Renegotiating Urban Water Management in Flagstaff, Arizona

Origins and Implications of Conservation Policies

Kristen E. Reed

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Abstract

The rise of water conservation measures in municipalities in the western United States is often attributed to drought stress and increasing urban populations, and I suggest it signals the emergence of a management model based on resource sustainability that intends to incorporate "Nature" into management decisions. Drawing from archival data, I trace socioeconomic and biophysical factors that led to the implementation of conservation measures in Flagstaff, Arizona. A content analysis of contemporary water problems, their causes, and potential management responses informed by semi-structured interviews with key water policymakers in the area, representatives from community interest groups, and scientists indicates that more than three times as many informants, including those with historically opposing viewpoints, prefer conservation measures over supply augmentation policies. Contributing to the broad political ecology literature, I incorporate concepts introduced by ecological Marxism and the social production of nature literature to interpret the popularity of conservation measures and suggest some subsequent implications.

1. Introduction

Significant changes are evident in the western United States. Rapid population growth in both urban and exurban areas (settlements located outside suburban boundaries) has occurred over the last decade (Case and Alward 1997). In addition, drier-than-average conditions over the last few years may continue, further straining both surface and groundwater resources. Set against this widening gap between supply and demand, municipal water management in the West is also undergoing significant changes. While Western cities continue to augment supplies, a different model of municipal water management is also evident in a limited number of cases, a model I term resource sustainability. Here, water conservation strategies are increasingly pursued, implemented, and endorsed by water managers and water users. These include strategies designed to improve water efficiency (e.g., low flow plumbing fixtures), promote water-conserving behaviors (e.g., replacing water-intensive landscaping with low water use plants), and/or restrict water uses (e.g., residential irrigation is limited or outlawed) (Pinkham and Davis 2002). While several commentators additionally call for a re-allocation of water resources by water marketing or collaborative community-based resource management strategies, inadequate theoretical attention has been paid to understanding the emergence of sustainable resource management and the implications of such a management model. I hypothesize that while certainly population and climate factors influence municipalities to enact sustainable water resource management policies, the "greening" of capital also plays a role in their emergence. Drawing from a political ecology perspective and qualitative methodology, this thesis critically investigates the role of biophysical factors, namely climate change and hydrologic conditions, and the political economy in shaping contemporary water management strategies in Flagstaff, Arizona. Specifically, the following research questions drive the investigation:

- What are the biophysical factors (climate patterns and impacts, regional hydrological characteristics), political economy factors (local economic conditions, regulatory frameworks), and urban growth factors (population and spatial expansion) that shape water supply, demand, and management in Flagstaff?
- Within the context of contemporary biophysical conditions and political economy, how do water policymakers, community interest groups, and scientists in Flagstaff define contemporary water problems, their causes, and potential management responses?
- What explains how water policymakers, community interest groups, and scientists in Flagstaff define contemporary water problems, their causes, and potential management responses, and what are the implications of these understandings on water management in Flagstaff?

1.1 Geography of Flagstaff, Arizona

Flagstaff is located in the northern third of Arizona (Figure 1), just north of the Mogollon Rim, a landform that forms the southern limit of the Colorado Plateau and that separates the desert climates of southern Arizona and the higher, forested areas in northern Arizona. The immediate area surrounding Flagstaff is a very scenic and breathtaking one, surrounded by three national forests containing dense stands of ponderosa pines and the San Francisco Peaks, a 12,000 foot mountain range. The Grand Canyon, the White Mountains of eastern Arizona, several national monuments, three national forests, many diverse vegetation types and landforms, and numerous vacation towns are located within a one half-day's drive from Flagstaff.

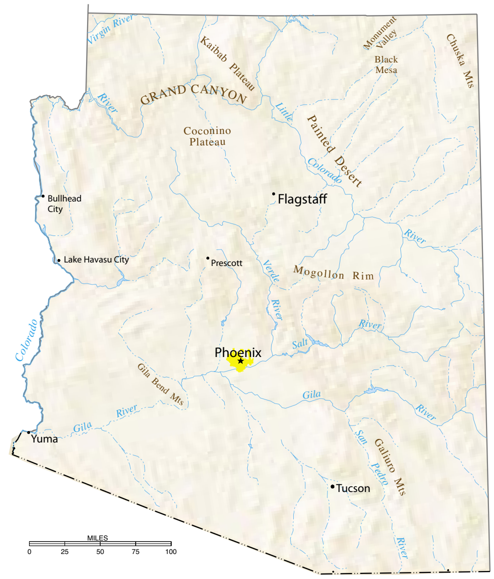

Figure 1. Map of Arizona.

1.2 Significance of Case Study

Flagstaff serves as an excellent representative case study for its experience provides useful insights for non-metropolitan municipal water management in other southwestern localities (e.g., Las Cruces, New Mexico; Santa Fe, New Mexico; and Yuma, Arizona) that are currently facing similar biophysical, political economy, and population changes, which in turn similarly affect water supply and demand. These areas are also implementing analogous water management policies. Similar conditions include climate regimes (Sheppard et al. 1999), local economies that are becoming more dependent on eco-tourism, outdoor recreation, second-home development, and service-oriented industries (Case and Alward 1997), rapidly growing (U.S. Census defined) metropolitan area population growth rates, averaging 141.4 percent since 1970 (Census Scope 2002), and similar metropolitan area populations, averaging 151,177 in 2000 (Census Scope 2002). Total municipal demand (as measured in total water production) has also increased. Between 1998 and 2002, total water production increased from 2.56 billion gallons per year (bgy) to 2.74 bgy in Flagstaff, from 5.71 bgy to 6.49 bgy in Las Cruces, and from 7.5 bgy to 8.6 bgy in Yuma.

Over the last four years, drier than average conditions have occurred in the southwestern United States. The Palmer Drought Severity Index (PDSI) is a widely used measure of drought in the United States. PDSI is an index of the degree that the actual moisture supply at a given place consistently falls short of the climatological mean moisture supply over a given time period, usually months or years. It has traditionally ranged between -4.0 (extremely dry) to +4.0 (extremely wet), with the central half (-2.0 to +2.0) representing average or near average conditions (Climate Prediction Center 2003). Between 1999 and 2002, PDSI values for Arizona averaged -2.59, and PDSI values for New Mexico averaged -1.18. In 2002, PDSI values averaged -4.54 in Arizona and -2.56 in New Mexico (PDSI data provided by the Climate Diagnostic Center).

During summer 2002, several southwestern cities (e.g., Flagstaff, Santa Fe, and Albuquerque) implemented conservation ordinances that required residents to reduce water use. In addition, several of these cities are currently (or have very recently) bolstered their water conservation programs (e.g., Flagstaff, Tucson, Santa Fe, and Albuquerque). Typical conservation strategies include restrictions on lawn watering and car-washing, as well as education outreach, inverted rate structures (where users are charged more, the more they use), and incentives for installing low-flow plumbing fixtures. Other cities have passed drought contingency plans, where restrictions on granting new water meters are implemented if demand exceeds supply for a defined number of days.

1.3 Is Flagstaff Really an Appropriate Case Study?

The same management model, resource instrumentalism (also termed resource utilitarianism), was historically evident in Flagstaff as well as the West in general although the specific means for managing water varied. I define the resource instrumentalism model as one that classifies entities in the physical landscape like trees or water as instruments, where the value of each 'instrument' is determined solely by its usefulness in producing goods and services like houses or agricultural crops. Here, instruments (i.e., natural resources) have to be continually available to maximize commodity production and, subsequently, economic wealth. Under the resource instrumentalism model, water supply augmentation was the sole water management strategy; any sort of water conservation policy was only evident during periods of extreme drought in Flagstaff (Cline 1994). Because both Flagstaff and the West in general embraced a resource instrumentalism approach to water management, very similar economic and political legitimation crises resulted, and are evident in contemporary economic landscapes (to be discussed later).

Recent water use proposals and hydrogeologic conditions in northern Arizona situate Flagstaff as a proving ground between the continual efficacy of resource instrumentalism policies and resource sustainability. In 2000, the Hopi Nation and Peabody Coal Plant committed funds to build a water pipeline from Lake Powell to the Peabody Coal plant located in the Hopi Nation in northeast Arizona. The pipeline water would replace groundwater pumped by the Peabody Coal plant from the confined aquifer located under the Hopi Nation, which is also used by the Hopi people for domestic, irrigation, and livestock purposes. If the pipeline was constructed, Flagstaff, as well as other communities in northern Arizona, could receive water from a spur line as long as they owned water rights on the Colorado River and held a high enough appropriation to receive water in times of low water supplies. The city of Flagstaff has expressed interest in purchasing existing Colorado River rights from retired agricultural lands in central and southern Arizona. Currently, environmentalists, Native American nations, and municipalities in northern Arizona are debating the economic, environmental, and cultural feasibility of this plan. Another water use proposal is currently undergoing review by the U.S. Forest Service (USFS) regarding use of reclaimed water. The Arizona Snowbowl ski resort submitted a request to use reclaimed water produced by the city of Flagstaff to make artificial snow. The city of Flagstaff approved the use, and the USFS should issue its decision by 2004. Similar to the pipeline proposal, environmentalists, Native Nations, and local businesses are currently debating the proposal. Given the on-going debates about the Lake Powell pipeline and snowmaking proposals, an average annual precipitation in Flagstaff of 21 inches (0.83 mm) per year, increasing municipal water demand, and the paucity of surface water in the immediate Flagstaff area, the Flagstaff case is ripe with reasons to renegotiate water resources management (and study the renegotiation) in Flagstaff.

1.4 Preview of Thesis Organization and Theoretical Perspective

Before brief reviews of the contemporary water resources management literature and a summary of my methodology, I attempt to theorize contemporary water management trends in Flagstaff using an ecological Marxism approach to political ecology. Drawing from recent literatures on the "greening" of capital, I hope to theoretically demonstrate that contemporary water management trends in Flagstaff are contingent on a particular construction of nature, ongoing social activism (couched within the broad environmental movement), and an economy dependent on nature as an amenity, as well as climatic and hydrogeologic factors. Ultimately, I am relying on this theoretical framework to answer the following questions: Why water conservation policies and reclaimed water use as opposed to the historically prevalent method of exclusively supply augmentation? Why Flagstaff? Why now?

I will then present the results of archival research on the biophysical dynamics (climate patterns and impacts, regional hydrological characteristics), aspects of the political economy (local economic conditions, regulatory frameworks), and urban growth changes that shape water supply, demand, and management in Flagstaff. Following that, I present a content analysis of qualitative data from interviews with area water-policy makers, community interest groups, and relevant scientists (e.g., hydrologists and meteorologists) in Flagstaff as an indication of the way current water problems, their causes, and responses are framed in Flagstaff. A presentation of empirical data can determine whether or not the contemporary water policymaking process in Flagstaff is reflective of my theoretical perspective, where resource instrumentalist policies are increasingly replaced with policies premised on sustainable resource management due, in part, to 1) the emergence of what James O'Connor (1994) terms the second contradiction of capital; 2) nature is constructed as an amenity and worth saving for the future; and 3) particular biophysical conditions, specifically recent drier than average precipitation trends and characteristics of the local hydrogeology. Finally, I will suggest some implications of the contemporary policy track and recommendations for future water resource policy in Flagstaff.

2. Theoretical Perspective

I employ three primary literatures to inform my theoretical perspective: political ecology, ecological Marxism, and the social production of nature. I supplement the general political ecology framework with shifts in how nature is constructed under two different water management models (resource instrumentalism and resource sustainability), and suggest the rise of resource sustainability is due to water policy responding to the second crisis of capital, a concept introduced by James O'Connor (1994) in the ecological Marxist literature.

2.1 Political Ecology

Political ecology is a research approach used to understand nature-society interactions, in particular, resource use systems of a particular place or region. Premised on unequal power relations, it links the biophysical environment, the institutional arrangements, and environmental narratives to understand different resource use systems, their differential effects on resource users, and resource conflicts. Political ecology studies often explain changes in the quality or quantity of natural resources[1] (usually physical degradation) by tracing the historically produced, socially constructed social, political, biophysical, technological, economic, regulatory, and cultural contexts at different scales. Early political ecology studies often countered the realist, colonial understanding of environmental degradation by offering a Marxist-influenced explanation of soil degradation (Blaikie 1985, Blaikie and Brookfield 1987). More recent empirical and theoretical works advance a post-structural political ecology focused on how "environmental knowledges are produced, represented, contested, and thereby enter into politics" (Blaikie 1999, p 142).

Among contemporary political ecology investigations, research is aimed in several directions. Some commentators demonstrate how governance institutions and/or environmental narratives contribute to biophysical changes by sustaining the agendas of powerful actors (see Peet and Watts 1996), while others focus on deconstructing environmental narratives (see Leach and Mearns 1996, Braun 2002), livelihoods (see Bebbington and Batterbury 2001), environmental and social change within the context of the neo-liberal agenda (see Guldbrandsen and Holland 2001), and sustainable development and biodiversity discourses (see Escobar 1996). Many of these studies are sited in the so-called Third World, specifically Latin America or Africa.

Several authors have contributed new directions and approaches to political ecology. Scoones (1999) suggests a fuller engagement of political ecology with new understandings of ecological interactions: a focus on the instability, uncertainty, and non-equilibrium of ecosystem dynamics, a contrast from the prior systems-based approach. Peterson (2000) argues for greater inclusion of ecology in political ecology, where a resilience-oriented approach to political ecology includes ecosystem dynamics and cross-scale interactions of the human-environment system. Other authors focus on the role of gender (and race and ethnicity) in resource use conflicts, and suggest a more feminist-based approach (see Rocheleau et al. 1996).

2.2 Literature Gaps

Although political ecology offers a compelling approach to understanding nature-society interactions, it is lacking in some areas. For instance, cases are rarely sited in advanced capitalist economies. Although some commentators have used a political ecology approach to understand changes in areas economically and culturally dependent on primary economic activities in the United States (see McCarthy 2002, Braun 2002), there have been fewer applications in places where it is generally agreed that tertiary and quaternary economic activities constitute the local economic base (see Demeritt 2001 for an exception). Several case studies are situated around conflicts that occur when an attempt to introduce a different construction of nature (e.g., nature as a tourist attraction or deserving protection) results in negative material implications for people who understood nature as common property used for sustenance, social reproduction, or livelihood purposes (see Nesbitt and Weiner 2001 for a case set in an advanced capitalist context; see Hecht and Cockburn 1989 for a case set in a developing nation).

2.3 Ecological Marxism

Although the political ecology approach has proven useful in its ability to capture the biophysical and political economy dimensions of natural resource use systems in areas where natural resources are used for subsistence purposes or to facilitate the growth of a capitalist economy dependent on production (of goods and services) activities, I hope to expand the utility of political ecology in understanding natural resource use dynamics in advanced capitalist economies. Drawing from James O'Connor (1994, 1998), Martin O'Connor (1993), Escobar (1996), and Watts and McCarthy (1997), I supplement the broad political ecology approach with an ecological Marxism theory to explain how area water policymakers and community interest groups and scientists define contemporary water problems, their causes, and potential management responses in Flagstaff. This theoretical framework broadens political ecology and directs it to natural resource use systems in a so-called First World context where natural amenities and eco-tourism increasingly constitute the economic context of communities in non-metropolitan areas rather than resource extractive activities. An important caveat: the tenets of ecological Marxism are often used to explain how resource policy facilitates capital's response to the second contradiction of capital (described below). While this research project is not designed to provide empirical evidence of a similar shift of capital in Flagstaff, I employ this theory to empirically demonstrate how contemporary water policy in Flagstaff responds to the defining criteria of a second crisis of capital and the capital structure associated with capital's response to a second crisis of capital: using nature (not just its 'parts') as an accumulation strategy. Below I outline the criteria of a second crisis of capital, its social impetus, capital's response, and the parallel natural resource policy response.

Similar to the restructuring of capital in the early-20th century that occurred in response to demand crises, where, in order to accumulate profits by decreasing labor costs, individual capitalists did not provide enough financial compensation or free time to laborers to allow them to buy the commodities they produced and further generate profit accumulation to individual capitalists (the "first contradiction of capital"), capital is undergoing another re-organization. However, James O'Connor (1994, 1998) attributes this restructuring to economic crises and legitimation crises arising from the "second contradiction of capital." Here, a second contradiction would occur when the costs for conditions of production (those things that are treated as if they are commodities, but that cannot be physically reproduced as commodities in accordance with the laws of the capitalist market, e.g., nature, labor, infrastructure, and space) rise significantly. He then posits that rising costs occur when one (or both) of the following conditions are met: 1) profits to individual capitalists accumulate by "strategies that degrade or fail to maintain over time the material conditions of their own production" (O'Connor, J. 1994, p 162); and 2) "[s]ocial movements demand that capital better provides from the maintenance and restoration for these conditions of life" (O'Connor, J. 1994, p 162).

Like the occurrence of any other re-organization of capital, the most recent reincarnation of capital is not primarily concerned with generating accumulation in a specific commodified sector (despite the intent of certain state policies), it is occurring exclusively to allow capitalism as a system to continue (O'Connor, M. 1993). However, the way that it has restructured has been contingent on the above two conditions: 1) deteriorating conditions of production (in this case, the quantity of available water supplies) and 2) previous and ongoing social resistance to the resource management model that led to deteriorating conditions of production (resource instrumentalism, in this case). The second requirement is intimately tied to how "nature" is constructed by those social groups that control how resources are allocated. Below, I provide a brief summary of recent changes in the ways "desirable nature" has been constructed, and the impetus for these changes. This discussion is designed to provide the reader with empirical and theoretical evidence of recent shifts in the construction of nature with respect to Western water management.

2.4 The Social Production of Nature

Similar to other fundamental geographic concepts like space (see Smith 1984), culture (see Mitchell 2000), and scale (see Smith 1992), scholarly pursuit into the social production of nature is currently occurring after some prodding (Fitzsimmons 1989). I draw my primary theoretical inspiration from literature that addresses the implications when science defines what counts (and does not count) in nature (Macnaghten and Urry 1998, Braun and Castree 1998) and political ecology studies focusing on the role of discourse in shaping the construction of nature (Escobar 1996, Watts and McCarthy 1997). Although this literature is certainly influenced by Smith's (1984) Marxist interpretation of the way nature is socially produced, it also highlights the role of human and non-human agency in producing particular constructions of nature.

In one of the earliest nods to the social production of nature, Smith (1984) demonstrated that, while biogeochemical and other physical processes determine material nature, the ruling class constructs that part of material nature that counts as nature. Further, he maintained that nature, under capitalism, is not an ontological domain, separate from social relations; rather, he envisioned a dialectical nature-society relationship, where nature is reproduced (prefix not in original; the term was introduced by Peet 1989) through human labor. That is, nature produces both a means of subsistence and a surplus at the same time. Under capitalism, unevenness, political contestations, and contradictions surround the allocation of surplus and lead to a nature-society dialectic defined by exchange values.

Katz (1998) and Macnaghten and Urry (1998) broaden the Marxist interpretation by introducing the role of human agency in shaping resource use policies through comparisons of how nature was constructed under resource instrumentalism polices and under more "environmentally-friendly" contemporary resource use policies. With the hopes of ultimately comparing these policies, and particularly the role of the way nature was constructed in each management model, the following paragraphs summarize the main characteristics of resource instrumentalism policies as they apply to Western water resources. It is important to remember that at any one time, several different constructions of nature are in place. It is the construction of the most powerful (whomever that happens to be, and whatever political contestations were associated with them "getting" there) that direct the way resources are allocated, and more broadly, what facets of physical nature are deemed important.

2.5 Nature under Resource Instrumentalism

A partial product of the welfare state economic policy, resource instrumentalism (also termed resource utilitarianism) heavily influenced the prior appropriation doctrine, Western water use policy in the mid-20th century (Worster 1985, Emel 1990), and natural resource policy since the late 1800s. Resource instrumentalism values natural resources only for their utility in accumulating surplus capital through commodity production. A higher and thus more "beneficial" use is defined as one that yields a higher economic return, given any economic context. Although the transition from one economic activity to the next is often surrounded by conflict and relies on a discourse to legitimate both economic activities, a resource instrumentalism approach will always favor the activity that yields the highest economic return in any given economic climate regardless of the consequences. Because resource instrumentalism treated natural resources as conditions of production (i.e., something that cannot be physically reproduced by the market, but is necessary for market activity), new supplies had to be continually sought to ensure continual economic growth once original supplies were depleted or degraded. Conservation policies were rarely if ever pursued because they would conflict with the primary end of resource instrumentalism: economic growth through commodity production.

A brief summary of the characteristics of Western water management in the mid-20th century provides a useful example of the dimensions of resource instrumentalism. Often referred to as the 'Big Dam Era,' Western water management between the 1930s and 1970s was characterized by the construction of many large-scale water supply projects consisting of dams, delivery infrastructure, pumps, and canals on several Western river systems, by primarily the Bureau of Reclamation (BOR). The BOR currently manages 348 reservoirs that can store a total of 245 million acre-feet and 58 hydroelectric power plants (Bureau of Reclamation 2003); a majority of these projects were constructed during the Big Dam Era. Nearly all canyons geologically capable (and some incapable) of supporting a dam were dammed, and the resulting reservoir water was piped hundreds of miles to urban residents and farmers. These projects (and their funding structures) were planned in closed door meetings among 'Iron Triangle' (Lowi 1979) members—private agribusiness representatives, federal land and water management agencies (e.g., BOR and the Army Corps of Engineers), and congressional appropriation committees. Officially unrecognized, these powerful players controlled water policy to their benefit during the Big Dam Era. In concert with federal subsidies, a positivist, Enlightenment approach to scientific knowledge (Wallace et al. 1996), and technologies that could overcome the uneven spatial distribution of surface water bodies (e.g., submersible groundwater pumps, large-scale dams, and delivery infrastructure), resource instrumentalism led to economic (and political) dominance of primary sector, resource extraction economic activities, and especially large-scale irrigated agriculture in the West.

Literature that critically examined Western water management in the mid-20th century emphasize several characteristics, namely that urban growth, irrigated agriculture, and associated private capital accumulation were facilitated by federal and state policies and the prior appropriation water rights structure. These processes have been detrimental to the interests of Native American and Hispanic peoples, water quality, hydrologic sustainability, and the democratic process (Reisner 1986, Gottlieb 1988, Gottlieb and Fitzsimmons 1991, Brown and Ingram 1987, Worster 1985). However, I would argue that these exploitative processes should also be attributed to capital seeking "the path of least resistance" (i.e., least financial, regulatory, and social costs and most profit), as well as to the resource instrumentalism doctrine. In addition, as indicated in the previous paragraph, the state plays a significant role in establishing conditions for capital by enacting laws and regulations governing natural resources, and constructing infrastructure favorable to capital.

2.6 Renegotiating Nature

Gaining steam in the 1960s and 1970s, ecologists and environmental scientists (for example, Rachel Carson, Paul Ehrlich, and Garrett Hardin), as well as the broader environmental movement, were contesting instrumental perspectives of nature (Cortner and Moote 1999). The notions that some human activities lead to negative impacts on the environment and that, at least to some degree, natural resources should be conserved have their roots in the mid-18th century, as evidenced in works by George Perkins Marsh and John Muir, the founder of the Sierra Club.

One of the seminal events of the environmental movement, environmental legislation enacted in the United States in the early 1970s acknowledged that unfettered capital accumulation produces negative environmental impacts. In this 'reconceptualized nature,' claims critical of previous views of nature are accepted as true, for example, resources are understood to be finite in number (Escobar 1996), material nature is constructed as a whole ecosystem instead of a sink of raw materials, and "fragile" material nature is worthy of protection from "exploitive" resource extractive economic activities (Katz 1998, Macnaghten and Urry 1998). The ultimate aim of many of these claims was to assign and establish some inherent value of nature to counter the purely economic value assigned to nature under resource instrumentalism.

In relation to Western water management, the broadly defined environmental movement and David Brower's Sierra Club brought increasing attention during the mid-20th century to the negative environmental impacts of resource instrumentalism, specifically the effects of continual supply augmentation, dams, and production sector economic activities like agriculture, logging, and mining. The broader environmental movement uses the following arguments to call for an end of the Big Dam Era:

- Alterations to Western river systems disrupt fish migration, flooding patterns, water temperature, sediment and nutrient loads, channel dimensions and patterns (Graf 1997, Collier et al. 1996), distribution and location of wetlands (Grimm 1997), and the number and species of fish (Minckley 1997).

- Large-scale irrigated agriculture has contributed to increased saline, sediment, pesticide, and fertilizer concentrations in downstream return flows and hydrologically-connected aquifers (National Research Council Committee on Irrigation-Induced Water Quality Problems 1989).

Citing the growing detrimental effects of water management policies associated with the Big Dam Era, the environmental movement has called for an acknowledgment of the environmental (and to some extent, social) costs of natural resource policies that seek to make water and land resources continually available for capital. Earlier evidence of the movement away from resource instrumentalism and toward resource sustainability is evident in the forestry conservation era, the idea that forests should be logged more sustainably as promoted by Gifford Pinchot, and the conservation ethic advanced by John Muir, all in the late 1800s and early 1900s.

2.7 Capital's Response

When the two conditions of a second crisis of capital manifest, capital interprets both conditions as threats to continued profitability. The first condition leads to an economic crisis where conditions of production are threatened, and the second criteria leads to a political legitimation crisis, where the previous construction of nature is contested by social movements. In either case, the conditions are threats to the sustainability of capitalism because financial costs for the conditions of production rise and capital flexibility is hampered (O'Connor, J. 1994). At this point, capital must abandon previous investment strategies and accommodate some the claims made by environmental movements. According to Escobar (1996), capital enters an "ecological phase," where it appears the goals of capital accumulation and the goals of the environmental movement are compatible. Essentially, it must agree that the ecological consequences of its own making are true. In general, this process has taken the form of a shift away from the form that resource instrumentalism took in the western United States: irrigated agriculture and other primary sector, resource extractive economic activities and not necessarily a shift away from the aim of resource instrumentalism: continual economic growth. Similar to the ways that capital organized during the resource instrumentalism model, it continues to 'seek the path of least (economic, social, regulatory) resistance (i.e., costs)'.

Here, we see the economic return of export-oriented resource extraction activities associated with the resource instrumentalism model dwindle as a result of the second crisis of capital. Increasing financial costs (e.g., access costs have risen for increasingly less accessible resources to extract), political costs (e.g., resistance by broadly supported social movements), and regulatory costs (e.g., environmental legislative requirements) lead capital to seek other outlets for investment (e.g., non-resource extraction economic opportunities) to ensure continuous profit growth through capital reinvestment. These outlets include knowledge-based services, trade, and consumer services that Case and Alward (1997) indicate are the leading economic sectors in many areas of the West today.

Another outlet is intimately linked with the reconceptualized view of nature associated with the broad environmental movement. In concert with the use of "pristine nature" as a marketing tool for urban growth (Prytherch 1999), the construction of nature as a whole ecosystem instead of a sink of raw materials has, in part, facilitated economic activities dependent on recreational or aesthetic consumption of nature (Power 1996) that are emerging in the West (Duane 1999). I define the phrase 'recreational or aesthetic consumption of nature' as a form of commodifying nature where capital accumulation results from the material goods (e.g., homes on the urban/nature fringe, hiking equipment, private conservation lands) purchased by people who receive enjoyment from the vegetation and wildlife contained in material nature. Nature is therefore increasingly incorporated by capital as an accumulation strategy, and protected by capital for its own ends; and thus, leads to the emergence of economic activities designed to "sustain" natural resources by limiting raw material exploitation. Further, I suggest that the increasing importance of these activities to the West's economy is reflective of the second crisis of capital.

The production and consumption of nature as an amenity implicitly implies that future capital accumulation in these sectors almost exclusively depends on maintaining the "pristine nature" that drives these industries. In this instance, nature as a "whole" is indirectly commodified (for example, expensive homes on the urban/forest fringe, increasing water rates used to encourage water conservation, or park entrance fees) instead of "its parts" being directly commodified, which was associated with resource instrumentalism. In this instance, capital attempts to protect its "production conditions" from a select group of threats, namely those that are unproblematic to the largest group of potential consumers. For, at the same time capital is interested in sustaining natural resources, it is degrading them through spatially expansive urban growth.

2.8 Parallel Shifts in Natural Resource Policy

Natural resource policy and capital have responded in a parallel fashion to the second crisis of capital: a shift away from the form that resource instrumentalism took in the western United States, and not necessarily a shift away from the aim of resource instrumentalism. Where capital shifts away from irrigated agriculture and other primary sector economic activities, water resource policy shifts away from supply augmentation and large scale dam projects. Further, Katz (1998) and Macnaghten and Urry (1998) provide examples of how nature is increasingly incorporated into resource use policies (in addition to capital's treatment of nature as a commodifiable amenity), often through commodifying nature. Katz (1998) demonstrates how the proliferation of "metaphors of investment, saving, and future gain" (p. 48) in environmental discourse leads to calls for defining places requiring protection in New York City, while Macnaghten and Urry (1998) point to the rise of green consumerism, eco-tourism, privatizing previously public environments, and the increasing use of the ecological modernization approach (i.e., the cost/benefit method) as examples. In these instances, it is assumed that the natural conditions of production can be commodified and incorporated into the capitalist system despite their inability to be physically reproduced capitalistically.

The federal-level multiple use policy for public lands management in the 1960s and 1970s is a representative example of one of the first attempts to reconcile nature with resource instrumentalism in the United States (Davis 2001). To environmentalists, this approach was interpreted to mean that other values besides economic were respected, especially in light of the passage of other environmental legislation in the early 1970s designed to clean up pollution associated with production sector industries like agriculture, manufacturing, logging, and mining. The multiple use policies made natural resources available for both production sector and tourist/recreation sector activities (for example, grazing and logging permits were granted at the same time hiking trails were constructed, all on public lands). They also fueled economies reliant on aesthetically or recreationally consuming nature that were located adjacent to numerous public lands, where the necessary infrastructure for further consuming nature was subsequently put into place: more hotels and highways to the tourist attractions, forest preserves, hiking trails, outdoor gear outfitters, and vacation homes.

Premised on the above theoretical demonstration that, in a general sense, a second crisis of capital has occurred in the West and that capital has responded to it, my study empirically demonstrates how the shift from resource instrumentalism to resource sustainability and the associated endorsement of conservation measures in Flagstaff emerged out of a response to the defining criteria of a second crisis of capital and the capital structure associated with a second crisis of capital, as well as to biophysical factors.

3. Literature Review

Changes in the way Western water resources are allocated and managed are leading to significant debates in the scholarly literatures. Scholars in water resources management, law, and resource geography are documenting the management shifts and speculating on potential means of re-allocation. They attribute these shifts to changes in regulatory, economic, water demand, and climate trends at the local, regional, federal, and global scales. While I realize these scales are socially constructed (Smith 1992, Delaney and Leitner 1997, Howitt 1993, Swyngedouw 1997), and want to acknowledge the contestations and unevenness associated with the construction process, these scale labels are often used by water resource management experts, and their use allows more compatibility of my research with resources management literature. The following paragraphs review regulatory, economic, water demand, and climate factors that water resource scholars in the resource geography, law, and water resources management disciplines have attributed as causes of contemporary shifts in Western water resource management. I mention these here to bring attention to the inadequate theorization of contemporary Western water management trends. While many commentators provide partial listings of the following factors to define current management trends and to justify different (and oftentimes conflicting) management changes, the 'laundry list' method leaves much to be desired.

3.1 Regulatory Factors

A report issued by the Western Water Policy Review Advisory Committee (1998), one charged by Congress for making recommendations about the appropriate role of the federal government regarding water management, cites a decreased availability of federal and state monies for water supply augmentation and decision-making gridlock within and among federal and state water management agencies as important regulatory factors (see Wilson 2002 for a critical examination of this claim). In the previous era of Western water management, two federal agencies (the Bureau of Reclamation and Army Corps of Engineers) directed water development in the United States, and federal dollars funded nearly all of the water supply projects, whereas water is currently managed by several, often competing, agencies. In contrast to federal control over water quality, water resources appropriation has long been controlled by states and municipalities. While the Colorado River Compact is the most well-known example, interstate water compacts also govern state appropriation decisions for adjacent states and/or countries. The Colorado River Compact is the primary legal document in the broader "Law of the River" that governs how much Colorado River water is appropriated to the Upper Basin states, to the Lower Basin states, and to Mexico.

3.2 Economic Factors

The most commonly cited economic factor is a shifting regional economic base from production-sector resource extraction activities like agriculture, logging, and mining to activities like knowledge-based services, customer-oriented services, trade, and construction sectors (Case and Alward 1997). Giansante et al. (2002) and Haughton (2001) point to the rise of the neo-liberal agenda affecting water policy in Spain and Australia, respectively, where neo-liberalism refers to an economic theory associated with economic policies proposed by Adam Smith (1791) where individual freedom from regulatory restraint, free competition, a self-regulating market, and privatization of all social interactions are implemented. This trend is evident in some of the reasons provided to justify changes in water policy (for example, decreased monies at the federal level), and is also evident in proposed management responses: privatization of water resources, implementing water markets, and water transfers.

3.3 Water Demand Factors

Changes in water demand include continual population growth in both large metropolitan areas and in exurban areas in the West (Plummer 1994, Case and Alward 1997, Riebsame 1997), increasing urban per-capita consumption of water (Solley 1998), and increases in competing claims (for example, Native American water rights, ecosystem rights) for an already over-allocated supply (Western Water Policy Review Advisory Committee 1998). Water demand, as determined by the number of people using it, the per-capita consumption, and the number of uses, is increasing.

3.4 Climate Factors

Given the widespread acknowledgment that the West is currently experiencing drought conditions, the effect of climate on water supplies is increasingly cited as a factor in contemporary shifts in water management trends. Several scholars outline the effect of climate uncertainty on Western water resources, especially in the context of prolonged periods of less-than-average precipitation (sustained droughts) (National Research Council Committee on Climate Uncertainty and Water Resources Management 1991, Tarlock 1991, Frederick and Major 1997).

In a sensitivity analysis of the urban water sector in Arizona to climate variability, Carter et al. (2000) found that under a five-year drought scenario, assuming supplies are equal to the 1995 supplies, groundwater overdraft would equal 59 percent in Phoenix, Arizona. In a ten-year drought scenario (and the same supply assumption and location), groundwater overdraft would equal 52 percent (Carter et al. 2000).

In drought simulation models for the Colorado River informed by the instrumental record of 29 stream gauging sites and two different historical stream flow reconstructions at Lee's Ferry using tree rings, Tarboton (1995) determined that the return period for an historic drought similar to the 1943 to 1964 drought in the U.S. Southwest, is 50 to 100 years and the return period for a severe drought, similar to the one from 1579 to 1600 as reconstructed from tree rings, is 400 to 700 years. The study defends their selection of drought scenarios by suggesting that the 1943 to 1964 drought is recorded on the instrumental record and likely to recur, while the 1579 to 1600 drought is the most severe, sustained reconstructed drought on the Colorado River where three hydrologic droughts occurred in sequence.

Of particular importance to the Flagstaff case because of their interest in Lake Powell, Harding et al. (1995) determined that the Upper Basin states would be disproportionately affected by a 38-year severe sustained drought leading to a dead storage condition on Lake Powell after the 22nd year of the modeled drought, assuming 1991 institutional and physical characteristics. The drought duration period was selected because it represents the most severe reconstructed drought on the Colorado River system (1579 to 1600) and a 16-year recovery period (1601-1616).

3.5 Contemporary Western Water Management Trends

Citing the above factors, several new management trends have been proposed by scholarly and gray literatures or have actually implemented in Western urban areas. In some locations, the shift toward a single approach is occurring, while in other locations, the direction of water policy is currently being contested. Trends in contemporary Western water management consist of shifting water resources from agricultural to urban interests (Western Water Policy Review Advisory Committee 1998, Folk-Williams et al. 1985), supplementing supply augmentation with demand-management (Maddock and Hines 1995, Willardson 1996), and replacing state-administered water policies with privatized water markets (Anderson and Hill 1997, Colby 1997, Graff and Yardas 1998) or with collaborative community-based resource management (CCRM) (Weber 2000). Often, CCRM groups are organized around watersheds or ecosystems instead of political boundaries (Griffin 1999, Kenney 1999). The water resources management, law, and resource geography literatures agree on contemporary trends in Western water management (i.e., shifts from agricultural to urban, from supply-side management to demand-side management). However, debates over potential directions for water management policy persist (see Anderson and Hill 1997, Freyfogle 1996 for contemporary debates on water marketing/privatization; see Wallace et al. 1996 and Wilson 2002 for contemporary debates on CCRM). In much of the water resources management literature, contemporary trends in water management are not adequately theorized. The social and political relations between water users and water policymakers are fully ignored, which were examined so thoroughly in historical investigations of the Big Dam Era (see Reisner 1986 or Gottlieb 1988 for examples of critical analyses of the Big Dam Era). In addition, contemporary trends tend to reproduce the same divides water policy analysis is often arranged around: urban/rural, supply side/demand side, and public/private.

3.6 Literature Gaps

While the literature is far from agreement about the effectiveness of either privatization or CCRM, several Western cities are increasingly implementing another management strategy, water conservation measures, in response to the above factors. This trend is apparently accepted by the literature as unproblematic, attested to by the fact that I was only able to locate a few articles that critically discuss it, even though conservation programs have been implemented in several Western states and municipalities. In an instance where conservation policies are critiqued, Woodard (2002) demonstrates that conservation policies designed to reduce permanent demand often lead to a 'hardened' demand, where demand is considered 'hardened' when it can only marginally at best be further decreased in the face of a severe drought or other supply disruption as a community's water efficiency increases.

Reviews by the Western States Water Council of state conservation programs indicated that the number of Western states that have implemented a state conservation policy increased from two in 1983 to nine in 1992 (Western States Water Council 1984, Willardson 1996). In addition, recent reviews by Maddock and Hines (1995) and Booth (2003) of municipal water departments in El Paso, Albuquerque, Las Vegas, Phoenix, Salt Lake City, and Santa Fe found that these cities had some form of conservation program, albeit along a wide spectrum from educational outreach and implementing inverted or seasonal water rates, incentives for installing low-flow plumbing fixtures, or lawn watering restrictions (these ranged from voluntary residential and commercial measures in Phoenix to complete moratoriums on lawn watering in Aurora, Colorado in February 2003), in addition to groundwater recharge and effluent re-use programs. These cities are also pursuing supply augmentation projects. Conservation programs were introduced in the 1980s and 1990s, and have been strengthened (in varying degrees) in the past few years.

The increase in the number of urban and statewide conservation policies can be related to broader natural resources management trends toward sustainable resources management. I define sustainable water resources management as a policy direction intended to limit water use through strategies designed to improve water efficiency (e.g., low flow plumbing fixtures), promote water-conserving behaviors (e.g., replacing water-intensive landscaping with low water use plants), and/or restrict water uses (e.g., residential irrigation is limited or outlawed). Scholarly research in water resources management literature that uses the term, sustainability, is not very well developed or theorized. In general, the little amount of sustainable water management literature that is published is focused on European or Middle Eastern experiences (see Bromley et al. 2001 or Hussein 2001, respectively) or experiences in the developing world (see Swaminathan 2000). As for the United States experience, Loaiciga and Leipnik (2001) present a water marketing approach for achieving, what they term, sustainable water management in Santa Barbara, California; Sophocleous (2000) introduces an additional factor, stream flow discharge, to calculate when determining groundwater safe yield in Kansas; and Burson (2000) presents the conflicts associated with forming a commission to study water sustainability on the Middle Rio Grande River in New Mexico. Papers presented at recent conferences about sustainable water management or water conservation in the United States do not go much farther in theorizing why conservation programs are so popular with contemporary urban water managers; many link the notion of sustainability with measures that are similar to existing conservation programs, like inverted rate structures, water recycling, water marketing, or engineering design improvements in effluent treatment technology (Natural Resources Law Center Summer Conference 1995, Wong et al. 1999). My study attempts to critically theorize the factors leading to and implications of one of the more stringent conservation programs in the western United States (Flagstaff, Arizona).

4. Methodology

The theoretical approach I used in this study requires a thorough understanding of the social and environmental conditions to adequately analyze changes in the human-environment relationship in a given place. Using archival research techniques, I analyzed historic and contemporary climate, hydrologic, economic, regulatory, and population data (described in more detail below) to understand how these factors shape water supply and demand in Flagstaff. It also allowed me to speculate on the extent that each component of the socioenvironment limits or enables specific changes in the relationship between water users, water managers, and water resources.

Semi-structured interviews with key informants served as the data source for a content analysis of how contemporary water management issues, their causes, and management alternatives in Flagstaff are defined by water policy-setting organizations, interest groups in Flagstaff, and the scientific community.

4.1 Archival Research

The first phase of research primarily addressed my first research sub-question, that of identifying the climatic, hydrologic, economic, regulatory/legal, and population factors that shape water supply, demand, and management in Flagstaff. This is important, not only to speculate on the constraints for future management responses, but also because the current policies result from interactions among historical socioenvironmental factors. Some insight into how historical conditions produced the current management model facilitates an understanding of how the current demand and supply context might affect future management choices. Specifically, I sought to answer the following questions of the historic and contemporary biophysical, political economy, population, and water management data.

1. What trends can be identified and when did they occur?

2. What are the significant events in the economic, population, and climate trends, where significant events are defined as any shift in an index or in any given factor?

3. How did trends and significant events affect water supply and demand?

Data sources consisted of governmental agency reports and data on the local hydrology, climatology, economy, and population; the relevant local, state, and federal policies; two books chronicling Flagstaff's history that are authored by a former local newspaper editor (Cline 1976, Cline 1994); City Council meeting minutes; local newspaper articles; Water Commission meeting minutes; and municipal planning documents. U.S. Census data, including population, housing, and employment trends, was available for 1970, 1980, and 2000. I used the Cline references for events occurring between 1876 (settlement of Flagstaff) and approximately 1990. The newspaper articles, City Council meeting minutes, municipal planning documents, and Water Commission minutes filled in the gaps between 1990 and the present.

4.1.1 Economic Data

In order to determine how Flagstaff's dependence on any given economic sector over time affected water supply and demand, I defined dominant economic activities as the economic sectors that employed the most people, sectors that contributed the most to the city's revenue base, and the amount of capital investment in each sector.

4.1.2 Population Data

Population, growth, and migration data in recent and historical censuses allowed me to determine changes in demand for residential water use. In addition, I consulted the population forecast modeled by the Arizona Department of Economic Security to determine potential demand in the future. I realize that population is not directly correlated to water demand, but it is an approximate proxy. I grouped land use changes into this category, looking for changes in the spatial extent of Flagstaff over time.

4.1.3 Flagstaff Water Management Policies

I looked for trends in water management policies enacted by the city of Flagstaff to overlay with the socioeconomic data. I defined water policies as any rate changes, supply source changes, bonds for infrastructure, and, in general, anything outside of routine maintenance (e.g., repairs on water lines, metering equipment, etc) that changed their demand and/or supply.

4.1.4 Hydrologic Data

Utilizing data from the United States Geological Survey (USGS) and the City of Flagstaff, I summarized the regional hydrogeology, including surface water features, and groundwater aquifers. Because Flagstaff utilizes both surface and groundwater supplies, I needed to understand the hydrogeology of both.

4.1.5 Legal/Regulatory Data

I consulted the city code, state statutes, Arizona case law, and federal policies regarding water to understand the current regulatory context that Flagstaff water policymakers are operating within with respect to state and federal regulations.

4.1.6 Climate Data

I utilized paleo and instrumental temperature and precipitation data for Flagstaff and/or northern Arizona in general, depending on what data was available. I was primarily looking for wet and dry trends in precipitation and hot and cool trends in temperature. I also examined literature indicating the nature and historical and forecasted frequency of climate patterns.

4.2 Semi-Structured Interviews and Content Analysis

Before I contacted any informants, I obtained project approval from the University of Arizona Human Subjects Institutional Review Board. Approval covered the overall project methodology, the consent to participate form, the site authorization form, the subject information form, and the interview protocol (see Appendix A for the approval letter). Upon initial contact with each interviewee, I introduced myself, explained my research topic, and sought initial participation consent. At the interview, I distributed a written consent form and, where required, a site authorization form, to each informant that agreed to participate in cassette-taped interviews. I sought continual consent throughout the data collection process to ensure all informants understood their role in my research project.

As additional preparation for the interviews, I created prompts for each interview question, but found that few subjects required clarification on any given question. Prior to the interviewing process, five Arizona water policy experts reviewed my questions and prompts for accuracy, clarity, order of questions and relevance. Reviewers included people working in regulatory and academic institutions. I incorporated many of the suggestions into the questions and prompts.

Drawing from the premise that qualitative research calls for research-participant perspectives on the research topic (Marshall 1989), these interviews constituted the core sources that I used to address my second research question. I queried each informant about the influences on the management process, major water issues in Flagstaff and their causes, suggested management responses, and information sources (see Appendix B for the full interview protocol). I conducted in-person, in-depth, semi-structured interviews with 30 representatives of key water policymaking organizations in northern Arizona and interest groups and the scientific community in Flagstaff. I used the same interview questions on subjects in each of the three main subject groups, with one exception: I queried subjects in representing policymaking organizations about what types of water management decisions they are authorized to make and the degree they serve a particular constituency group.

My sampling technique sought to maximize representation among water policy-setting organizations, interest groups in Flagstaff, and the scientific community in Flagstaff using several different sources: the city of Flagstaff web site, phone book, relevant newspaper articles, internet searches for Flagstaff organizations, and referrals by other informants. Out of approximately 17 water policymaking organizations in northern Arizona, my interviewee selections met at least one of the following criteria: 1) a government agency that can legally influence water policy decisions in Flagstaff, and, 2) an organization that would be directly affected by changes in Flagstaff's water policies. Organizations outside of those that met the above criteria were interviewed if they were recommended to me by water policymakers, community interest groups, or scientists in Flagstaff. I based this decision on the fact that these would most likely be the organizations with the most influence over the referee. Please refer to Table 1 for the list of potential, contacted, and interviewed area water policymaking organizations.

I selected community interest groups and members of the scientific community based on their influence in the community, as determined by their participation in city policy-setting and/or referrals by other informants.

Table 1. Area Water Policymaking Organizations.

Jurisdiction	Organization	Interviewed
City of Flagstaff	Elected Officials	X
	Water Commission	*
	City Staff	X
Coconino County	Elected Officials	X
	Private Water Haulers	X
	Private Water Companies	X
Region	North Central Arizona Water Supply Study	X
	Coconino Plateau Water Advisory Council	X
Native American Reservations	Hopi Reservation	X
	Navajo Reservation	
	Havasupai Reservation	
	Hualapai Reservation	
Arizona	AZ Department of Water Resources	X
	AZ Department of Environmental Quality	**
	Arizona State Legislature Water Policy Committees	*
	Arizona Governor	*
	Arizona State Parks	
	Arizona State Trust Lands	
Federal	USFS – CNF, KNF, PNF	**
	National Park Service – GCNP, WNM, SCVNM, WCNM	
	Bureau of Reclamation	X

X Interviewed
* Agendas or minutes acquired
** Interview requested, but informant declined

I did not attempt to interview agencies that cannot legally influence water policy decisions in Flagstaff, would not be directly influenced by water policies in Flagstaff, and/or were not recommended to me by other informants.

Table 2. Sample Composition.

Category	Number
Area water policymakers	14
Scientists	2
Community Interest Groups	14
Conservation/Environmental	2
Economic Development	2
Forestry/Fuels Management	2
Land Development	1
Large Industrial Water User	1
Large Local Employer	1
Large Reclaimed Water User	2
Ranching	1
Tourism/Recreation	2

Reasons given as to why some contacted organizations declined an interview included scheduling conflicts, unavailability due to workload, and concerns regarding commenting on water issues in another jurisdiction. A limited number of organizations that I contacted indicated they did not know enough about water issues to comment; in some cases, I was referred to a similar organization. Some organizations never replied despite repeated contact attempts on my part.

Representation was limited in the land development group, the city water commission members, and water quality experts. Development companies in the area and the local land development organization were extremely hesitant to participate. I contacted all the development companies that were listed in the local phonebook, and many did not respond to my interview requests. One company directly declined. As for the water commission members, I interviewed two members also affiliated with city government. I did not receive a response from the other five appointed citizen members, however, I did review their commission minutes. Because my project is focused on water supply issues, I did not concentrate heavily on water quality concerns, although quantity can be affected by quality. I did consult some U.S. Geological Survey reports on water quality in the Flagstaff region during the archival research phase (Bills and Flynn 2002, Bills et al. 2000, McGavock et al. 1986). My final sample composition is reflected in the Table 2.

Following Gillham (2000), I conducted a content analysis of the interview data after the interviews were completed. After transcribing all of the interviews, I reviewed the transcripts searching for substantive statements about each of the primary interest areas: pressing water problems, causes, favored management responses, information sources, and influences on the decision-making process. Using the question groups as guidance, I determined categories for the responses. I was particularly interested in differences among the three subject groups: water policymakers, interest groups in Flagstaff, and the scientific community in Flagstaff.

5. Findings

Here, I directly address the first two research questions, as well as provide empirical evidence to support the theoretical perspective (i.e., the "results" to the third research question) that I employ to explain the results of the first two research questions. Specifically, I provide evidence of the three factors I hypothesize led to the emergence of the sustainable water management model in Flagstaff: 1) the defining criteria of a second crisis of capital (i.e., deteriorating physical conditions of production, namely available water supplies, and contemporary local social movements against resource instrumentalist approaches to water resources management), 2) a capital structure associated with its response to a second crisis of capital (i.e., using nature as an accumulation strategy), and 3) biophysical factors, namely climate variability and local hydrologic characteristics. Because these three phenomena are intimately bound up with each other and temporally fluid, it is nearly impossible to determine which factor held the most influence over water policy at any particular time. With that in mind, I present the results of my first two research questions, intertwined with empirical evidence of my theoretical approach (i.e., the answer to the third question).

5.1 Results of Research Question #1

What are the biophysical factors (climate patterns and impacts and regional hydrological characteristics), political economy factors (local economic conditions, regulatory frameworks), and urban growth factors (population and spatial expansion) that shape water supply, demand, and management in Flagstaff?

The intersection of biophysical factors, the political economy, urban growth, and water resources management in Flagstaff is dialectical, complex, and often not suggestive of a single trajectory in any context. While I am not interested in demonstrating the material effect of one on another (i.e., the effect of water supply development on urban growth or the effect of urban growth on water supply development), I paint a picture of the socioenvironmental context in Flagstaff as it relates to water resources management, in both historic and contemporary times. With the aid of Figure 2, I hope to not only introduce the reader to the Flagstaff case, but also provide some empirical evidence of the

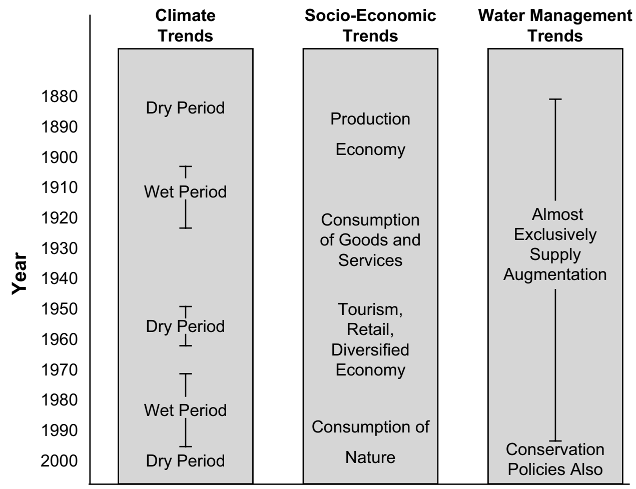

Figure 2. Intersection of Climate, Socioeconomic, and Water Management Trends,

theoretical perspective employed here. What follows is a history of the water management trends in Flagstaff followed by discussions of climate variability in northern Arizona, local groundwater hydrology, economic structural changes, demographic changes, and attitude changes in Flagstaff. A more detailed account of the local hydrogeology is located in Appendix C.

5.1.1 Water Resources, Water Management, and Water Infrastructure Change in Flagstaff

Supply augmentation has always played a leading role in Flagstaff's water management strategy. Since Flagstaff was settled in the late 1880s, and up to 1990, supply augmentation was the only long-term water management policy. Since approximately 1990, some degree of demand management has been included in their management approach. See Table 3 for a timeline of the City of Flagstaff's water resources management events. I include it as a reference for the reader's convenience during subsequent sections of the thesis.

The current water supply of Flagstaff consists of surface water, groundwater, and reclaimed sources (Figure 3). Surface supplies consist of a series of small reservoirs fed by springs in the San Francisco Peaks and Upper Lake Mary, located southeast of town. The caldera known as the Inner Basin is located on the northeastern side of the San Francisco Peaks, where it was glacially carved out and contains glacially deposited alluvium. Three reservoirs and the associated infrastructure were completed in the Inner Basin between

Table 3. Water Management Timeline.

1883–1896	Water hauled from area springs.
1894	The city of Flagstaff incorporated.
1898	The first reservoir, with a capacity of 2.5 million gallons was constructed on small springs in the Inner Basin.
1914	An additional reservoir (capacity = 47.5 million gallons) in the Inner Basin was completed and the transport pipe is upgraded.
1925	The final 50-million gallon reservoir was completed in the Inner Basin.
1930s	Water was trucked in from Winslow after Inner Basin reservoirs go dry.
1941	Lake Mary reservoir (2 billion gallon capacity), treatment plant, and delivery infrastructure was completed.
1954	Beginning of Woody Mountain wellfield development; groundwater encountered at 1250 feet.
1956	Fines imposed on heavy users.
1957	Water commission formed to address growth outside city limits.
1963	Beginning of Lake Mary wellfield development.
1966	Beginning of Inner Basin wellfield development; groundwater encountered at 150-200 feet.
1982	New treatment plant and storage reservoir constructed near Inner Basin reservoirs.
1984	Upgrade started on Lake Mary Treatment Plant, more upgrades in 1986, 1988, 1989.
1987	Transfer pipe from Inner Basin is repaired.
1988	Conservation ordinance adopted.
1990	$3 million bond for six new wells, reclaimed program, and conservation program.
1990	Inverted block rate structure implemented.
1991	Rebate program for low water use fixtures.
1993	Rio de Flag reclaimed plant finished.
1995–1998	Drilled six new wells, in town and in the Woody Mountain wellfield.
2000	Joined Coconino Plateau Water Advisory Board.
2001	Two in-town wells drilled; groundwater encountered at 1600 feet.
2002	Conservation ordinance implementation triggered by drought conditions.
2002	Negotiate a deal with the NPS to maintain Lake Mary at least 11 percent full.
2003	Council passes a ‘Long Term Water Resource Sustainability Strategy for Water Conservation and Water Use Efficiency,’ whose main tenet is year-round watering restrictions.

Coding Key:

Supply Management Strategies
Demand Management Strategies

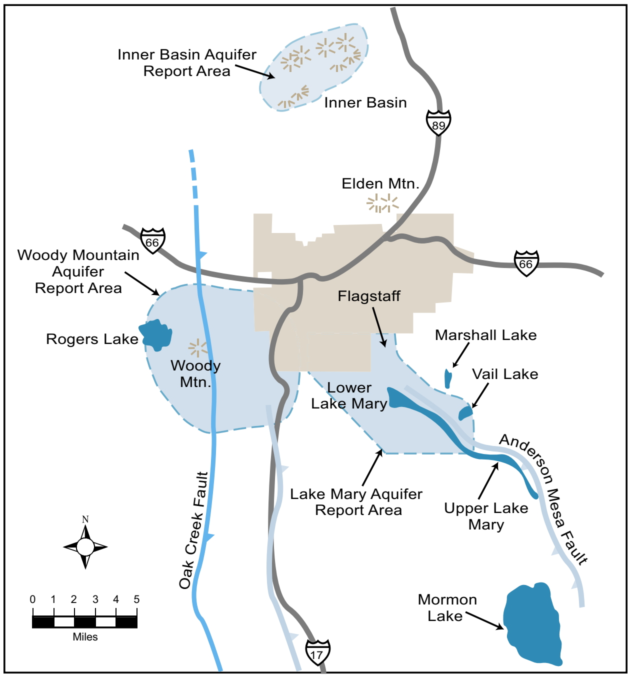

Figure 3. Water Supply Locations.
Source: Errol L. Montgomery & Associates.

1889 and 1925. Much of the costs for early water supply development were paid by local timber mill owners and ranchers, either directly or through financing low-interest bonds to the city. The railroad's water use was often heavily subsidized by the city. Following the 1903 flood, a local historian notes that one of the railroad's engineers suggested a second reservoir be built in the Inner Basin. He indicated that, "during spring thaws and summer rains, as much as 25 million gallons—enough to supply the sawmill and railroad for a year…—was running to waste" (Cline 1994, p 86). It was completed in 1914. Cline (1994) notes a dry year occurred in 1919.

At that time, the largest water users (the railroad, timber mills, and slaughterhouses) were directed by the City of Flagstaff to look elsewhere for their water needs as the supplies then were completely dependent on snowmelt runoff and summer monsoons.

Serving as Flagstaff's only water supply until 1941, water from the Inner Basin reservoirs contributes only a very small portion of Flagstaff's current supplies, averaging 2.77 percent of the total supplies in the last ten years (City of Flagstaff Utilities Department 2002). Because the springs are fed by snowpack runoff and perched aquifer systems, they are very susceptible to fluctuations in snowfall, precipitation, and recharge. The perched aquifer system that feeds springs in the Inner Basin is inconsistently saturated from the surface to approximately 150 feet (45.7 m) below the surface. Saturation variability is due to the degree, extent, and openness of local fractures (McGavock et al. 1986). When water is present in the Inner Basin reservoirs, Flagstaff municipal water managers prefer to use the Inner Basin water due to its high quality and low transport costs as compared to that of Flagstaff's other sources (Montgomery et al. 2000).

During dry winters in the 1930s, many of the springs in the Inner Basin dried up, Flagstaff imported water from around the Prescott area, car-washing and irrigation were decreed illegal, industrial users were instructed to look elsewhere for water, the Inner Basin reservoirs were reserved for municipal and firefighting use only, and the intake on the Inner Basin pipeline was lowered. A Flagstaff historian credits increasing industrial demand and the city's desire to continue receiving substantial payments by industrial users to service the municipal debt, in addition to dry winters in 1931 and 1932, for the push to find additional supplies, especially supplies outside of the Inner Basin (Cline 1994, p. 321).

In response, proposals were circulated to dam either Switzer Canyon or extend Lower Lake Mary. Since its construction in 1905 by the owner of one of the local sawmills, Lower Lake Mary was reserved for recreation and water for livestock. The Lower Lake Mary site was selected. Cline (1994) attributes its selection over the Switzer Canyon proposal to comments made by a Santa Fe Railroad Company water engineer and a university geologist in support of the Lake Mary project. They argued that Upper Lake Mary would draw from a larger watershed creating a larger supply and cost less to construct than the other proposal. The Upper Lake Mary reservoir, dam, treatment plant, and delivery infrastructure were completed in 1941.

The construction of Upper Lake Mary is a pivotal event in Flagstaff's water management history, as it indicates the first time the water supply source was expanded. When Flagstaff constructed Lake Mary in 1941, the local newspaper editor remarked that, if the Lake Mary project was not completed when it was, "the city would now find itself in the throes of a water shortage from which there could be no relief" (as cited in Cline 1994, p. 325).

Upper Lake Mary has a capacity of 15,600 acre-feet. From the 1940s through the late 1980s, Upper Lake Mary served as the city's primary water supply, averaging 46.15 percent of the total water produced during that time (City of Flagstaff Utilities Department 2002). The watershed of Lake Mary is approximately 60 square miles and lake inflow is dependent on spring runoff from snowpack. Significant evaporation and seepage to the underlying aquifer occur from Lake Mary due to the fractured surface it overlays, the Anderson Mesa Fault. On the Coconino Plateau, faults and fractures serve as primary conduits for recharge into the regional groundwater system. It is estimated that 42 percent of the inflow to Upper Lake Mary seeps down, and 28 percent of the inflow is evaporated (Montgomery et al. 2000). Therefore, the lake retains only approximately 30 percent of the incoming snowmelt.

Although the head city councilman during Lake Mary's construction claimed it would supply the city with enough water for 100 years, "estimating normal growth" (Waldhaus, 1940 as quoted in Cline 1994, p. 325), the City Council appointed a water committee in 1952 because "the city's two water sources…were nearing limits, and it was time to develop another source" (Cline 1994, p. 402). The city government agreed that it would direct its attention underground for subsequent water supply development, and three hydrologists suggested that Woody Mountain would be the most probable location for groundwater. Two wells were drilled in 1954, and groundwater was encountered at 1,250 feet (381 m) below ground surface. Voters approved the financing bond, 303-7.

It is worth noting that 1953 marked the first of 12 successive years of below-average precipitation. The lack of winter precipitation especially affected the surface water supplies, as they were wholly dependent on snowpack runoff for inflow. During this time, "Lake Mary was at its lowest level of record, and the thin flow from the Inner Basin springs was only a bit more than in the terrible drought years of 1931 and 1934" (Cline 1994, p. 405). The two Woody Mountain wells were online by 1956; however one well was pumping sand, and the other well pump overheated. Despite repeated requests by the City Council to reduce water use in Flagstaff, water demand increased until the council declared 'water wasting' illegal and threatened fines and imprisonment. Demand then decreased and the two pumps were repaired, soon thereafter. Some drought amelioration was provided by near or above-average precipitation in 1957, 1958, and 1959.

Subsequent proposals to expand the Woody Mountain wellfield or develop other wellfields were not so popular with Flagstaff residents. In 1960, the City Council decided a new well was necessary in the Woody Mountain wellfield, because the current well production could not meet demand and there was widespread feeling that the surface supplies would prove unreliable during dry years. After a bond issue in 1959 to extend utility lines narrowly passed a public vote, the City Council deemed it appropriate to garner support before another bond issue was advanced. Despite a confident proclamation made by a U.S. district geologist that a new well in the Woody Mountain wellfield would give Flagstaff "the most dependable groundwater supply in Arizona" and that the new well should be followed by subsequent wells as demand increased (Dennis, 1960 as quoted in Cline 1994, p. 428), the bond measure passed by only 37 votes because, according to Cline (1994), "the population growth had diluted the exchanges and discussions of issues that had built consensus in earlier times." (p. 429). Water production from the new well just met peak demand, and the city investigated potential wellfield sites recommended by the U.S. District geologist in 1960: Lake Mary and the Inner Basin. In municipal elections in 1963 and 1966, wells and associated transfer infrastructure were approved for the all three well fields.

Although mechanically online in 1956, the Woody Mountain wells were not a significant portion of the Flagstaff municipal water supply until approximately 1963 (refer to Figure 3). In addition, the Lake Mary wells were not incorporated into the system supply until the mid-1970s, despite the passage of the bond to incorporate them into the distribution system in 1963. In part, this could be due to near average precipitation through the late 1960s and early 1970s. Water production increased in all three wellfields and Lake Mary through the 1970s and 1980s, and new wells were drilled in all three wellfields during this period. It appears water demand steadily increased during the late-20th century despite that being a period of significantly-above-average precipitation (refer to Figure 7). In one (1989) of three (1979, 1984, 1988) relatively dry years in approximately 15 relatively wet years (1978–1994), water demand peaked in Flagstaff. According to data released by a hydrological consultant to the City of Flagstaff, very little surface water supplies were utilized that year. It appears the dry year led to two outcomes: increased demand and very little, if any, available surface water.

All of Flagstaff's groundwater wells are drilled into either perched water-bearing zones within the upper 500

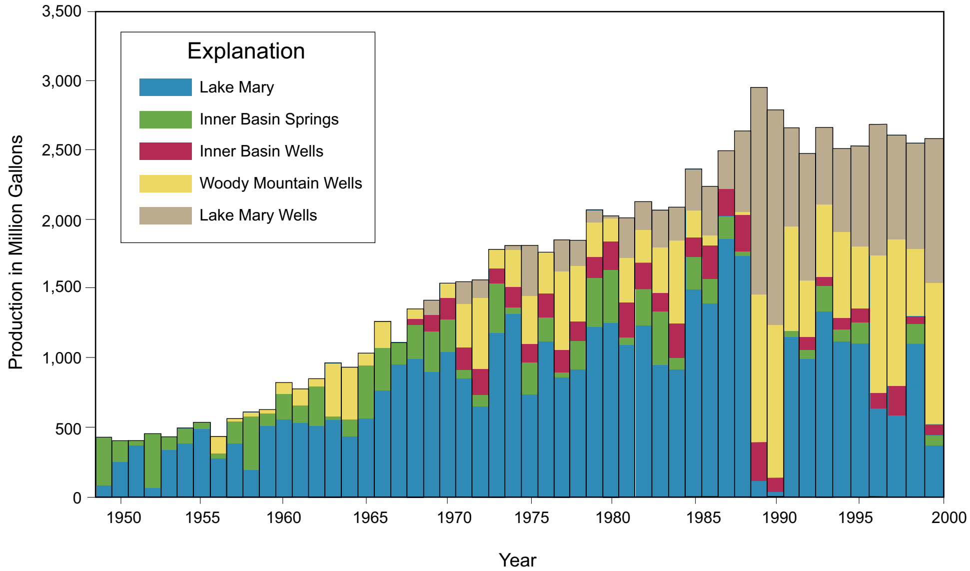

Figure 4. Annual Production by Supply Source. Source: Errol L. Montgomery & Associates.

feet (152.4 m) or in the deeper C-Aquifer. The water table was encountered at 1,600 feet (487.7 m) in the most recent well drilled in 2002. Groundwater reliance has increased over the last decade to the point that 70 percent of the demand is met by groundwater wells (City of Flagstaff Utilities Department 2002) (see Figure 4). By 1993, a decrease of 90 feet (27.4 m) in the water table was measured in the Lake Mary well field (Montgomery & Associates 1993). The same study calculated that between 4 and 17 percent of average annual precipitation recharged groundwater in the Lake Mary area. The effect of groundwater pumping on the water level in Lake Mary is not known. In the Woody Mountain well field, several tens of feet of decline were measured over the last 20 to 40 years (Bills et al. 2000).

A 1990 municipal bond provided funds for six new wells, a new wastewater treatment plant engineered to efflux reclaim water, a wastewater reclamation program, and a water conservation program. Of the six new groundwater wells, four were drilled in areas other than the three main well fields due to the increased costs of drilling and pumping in areas where the water table had declined. Reclaimed water is wastewater treated to a quality that the state environmental agency deems appropriate for uses such as landscape irrigation, snowmaking, and car washing. In the early 1990s, the city solicited buyers for the reclaimed water, like private golf courses and the state university to use reclaimed water for irrigation purposes, and has subsequently entered into contracts with the school district, a local cemetery, additional private golf courses, and other city departments to sell reclaimed wastewater for irrigation purposes. The conservation program consisted of education outreach to schools and civic organizations, a rebate program for low-flow toilet fixtures, and an inverted rate structure, where the user is charged a higher amount the more he/she uses.

Water conservation programs in Flagstaff are considered quite progressive for Arizona. Use restrictions were implemented much earlier in 2002 than any other municipality in Arizona, signaled by triggers defined by the existing drought contingency plan enacted in 1988. Water managers in the Phoenix area did not start discussing restrictions or rate hikes until January 2003. Between November 2002 and April 2003, the Flagstaff City Council formulated a new water conservation ordinance that includes permanent restrictions on outdoor irrigation and stricter triggers for successive conservation levels, as part of an ordinance titled, "A Long-Term Water Resource Sustainability Strategy for Water Conservation and Water Use Efficiency to Ensure Adequate Water Availability for the Future and During Times of Emergency." The measure passed in April 2003, with a unanimous vote.

5.1.2 Climate Variability

Climate, and especially climate variability, are important determinants of the availability of water supplies. Flagstaff, located at 7,000 feet (2,133.6 m), has an average temperature of 46° F (7.8° C) and an annual precipitation of 21 inches (0.83 mm). Summer (June–August) temperatures average 63° F (17.2° C) and summer precipitation averages 5.8 inches (0.23 mm), while for winter (December–February) the averages are 32° F (0° C) and 6.8 inches (0.27 mm), respectively. Snow contributes a substantial portion of the recharge to local water resources (see above section), with 75 percent of winter precipitation falling as snow (Sheppard et al. 1999). These averages do not, however, reflect the high level of annual and decadal-scale climate variability in the area. This high degree of variability has implications for water management.

Reconstructed precipitation[2] at the climate division level indicates that precipitation trends in northern Arizona have been quite variable over the last 1000 years (Figure 5), with sudden shifts from sustained wet periods to sustained dry periods occurring (Ni et al. 2002). The study detected periods of sustained dry periods comparable to droughts occurring in the 16th-century and the 1950s, and sustained wet periods in the 1330s, 1610s, and post-1976 period. Further, the instrumental record in Flagstaff also indicates a sustained wet period from approximately 1976 to 1993 and sustained dry periods, or droughts, from approximately 1950 to 1963 (Figure 6). Both reconstructed and present-day indices of precipitation indicate that the climate of northern Arizona is characterized by seasonal, annual, and multi-year variability rather than steady, unchanging trends. The instrumental temperature record for Flagstaff indicates significant multi-year variability, with a general warming trend occurring over the last 50 years.

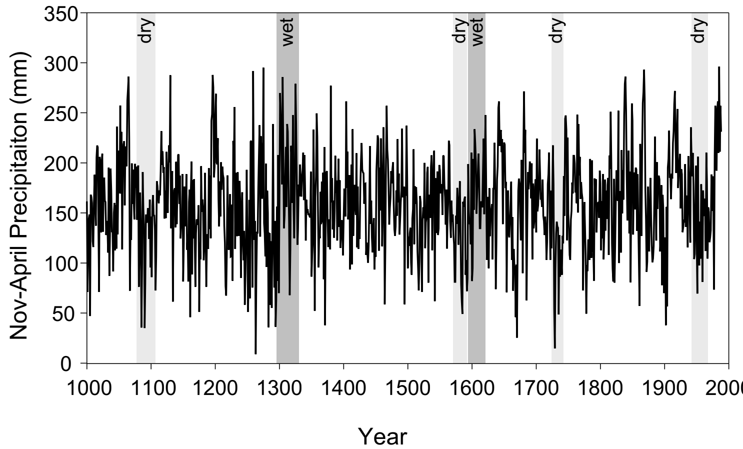

Figure 5. Reconstructed Precipitation in Northern Arizona (Climate Division 2). Source: Ni et al. 2002.

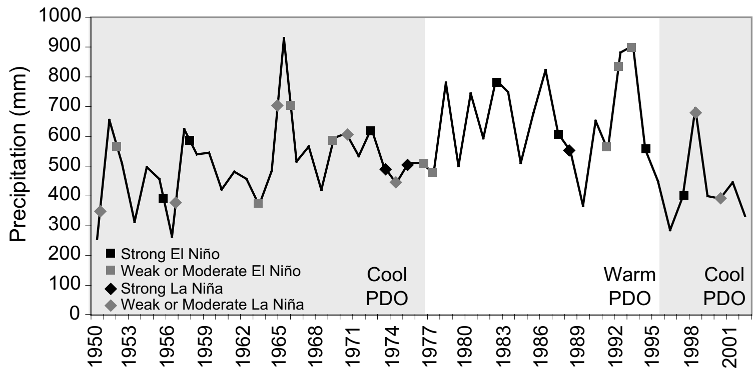

Figure 6. Instrumental Precipitation and El Niño/La Niña Events. Source: Null 2002.

In relation to climate factors, surface water supply is mostly a function of winter precipitation and temperature in Flagstaff; however, summer precipitation also plays a role in water supply availability and demand because the peak water demand occurs in the summer. On the Colorado Plateau, convectional activity accounts for most of the summer precipitation. There may be some link between summer precipitation and with ENSO and PDO as well (Higgens et al. 1999, Higgens and Shi 2000). The magnitude and timing of summer precipitation is important because water demand is highest in the summer, and has been shown to increase during dry periods (Woodard 2002). The degree that a surface water source is available is a function of the amount and timing of summer precipitation, the degree of evaporation, and the amount of stored winter runoff.

Winter precipitation variability in the U.S. Southwest is due to a variety of climate processes, including frontal systems, the El Niño Southern Oscillation (ENSO), and the Pacific Decadal Oscillation (PDO). It has been established that the Southwest has a teleconnection with ENSO (van Loon and Madden 1981, van Loon and Rogers 1981). In general, when the ENSO pattern is in the warm phase (El Niño), winters in the Southwest tend to be relatively cool and wet (Kiladis and Diaz 1989). Conversely, winters in the Southwest tend to be relatively warm and dry during the cool phase (La Niña) of the ENSO (Kiladis and Diaz 1989). Moreover, the La Niña signal is more consistent than the El Niño signal in the Southwest, an important indicator of drought (Western Regional Climate Center 1998). That is, warm and dry winters in the Southwest are more consistently correlated (and thus, more confidently forecasted) to the La Niña phase than cool and wet winters in the Southwest are correlated to the El Niño phase. ENSO has a period of approximately two to ten years (Sheppard et al. 1999). Figure 6 indicates El Niño and La Niña events plotted on the instrumental precipitation record in Flagstaff. Strong events are indicated with darker markers and weaker events are indicated with lighter markers (Null 2002).

It has also been shown that winter precipitation in southern North America is positively correlated with the warm phase of the PDO (Mantua et al. 1997),

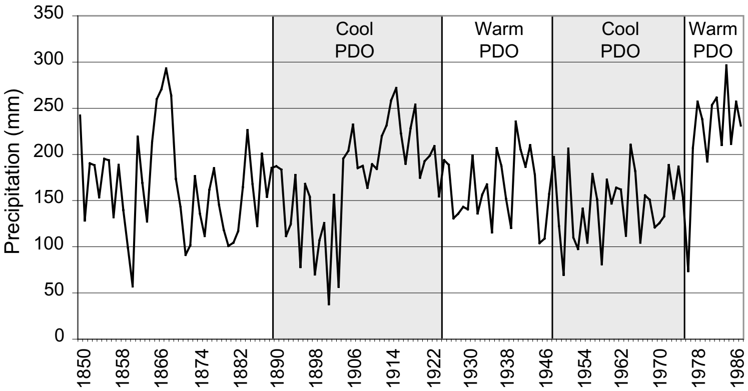

Figure 7. Reconstructed Precipitation and PDO Shifts (Climate Division 2). Source: Ni et al. 2002.

where winter precipitation increases when the PDO enters its warm phase and vice versa. Gershunov and Barnett (1998) identified three PDO phase shifts in the 20th century, two warm phases from 1925 to 1947 and from 1977 to the mid-1990s, and a cool phase from 1947-1977 (Figure 7). As Figure 6 shows, there were shifts in the PDO during the Flagstaff instrumental record in 1977 and in the mid-1990s.

The PDO index suggests that the PDO might have entered a cool phase in the late 1990s, indicating winters in the Southwest may be more consistently drier over the next 20 to 30 years than the climatological average would suggest. That isn't to say that Flagstaff is in for 30 years of little to no rain. Multi-decadal dry periods have been shown to be interspersed with one to two years of average or above average precipitation associated with strong El Niño events, and recent research indicates that wet monsoons may follow dry winters in Arizona and New Mexico (Higgens et al. 1999), which could mitigate summer water demand. However given that local surface water resources are much more dependent on winter precipitation in the form of snowmelt for inflow, increased summer precipitation may not contribute to long-term water storage.

Using Arizona and New Mexico winter precipitation data from 1950 to 1997, Gutzler et al. (2002) found that when the PDO phase and ENSO phase align, the ENSO effect is compounded. For example, during the cool PDO phase before 1977, negative winter precipitation anomalies are tied to La Niña events. During the warm PDO phase after 1977, positive winter precipitation anomalies are tied to El Niño events. These data would suggest that the Southwest may be more prone to drought conditions when a La Niña event occurs during a cool PDO phase.

Reconstructed precipitation, the instrumental record, and empirical PDO and ENSO research supports the statements made by Cline regarding historical dry and wet periods in Flagstaff (refer to previous section). Moreover, ENSO and PDO forecasts suggest the Southwest has entered a prolonged dry period. In Flagstaff, less than average precipitation since 1999 (see Figure 6) and relatively warm temperatures over the last half-century have occurred in Flagstaff. In concert, these conditions have been shown to increase water demand in other Arizona municipalities (Woodard 2002). Granted a detailed examination into the distribution of summer and winter precipitation and local hydrological characteristics would shed more light on the exact drivers of surface water supply decline in Flagstaff, several recent indicators pointed to drought conditions:

- Lower Lake Mary and Morman Lake, a lake located southeast of town were nearly dry in summer 2002 (see Figure 8).
- Residential and commercial water restrictions have been in effect since April 2002.
- Flagstaff sold some of its water to a nearby community whose supplies dried up in summer 2002.
- The surrounding national forests were closed to minimize the fire risk in summer 2002.
- Surrounding ponderosa pine forests continue to be infested by bark beetles because they cannot produce enough sap due to a lack of moisture.
- PDSI values averaged -1.87 in northern Arizona since 1999, and -4.39 in 2002 (see section 1.2 for a description of the PDSI index).

Although recent precipitation has mitigated current drought conditions to some extent, climate history

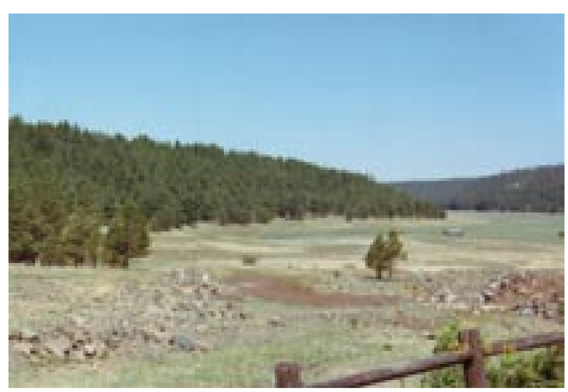

Figure 8. Bed of Lake Mary in August 2002. Photo by Kristen Reed.

suggests that dry conditions could persist for as much as a decade or more.

Prediction capability at decadal to centennial time scales is still in its infancy, and regional climate change models for the U.S. Southwest are not yet exceptionally skillful. However, one possible future scenario appears in the 2001 Intergovernmental Panel on Climate Change (IPCC) Assessment Report. In this case, the results indicate that western North America will experience year-round greater to much greater than average warming between 2071 and 2100, where average warming is defined as ranging between 2.5º C to 4.9º C (36° F to 40° F) under 1 percent per year increases in greenhouse gas concentrations (Giorgi et al. 2001). The same study also predicted a small increase in winter precipitation, given the same premises. The effect on summer precipitation could not be determined.

The impact of such changes on the future availability of water in Lake Powell remains unclear, but heightened temperatures would likely change the flow regime in the Colorado River system (see Stewart et al. 2004) and would increase evaporation rates. Such changes could have implications for management of the Colorado River and allocation of water to rights holders (Gleick and Chalecki 1999). In this context, it is important to note that the average flow of the Colorado River was calculated during a period of above-average precipitation and used to define allocations to the basin states. Thus, long-term climatic changes leading to reductions in water supply have the potential for junior right holders (including the Central Arizona Project that delivers Colorado River water to the central portion of the state) to have their allocations reduced or eliminated.

5.1.3 Local Groundwater Hydrology

The fractured nature of the geology does not facilitate an easy prediction of where groundwater is located. The many crevices and faults between the surface, the regional aquifer (the C-aquifer), and the lower aquifer located west of Flagstaff (Redwall-Mauv limestone layer) make groundwater flow and the linkages between recharge and the two aquifers difficult to model. (Refer to Appendix C for a summary of the regional groundwater hydrogeology.) Previously, geologic faults proved to be a productive source of groundwater, as they facilitate easy recharge. However, the Lake Mary wellfield and the Woody Mountain wellfield are already drilled in the known fault locations, and static water levels are declining in these areas. The static water levels of the most recently installed wells ranged between 1,100 (335.3 m) and 1,300 feet (396.2 m) below ground surface.[3] Drilling costs to drill deep enough to tap water, in addition to pumping costs, are significant. According to the water commission minutes in 1996, costs for two wells completed between 1996 and 1998 in the Woody Mountain field averaged $2 million. Although the regional aquifer is thought to be quite expansive and state statutes place essentially no limits on groundwater development in Flagstaff, the exact nature, extent, degree of recharge, and hydrologic connection with other regional aquifers and surface flows is mostly unknown. Outside of the impact on surface streams, the exact discharge into appropriated surface waters (i.e., the Little Colorado River, the Colorado River, and the Verde River) is also unknown.

There is growing acknowledgment among hydrologists and residents that groundwater feeds some streams in the region, especially after a 1998 Environmental Impact Statement for a proposed land development near the south rim of the Grand Canyon deemed the development unfeasible because its groundwater pumping would lead to reduced flows in the Colorado River through the Grand Canyon. This information has been readily incorporated into the justifications for water conservation measures.

5.1.4 Economic Structural Changes

Fueled by ponderosa pine forests surrounding Flagstaff, grassy plateaus northeast of the city, and the transcontinental railroad, a production economy based on logging and cattle and sheep ranching could be found in Flagstaff between the 1880s and approximately 1930. I define a production economy as an economy where the production of goods and services prevails over the consumption of goods and services. Similar to many other Western areas at the time, natural resource extraction activities defined the local economy. Logging and ranching served as dominant industries between 1880 and 1930, and a small amount of potato farming and sandstone mining also occurred. The first sawmill opened in 1882 (along with the first train run through Flagstaff), and employed 250 out of Flagstaff's 963 people in 1890.

Along with the timber mills and the railroad, local slaughter houses affiliated with the significant ranching presence constituted the largest water users in early Flagstaff. Steam powered train engines required significant amounts of water. In 1922, 75 percent of the water supplies were used for industrial purposes, and the remaining by growing residential and commercial uses (Cline 1994). During this period, the springs in the Inner Basin were increasingly dammed, and pipelines were constructed between the reservoirs and the town (see Figure 3). A local historian claims that the second Inner Basin reservoir was constructed because local sawmills, slaughterhouses, and the railroad were driving up water demand, and that the third Inner Basin reservoir was built to meet increasing water use by the railroad (Cline 1994).

Flagstaff did not follow the same economic trajectory as did many other natural resource-dependent areas in the West at the time (e.g., endorsement of and reliance on primary sector economic activities) for several reasons. In 1880, the federal government started implementing the forest preserve program, which pulled some lands out of ranching and logging, and limited land use in other locations. In 1908, the Coconino National Forest was inked out of the previous San Francisco Peaks Preserve near Flagstaff.

Flagstaff's economy started showing evidence of one based on consumption (of goods and services) much sooner than did other areas in the West. Throughout Flagstaff's history, tourism has been a major force in shaping its economy. At first, it supplemented logging and ranching activities and was later part of a more diversified economy. The natural beauty of the area and Native American culture were Flagstaff's largest magnets, attracting tourists (mostly in-state) to the Grand Canyon and to the artifacts, dances, and other ceremonies on the nearby Native American Reservations of the Hopi and Navajo peoples. Weekend vacationers from southern Arizona visited Flagstaff to enjoy the cooler climate and an escape from the city (Cline 1994). In 1900, a road from Phoenix was completed, and a major federal tourist highway (Old Trails Highway) was constructed through Flagstaff. It would later be renamed to U.S. Route 66. By the 1920s, tourism to regional physical and cultural landscapes constituted an important part of Flagstaff's economy. At that time, it was estimated that between 26,000 and 30,000 people visited Flagstaff in a six-month time period when the local population was only 3,000 people, approximately a 10-fold difference. In 1929, cabins and hotels were constructed, and the city organized the first ever 'Indian Pow-Wow' in 1930 to attract tourists from Phoenix. The ski resort now known as the Arizona Snowbowl opened in 1938. That isn't to say logging was no longer important to Flagstaff. Between 1927 and 1931, four large sawmills were located around Flagstaff. However, even the patriarch of the most prominent logging family noted that

> Flagstaff and the surrounding area have… "greater assets in climate and scenery than in timber, sheep, cattle and farms, and capitalizing on them through developing tourist traffic will greatly increase the town's population and wealth."
>
> –Tim Riordan, 1920 speech to a National Park-to-Park Highway Association meeting, as quoted in Cline 1994, p. 240.

By 1931, Flagstaff was beginning to see some of the economic impacts associated with the Depression. These impacts included diminished demand for timber because mines shut down, less tourism, a smaller number of train runs, and failure of the local bank (Cline 1994). After the Depression, Flagstaff received several financial boosts like many other localities during the era of the federal-level welfare state. These included cattle subsidies, housing incentives, and federal and state funding for street improvements, new government buildings (e.g., schools, university buildings, and state and government agency offices), and several highways through Flagstaff, including U.S. Route 66, a popular tourist highway.

Flagstaff's economy during the mid-20th century remained quite diversified with growing employment opportunities in government, retail, and education sectors, and some, albeit decreasing, opportunities available in the production sector. These were comprised of one large ranching operation, two timber mills, and a military ordinance depot that was constructed during World War II. Flagstaff served as the gateway to the Grand Canyon and nearby Native American reservations, a regional hub for movie making, and the headquarters for the Glen Canyon Dam construction project. A reflection of the shift from a production to a consumption economy in Flagstaff, the city implemented a retail sales tax in 1964 to tax purchases made by tourists, college students, home builders and buyers, and shoppers.

Tourism, retail trade, and education still serve as the mainstays of the Flagstaff economy. The accommodation and education sectors were the only sectors to increase employment between 1990 and 2000, and the tourism tax on hotels, motels, restaurants, and bars (the Bed, Board, and Booze tax) constituted the largest contributor to the city's sales tax revenue (Figure 9).[4]

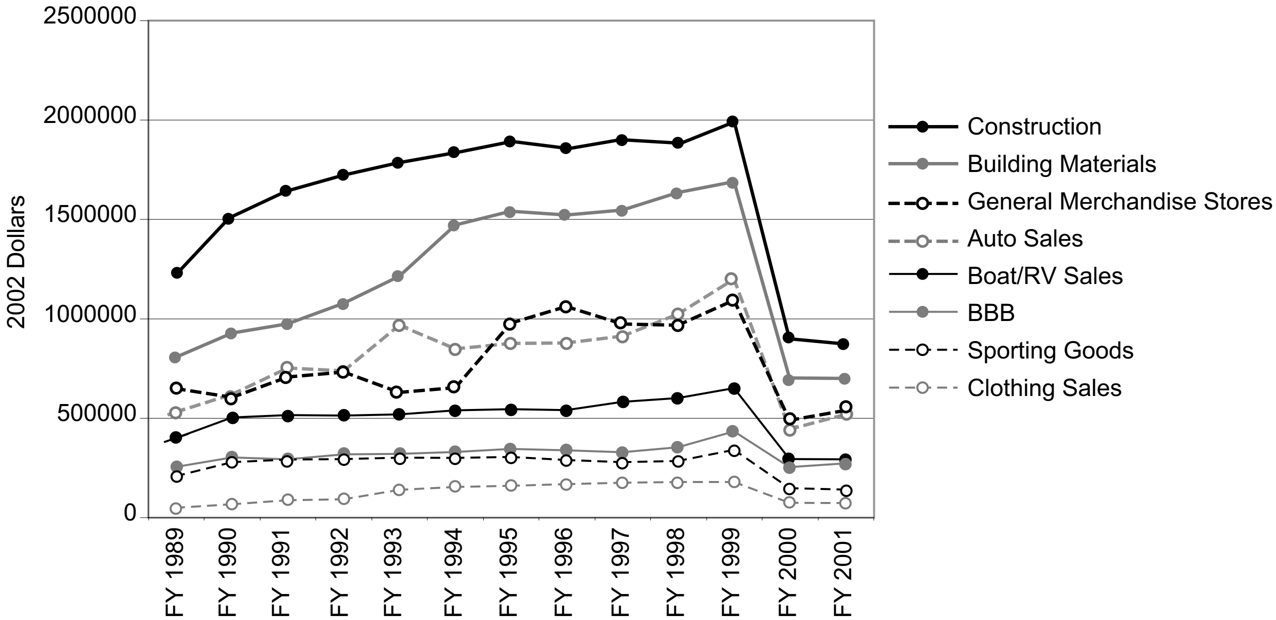

Figure 9. City Sales Tax Revenue from Select Sectors. Source: City of Flagstaff.

According to the City of Flagstaff Tax and Licensing Department, the rapid decrease in sales tax revenue between fiscal years 1999 and 2001 can be attributed to the general economic slowdown and the associated decrease in tourism, saturation of the hotel market in Flagstaff, and the closing of a local car dealership.

However, a different, much more subtle economic trend has been emerging in Flagstaff over the last decade, one that treats nature as a commodifiable amenity and as something worth protecting. Flagstaff has shifted its marketing approach to attract visitors, potential employers, new residents, and second-home owners with its surrounding forests, open spaces, cool climate, a picturesque downtown shopping area, and local outdoor recreation activities. The current relocation guide shows the San Francisco Peaks as the backdrop to a quaint downtown setting, a skier, and the renovated county building that was restored to look like it did in the early to mid-20th century. Whereas Flagstaff's diverse economy in the mid-20th century was partly due to Keynesian policies at the federal and state levels, it is now a competitor for capital investment. And, who better to market to than those with capital to invest?

The percentage of partial-year housing units in Flagstaff increased from 2 percent in 1980 to 4.5 percent in 2000, and the number of residential building permits doubled between 1990 and 2000 from 254 to 513. Most of this development occurred on the outskirts of town, in new subdivisions and in unincorporated areas nearer to "nature." The inflation-adjusted average value of a new single family residence peaked at approximately $155,000 in 1998 and 2000, and was estimated at $132,000 for the first three months of 2003. The average annual income in Flagstaff was $37,000 in 2000. At the same time, the education and government sectors, which have historically been among the most stable, reliable, and relatively high-paying employers in Flagstaff, have seen layoffs over the last two years. Any evidence of the logging industry was eliminated in 1993, when the remaining timber mill closed. Three manufacturing companies constitute most of the remaining production sectors. A diverse economy is giving way to one that is defined by consumers and people that facilitate consumers consuming.

Public land policies contributed to the production of nature as an amenity through 'multiple use' policies, first passed in the 1960s and 1970s. Publicly owned lands surround Flagstaff and very few private lands are available for any future development. The multiple use land management model yielded a significant effect on Flagstaff by facilitating a new economic direction for the city: increased outdoor recreation in adjacent public lands. Since these policies were put into place, Flagstaff continues to serve as the gateway to the Grand Canyon, as well as cater to people that enjoy mountain biking and hiking in the adjacent public lands. Additional hotels, outdoor gear outfitters, and vacation homes were constructed to meet the increasing demand for outdoor activities.

5.1.5 Demographic Changes

Population growth in Flagstaff averaged approximately 30 percent every decade between 1890 and 1910. Between 1910 and 1920, local population nearly doubled to just over 3,000 people. Another 700 people had been added to Flagstaff's population by 1930. The annexation of the area south of town where a large mill and its employee housing were located partially contributed to the population and spatial growth of the town between 1920 and 1930. Their annexation was spurred by a city decision to tax water use by non-Flagstaff (proper) residents more than water users in Flagstaff as part of the funding mechanism for the third, and final, Inner Basin reservoir.

Urban growth was rampant in Flagstaff during the mid-20th century. Between 1950 and 1960, Flagstaff's population grew 138 percent from approximately 7,500 people in 1950 to approximately 18,000 in 1960 (Figure 10). The first subdivision was built in 1947, with growing areas outside of the city proper annexed in 1956 and 1958. In the late 1950s, annexations totaled 57 percent of taxable property, and 1,000 new homes, commercial properties, and hotels were constructed in outlying areas. Urban growth was mainly due to the growth of Northern Arizona University and federal economic policy of providing dollars for growth in stable, well-paying government jobs (Cline 1994). According to Cline (1994), the growing domestic water usage (and payments to the city water department) partially made up for municipal revenue lost after the Railroad replaced steam locomotives with diesel engines and developed their own water source. The last steam engine ran through Flagstaff in 1953. While data on projected water demand are not currently available, (although a report, the North Central Arizona Water Demand Study: Phase II, is currently being prepared), the Arizona Department of Economic Security projects that Flagstaff's population is expected to gain approximately 1,000 people per year for the next 50 years.

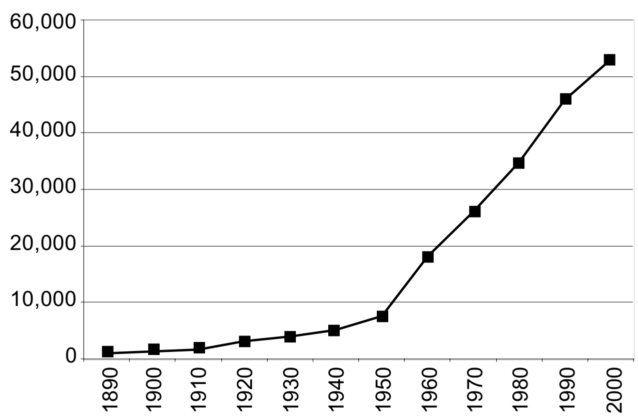

Figure 10. Population Growth in Flagstaff.
Sources: Arizona Department of Economic Security and U.S. Census Bureau.

In concert with the potential of a large-scale water pipeline importing water into Flagstaff, contemporary climate, hydrologic, economic, and demographic trends pose opportunities for water policy negotiation in Flagstaff. The next section details how water managers, community interest groups, and scientists in Flagstaff envision contemporary water problems and potential management responses.

5.2 Results of Research Question #2

Within the context of contemporary biophysical conditions and political economy, how do water policymakers, community interest groups, and scientists in Flagstaff define contemporary water problems, their causes, and potential management responses?

5.2.1 Data Preview, Limitations, and Nuances

In addition to outlining the findings to the above question, I also include interview responses from questions on my interview protocol about information sources, management influences, and the feasibility of regional water management. The management influences and the regional water management feasibility findings proved to not be as useful as findings from questions about current problems, their causes, and favored management responses for several reasons. I will outline these reasons when I present the findings from these questions.

Further, the findings I present are limited to what the informants said, not necessarily what they do. For example, I did not compare the consistency of a City Council member's voting history with their responses to the interview questions. Neither did I correlate responses from community interest groups with arguments they have presented before the City Council on a given issue or the discourse in their promotional literature. This method ensured that all potential parties that could be affected by a water management policy change could contribute to this study. Had I limited my data sources to only those people that participate in the policy-setting process, I might have more accurately captured the Flagstaff water policy-setting dynamic, but the results would exclude other organizations that, for whatever reason, do not participate in policy-setting but are affected by policy changes. In addition, the interview method was the most efficient data collection method considering the time constraints for the research.

Because I let informants frame their range of responses as is called for by general qualitative methodology (Marshall 1989), some of the response categories might not necessarily reflect the complete number of responses had I inquired about specific topics. That is, instead of directly asking informants if they thought drought conditions were partially causing contemporary water problems, I asked informants what factors were causing contemporary water problems, as they defined contemporary water problems. I did follow up with prompts for any additional causative factors they wanted to add. This led to some informants providing several responses, while others provided very few. I assigned equal weights to each response, regardless of how many other responses were provided by the same informant. Also, some of the informants chose not to answer some questions because they felt they weren't qualified enough, did not care to comment, or limited their responses to their particular jurisdiction, where I use 'jurisdiction' in the broadest sense of the word. In addition, if it was clear that the informant wanted to limit their responses to water issues only affecting their particular group, company, or jurisdiction, I did not pry too much into their opinion regarding water issues that impact Flagstaff as a whole. Due to the reasons outlined above, few of the questions yielded a 100 percent response rate. That is, the sum of the responses in any given question will probably not sum to 30, the total number of interviews I conducted.

Also, I aggregated responses from individual informants regardless of when the response occurred during the interview. For example, if the informant answered they favored management responses that heavily taxed standpipe users, I indicated they attributed water use by standpipe customers as one of the causes of current water problems. Finally, because many of the informants tended to blur the boundary between contemporary water problems and their causes, I separated these as best I could. For example, many informants named drought conditions as a contemporary water problem; however, I re-assigned that response to a cause of problem category, entitled, 'Providing Supplies during Drought Years.'

I use the following coding to indicate informant types:

Area Water Policymakers	P
Scientists	Sc
Community Interest Groups:	
Conservation/Environmental	CE
Economic Development	ED
Forestry/Fuels Management	FF
Land Development	LD
Large Industrial Water User	I
Large Local Employer	LE
Large Reclaimed Water User	RU
Ranching	R
Tourism/Recreation	TR

5.2.2 Contemporary Water Problems

According to Table 4, whereas nearly equal numbers of policymakers and interest groups, namely representatives of conservation/environmental groups, forestry/fuels management, and large employers, named 'declining groundwater tables' as their primary concern, representatives from economic development and land development organizations and reclaimed water users thought that too little supply to meet demand was a more pressing problem. Although Flagstaff has traditionally relied on surface water supplies, dewatering of these supplies was not mentioned as a specific problem. In general, the most common responses point to an imbalance between supply and demand, either continually, during peak demand times, or during drought periods, and the material consequences that result from creating the imbalance. Other informants named a lack of reliable infrastructure, unknown amount of groundwater in the regional aquifer system, threats from other areas to use water in northern Arizona, and debating regional water management as contemporary water problems.

After some prompting, some informants commented on the sustainability of water resources in Flagstaff. This question did not result in many findings because informants often indicated they felt inadequate to answer it without knowing the amount of water in the regional aquifer, the amount of water in surface supplies, and the amount of water consumed. However, of those that did answer, three policymakers, an economic development organization, and a tourism/recreation organization thought there were enough water supplies to meet current demand, but not any additional demand. For one informant, the fact that current demand equals current production plus production from groundwater wells coming online now indicated to him that no slack is available for additional demand. Another informant indicated that his assessment of

Table 4. Contemporary Water Problems in Flagstaff.

	Policymakers	Interest Groups	Scientists	Total	Which Groups?
Declining groundwater table	4	3		7	CE, FF, LE
Less supply than demand	1	4	1	6	ED, LD, RU, RU
Providing supplies during drought years	1	2		3	RU, TR
Meeting peak demand	1	1		2	LD
Lack of reliable infrastructure		1		1	LE
Unknown amount of groundwater in regional aquifer system	1			1	
Threats from other areas to use water in northern Arizona	1			1	
Considering regional water management	1			1	

sustainability is based on hydrologic and demographic studies that come to similar conclusions. One forestry/fuels manager thought the current water supply was not sustainable at all because Flagstaff "should be using a lot less."

5.2.3 Causes of Contemporary Water Problems

Informants identified several biophysical, socioeconomic, and water use factors that contributed to their understanding of contemporary water problems (Table 5). Here I focus on the named causes of the most common problems identified: an imbalance between supply and demand and the material implications of how that imbalance came to be. More than half of the informants attributed contemporary water problems to drought conditions. Of those, half identified some degree of sustained drought as the primary driving factor. The composition of community interest groups that pointed to drought conditions included economic development, reclaimed water users, and tourism/recreation organizations. Many informants outside of policymakers pointed to urban growth as another significant factor. These groups included conservation/environmental, forestry/fuels management, reclaimed users, and tourism/recreation organizations. In addition, seven other informants touched on some aspect of urban growth leading to demand outpacing supply.

Indicative of constructions of the 'reconceptualized nature' I discussed in Chapter 2, two policymakers, a conservation/environmental organization, and a land development organization attributed the imbalance to the lack of attention paid to the physical limits to water resources. This response ranked third out of 15 socioeconomic factors.

Five policymakers, a large employer, and a tourism/recreation group pointed to the high financial cost of accessing and pumping groundwater, which can be attributed to the local hydrogeology and to declining groundwater tables. The other socioeconomic factors fell generally into the category of regulatory constraints to the preferred management response policy (i.e., legal constraints on developing other supplies or institutional resistance to graywater systems).

Several informants attributed the current imbalance between supply and demand to some sort of inappropriate water use, where 'inappropriate' was defined by the informant. Nearly all water use categories were named here, and included (in order of responses, from highest to lowest) tourists that stay in hotels, other areas in the region, native trees, lawns composed of grass, seasonal home owners, NAU, other cities, industries, water-hauling community, Flagstaff residents, domestic uses, and affluent people.

5.2.4 Favored Management Responses

In general, informants preferred conservation measures to developing additional supplies more than a two-to-one ratio (Table 6). In general, some policymakers favored supply augmentation projects like additional well drilling, buying water rights on the Colorado River, or construction of the Lake Powell pipeline (described in Chapter 1), while representatives from nearly all the community interest groups I interviewed and other policymakers favored conservation measures. These groups included conservation/environmental organizations, land development organizations, large employers, economic development, reclaimed water users, forestry/fuels managers, and tourism/recreation organi-

Table 5. Causes of Contemporary Water Problems.

	Policymakers	Interest Groups	Scientists	Total	Which Groups?
Biophysical Factors					
Sustained drought conditions	8	8	2	18	ED, FF, FF, LE, R, RU, TR, TR
Lack of surface water supplies	3	2		5	ED, FF, FF, LE, R, RU, TR, TR
Characteristics of local geology	1	1	1	3	ED, FF, FF, LE, R, RU, TR, TR
Socioeconomic Factors					
Urban growth	3	7	1	11	CE, FF, FF, R, RU, TR, TR
High financial cost of accessing and pumping groundwater	5	2		7	LE, TR
Physical limits to water resources aren't acknowledged	2	2		4	CE, LD
Legal constraints on developing additional supplies	3			3	
Popularity of green grass and lawns		3		3	CE, FF, FF
Second-home construction/seasonal population	1	1		2	ED
Urban growth decisions don't consider water resources	1	1		2	CE
Institutional resistance to graywater systems	1	1		2	CE
Unresolved Indian rights	1	1		2	TR
Legal authority for water does not sit with municipalities		1		1	CE
Uncontested urban growth in southern and central Arizona	1			1	CE, FF, FF, R, RU, TR, TR
Arizona legislature is dominated by development interests	1			1	LE, TR
Conflict between pro/anti growth sectors in Flagstaff	1			1	CE, LD
Future residents might have different values than current residents		1			R
AZ law doesn't recognize connection between surface and groundwater		1		1	CE
Excessive* Water Users					
Tourists that stay in hotels	5	2		7	FF, TR
Other areas in region	2	2		4	ED, TR
Water storage in increasingly larger forests	1	2		3	FF, FF
NAU use	1	1		2	CE
Use by other cities	1	1		2	RU
Industrial use	2			2	
Water-hauling community		1		1	TR
Domestic consumption in Flagstaff		1		1	R
Individual use	1			1	
Affluent people		1		1	FF

* Excessive use (or waste) was defined by informant

Table 6. Preferred Management Responses.

	Policymakers	Interest Groups	Scientists	Total	Which Groups?
Develop New Sources					
Lake Powell pipeline	2			2	
Purchase rights on Colorado River	1			1	
Import surface water instead of using groundwater	1			1	
Desalinization powered by residual nuclear energy on spent rods	1			1	
Cloud seeding		1		1	TR
Drill more groundwater wells		1		1	TR
Total	5	2	0	7	
Limit Per-capita or Total Demand					
Encourage conservation measures (of varying degrees and types)	3	6		9	CE, CE, FF, RU, TR, TR
Education on conservation measures in residential and commercial sectors	4	1		5	FF
Demand-side management	1			1	
Implement all conservation measures before considering groundwater pumping		1		1	CE
Total	8	8	0	16	
Other					
Collect information on hydrogeology, climate, supplies, and demand	3	2	1	6	ED, RU
Proactive planning	4		1	5	CE, FF, R, TR
Compile a regional or statewide water development plan	2			2	
Don’t allow development interests to influence other counties in Arizona		1		1	ED
More consideration of ideas suggested by citizens	1			1	
Partnerships with other communities	1			1	
Oversight committee for northern Arizona to deny water requests from other areas in state			1	1	
Nothing until water table drops	1			1	
Total	12	3	3	18	

zations. A number of other respondents favored other responses, like engaging in data collection or passing a regional or statewide water development plan.

Of the respondents that favored conservation measures, some mentioned specific examples of conservation measures they preferred (see Table 7). Following Pinkham and Davis (2002), I divided these conservation measures into three categories: measures that increase water-use efficiency, wise-water uses, and curtailment practices. I define an increase in water-use efficiency as providing the same end product with a lesser amount of (usually, potable) water, for example through use of low-flow plumbing fixtures; adoption of wise-water uses as alternative methods of achieving similar end products, like xeriscaping or turning off the faucet while brushing one's teeth; and curtailment practices such as those that restrict or prohibit certain uses, like daytime watering bans or water meter moratoriums. Out of these, the majority of respondents preferred some degree of curtailment, followed by wise-water uses. Limiting urban growth topped the list of curtailment measures, followed by implementing year-round mandatory water restrictions and living within Flagstaff's "groundwater means." Often curtailment policies were suggested for those sectors that respondents defined as water "wasters," and included limits on the number of new hotels and water-intensive industries. Policymakers tend to favor water conservation measures or curtailment over increasing water-use efficiencies, while many of the community interest groups favored specific measures in each category. It is important to note that community interest groups with traditionally opposing viewpoints agreed with some degree of conservation measures. These groups included land development, forestry/fuels management, conservation/environmental, a large employer, tourism/recreation, and reclaimed water users.

Perhaps most interesting are the justifications for favored management responses. The following two sections outline the justifications provided for augmenting supplies and implementing conservation measures.

Supply Augmentation

Justifications for increasing supplies generally reflected a preference for meeting current and future demand with the least expensive supply-augmentation option(s) at the earliest possible time. The following justifications to increase supplies were provided by five policymakers and one economic development organization:

- Meet current and future water needs.
- Decide now to save inflation costs later.
- When/if Bureau of Reclamation (BOR) decides pipeline is best option, Flagstaff already owns rights.
- Surface supplies are not dependable.
- Supply problems exist despite drop in per-capita water use.
- Other municipalities in Arizona rely on the Colorado River.
- Be able to meet peak demand.

Conservation Policies

In contrast, justifications for limiting per-capita demand or total demand (i.e., conservation measures) included the following, made by 6 policymakers and 11 community interest groups (conservation/environmental, forestry/fuels managers, large employer, reclaimed users, and tourism/recreation organizations):

- Sustainability of water resources.
- Resource is going to be final limiting factor.
- Balance availability of supplies with demand.
- Slow down groundwater depletion curve.
- Plan for the worst in terms of future climate conditions because they are unknown.
- Balance urban development with open space.
- Minimize impact on environment by water supply development and use.
- Ensure water for both humans and wildlife/riparian uses.
- Value water as common and public property.
- Recognize water is an important commodity.
- Support the reason that many people moved to Flagstaff—the natural environment.
- Save for future generations.
- Opportunity for big savings to result from a lot of people doing a few little things.

In general, these responses reflect a desire to balance current water uses with other uses, like future users, wildlife, or open space, and are reflective of the construction of nature under a sustainability management model, where natural resources are seen as finite in number, worthy of protection, and made available for uses other than commodity production or urban growth.

Related to conservation measures, I queried informants about the appropriate uses of reclaimed water because several informants included reclaimed water use in their preferred management responses. More than 50 percent of the informants favored reclaimed water use

Table 7. Types of Conservation Measures.

	Policymakers	Interest Groups	Scientists	Total	Which Groups?
Increase Water Use Efficiency					
Low flow plumbing fixtures in commercial and residential properties	1	2		3	FF, LD
Conservation technologies (e.g., leak detection devices)		3		3	CE, LD, LE
Encourage more efficient irrigation practices	1	2		3	FF, FF
Remove engineering hurdles to install low flow plumbing fixtures		1		1	LD
Increase water rates	1			1	
Total	3	8	0	11	
Wise water uses					
Encourage xeriscaping	2	5		7	CE, CE, FF, FF, LE
Encourage hotel guests to limit water use	2	3		5	FF, LE, TR
Facilitate residential and commercial graywater use and rain harvesting	2	2		4	CE, LE
Enforcement of municipal water use restrictions	1			1	
Total	7	10	0	17	
Curtailment					
Limit urban growth	3	3		6	CE, ED, FF
Year-round mandatory water restrictions	1	2		3	FF, RU
Live within “groundwater means”	2			2	
Per capita limits to water use	1			1	
No increase in the number of hotels		1		1	FF
No increase in water-intensive industries		1		1	LD
Thin forests		1		1	FF
Technological constraints on showering time in hotels		1		1	LE
Require people to request water in restaurants	1			1	
Last resort—stop issuing building permits	1			1	
General use restrictions		1		1	TR
Total	9	10	0	19	

*Note: My use of the word ‘encouragement’ refers to increased education effort, financial incentives, or marketing for private residential and commercial irrigation, overall more uses, and/or irrigating publicly-owned property like schools and parks. Nine policymakers preferred these uses, as did several, usually conflicting, organizations like conservation/environmental groups, land development groups, large employers, reclaimed water users, and tourism/recreation organizations. Fewer informants preferred reclaimed water use for making snow at Snowbowl, irrigating golf courses, recharging the aquifer, riparian community growth along the effluent discharge channel, dust mitigation, or drinking water. Justifications for the most preferred reclaimed water uses tend to fall in line with the justifications for general conservation measures, while justifications for the less-supported reclaimed water uses introduced concepts of "lost" water and "better" water uses. Economic development and tourism/recreation groups justified reclaimed water use for snowmaking as an economic stimulus for the community that would return economic profit to the businesses that profit from skiers and the government agencies that collect taxes on those purchases. The groups against using reclaimed water for snowmaking claim the water will sublimate, and thus be "lost" for any additional uses in Flagstaff.

5.2.5 The Future of Water Management in Flagstaff

When asked about the future of water management in Flagstaff in the next 5 and 25 years, nine informants, including four policymakers and five community interest groups (two conservation/environmental groups, a large employer, a reclaimed water user, and a tourism/recreation organization) thought the city will have implemented more conservation measures (of varying types and degrees), whereas supply augmentation was predicted by three policymakers. Over the next 25 years, projections were evenly split between increased conservation measures and supply augmentation. A policymaker, forestry/fuels manager, and a land development representative did not think anything would be different in the future. Some informants prefaced their prediction with different scenarios. If the drought continued, three policymakers predicted that more stringent conservation measures will be in place, along with some degree of water supply development.

Justifications for increased conservation measures included arguments that Flagstaff is located in an arid region, where water supplies are inherently scarce and are being increasingly depleted. In contrast, supply augmentation options were justified by the inevitability of urban growth, or the importance of urban growth to economic development in Flagstaff.

5.2.6 Information Sources

Presuming that informational sources affect decision-making, I queried respondents about what kinds of climate, hydrologic and general information sources they use. The majority of policymakers receive their hydrologic and water use information though the City of Flagstaff Utilities Department, while community interest groups consult the local U.S. Geological Survey office and NAU faculty, in addition to the City Utilities Department. A total of 32 out of 33 responses indicated that many informants reference or monitor some kind of hydrologic information.

While some informants indicated they consult the local National Weather Service office for weather forecasts or historical precipitation trends, climate information use was very limited. Five respondents relied on personal observations or technical monitoring to assess current weather conditions, and the Weather Channel was also mentioned as a source of weather information.

Many respondents, both policymakers and community interest groups indicated the local media and local organizations, like the Grand Canyon Trust or the Nature Conservancy served as their general information source.

The degree of trust respondents attach to different information sources indicates how much they might incorporate the provided information into their decisions. These responses are provided in Table 8. In general, nearly the same number of respondents that put little faith in hydrologic models of the regional hydrogeology, forecasts of winter precipitation, and the newspaper put a lot of faith in all the other information sources combined. Because many decision-makers and community interest groups rely on and generally trust agencies that provide water resources information, it might behoove those providing climate information to filter climate information through these agencies. In addition, the difference between climate and weather is not well understood, and leads to very little trust in climate outlooks because respondents perceive weather forecasts are often wrong. Some respondents indicated they trusted personal observations of weather conditions over any sort of forecast.

5.2.7 Influences on Water Management

Responses here essentially paralleled the decision-making structure currently in place in Flagstaff. The majority of policymakers and community interest groups

Table 8. Degree of Trust For Different Information Sources.

	A lot	Somewhat	Very Little	Total
Hydrologic models		7		7
Forecasts for winter precipitation		1	3	4
Newspaper	1	2		3
Personal observations/monitoring	3			3
U.S. Geological Survey	2			2
"Increase-supply" proposals by city			2	2
Grand Canyon Trust	2			2
Rocky Mountain Institute Study	2			2
Long Term Climate Forecasting	1	1		2
National Weather Service	1			1
NAU	1			1
Flagstaff Utility Department	1			1
Nature Conservancy	1			1

indicated the Utilities Director has the most influence over water policy in Flagstaff, followed by the City Council and Water Commission. Policymakers and community interest groups were split on whether the current degree of public involvement is sufficient.

5.2.8 The Feasibility of Regional Water Management
Similar to the questions about influences on water management, questions covering the feasibility of regional water management or locally based watershed initiatives did not yield much useful information for two reasons. First, I narrowed my focus significantly after the interviews were conducted, and these questions were no longer directly relevant. Second, many respondents outlined existing regional groups that include Flagstaff as a participant. These include the Coconino Plateau Water Advisory Council (CPWAC) and its associated technical group, and the Northern Arizona Municipal Water Users Association (NAMWUA). Initially formed to produce a collective water resource management plan for the Coconino Plateau in association with the Rural Watershed Initiative of the ADWR, the policymaking arm of CPWAC has been by and large disbanded, and the group is now focused on developing baseline information about water resources on the Coconino Plateau. In its infancy, NAMWUA is currently seeking to add municipal members to its charter base of municipalities in the Verde Valley. Outside of general comments alluding to an organization of municipal water management utilities in northern Arizona seeking to advance collective water resource interests, I cannot find an official, published NAMWUA mission.

Other respondents cited constraints to forming this type of group, like legal requirements associated with the Law of the River or the sovereignty of current municipalities and counties in the area. Of those respondents that did entertain the thought of a different regional water management opportunity, a majority of policymakers, community interest groups, and scientists voiced support for one, mainly because Flagstaff shared their groundwater source with many other communities and uses. However, it should be noted that three policymakers did not support a regional management entity that mimicked the existing AMA structure in more metropolitan and agricultural areas in Arizona. Respondents in favor of some kind of regional entity thought it should serve planning and management purposes, representatives from Coconino County and municipalities in northern Arizona should participate, and that it should be bounded by the Coconino aquifer boundary. Other groups in the region were mentioned as possible participants, but did not garner as much support as Coconino county and municipalities in northern Arizona.

6. Analysis

6.1 Political Ecology

Shaped by the three primary dimensions called for by the general political ecology approach (biophysical conditions, environmental narratives, and socioeconomic institutions), contemporary water policy in Flagstaff is contingent on the particular arrangement of these dimensions and how the ruling class socially constructs what counts as "nature" and what constitutes the "most appropriate" role for water resources (the application of political ecology's premise of unequal power relations is discussed later in this chapter) While contemporary Flagstaff evidences a continuum of environmental narratives and socioeconomic institutions, definite trends are discernible. In the following sections, I outline the arrangement of biophysical conditions, environmental narratives, and socioeconomic institutions in Flagstaff as they relate to water policy.

6.1.1 Biophysical Conditions

Over the last four years, sustained drought conditions in Flagstaff have led to an increasing acknowledgment that drought conditions have stressed both surface supplies and groundwater resources. Although historically during times of drought, Flagstaff implemented policies to reduce short-term demand and augment supplies, current drought conditions and their likely continuation, in concert with particular environmental narratives and socioeconomic institutions in Flagstaff, may lead to a different policy track for Flagstaff.

6.1.2 Environmental Narratives

Two primary environmental narratives that manifest as resource use models are present in Flagstaff today. These are resource instrumentalism and resource sustainability. I associate the resource instrumentalism narrative with a management approach that pursues increases in supplies as soon as demand exceeds supply (for example, due to population growth or an increase in water demand by industrial users) or supply cannot meet demand (for example, due to a multi-year drought) with the sole intent of economic growth. The linkage between increasing potable water supplies and resource instrumentalism is evidenced by informants' justifications for long-term supply augmentation: water supplies must be available to support inevitable growth, which is important for economic development in Flagstaff. However, I suggest it is also present in justifications to expand the reclaimed water program. Interview data indicate that justifications for using reclaimed water for golf course irrigation or making artificial snow are in line with the aim of resource instrumentalism: allocate water to the use that returns the highest economic profit. In Flagstaff, that use is tourism. Although reclaimed water use is often associated with conservation policies and the resource sustainability model, it can also be categorized as a materialization of resource instrumentalism, if it is used to facilitate the economic growth of an economic activity that might not otherwise exist in a given biophysical context.

The link to resource instrumentalism is further solidified when the conflict over reclaimed water use in Flagstaff is compared to the contemporary debate over Western water appropriations under the prior appropriation doctrine, a doctrine thoroughly established with resource instrumentalism (Emel 1990, Worster 1985). In each, the earliest appropriations and largest water users are comprised of mostly private, water-intensive industries that are associated with the local political economy (in the Flagstaff case, irrigating golf courses; in the general Western case, irrigated agriculture) are contested by people advocating uses that are more "environmental," (such as maintaining the riparian community that surrounds the effluent channel in Flagstaff or reallocating water for in-stream uses in the West). While it is clear that resource instrumentalism is present in contemporary Flagstaff as indicated in the following quote, interview results indicate that this model is not popular with a majority of the informants.

> "So, we're looking in all directions and trying to satisfy our need for water. And, of course we will continue to look at possibilities of drilling some more wells in and around the Flagstaff area."
>
> -Area water policymaker

This type of management approach was more prevalent in historical water management policies in Flagstaff as evidenced in claims that each new supply expansion project would "solve" the "unreliability" of water supplies in Flagstaff despite the fact that new water supplies were continually needed to replace those exhausted by use and/or drought conditions.

The other contemporary environmental narrative is what I term, resource sustainability, where "nature" is incorporated into resource use decisions in the form of conservation measures, and justified with discourse consistent with a 'reconceptualized nature' that I introduced in the Chapter 2. Examples provided in the interviews include the notion that natural resources are finite in number, that natural resources exist in ecosystems instead of as individual 'instruments,' and that nature is worthy of protection. This category contained almost three times as many informants as the resource instrumentalist category.

What led to the shift from resource instrumentalism to resource sustainability? While I outline two possible theories below, I argue that the shift can also be, at least partially, attributed to a parallel shift in the third dimension of the political ecology approach: socioeconomic institutions. In this study, we see that although many of the factors that the majority of area water policymakers, community interest groups, and scientists attribute to the current imbalance between water supply and water demand have been historically present in Flagstaff, resource sustainability did not surface in water policy until approximately 1990. Many informants attribute the current imbalance between water supply and demand to drought conditions, urban growth, and regulatory constraints. During the 1950s, Flagstaff experienced one of its worst droughts on record, while growing at nearly ten times the rate that Flagstaff grew between 1990 and 2000. However, during the 1950s and 1960s, Flagstaff began drilling three groundwater well fields, a sure indication of resource instrumentalism. If these two conditions (e.g., sustained drought and rapid urban growth) lead to implementing a resource sustainability management model, it would seem conservation measures would have been sought in the 1950s and 1960s. In addition, since its promulgation in 1980 the state's groundwater code has yet to be expanded to govern areas outside the originally designated Active Management Areas located in the central and southern part of the state. Thus, regulation of water supply and demand in Flagstaff remains, for all intents and purposes, at the local level. If the rise of resource sustainability cannot be exclusively attributed to drought conditions, urban growth, or the regulatory context, perhaps it can be attributed to the success of the environmental movement. However, as I outline below, only some tenets of the environmental movement are incorporated into contemporary conservation measures, not all. Presented in this light, it appears that other factors, outside of drought conditions, urban growth, or the success of the environmental movement also explain the popularity of the resource sustainability model. I argue that the emergence of resource sustainability is a response to a second crisis of capital, as defined by James O'Connor (1994).

6.1.3 Socioeconomic Institutions

Ecological Marxism

Here, I aim to demonstrate the manifestation of the two conditions of a second crisis of capital and identify the parallel rise of a contemporary political economy that exemplifies the way capital responds to a second crisis of capital. I claim that the manifestation of the conditions of the second crisis of capital in Flagstaff, and a capital structure associated with the response to a second crisis of capital (i.e., commodifying nature) also led to the emergence of the resource sustainability model in Flagstaff.

The second crisis of capital manifests when two conditions occur: 1) deteriorating conditions of production (in this case, the quantity of available water supplies) and 2) previous and ongoing social resistance to the resource management model that led to deteriorating conditions of productions (resource instrumentalism, in this case), and results in increasing costs for conditions of production.

Condition #1: Deteriorating Conditions of Production

According to interview results, one of the most pressing water problems in Flagstaff is an imbalance between water supply and demand. Area water policymakers, community interest groups, and local scientists ranked 'declining groundwater levels' as the leading contemporary water problem, followed by 'less supply than demand' and 'providing supplies during drought years.' Informants attribute the imbalance to different factors (either too little supply or too much demand), but do agree on the imbalance, or in O'Connor's terminology, deteriorating conditions of production. Local water use and demand data support these assessments.

The local economy in Flagstaff has adapted to decreasing water supplies in two opposing ways. One response is more conservation oriented, as evidenced by the decision by one arm of the local economic development base to not recruit or accept high-water using industries. The other response is to increase water rates, which provide revenue to continue existing economic production in an area where limited supplies are very expensive to access.

Condition #2: Ongoing Social Resistance
Several organizations in Flagstaff classify themselves as conservation or environmental organizations, and several informants mentioned the significant presence of the environmental community in Flagstaff. In addition, several respondents provided justifications for increased conservation measures and supported a general conservation ethic that are consistent with the ways that nature is valued by the broad environmental movement. These values include achieving a general environmental sustainability in the interest of signifying some sort of inherent value to nature, providing for the health and maintenance of non-human and non-economic uses such as ecosystems, riparian areas, and wildlife populations, and making do with currently available water supplies. For the remainder of this thesis, I refer to this bundle of values as 'general environmental sustainability.'

Nature as a Commodified Amenity
Socioeconomic trends indicate that the aesthetic consumption of nature has occurred in Flagstaff since the early 1900s. First associated with tourism to surrounding landforms like the Grand Canyon, it now takes a more "participatory" form. Instead of treating nature as something to visit and using Flagstaff as the gateway point, public lands surrounding Flagstaff, the recreational activities located on them, and Flagstaff's more temperate climate (especially in relation to the deserts of southern Arizona) are used to facilitate entities dependent on defining nature as an amenity, like second home development on the urban/forest fringe or using local scenery to market Flagstaff to potential new employers and visitors. Here, nature, especially "pristine nature" is treated as a condition of production, and some degree of it must be preserved by capital from its own excesses and contradictions. The way that some members of the local business community have embraced some arguments by the environmental community in Flagstaff indicates they view water resources in the Flagstaff area as something to protect, but not necessarily for the same values associated with general environmental sustainability. The following quotes indicate the desire of the local business community to preserve water resources, but do not mention why they should be preserved:

> "…and the environmental people are great when they get angry at us. They tell us that we still live in a desert here, and the fact of the matter is, that deserts don't get a whole lot of water. It's time we woke up here, and started realizing that because of our location, there's never going to be a significant amount of water that comes here, and we need to be able to deal with that."
>
> -Tourism/recreation industry spokesperson

> "You've got to maintain a healthy economic base for the people you have here, but you've got to do it in such a way that you don't destroy your environment, otherwise—sustainability is the key. Water conservation and water use and sustainability—they go hand in hand."
>
> -Area water policymaker

Opposed to the eras of production and consumption of goods and services when water resources were only necessary for industrial, commercial, or domestic uses, capital accumulation in Flagstaff is increasingly dependent on preserving and protecting those parts of nature that are valued by the people fueling the local political economy. In this instance, capital co-opted some of the tenets of the environmental movement (i.e., resources are limited, therefore they must be preserved), but did not do so with the same intent as the environmental movement (for example, to signal some sort of inherent value in nature or to save water resources for riparian or wildlife uses).

6.2 Water Policy Response

In response to the contemporary intersection of biophysical conditions, environmental narratives, and socioeconomic institutions outlined above, water policy in Flagstaff has been reordered to a more "sustainable" form by incorporating nature through measures designed to preserve water resources. While there is definitely a continuum of favored management responses from developing new supplies to growth moratoriums, interview findings indicate that three times as many informants support conservation measures as support supply augmentation projects. Apparently, some of these ideas are making it to the City Council, as the Council members recently passed a new water conservation ordinance that permanently bans daytime watering.

Why are the resource sustainability model, its associated conservation measures, and aims to preserve water resources so widely accepted among area water policy makers, community interest groups, and scientists in Flagstaff? It appears that water conservation measures advocate a general environmental sustainability and also sustain the local political economy; these are policy 'ends' that resonate with many people in Flagstaff. While interview informants often frame the current renegotiation of water policy in Flagstaff as a conflict between supply-side and demand-side management (which definitely exists given the preference of some policy makers for supply augmentation), I suggest a rift within the resource sustainability faction could also manifest because conservation measures actually serve as a means to an end instead of an end themselves. In this case, the ends differ substantially between those interested in limiting potable use for the sake of improving general environmental sustainability and those interested in sustaining politically legitimate capital accumulation at the least possible financial cost, where the latter two conditions manifest as the second crisis of capital.

The fact that two, traditionally quite opposing paradigms (environment/economy) are in agreement about the direction of water policy in Flagstaff raises the question, sustainability of what? The following justifications provided in the interviews for implementing conservation measures both today and in the future highlight the subtle ways that support for conservation measures can advance two fundamentally opposing ends: signifying a general environmental sustainability and sustainability of the local political economy in Flagstaff.

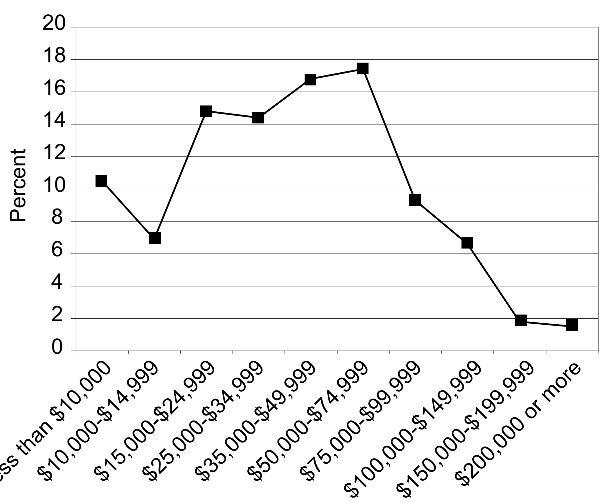

Figure 11. Annual Household Income Distribution in Flagstaff, 2000. Source: U.S. Census Bureau.

- Sustainability of water resources [Why?]
- Slow down groundwater depletion curve [Why?]
- Balance urban development with open space [Why?]
- Save for future generations [Why?]
- Acknowledge the finiteness of water resources [Why?]

I added the brackets and emphasis to highlight the absence of which end is served by support of conservation measures.

The issue of real actions versus interview responses is an important one to introduce here. The fact that a majority of the interview informants indicated they supported conservation measures does not necessarily translate into lowered water consumption by Flagstaff residents. Consumer behavior literature would suggest that consumers respond to a number of stimuli, including the price of a good and personal attitude, among a host of other factors. Hajispyrou et al. (2002) found that household consumption varied significantly across regions in Cyprus, with the highest income households consuming the most water despite a progressive pricing structure (i.e., the per unit price of water increases as income increases). That study also found the elasticity of water increased as income increased, indicating that water becomes more of a necessity as income decreases. These findings would suggest that price and income, in addition to the attitudes expressed in the interviews, are also important determinants of water use behavior. Annual household income in Flagstaff in 2000 (Figure 11) is not normally distributed. Similar to the distribution in Arizona and in the United States as a whole, the distribution is generally bimodal, with high points at the $15,000 to $24,000 category and $50,000 to $74,999 categories. In concert with the above literature, these data would suggest that a substantial number of Flagstaff residents would likely continue to use high amounts of water, despite increases in the price of water and professed attitudes. However, the price increases would unequally affect the other substantial income cohort in Flagstaff: the 14.8 percent of the population that earns between $15,000 and $24,999 per year.

Figure 12 demonstrates my proposed management model for the contemporary water management structure in Flagstaff. Here, both resource instrumentalism and resource sustainability are present, and their associated management means are linked to potential ends.

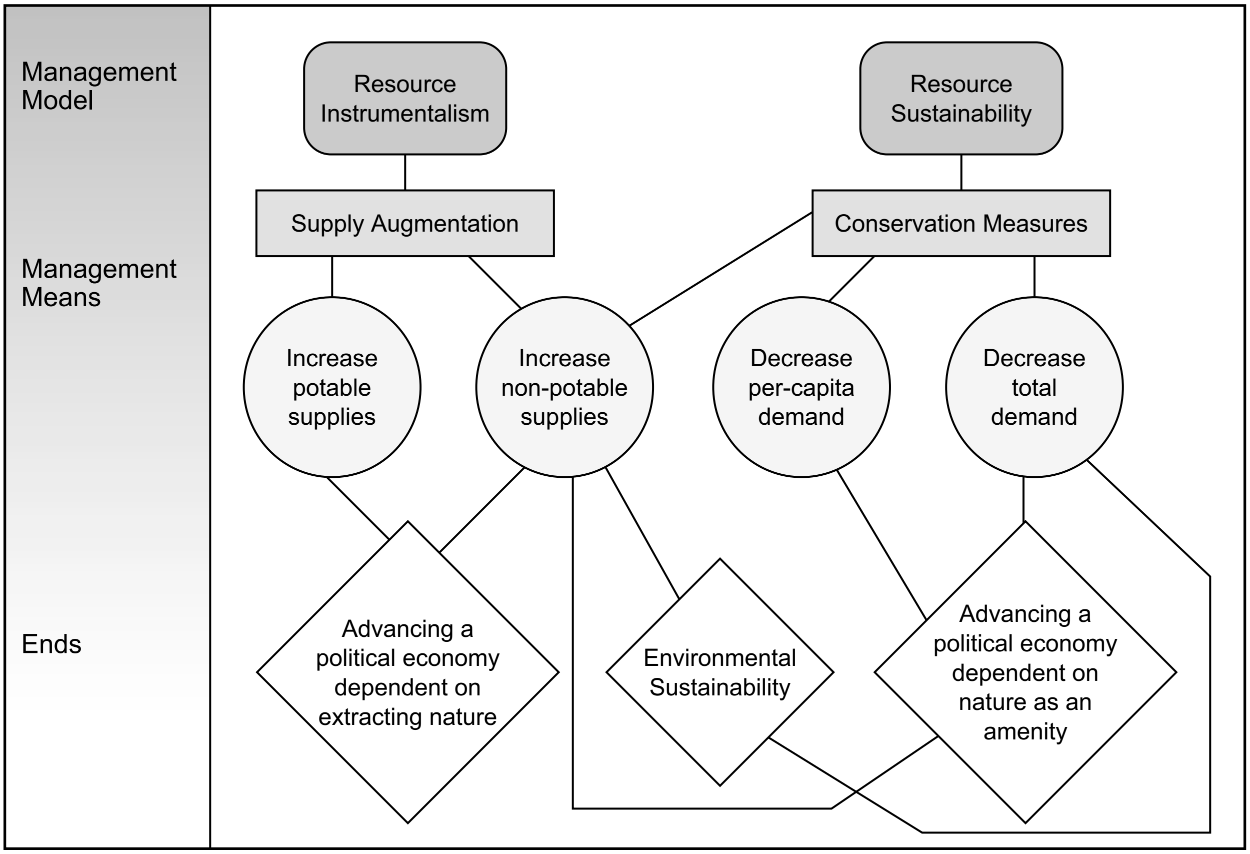

Figure 12. Proposed Model of Contemporary Water Management in Flagstaff.

Given that the resource sustainability model is linked to two fundamentally different political and economic value systems that both prioritize natural landscape attributes of the area, it is quite productive to take a closer look at existing conservation programs to determine which end(s) they serve.

Because it appears that a number of the contemporary conservation measures can promote opposing agendas, it is appropriate to briefly examine the political power structure in Flagstaff. Currently, the City Council votes on all of the major policy changes at the recommendation of the water manager and the Water Commission. Because of this, the latter two entities have an inordinate amount of power in the way that policies are introduced to the Council and how the range of policy alternatives is bounded. Because the interests on the City Council are broadly split between development and environmental interests and the degree of power held by the Commission and water manager, the way that proposals are presented to the Council will likely determine how the ultimate vote will fall. In addition, Northern Arizona University's water use policies play an important role in Flagstaff's water resource management, due to its position as a major employer and its close ties with the community.

6.3 Analysis Applied

In general, Flagstaff's contemporary water policies can be grouped into four categories: increase potable supplies, increase non-potable supplies, decrease per-capita demand, and decrease total demand. These measures include drilling more groundwater wells, the reclaimed water program, the inverted rate program, restrictions on residential and commercial irrigation, and policies to encourage low flow plumbing fixtures. Although it is obvious that drilling additional wells will increase potable supplies, the short term and long term water resource consequences of the other measures are not so definite. There is evidence to suggest that conservation programs have the potential to encourage potable water consumption, or at least not decrease potable consumption (i.e., a trend that is not the aim of many conservation policies), given that after an initial decrease between 1990 and 1992 (which, should be noted were years of above-average precipitation associated with the El Niño phase of ENSO), total water production has remained fairly stable through 2002. A slight increase in total water production was measured between 1998 and 2002.

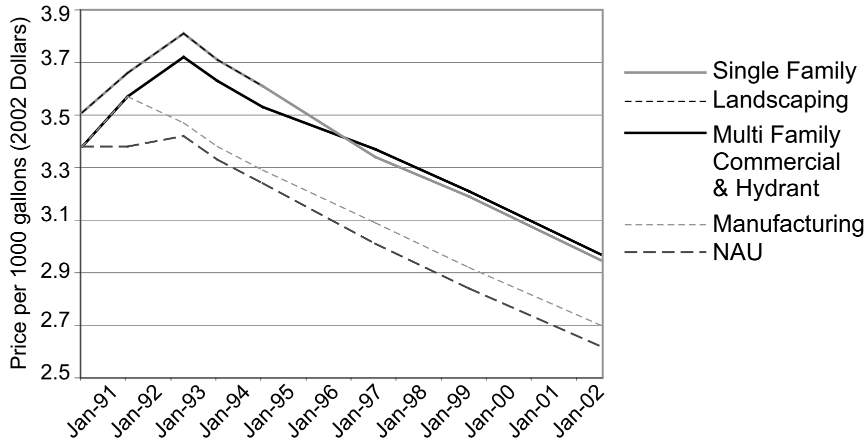

Figure 13. Flagstaff Water Rates, Adjusted for Inflation. Source: City of Flagstaff.

Here I critically examine the inverted rate structure and the reclaimed water program in an effort to suggest that conservation measures do not necessarily lead to a decrease in potable water consumption, and can further several ends, including advancing a political economy dependent on extracting nature, advancing a political economy that is dependent on constructing nature as an amenity, and promoting general environmental sustainability. The inverted rate structure was enacted to provide financial incentives to reduce potable demand. In an inverted pricing structure, users are charged more, the more water they use. Although real prices do increase as use increases, the inflation-adjusted price (i.e., nominal price) for the average user has actually decreased since 1993 (see Figure 13).

According to the neoclassical economic theory that this policy is based on, instead of decreasing the number of users or amount used, it is actually encouraging more potable water use (for any 'end') by keeping prices even lower than before the inverted rate structure was put into place, once inflation is taken into effect. Although this might be just an oversight, bringing water into any kind of market-driven system has been shown to lead to water profligacy as well as water conservation (Biro 2002)[5]. The reclaimed program relies on the production of wastewater, which is generated by potable in-home or in-business use. When the program expands (a move supported by many interview informants), increasing reclaimed water uses are provided by greater amounts of in-home or in-business potable use. This, in effect, hides increasing total potable demand brought on by higher per-capita use by existing customers or by additional customers, even if the per-capita use of additional customers decreases. This process is similar to grocery shopping on a fixed budget. For example, if a customer uses coupons (i.e., the reclaimed program) to save money (i.e., water) on items he/she would not buy had there been no coupons available, the customer perhaps spends more money using coupons than not. When the reclaimed program is viewed in this context, it appears that it is essentially increasing the availability of non-potable supplies to uses that might not be feasible otherwise.

It remains to be seen whether or not current conservation policies can effectively move toward long-term hydrologic sustainability and allow capital dependent on the aesthetic or recreational consumption of nature to accumulate. As I have argued, these goals are often contradictory, and conservation measures aimed at reducing potable water production can potentially increase potable production in the long-term. The implications of apparent agreement on "sustainable" resource management policy in an advanced capitalist context may lead to future conflicts when capital will inevitably restructure again due to shifting economic, social, and regulatory conditions that afford both constraints and opportunities to capital. In that instance, the inherent value of nature might not necessarily be so important to capital, and the contradictory motives of environmentalists and capitalists will manifest. Given the indeterminate effect of contemporary water policies on groundwater levels and forecasted long-term drought conditions on surface water supplies, adopting and implementing a water budget in Flagstaff could ease the transition.

7. Conclusions

One of the few municipalities to introduce a resource sustainability model in Arizona, Flagstaff is well on the way to recognizing ecosystem, as well as economic rights, to water. In addition, local policymakers seem open to community input, and would respond well to a call for a community debate regarding the potential effects and conflicts associated with the direction of water management. The adoption of the recent Water Sustainability measure by the city council testifies to the commitment by community members and decision-makers to long term water sustainability through conservation measures, as well as to supply augmentation.

7.1 Recommendations

I suggest that Flagstaff develop and adopt a formal water budget, similar to the one developed by the USGS (Bills et al. 2000) or Carter et al. (2000). A city-wide water budgeting exercise might perhaps address the number-one contemporary water problem cited by informants: an imbalance between water supply and demand, by concretely identifying how much water is consumed and recharged. A 1999 audit of the Arizona Department of Water Resources conducted by the Arizona Auditor General warns of the significant implications of not closely tracking water consumption because assured water supplies are not legally required in non-Active Management Areas (Norton 1999).

Although there is some acknowledgment among informants that current drought conditions have been present for some time and may persist into the future, climate information is vastly under-utilized by Flagstaff water policy makers and community interest groups, and could prove to be vitally important in understanding and planning for potential precipitation and temperature trends. A better handle of long-term precipitation and temperature forecasts could allow additional flexibility in Flagstaff's policy preparation or policy response to these trends. Flagstaff water policymakers and community interest groups could also benefit from climate information at a higher spatial resolution than the climate division level. Because the climate division that Flagstaff is assigned to includes nearly all of northern Arizona, fine-scale climate patterns that could impact Flagstaff are not picked up by aggregated models.

7.2 Suggestions for Future Research

Because this research project is designed to be a broad, exploratory engagement with the contemporary socio-environment in Flagstaff, several different paths for additional research endeavors would clear up some questions about contemporary water management in Flagstaff, and in the Southwest more broadly. A comparison study between informants' interview responses and the actual voting record of policymakers or promotional literature or activist history of community organizations may illustrate more clearly the differences between different 'ends' that are used to justify conservation measures. Although I am not sure of the feasibility of the following project, statistically isolating the signal of different conservation measures in total groundwater production over time would clarify how these programs affect groundwater production totals, and thus, total groundwater overdraft. Additional research on how nature is commodified in Flagstaff (i.e., a content analysis of promotional literature published by the City and the Chamber of Commerce or surveying recent emigrants regarding the extent that local scenery influenced their relocation choice) would lend additional credence to an ecological Marxist interpretation of contemporary water management practices. A comparison study of communities (Sedona, Arizona, for example) enacting water policies similar to those currently pursued by Flagstaff would shed light on the extent that similar biophysical and socioeconomic drivers are manifesting in other Western communities. In concert with research on socioeconomic trends in the area (i.e., migration trends, urban growth, income distribution, distribution of housing prices), additional research on the relationship between socioeconomic characteristics, attitude toward water use, and actual water use behavior would likely aid in projecting water consumption trends resulting from implementation of conservation measures. Often, attitudes and behaviors are quite different, and sometimes, contrasting. Finally, on-going research to improve regional global warming models, PDO forecasting, ENSO forecasting, and models of the hydrogeology structure in northern Arizona could aid water managers.

7.3 Concluding Remarks

In the introduction to this thesis, I introduced an emerging model of Western water resources management, a model based on sustainability to counter the historically dominant resource instrumentalism. Data from archival sources and interviews in Flagstaff suggests that a resource sustainability model emerged in parallel with a political economy dependent on the commodification of nature, drought conditions, increasing costs for water supply augmentation, and social activism, and could lead to more conflicts than resolution among those advocating conservation measures. The appeal of resource sustainability is also its downfall because it draws attention to the means to accomplish sustainability and away from the conflicting motives that often support it. In addition, resource instrumentalism is alive and well in Flagstaff, and its manifestation further complicates the water management structure because policies like the reclaimed water program and the inverted rate structure, which seem to be associated with the resource sustainability model, have the capacity to serve a political economy dependent on extracting nature. Ultimately, I argue that conservation measures can advance the agenda of people calling for general environmental sustainability, for a local political economy dependent on preserving water resources, and for a local political economy not dependent on preserving water resources. The Flagstaff experience is useful to other communities characterized by high growth, an interest in the natural landscape, and limited water resources because it highlights potential conflicts within the resource sustainability faction in addition to the palpable conflict between those advocating resource instrumentalism and those advocating resource sustainability. The Flagstaff case provides a starting point for community discussion and debate before conservation measures are aggressively pursued in other cities.

Endnotes

[1]I would like to acknowledge that although my use of the term 'natural resources' as material nature reinforces the utilitarian construction of nature, the term is widely used in the literature and its meaning is understandable to potential readers of this thesis.

[2]Reconstructed precipitation refers to a proxy estimate of historical precipitation trends.

[3]Static groundwater levels are currently deeper than those allowed by the Arizona Department of Water Resources (ADWR) under its 'Assured Water Supply' provision, which applies to critical groundwater overdraft areas in the Phoenix, Tucson, and Prescott metropolitan areas and agricultural areas in Pinal County.

[4]It is important to note that the BBB tax rate is two percent higher than the other retail sectors, thus it will most likely always lead other categories in tax revenues. Assuming that the City Council would tax the sector it thought would return the most revenue at a given tax rate, its selection of the tourist sector would indicate its high economic importance to the community.

[5]When water is treated as a commodity, mixed outcomes (conservation and profligacy) result because incentives exist for buyers to conserve as well as for owners to stimulate demand. In addition, pricing mechanisms may favor supply-side or demand-side management strategies.

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Appendices

Appendix A: Human Subjects Approval

Human Subjects Protection Program
http://www.irb.arizona.edu

THE UNIVERSITY OF
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TUCSON ARIZONA

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6 September 2002

Kristen Reed, M.A. Candidate
Advisor: Barbara Morehouse, Ph.D.
Geography and Regional Development
PO Box 210076

RE: **BSC B02.176** MUNICIPAL WATER MANAGEMENT RESPONSES TO CONTEMPORARY ECONOMIC, DEMOGRAPHIC, AND ENVIRONMENTAL CHANGE IN FLAGSTAFF, ARIZONA

Dear Ms. Reed:

We received your research proposal as cited above. The procedures to be followed in this study pose no more than minimal risk to participating subjects. Regulations issued by the U.S. Department of Health and Human Services [45 CFR Part 46.110(b)] authorize approval of this type project through the expedited review procedures, with the condition(s) that subjects' anonymity be maintained. Although full Committee review is not required, a brief summary of the project procedures is submitted to the Committee for their endorsement and/or comment, if any, after administrative approval is granted. This project is approved effective **6 September 2002** for a period of one year. **Note: Site authorization must be submitted prior conduct of interviews in business locations.**

The Human Subjects Committee (Institutional Review Board) of the University of Arizona has a current assurance of compliance, number M-1233, which is on file with the Department of Health and Human Services and covers this activity.

Approval is granted with the understanding that no further changes or additions will be made either to the procedures followed or to the consent form(s) used (copies of which we have on file) without the knowledge and approval of the Human Subjects Committee and your College or Departmental Review Committee. Any research related physical or psychological harm to any subject must also be reported to each committee.

A university policy requires that all signed subject consent forms be kept in a permanent file in an area designated for that purpose by the Department Head or comparable authority. This will assure their accessibility in the event that university officials require the information and the principal investigator is unavailable for some reason.

Sincerely yours,

Theodore J. Glattke

Theodore J. Glattke, Ph.D.
Chair
Social and Behavioral Sciences Human Subjects Committee

TJG:tl
cc: Departmental/College Review Committee

Appendix B: Interview Protocol

Assessing Influences on Water Management
- In what capacity are you involved in Flagstaff's water management?
- What authority do you have?
- What types of decisions do you make regarding water management?
- Who do you answer to?
- Who, in your opinion, has the most influence over current water supply planning and decision-making in Flagstaff?
- Why?
- Who, in your opinion, should be involved in planning for future water use in Flagstaff?
- Why?

Establishing the Major Water Issues in Flagstaff
- In your opinion, what are the major water issues in the Flagstaff area?
- Why?
- Do you think either the quality or amount of Flagstaff's water supply and demand has changed since, approximately, 1970?
- If yes, how do you think it/they have changed?
- If yes, when did you become aware of these changes?
- In your opinion, what is causing these changes?
- Why?
- Do you think Flagstaff's current water supply can sustain the current population, current number of tourists, current economic growth rates?
- Why?
- Do you think Flagstaff's current water supply can sustain increasing population, tourists, or economic activity in the future?
- Why?
- What do you think are the appropriate uses of Flagstaff's water (separate potable and reclaimed)?
- Why?

Information Sources
- What types of climate (>2 weeks), weather (<2 weeks), and hydrological information do you use to assess changes in the current and future quantity and/or quality of Flagstaff's water?
- How often do you consult these sources?
- How much do you trust this information?
- Why?
- What information would you like to have?

Assessing Management Alternatives
- In your opinion, how should Flagstaff respond to these changes/issues?
- Why?
- Are you aware of any other recommendations to cope with these changes/issues?
- If yes, what are they?
- When did you become aware of these recommendations?
- How did you become aware of these recommendations?
- Do you know who suggested them?
- Which of these recommendations do you most agree with?
- Why?
- Which of these recommendations do you most disagree with?
- Why?
- For each recommendation, to your knowledge, has this been acted on?

Assessing the Feasibility of Regional Water Management
- Do you think Flagstaff needs to define a water management area, other than (or in addition to) the current service area?
- If yes, where would you draw the boundary of Flagstaff's water management area for operation purposes?
- If yes, where would you draw the boundary of Flagstaff's water management area for planning purposes?
- If yes, where would you draw the boundary of Flagstaff's water management area for decision-making/rule-setting purposes?

The Future
- Describe how you think Flagstaff's water will be managed five years from now.
- What about in 25 years?
- Is there anything related to water management that you would like to add, or that we haven't discussed?

Appendix C: Groundwater Hydrology on the Coconino Plateau

Part of the spatially larger Colorado Plateau, the 5,000-square-mile (12,950 km^2) Coconino Plateau regional aquifer system in northern Arizona is bounded by the Colorado River to the north, the Verde River to the south, and the Aubrey-Toroweap Fault System to the west for a total area of 10,300 square miles (26,677 km^2) (refer to Figure 14). The regional aquifer system consists of two aquifers and several perched water-bearing areas near the surface. Aquifers on the Coconino Plateau consist of the Coconino Aquifer (abbreviated C-Aquifer,) and the lower Redwall-Mauv Limestone Aquifer. Defining the spatial extent of the two aquifers is difficult because they are hydrologically connected to each other in some areas, to the three rivers (Little Colorado River, Verde River, and Colorado River) bordering the Coconino Plateau, and to perennial and ephemeral springs through faults and fractures. Surface precipitation filters vertically though the faults to the C-Aquifer and then to the underlying Redwall Mauv Limestone Aquifer. Some recharge remains in perched water bearing areas near the surface, where the water table is between zero feet and 200 feet (61 m) below ground surface. It is known that differences in the degree of confinement, lithology, occurrence of fractures, flow, water table, and permeability varies considerably throughout the aquifers (Springer and Ramsey 2000, Bills and Flynn 2002, Hart et al. 2002, McGavock et al. 1986, Bills et al. 2000).

The C-Aquifer, the saturated part of the Coconino Sandstone layer that is between 1,000 feet (304.8 m) and 4,700 feet (1,432.6 m) thick, is approximately 300 feet (91.4 m) to 1,100 feet (335.3 m) below surface (Bills and Flynn 2002). The C-Aquifer underlies the Little Colorado River watershed and the Coconino Plateau (see Figure 15), but is only saturated in the eastern half of the Coconino Plateau. Flagstaff is situated on the most western edge of the water-bearing formation where the regional water table rises due to localized faulting and fracturing, thus the water table near Flagstaff is approximately 300 feet (91.4 m) higher than in other areas of the aquifer. Hydrologically connected to the Little Colorado River in some areas, the C-Aquifer discharges into four areas: the lower aquifer, the Redwall-Muav Limestone, the lower 13 miles (20.9 km) of the Little Colorado River, groundwater wells, and small springs. Several tributary streams to the Verde River and the Little Colorado River are fed by groundwater flow from the C-Aquifer.

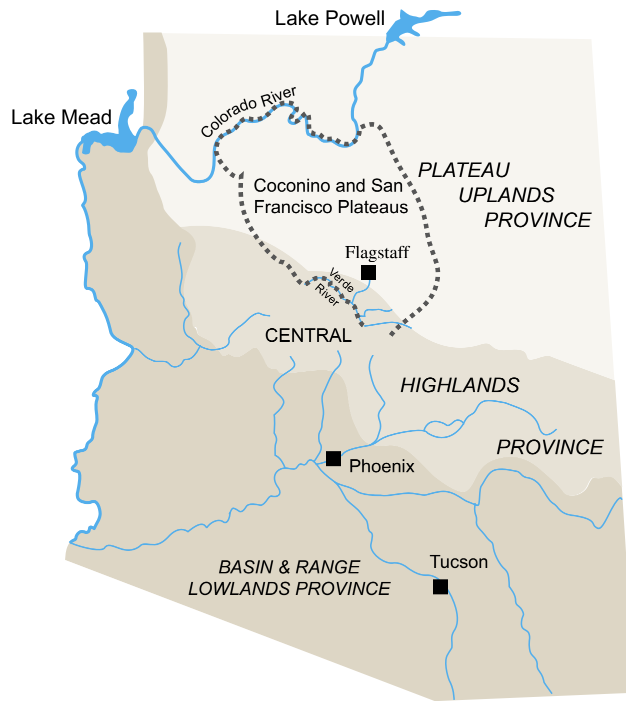

Figure 14. Coconino Plateau. Graphic published with permission from Errol L. Montgomery & Associates, Tucson, Arizona.

Groundwater mounding occurs between Upper Lake Mary and Morman Lake. From this mound, flow splits either to the northeast toward the Little Colorado River or southwest toward discharge at the Verde River. Groundwater in the C-Aquifer under Flagstaff flows laterally toward the Little Colorado River, where it is fed by the Little Colorado River flow until it discharges through a fault and fracture zone under the eastern section of the Kaibab National Forest into the Redwall-Muav limestone aquifer, which ultimately discharges into springs in the lower 13 miles (20.9 km) of the Little Colorado River. Groundwater flow east of the Little Colorado River flows westward, towards discharge at the river.

Faults and fractures are important conduits for recharge, and well fields are often drilled in these areas because they are the most productive, and often contain springs. Examples include the Oak Creek fault (and associated Oak Creek) and the Anderson Mesa fault (location of Lake Mary wellfield) (McGavock et al. 1986). At these locations, a direct hydrologic connection between the C-Aquifer and the lower Redwall-Muav limestone layer is established, and springs can be present. Fractured areas occur primarily in the western

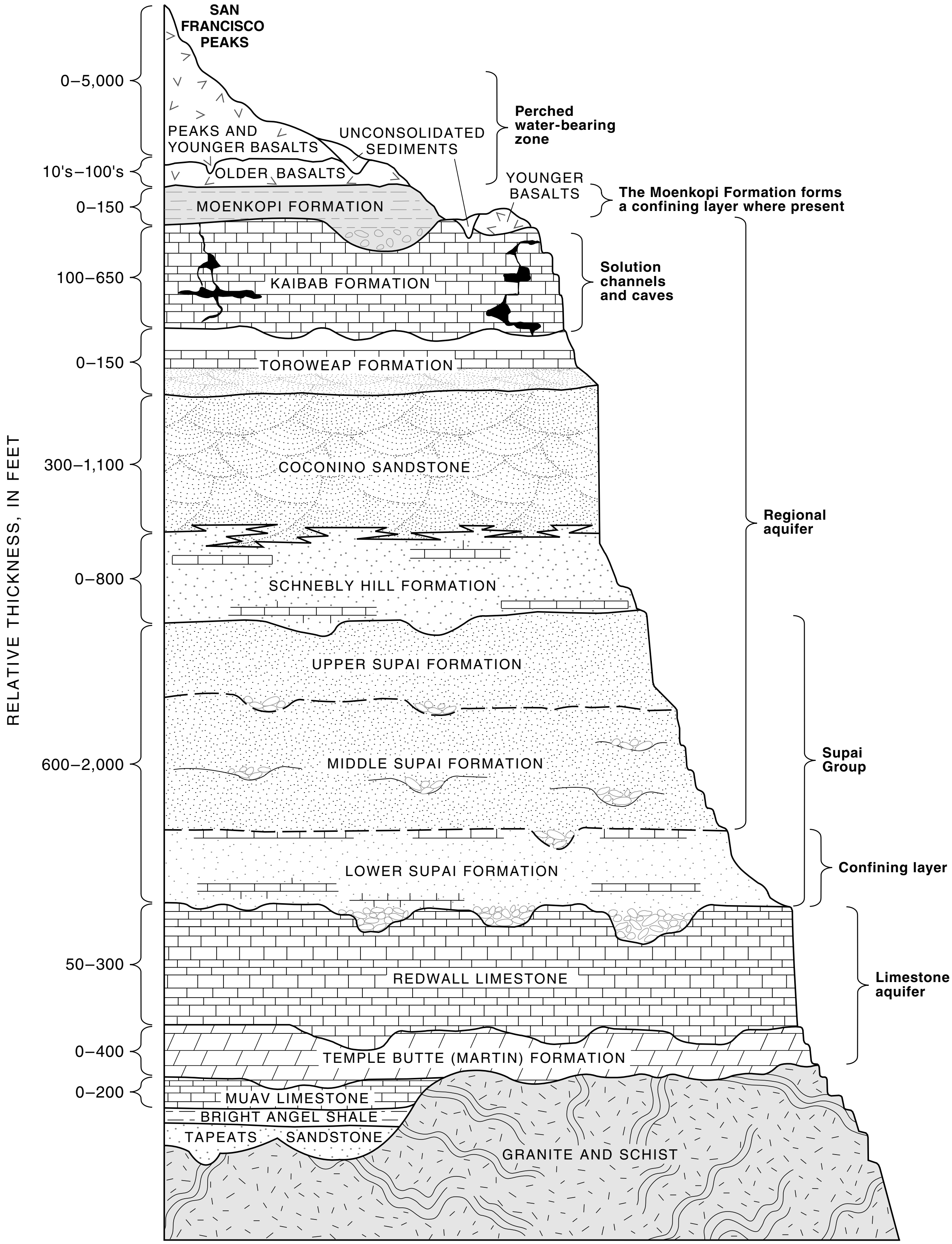

Figure 15. Coconino Plateau Hydrogeology. Source: USGS.

third of the Little Colorado River watershed, or from Flagstaff to the Little Colorado River. Assuming no groundwater pumping, Hart et al. (2002) calculated that the C-Aquifer discharged 319,000 acre-feet per year. However, one of the major assumptions of the study was that the aquifer system was in a steady-state condition, where inflow equals outflow. Declining water table levels in several wells would indicate that is not the current state. An accurate water budget calculation requires monitoring of both inflow (precipitation, infiltration from perennial streams and lakes, and underflow) and outflow (discharge to surface water features or downward flow). More accurate calculations of the aerial extent, discharge, and recharge amounts are currently being modeled and measured.

The Redwall Muav Limestone is the primary water bearing unit on the Coconino Plateau west of Flagstaff. Between 50 feet (15.2 m) and 3,400 feet (1036.3 m) thick, the Redwall Mauv Limestone Aquifer water table is located at approximately 3,000 feet (914.4 m) below ground surface. Havasu Creek splits the Redwall Muav Limestone Aquifer northwest to southeast and is the primary discharge area. North of Havasu Creek, groundwater in the Redwall Muav Limestone Aquifer layer flows southwest until it discharges in Havasu Creek. Groundwater southwest of Havasu Creek flows northeast. Havasu Creek ultimately discharges into the Colorado River in the Grand Canyon on the north side of the Havasupai Indian Reservation.

The relationships and water budget between the faults, the C-Aquifer, the Redwall Muav Limestone Aquifer, surface water features, and other regional or local aquifers is currently being defined by the U.S. Geological Survey, in association with the Arizona Rural Watershed Initiative through the Arizona Department of Water Resources, but the extent these studies will be able to accurately model the local hydrogeology is unclear at this point. The exact amount of water stored in the aquifer system, its age, and degree of recharge is currently unknown. Hydrologists do feel confident that a more complete well database for the Coconino Plateau can be completed, and discharges can be more closely monitored, but it is nearly impossible to measure the amount and rate of recharge (Bills et al. 2000). In a study conducted by Bills et al. (2000) for the area immediately surrounding the city of Flagstaff (25 miles (40.2 km) north, 18 miles (29 km) west, 8 miles (12.9 km) south, and 14 miles (22.5 km) east), annual recharge was estimated at 290,000 acre-feet, annual discharge was estimated at 400,000 acre-feet, saturated thickness was estimated at 1200 feet (365.8 m), and volume stored was estimated at 4,800,000 acre-feet—10 percent of the estimated total aquifer storage capacity. Aquifer age was estimated at 200 years in the Lake Mary area and more than 5,000 years approximately 30 miles (48.3 km) north of Flagstaff. In addition, travel times between well fields were also calculated. It would take approximately 990 years for groundwater to travel from the Lake Mary area to the Woody Mountain area, and 5,500 years for groundwater to travel from the center of Flagstaff approximately 30 miles north. In the same study, water level fluctuations varied greatly among wells. Some showed a significant decrease, some no discernible trend despite considerable pumping.

Water quality in both the C-Aquifer and the Redwall Mauv Limestone Aquifer is dependent on the solubility of the geology that recharge percolated through. Dissolved solids in the C-Aquifer increase as the groundwater flows towards the Little Colorado River, where sodium chloride, i.e., salt, constitutes the primary constituent (McGavock et al. 1986). Locally intensive pumping could also pull salts into solution if the water table fluctuates into that range. Some springs discharging from the Redwall Muav Limestone to the Colorado River also contain an increased sodium chloride concentration.