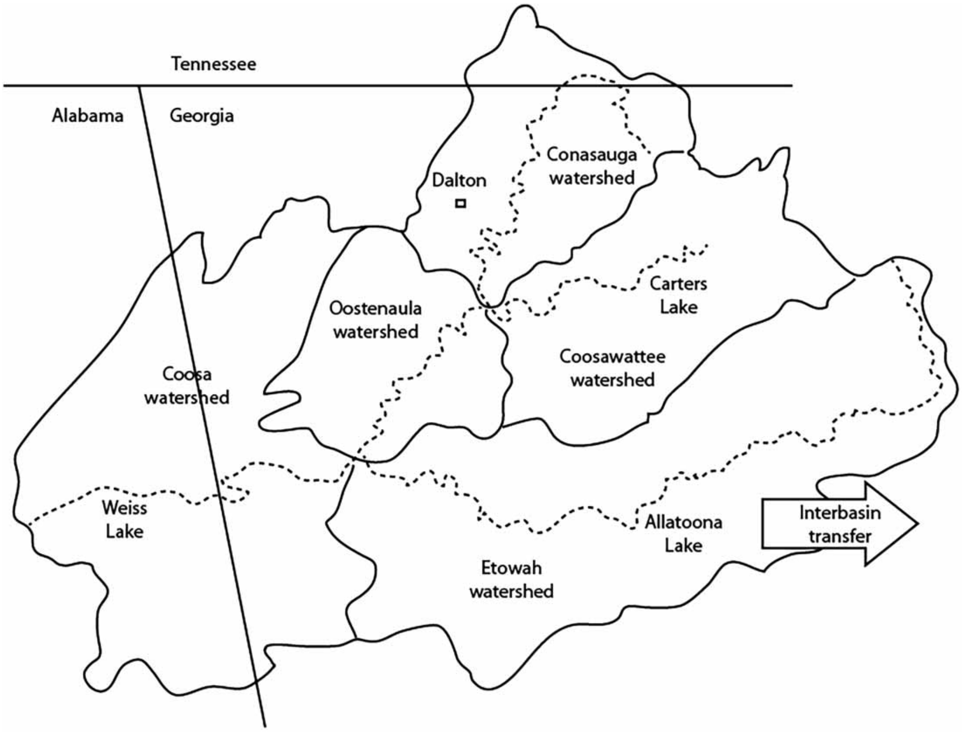

Fig. 2. Upper region of the Coosa basin showing Conasauga watershed.

The larger ACF system is dominated by Atlanta, which is located in the upper part of the basin (see Figure 1). The Atlanta region is the dominant economic influence in the region and has been growing at a rapid rate for decades. Although water is abundant in this humid region, Atlanta receives water via an interbasin transfer from the Etowah River's Allatoona Lake. Both the ACF and the ACT river systems have federal and utility electric power storage projects and Georgia is studying state-sponsored or state-assisted reservoirs. The Corps of Engineers exercises authority across the whole system, but coordinates release decisions with electric power companies. Weiss Lake is the largest storage project on the Coosa River mainstem and navigation occurs on the ACT below the Coosa on the Alabama to Mobile River reaches and on the ACF only in the Florida reaches.

This present paper does not focus on the large-scale conflicts but on the narrower issue of how decisions are made according to scale. Beginning at the smallest scales in the Upper ACT, the City of Dalton, Georgia has urban watersheds for its wastewater and stormwater systems. The Conasauga River above the city drains some 772 square miles where it joins the Coosawattee River to form the Oostenaula River in a nested set of watersheds. The map in Figure 2 shows the levels down through four (see Table 1), and the Coosa River drains further toward Mobile Bay as can be seen in Figure 1.

Within the Conasauga basin, at the urban scale Dalton has a heavy concentration of carpet mill industries and the city has a separate utilities department, which is governed by a Board of the Water, Light and Sinking Fund Commissioners (Dalton Utilities, 2014). The city utility makes decisions on water withdrawals from the river and aquifers. Water withdrawals in Georgia are regulated by the state water law, based on permits, and the regulating agency is expected to consider downstream impacts, such as on the Oostenaula watershed. Dalton has sewersheds and stormwater basins as do other cities. Non-point source controls include a total maximum daily load program, which is organized by small watersheds and regulated by state government under federal rules.

Although there is no water management authority at the small watershed level, there is a Conasauga River Alliance (2014). Like a number of watershed groups, it was organized on the basis of Clean Water Act goals and funding. It began during the 1990s by initiative of a Resource Conservation and Development Council which was seeking a federal grant and in 2004, the Alliance received non-profit status and began to operate as a partnership between citizen leaders and government funding. There is no river basin authority or planning effort at a larger scale on the ACT, other than the federal efforts related to the Corps mission. Although most of the ACT river basin is in the State of Alabama, the state government lacks an integrated approach to planning for river management.

3.2. Western case: Platte River system

The western case starts at the Cache La Poudre basin in Northern Colorado, a tributary to the South Platte River. It extends through the Platte River basin to the large-scale Missouri–Mississippi River basin, which drains a major portion of the central USA (Figure 3). The full system (shown in Figure 1) includes several major subsidiary river basins, including the Upper and Lower Mississippi basins, the Missouri River basin, the Arkansas–White basin, the Ohio River basin (which includes the Tennessee River), and the Red River basin.

As the upper watershed, the Poudre River basin corresponds in size to the Conasauga basin. The City of Fort Collins is the example city in the basin and corresponds to Dalton, Georgia in the eastern case. The Poudre runs through Fort Collins and drains to the regional river basin or South Platte, which joins the North Platte to form the Platte River, a tributary of the Missouri. Although the Poudre has been studied extensively, it lacks a single watershed group like the Conasauga Alliance, and there are

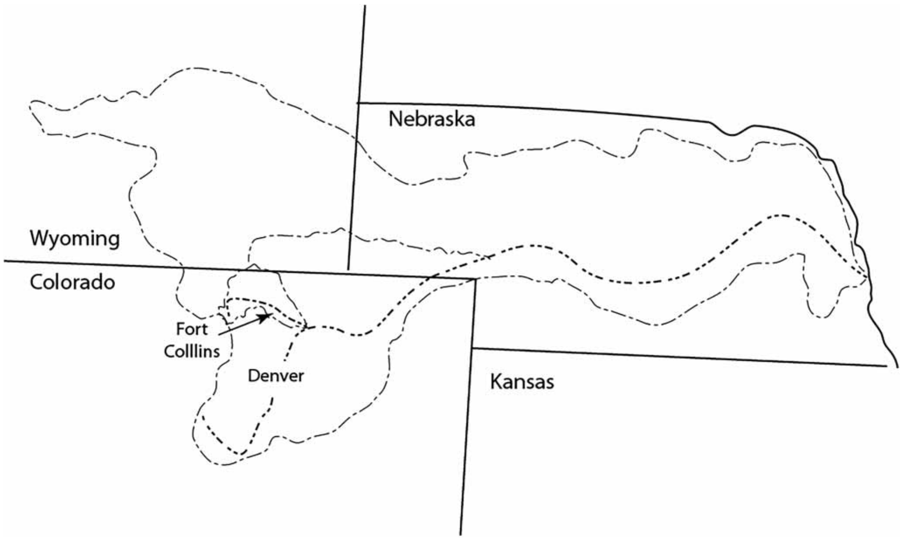

Fig. 3. Upper reaches of the Platte basin showing Poudre watershed.

extensive research studies about it due to local interest at the university and at federal and state agencies. The nearby Big Thompson River, which has about the same drainage area as the Poudre, has a watershed forum that was organized by the local governments to monitor water quality. Within the Poudre, water users coordinate water rights among themselves in a users' association, which does not include water quality. There is a complex interbasin transfer where trans-mountain water is imported from the Colorado River to the Big Thompson, then brought to the Poudre Basin via a canal system.

Water withdrawals are regulated by the Colorado water law, which is court-based and follows the appropriation doctrine of water rights. This introduces a sharply-defined system of water rights and leads to unusual situations, such as in 1986 when the Denver suburb of Thornton secretly purchased agricultural water rights from the Fort Collins area. This will eventually lead to an interbasin transfer if the rights are perfected. The mobility of water is especially evident in this region. The Poudre River also receives interbasin transfer water from the Western Slope's Colorado River headwaters, and some of this water is exported from the area in a Southern Water Supply pipeline.

Wastewater management is handled by individual municipalities and industries, with the exception of the Denver Metro Water Reclamation District, which consolidates a number of collection systems into one treatment system. A number of sewersheds are in place as the cities have their own collection systems. Non-point source controls are by small watersheds and regulated by state government. Denver has an effective multi-jurisdictional urban drainage and flood control authority, which was established after 1960s flooding revealed problems from uncoordinated approaches.

Water storage is practiced extensively in the West and the purposes include irrigation, which is not the case in the East. The Fort Collins area has several new reservoirs or reservoir expansions in the planning and permitting stages, with the outcomes being uncertain due to strong opposition from environmental interests. In 1990 a major Two Forks reservoir proposal for the South Platte above Denver was vetoed by the United States Environmental Protection Agency. Colorado has a basin roundtable program to discuss collaboration, but decisions at this scale have proved difficult, even with coordination within river basins. In 2014, the work of the roundtables was summarized in a Colorado Water Plan, which is mostly a compendium of facts and a basis for further study. At larger scales, decisions align with river basins as illustrated by a state-federal agreement for environmental recovery on the Platte River and a coordinated system for reservoir operation on the full Missouri River.

4. Discussion of cases

The cases have similar spatial characteristics at the smaller levels and exhibit more significant spatial variations at the larger scales. As Table 2 shows, the Missouri is a region itself and the Missouri–Mississippi is a combination of several regions. On the other hand, the ACF-ACT does not reach the status of a region, and its receiving waters in the Gulf of Mexico might be considered its water body at that scale.

At the sewershed level, water resources management is similar in the actions of Fort Collins and Dalton utility operations. Above that, at the subwatershed level, issues would also be similar, even though the hydrology of the humid region would vary from that of the drier western case. At the watershed level, the Conasauga and Poudre basins also face similar issues, and water users can talk directly to each other, when they choose to do so. Once the scale increases beyond the watershed level, differences begin to emerge. Mainly, there is more mainstem regulation in the eastern case and heavier

Table 2. Identification of comparable basins, eastern and western cases.

Level	HUC*	Category	Average area, sq mi	Eastern case	Western case
6	12	Subwatershed	40	Dalton sewersheds	Ft Collins sewersheds
5	10	Watershed	227	Conasauga River	Tributary to Poudre
4	8	Subbasin	700	Oostenaula River	Poudre River
3	6	Basin	10,596	Coosa River	S. Platte River
2	4	Subregion	16,800	Mobile River at Bay	Platte River
1	2	Region	177,580	NA	Missouri–Mississippi

*HUC = hydrologic unit code.

concentration of water-using industries. The possibility for collective decision-making seems diminished in both cases as watersheds grow larger and become river basins.

The cases show how climate, geography, and population density are important in characterizing the alignment of watersheds and decisions. The long rivers and large watersheds in the West create different scenarios than the shorter rivers and smaller river basins in the East, mainly at the larger basin scales. This suggests metrics to assess the scale of management complexity such as population/square mile and number of government units in watersheds. At the local and small watershed levels, decisions are similar but the eastern watersheds are apt to have less public land and higher population density than the western ones. In both cases, the cities manage subwatersheds for drainage and sewerage service, as well as strips of riparian land along major streams and tributaries. Interbasin transfers also occur at the subwatershed scale as a result of distributing water and collecting wastewater.

Most water withdrawal and wastewater discharge decisions are by single players at the subwatershed level although regional wastewater treatment is also practiced. Storage decisions are by local players or by authorities at higher levels and normally align with watersheds or river basins. Pipeline infrastructures for water conveyance are associated with storage decisions because they transmit water from reservoirs to points-of-use and can include interbasin transfers.

In both cases, spatial and governance scales affect the complexity of decisions across a range of contextual situations. Spatial scale measures watershed size or regions such as the Atlanta and Denver metropolitan areas, which exert major influence on water demands and uses. Both Atlanta and Denver reach beyond their own watersheds to import water. In both cases, governance scale involves local governments proposing actions with other decisions extending to states and multiple states and then to multiple federal agencies. Governance scale also includes scope of authority, which is especially evident by actions of the Corps of Engineers in major river basins, both in the eastern and western cases.

While state government boundaries are not aligned with watersheds, the states can exercise authority by river basins, as in setting water quality standards or allocating water supplies. For example, the Poudre-South Platte system in Colorado is overseen by the Colorado Department of Public Health and Environment and the Division of Water Resources for such basin-based regulatory actions. Comparable oversight for water quality is evident in the ACF-ACT system, with the additional complexity of multiple states being involved. In both cases, the federal government has large roles in overseeing state governments for water quality and environmental statutes and in operating large reservoir systems. In eastern states regulation of water quantity is much weaker than in western states.

In both cases and even within watersheds, decisions are made by different clusters of players with diverse interests focused on the issues at hand. Capital infrastructure investments for reservoir storage, conveyance of water, treatment of water, and distribution of water are mainly utility-based decisions, as are operating decisions to meet water demands and comply with regulations. Most water withdrawal decisions are by single players, such as cities, power companies, and irrigation districts, and are coordinated only through regulatory authorities. Large storage projects are usually run by power companies, federal agencies, regional authorities or large cities, such as Atlanta or Denver. Unlike the case with natural gas transmission, pipelines to move water are usually dedicated to the needs of local or regional water supply providers.

At the local level, inter-municipal rivalry is a reality. This was especially evident in the Cache La Poudre watershed case, which even featured a secret raid by another city on local water supplies. Within watersheds, local people can still work together, as in the Poudre water users' association and local watershed groups, but these are often focused on only a few goals and are not comprehensive. The formation of a special multi-jurisdictional drainage district in Denver to remedy stormwater issues was a noteworthy achievement in institution-building among local governments.

At the local level, the mismatch between watersheds and jurisdictions is most evident. Cities are normally located along streams and do not control large watershed areas, except in the case where they may own land in a dedicated watershed, usually to protect the quality of drinking water supplies. Watershed influences of cities are evident by the added incremental tributary area from upstream to downstream, which can result either from a large watershed discharging through the city or from a large subwatershed within the city.

In the two cases, spatial scale measures the sizes of watersheds or river basins or it can measure the size of a service region that cuts across basin lines as in the case of the drainage district in Denver. Vertical governance measures scale at the three levels of government and horizontal scale of governance measures regional scope, such as in multiple purpose special purpose organizations.

Water decisions at the watershed scale are driven by isolated local demands and regulatory controls from higher levels and not by integrated decisions on the basis of collective action. Natural watershed boundaries are considered in analytical studies, such as waste load allocation and drought response, indicating that these boundaries are useful for water accounting and assessment. They are normally used in assessment and regulatory processes rather than in coordinated basin decisions about water use. They do offer the possibility to provide needed information for shared governance in watersheds.

Mobility of water broadens the need for governance beyond the watershed level. As water passes downstream, it moves from upstream watersheds where people negotiate with each other, to downstream watersheds with different people. Where it is practiced, interbasin transfer is even more influential in expanding governance issues beyond the internal workings of a single watershed. Even small-scale instances of interbasin transfer occur due to the piping of water from one zone to another, where it is collected in a sewershed for treatment and disposal.

Measures of scale used by geoscientists for watershed geometry and stream order can be combined with those from life sciences to assess ecologic systems. Among policy communities, scale measures the scope of government authority, by level of governments as in local-state-federal levels and by number of functions, as in multi-purpose organizations. How these combine to scale up the complexity of water decision scenarios is not well defined, but it also depends on the numbers of system elements and functions served.

While shared governance in watersheds is the ideal, the demand for water is the primary driver of decisions and is expressed socio-politically and not by watershed boundaries. This results in a polycentric approach to management institutions, which features multiple overlapping jurisdictions and authorities. For policy scales, state government planning and regulatory decisions are the primary drivers for river basin decisions, except in the case of interstate rivers, where state governments must share authority with each other and federal roles emerge more strongly. The federal government has dominant roles at the larger scales in both projects and regulatory actions, and its influence also reaches to the local level where policies determine the rules for water quality and environmental impact. For management scales, ranges of complexity in sizes of systems and numbers of functions are evident across the examples. Decisions of small cities and irrigation districts involve fewer variables and less complexity than those of large cities such as Atlanta and Denver.

The governance scale depends on level of governments involved and who can talk to whom, which depends on watershed scale. The cases illustrate clearly the sensitivity of watershed or river basin scale to both parameters, with the possibilities for direct negotiation diminishing quickly once the basin size passes the small watershed scale. At the municipal scale public meetings about siting of infrastructure may be held to deal with subwatershed issues, and in city-to-city issues local leaders can talk to each other in regional forums. However, a river basin like the South Platte or Coosa is too large for local people to work together directly, although state governments can organize inter-watershed forums, such as in the South Platte case. Once the basin is larger with multiple states involved, like the ACT or Platte, decisions are more complex and require formal state-to-state negotiations. At and even larger scale, such as the Missouri and Mississippi Rivers, special arrangements are needed. There are only a few cases such as this, and they require some degree of federal involvement.

Water decisions seem to work better if they are made by watersheds, but once the watershed passes the direct negotiation scale the incentive for water users to make sacrifices to help neighbors is diminished. In water negotiations, individuals might sense losses to the common good and the spirit of collective action is weaker. Watershed scales of about 500–1,000 square miles seem workable for direct negotiations. These will be rare, however, because collective action is difficult and each water user wants to focus on individual goals. In the absence of a watershed basis, how then to proceed? It seems wise to keep the regulatory approach but seek to make it work better with coordination mechanisms through 'pragmatic federalism'.

5. Conclusions

Conceptually, aligning water management decisions with watershed boundaries would seem to improve the chances for successful integration, but this concept is realistic only for issues where less is at stake, such as in assessment and broad planning, than it is when investment or resource allocation decisions are involved. Decisions involving investment and resource allocation are made by governance units with the fiscal and legal accountability that come with political jurisdictions.

Watershed boundaries are convenient units for assessment because they form natural accounting units for hydrologic and ecological variables. They may also be useful for joint broad planning because they provide a venue for coordination mechanisms to operate. Because assessment and joint planning do not usually involve hard decisions about investments or resource allocation, stakeholders may be willing to participate on the basis of watershed boundaries.

In the US federalist system, the allocation of powers between the federal and state governments establishes a hierarchy of authorities for certain functions, mainly regulatory ones, but the requirement for integration in management decisions extends much lower to the subwatershed levels. Local governments, including special purpose districts, control many water decisions, but the reach of state and federal governance extends to the local scale as well as to larger scales.

Polycentric governance boundaries are set for many purposes and will seldom align with watersheds, especially as the nested sets of watersheds grow larger. This requires ‘pragmatic federalism’ to achieve coordination on the basis of governance units in both vertical and horizontal dimensions. This is how lines of authority can overlap and successful collective action can be marshaled through leadership and even personal relationships in overlapping polycentric governance structures. The degree of polycentricism increases with spatial scale and the roles of federal and state governments undergo subtle shifts as spatial scale increases with abrupt jumps at governance boundaries.

This complex institutional arrangement operates over a wide range of types of water decisions in diverse and multi-faceted scenarios where many interconnections and feedbacks occur among nested systems of watersheds and river basins. The major issues are the level and nature of negotiations as defined by the stakeholders and how they communicate. At lower and simpler levels of scale, negotiations can be in person-to-person venues but at larger scales they draw in institutions with their own trajectories and inertias. Combining how players communicate and the mixtures of authorities agencies shows how complexity is measured by the intersection of spatial and governance scales.

Watershed scale is a factor in whether decisions can occur within the basins themselves. For example, if water management actions and their consequences are contained within a watershed, collective action by stakeholders is possible because they have the authority to work out conflicts. If the actions take place in the watershed but the impacts are felt outside of it, then regulatory controls are probably needed due to lack of incentives to protect those outside of the watershed from losses. Examples of this situation are water diversions and wastewater discharges, which are normally by individual units or persons and require regulation to offset the outside-the-watershed impacts. Stormwater management works well by watershed boundaries, especially at the subwatershed level, and is an example of water governance by hydrologic unit, even when the hydrologic units are contained within a larger jurisdiction. However, upstream actions in nested watersheds can impact those located further downstream and mitigation may be required. Instream flow management for navigation and hydropower is a special case and requires actions by owners of reservoirs, principally federal agencies and power companies who exercise high degrees of regulated authority over decisions.

As the primary issue in IWRM is to achieve successful collective action by stakeholders, success is possible at the small watershed level when issues are contained and neighbors can cooperate. However, it is more difficult at larger scales where individuals are represented by institutions.

Accordingly, how well the watershed-based approach works depends on spatial scale and social settings that determine the possibility of neighbor-to-neighbor cooperation. The cases showed that at the subwatershed level, all cities have similar neighborhood issues and even at the watershed scale civic leaders often know each other and can cooperate through city-to-city negotiations. A shift occurs at the level of inter-watershed forums where stakeholders become representatives, rather than individuals. State-to-state river basin negotiations are the next level and are normally difficult, whether in humid or dry regions. When several states are involved, federal involvement is normally required.

How scale affects the possibilities of collective action versus regulation is also a matter of context, as illustrated by the differences between water law systems in a humid state versus in a semi-arid state with a court-based, water rights ownership system. The differing water law systems evolved to correspond to the discriminating variables in these contextual situations such as population density and climate.

The basin organization can be an effective institutional mechanism to cut across the governance boundaries that block IWRM, and many different types are in operation across the USA and other parts of the world. They range widely in scale, function and enabling authority. The politics behind their organization can often be fractious and long-lasting, as in the case of Tampa Bay Water which was cited as an example of how local governments can cooperate on wholesale water supply and environmental protection.

The convergence of organizational types, problem scenarios, and governance realities means that the concept of the problem of fit remains an idealistic notion as it relates to water resources management. However, the concept does provide insight into the nature of water resources decision-making, contributes to discussions about the theory of scale in environmental governance and helps in institutional development. Ultimately, it is a measure of management complexity which is exacerbated by mismatch of watershed and jurisdiction boundaries.

Ultimately, the increasing need for IWRM and the capacity of governance systems to achieve it are critical issues in water governance, but scale factors and diverse problem types produce different situations from small watersheds to large transnational scales. In the absence of successful management at small watershed levels, negative consequences will result. Better institutional arrangements are needed to foster non-coercive approaches to collective action from small to large scales. Problem-solving at the small watershed level requires effective organized groups, which work well for some functions but are rarely comprehensive. If all water decisions are made on the basis of watersheds, some individuals may lose advantages in a collective approach, so in the absence of a firm watershed basis, how should IWRM work? Pragmatic approaches on the basis of watersheds but coupled with selective regulation seem to be the best answer, at least for the types of problems explained here.

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