The Las Vegas Wash: A Changing Urban Commons in a Changing Urban Context

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Abstract

The Las Vegas Wash, a 12-mile natural wash, provides the primary drainage for Las Vegas, NV, the fastest growing metropolitan area in the U.S. Sewage effluent from three treatment plants, resurfacing groundwater, and stormwater travel through the wash to Lake Mead. The population of the drainage area has grown from a few people at the turn of the century, to 200,000 in the late 1960's to over 1.3 million today. This increased population led to increased wash flow, from less than 1 ft^3/sec to over 250 ft^3/sec, and consequent ecological changes from a nearly dry wash to a rich wetland, and finally to an eroded and channelized system. As the wash ecosystem has changed, the valuation and use of the wash by valley residents has also changed. This paper discusses the links between urban development and ecosystem change in the Las Vegas Valley, focusing on the changes in the way residents have valued and managed the wash resources, and the institutional and organizational structures that have developed to manage the resources.

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Introduction

On April 8, 2000, more than 2000 people turned out for the Fourth Annual Las Vegas Wash Cleanup. In groups of 15 they were shuttled from the meeting point to sites along the Wash. After a brief safety lecture (drink plenty of water; don't pick up tires, glass, or needles), they fanned out in smaller teams with large plastic trash bags to comb the brush. Two enthusiastic teenagers rolled a refrigerator end over end to the pickup point. Families picked windblown grocery bags off the sagebrush. Dropping ten feet to the bottom of the Wash channel, my group found a nest of construction debris – hundreds of feet of cable half-buried in the silt. "It's a real shame that these contractors dump this stuff down here," one of the sweat-covered volunteers said as we hauled it out. "It's not the contractors!," another said defensively, "it's the homeless bums who live out here. They steal the cable off construction sites and strip it for the copper wire. That's how they make money." A group of boy scouts chattered excitedly about the shack they had demolished last year. Another volunteer described the makeshift dwelling he found in a clearing in the tamarisk earlier in the day. "Someone clearly was still living there – there was a cooler with unspoiled food in it, toilet paper rolls. I felt really uncomfortable being there, so I left it alone." Two men shared stories about the dirt bike trails they ride regularly in the Wash. When it was time to leave, one of the organizers rounded us up. "I got worried a little while ago when I heard shots down the Wash, but it turned out to be the paintball players."

The Las Vegas Wash, a natural stream channel, provides the primary drainage for a 1,586 square mile watershed that contains the Las Vegas, NV metropolitan area. The watershed extends from the Spring Mountains at the western edge of the Las Vegas Valley over 40 miles southeast to the Wash outlet into Lake Mead at Las Vegas Bay (Figure 1). Once ephemeral for nearly its entire length, the Wash today has perennial flow for the last 12 miles of its reach. This perennial flow has led both to the development of a rich riparian wetland ecosystem extending approximately one-half mile on either side of the channel, and to erosion in the Wash channel that threatens to destroy the wetland ecosystem. Over 1.3 million people live in the Las Vegas Valley drainage basin, a population that has been increasing by 5,000 people per month for the last decade. All sewage effluent from the city, shallow subsurface groundwater, overland flow from streets and other impervious surfaces, and stormwater drains via the 12-mile lower section of the Las Vegas Wash to Lake Mead, discharging into the lake six miles upstream from the city's drinking water intake. Water taken from Lake Mead for the Las Vegas metropolitan area's water supply returns to the Las Vegas Valley upstream from the Wash, creating a physical loop in the metropolitan area's water system. Water not withdrawn from Lake Mead eventually passes by Hoover Dam and continues down the Colorado River toward California and Mexico.

This paper examines the Las Vegas Wash ecosystem as a commons. Although not technically an open access resource, owned by no one, in which resource use is entirely unregulated and open to everyone (Feeny et al. 1990), the Wash is seen by many as a communal resource, effectively open to Las Vegas residents as public land. A widespread western U.S. view of public land could be represented by the statement: "if it's public, it's ours to use as we want." Regulations for some uses are in place and enforced, but many uses are effectively

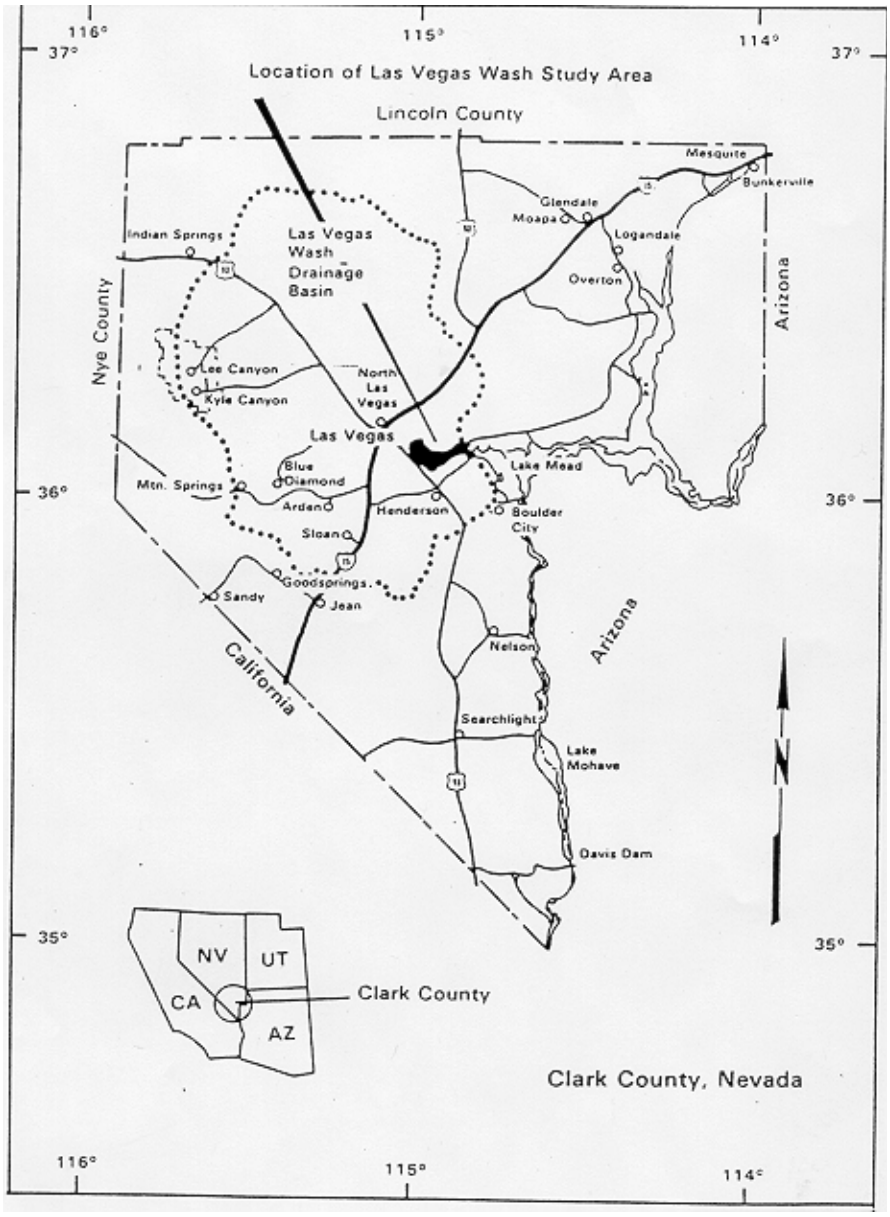

Figure 1. Las Vegas Valley Watershed (dotted line) showing location of Las Vegas Wash (Source: Roline, R. and J. Sartoris 1998).

uncontrolled. Over 20 local, regional and federal entities, as well as local businesses and residents, have interests in the Las Vegas Wash ecosystem, each identifying different system characteristics as desirable and different management issues as problematic. The channel itself, the water, vegetation, and land serve different purposes for different resource users. The wash

channel is a conduit carrying effluent away from the three sewage treatment plants that serve the Las Vegas Valley and disposing of it in Lake Mead. The water supports riparian vegetation. The vegetation, uncommon in this arid region, provides unique habitat for wildlife, including two bird species listed as endangered. Hikers, motorcycles and off-road vehicles, bird-watchers, paintball clubs, scouting groups, and "homeless" people use the land. Others use it as an illegal trash dump for everything from abandoned cars to furniture, to yard and construction waste. Entities responsible for the management of Wash resources include local, county, and federal agencies.

Some of the uses of Wash resources are complementary and some are incompatible. In some cases, increasing the use of one resource subtracts from the benefits of other Wash resource users, either directly reducing the same resource, or changing the desirability of another resource in the system linked by ecosystem processes. In this way, the Wash exhibits the common-property resource characteristic of subtractability (Feeny et al. 1990). In addition, access to most Wash ecosystem resources is difficult to control. The 12 square miles of land, crossed by myriad formal roads and dirt tracks, is easily accessible to a variety of resource users. Dense vegetation in many places makes many kinds of human activity easy to conceal. Various management mechanisms have been developed to address Wash resource use over the last 50 years or so. Early approaches tended to be developed by and provide direct benefit to single or small subsets of resource users. Management approaches evolved, however, in response to changes in resource desirability and resource conditions, leading to the recent development of the Las Vegas Wash Coordination Committee, a local management authority comprising 28 stakeholders.

Examining the Las Vegas Wash ecosystem and the set of resource users and managers connected with it as a common pool resource system shows several things. First, it adds another case countering Hardin's (1968) thesis that degradation of open access common pool resources is inevitable. It shows clearly how feedback from perceived degradation leads to collective action that addresses degradation. Second, it shows the importance of interconnections in the system both within the local Wash ecosystem and between the Wash and its watershed and larger regional hydrologic system. Third, it shows how multiple uses of commons resources both complicate commons management and strengthen the feedback that counters degradation. Fourth, it shows how interconnections and multiple uses generate indirect subtractability. Finally, it shows that change is an integral part of this system.

Because of its ecological characteristics, hydrologic context and regional setting, understanding the resource demands placed on the Wash, the sources and consequences of resource degradation, and the management challenges and mechanisms that have evolved requires a systems perspective. The Wash must be seen first as not just a single resource, but rather a set of interacting resources. Interactions among resources, resource users and resource managers feed back to influence biophysical and social system changes. Understanding the way feedback works in the system requires examining connections at three spatial scales: the local Wash ecosystem, the Las Vegas Valley watershed, and the Lower Colorado River system.

This paper investigates the characteristics of interconnectedness, multiple uses and indirect subtractibility in the Las Vegas Wash ecosystem. To begin, it describes biophysical and social system interconnections at the three relevant spatial scales: local ecosystem, watershed and regional context. It then describes the multiple uses of Wash resources that have developed over time. It ends by describing how a systems perspective helps understand the way feedback mechanisms between the biophysical and social settings have led to the continuing evolution of the ecosystem and mechanisms for managing Wash resources.

The Las Vegas Wash Ecosystem: Local Context

The Las Vegas Wash lies in the broad, flat Las Vegas Valley. The valley floor has a slope of less than one percent to the southeast (USBR and CCPR 1998). The lower 12 miles of the Las Vegas Wash has perennial flow with dry weather flows averaging approximately 240 cubic feet per second (cfs), or roughly 153 million gallons per day (LVWCC 1999). Elevations in the Wash range from 1,700 feet at the upper end to approximately 1,550 feet at the outlet of the Wash to Lake Mead. The Wash contains three basic soil types: desert upland and alluvial remnant soils, mixed alluvium and recent alluvial flats near the Wash channel, and well drained soils on alluvial flats and pediments (USBR and CCPR 1998). These sediments are easily eroded silts and clays with small amounts of sand and gravel (LVWCC 1999). Soils are saline and alkaline, favoring vegetation such as saltgrass (*Distichlis* spp.), saltbush (*Atriplex* spp.) and tamarisk (*Tamarix chinensis*) – a non-native invasive species.

Vegetation in the Wash area consists of meso- and xeroriparian communities typical of the Mojave desert scrub biome in the lower Colorado River region, and includes areas of emergent wetland vegetation (USBR and CCPR 1998). Nine vegetation communities were identified in a 1994 vegetation survey of the area. Emergent wetlands dominated by cattails (*Typhus* spp.), accounted for 2 percent of the study area closest to the Wash channel; stands of common reed (*Phragmites communis*) covered 6 percent of the near-channel area; dense, monocultural stands of tamarisk constitute 19 percent of the floodplain on either side of the Wash channel; an Upland Mojave desert scrub community consisting of creosote bush (*Larrea tridentata*) and saltbush (*Atriplex* spp.) covered 46 percent of the land, common in the most xeric areas furthest from the Wash channel. A slightly more dense xeroriparian community containing scattered native tree species such as catclaw acacia (*Acacia greggii*) and honey mesquite (*Prosopis glandulosa*) was found in less than 1 percent of the area. Disturbed land and urban development accounted for 24 percent of the land surveyed.

The area supports a diversity of wildlife, including bats, rodents, reptiles and amphibians, foxes and coyotes, and fish (USBR and CCPR 1998). One hundred and sixty-eight migrant and resident bird species have been observed, including two – the Yuma Clapper Rail (*Rallus longirostris yumanensis*) and the Southwestern Willow Flycatcher (*Empidonax traillii extimus*) – listed as endangered species.

The Las Vegas Wash: Watershed Context

The Las Vegas Wash ecosystem is not a closed system. It is connected upstream to, and affected by changes in the entire Las Vegas Valley watershed. Figure 1 shows the location of the Wash in the Las Vegas Valley watershed as well as Lake Mead and the Colorado River downstream from the Wash. The hydrologic structure of any drainage basin means that the flow at the outlet reflects and aggregates the effects of events and activities in the basin. In this way, the characteristics and changes in the Wash reflect changes in the larger Las Vegas Valley watershed.

The Las Vegas Wash ecosystem is not in a steady state; it has been in constant transition throughout its history in direct response to environmental conditions and, more recently, human activity in the watershed. Regional climate is a key environmental factor influencing the development of the Wash ecosystem. The Las Vegas Valley is ringed by mountain ranges rising to nearly 12,000 feet in the west. The climate is arid, with low precipitation, low humidity, and high temperatures. Average daily maximum temperatures range from 56 °F in January to 104 °F in July; minimum temperatures range from 33 °F (January) to 75 °F (July) (USBR and CCPR 1998). The Las Vegas Valley receives an average of four inches of precipitation per year, mostly occurring in July and August and the winter months (CCCP and CCPR 1980). Short duration and high intensity summer rainstorms often generate flash flooding when storm intensity overwhelms the infiltration capacity of valley soils. Geologic analysis shows at least three cycles of downcutting and backfilling in the Wash's history (LVWCC 1999). Erosion from the mountains that bound the valley produces sediments that are carried down and deposited in the Wash by wind and flash floods. Larger storm flows then erode previously deposited sediments. This could be described as a very long-term dynamic equilibrium in which climate, geology and topography established a balance between deposition and erosion of the Wash channel. In the last 150 years, however, the environmental characteristics of the Wash have been more closely tied to human activity in the Las Vegas Valley.

The most important connection between human activity in the watershed and environmental characteristics in the Wash is the connection between urban development and the hydrology of the Wash. Phenomenal population growth in the Las Vegas Valley in the last several decades has led to widespread changes in water use and urban infrastructure. Las Vegas is the fastest growing metropolitan area in the U.S. The resident population of the drainage area has grown from a few people at the turn of the century, to 200,000 in the late 1960's to over 1.3 million today. The number of tourists visiting the Valley has also been growing, topping 43 million people per year. Eighty-five percent of the water that sustains this population is brought into the Valley from Lake Mead; the rest is withdrawn from groundwater in the Valley. Thirty percent of the water is used in homes and sent to one of the Valley's three sewage treatment plants, all of which discharge into the Las Vegas Wash. Another 30 percent is used for residential irrigation, much of which reaches the Wash as urban runoff or shallow subsurface flow. Dry weather flows in the Wash are sustained primarily by effluent from the three sewage treatment plants in the valley, which discharged 138 million gallons per day in 1997 (LVWCC

1999). Urban area, including roads, parking lots, drainage channels, and residential and commercial buildings, covered 22,000 acres (less than 2% of the drainage area) in 1960 and more than 187,000 acres (18% of the drainage area) in 1999 (LVWCC 1999). Urban development replaces natural vegetation with impervious surfaces, moving greater volumes of stormwater and urban runoff to the Wash faster than they might otherwise.

All these changes have led to increased wash flow, from dry weather flows of less than 1 ft^3/sec in 1928 (Roline and Sartoris 1998) to over 260 ft^3/sec in 1999 (LVWCC 1999), and has intensified the effect of flash floods. Following storm events, flow in the Wash can range from 500 to 10,000 cfs (LVWCC 1999). These changes in the Valley have caused ecological changes in the Wash, turning a nearly dry wash into a rich wetland, and then to an eroded and channelized system. These changes continue a pattern begun in the last century.

Before the turn of the 20th century, the Las Vegas Wash was ephemeral for most of its length, except for a small wetland area and several springs. At that time, artesian springs were common in the Las Vegas Valley. A set of three of the largest springs formed a sort of oasis in the desert that gave the city its name. "Las Vegas", Spanish for "the meadows", was the name given to this stop along the Spanish Trail between 1831 and 1848 (Paher 1971). Flow from the springs spilled over into Las Vegas Creek. The Las Vegas Creek flow did not reach the Wash channel, but the Creek contributed to soil moisture in the Upper Wash area, and thus helped sustain a "vast mesquite forest" reported there (Paher 1971). In the period from the 1860's to 1900, Las Vegas was settled first as a Mormon outpost, then as a small farming and ranching community. During this period, water from the springs and Las Vegas Creek was diverted for irrigating agriculture, and Las Vegas Creek was used for waste disposal, decreasing the quality of the water. When the City of Las Vegas was established officially in 1905, water from springs and Las Vegas Creek was used in increasing amounts. The creek began to dry up and the water table at the springs was lowered. Increased diversions reduced the amount of water that eventually made its way to the Wash, which in turn changed the vegetation that grew there.

As population growth and development increased water usage, wastewater discharge also increased. By the late 1950's, two municipal sewage treatment plants were discharging to the Wash. Perennial flow increased and erosion on a grand scale began with headcutting in the channel. Headcutting occurs when increases in flow erode and incise the channel bottom, creating a marked difference in hydraulic gradient at a given point in the channel. The face of this step or cliff is then eroded away, and the headcut moves upstream, deepening the channel. Storm events set up the conditions for headcut erosion, and increased baseflow in dry weather continued to destabilize and erode the channel. By 1975, the headcut in the Wash had proceeded about 1.5 miles upstream from the outlet of the Wash into Lake Mead, by 1980 it had moved another 4 miles upstream (Morris 1983:Figure 2). As the headcut deepened the channel, it drained more of the shallow subsurface water, which changed soil moisture available to vegetation.

Changes in flow to the Wash have resulted in changes in the composition of vegetation in the riparian area. Before settlement, vegetation in the Wash was primarily xeric and xeroriparian. In an annotated sketch made in 1855, John Steele shows a mesquite forest extending from near the Las Vegas springs toward and along the route now traced by the Wash. A swath of "tooly grass" extended two and a half miles and a half-mile wide in the same direction (Paher 1971:20-21). As modern settlement progressed, increased use of water, as well as use of the mesquite for building materials, decreased the extent of the mesquite forest. By 1975, however, water discharged to the Wash had increased total wetland vegetation, including mixed scrub and mesquite, reed and cattail marsh, and xeroriparian vegetation, to an estimated 1,422 acres (73% of the Wash acreage at the time) (LVWCC 1999). By 1998, after erosion had incised the channel and lowered the water table, the wetland area had shrunk to 305 acres (20%). At the same time, the acreage of tamarisk has increased, from 360 acres in 1975 to 1,021 in 1998.

The Las Vegas Wash: Regional Context

In the same way the Las Vegas Wash ecosystem is nested within the Las Vegas Valley watershed, the watershed is also nested within the larger Lower Colorado River drainage system. Changes in the Wash, therefore, affect the environment and resource characteristics downstream from the Wash in Lake Mead and the Lower Colorado River. After passing through the Wash, flow enters Lake Mead at Las Vegas Bay. Although flow from the Las Vegas Wash provides only about one percent of the annual inflow to Lake Mead, this is the second highest volume of inflow after the Colorado River (LaBounty and Horn 1997). It is also locally more important, as water quality at the mouth of the Wash can affect recreational use in Las Vegas Bay, including boating, swimming and fishing. Further downstream, the flow from Lake Mead passes under Hoover Dam and continues down the Colorado River. In addition, the intake for the Las Vegas metropolitan area's water supply is located six miles downstream from the outlet of the Las Vegas Wash. This means the water supply system is both upstream and downstream from the Wash.

The downstream effects of changes in the Wash bring other stakeholders into the set of users with interests in Wash resource management. Flow from the Wash is higher in salinity, temperature, and nutrients than water in Lake Mead (LaBounty and Horn 1997). Increased salinity could affect the use of Colorado River for agriculture, municipal and industrial uses downstream. Recreational users in the Las Vegas Bay are also concerned about health risks from pathogens in Wash water.

The connection of the Las Vegas Wash to Lake Mead and the Colorado River system has benefitted the Wash as well, helping several species of wildlife return to the Wash after human activity severely limited or depleted their numbers. For example, beaver (*Castor canadensis*), trapped out of existence in the Wash in the late 1800s, made their way back into the Wash via the Colorado River and Lake Mead by the 1980s. The crayfish population, decimated following

pesticide spraying in the 1970s to control for mosquitoes, has also returned to the Wash through connections to Lake Mead and the Colorado River.

Multiple Uses: Resource Uses, Users, and Management Issues

The Las Vegas Wash has supported a number of resource uses throughout its history. These uses have evolved within the biophysical context of the changing ecosystem and as a result of changes in the social context as the Las Vegas urban area expanded. Four main types of use can be identified: sustenance, infrastructure, recreation and education. Since the individuals, groups and agencies involved in each type of use have varied interests, missions and legislative directives, the participants in these resource uses often overlap. However, each set of uses is clearly linked to changes in the urban development and changes to the wash ecosystem. The importance of different types of uses has shifted over time as the evolving physical characteristics of the Wash ecosystem changed resource availability and quality, and as the changing social context of the resource users changed the desirability of different resources. Today, all four types of resource use are considered important.

Sustenance Use

Use of the Las Vegas Wash ecosystem for food, water and shelter dates back to the early Paiute Indians of the Las Vegas Valley and, though a great deal has changed over the past hundred years, this type of use is still important today. Before the Spanish Trail became a popular migration and trade route, the native valley residents used areas in and around the Wash and springs for winter homes, small scale agriculture, food gathering and hunting. The mesquite forests provided the materials necessary to build their "wickiups" (shelters) and screw beans that were used for making drinks and ground for making cakes. (Paher 1971, BCC 1974, Nevada Archeological Survey 1975). Early Mormon settlers also used mesquite wood for fuel and fence building. Although settlement and growth in the valley became less and less dependent upon the food and wood resources from the Wash, water remained a paramount use for the valley population. The first well was drilled in 1907 and within a few years, city leaders were already concerned over the future supply of water to support the booming town (Jones and Cahlan 1975).

The completion of the Hoover Dam in 1935 and creation of Lake Mead led to a significant increase in the sustenance value of the Wash. The springs' flow was gone, ground water sources were tapped at maximum and with continuing population growth in the valley, the reservoir forming behind Hoover Dam offered a potential new water source for Las Vegas. Within two decades, the City of Las Vegas began pumping water from Lake Mead (Hulse 1998). By 1971, Lake Mead had become the source of over half of Las Vegas Valley's water supply (LVVWD 1972). With the intake downstream from the Wash, the quality of Wash outflow began to be a concern of water supply managers. By the 1960s, pollution in the Las Vegas Wash was already linked to deteriorating quality of water in the lake. In addition, erosion in the Wash due to increased waste water flow and flash flooding threatened to destroy a water supply pipeline in the early 1980s that crossed the Wash channel.

The unique structure of the Las Vegas water supply system sets up another Wash management issue related to the sustenance use of Wash resources. Las Vegas' use of Colorado River water is limited by the Colorado River Compact to 300,000 acre-ft per year (LVWCC 1999). But since the Valley returns some of the water withdrawn to Lake Mead via the Las Vegas Wash, it receives credit for the flow returned to the Lake. These "return flow credits" allow the metropolitan area to withdraw from Lake Mead the 300,000 acre-ft per year allocated plus the amount of return flow credited. In 1999, the total withdrawn was 450,000 acre-ft. This creates an incentive to move water discharged from the wastewater treatment plants to the lake as quickly as possible, and not risk losing the water to evaporation or transpiration by wetland plants. This sustenance use can also be considered an infrastructural use.

Another group that has used the Wash over the years for sustenance are the "homeless" people who use the Wash for shelter. Some of them created elaborate and sturdy shelters in the past that they inhabited for extended periods of time, making the term "homeless" somewhat inaccurate. The size of this user group has been hard to determine, but was estimated in a recent "clean-up" effort to be close to 150 individuals (Sillitoe, pers. comm.). These "wash dwellers" are considered by some to degrade the Wash for recreational or educational use simply by their presence, creating a real or perceived danger to other people. Others see them as a source of pollution in the wash, contributing feces to the water and other trash to the land.

Finally, the downstream, regional connections described above make downstream water users part of the sustenance user group.

Infrastructure Uses

In addition to the use of the Wash channel as a "return flow" conduit as described above, the channel serves to dispose of flood and wastewater for the Valley. Without a way to move stormwater away from the developed area of the Valley quickly during storm events, local flooding could be severe. If the wastewater treatment plants were not permitted to discharge to the Wash, they would have to find alternative disposal methods that could be costly or less convenient. Infrastructure user groups of the wash include the residents and tourists within Clark County, the City of Las Vegas, the City of Henderson and the various agencies charged with infrastructure services such as sewage disposal and flooding. The discharge of wastewater in the wash began in 1956 and 1957 (LVWCC 1999). Since then, the infrastructure systems for disposal of sewage have been upgraded and moved several times. Currently there are three sewage treatment plants operated by the City of Las Vegas, City of Henderson and Clark County that discharge into the Las Vegas Wash. These governmental agencies must not only monitor sewage discharge but also industrial discharges from businesses that are federally and non federally regulated. For example, electroplating and pharmaceutical companies must obtain a permit from the Pretreatment Unit at the City of Henderson prior to discharge.

Management issues related to flood control include the management of flow volume, as well as water quality. Increased runoff and seasonal flash flooding throughout the valley due to urban development have added to problems of pollution, sedimentation, erosion and salinity in the Wash, the Las Vegas Bay, Lake Mead and the Colorado River. These problems are of interest to local, state and federal agencies such as the Nevada Department of Environmental Protection, the U.S. Bureau of Reclamation, the U.S. Environmental Protection Agency, the Colorado River Commission and the U.S. Soil Conservation District.

The disposal of trash in the Wash area can also be considered an infrastructural use. "Desert dumping" is a common problem on public land, or land considered "vacant". In this case, use of the land for trash disposal could be interpreted to mean not that the dumper values the land for this purpose, but that he or she does not value the land for other purposes. The desert is seen by some people as waste land, not providing any aesthetic or ecological value.

Recreation

The open spaces and wildlands of the west and of the Vegas Valley have always provided a playground for its residents. The Wash, surrounded by scenic geologic formations including the colorful Rainbow Gardens and Frenchman Mountain, has drawn people from the beginning of settlement in the valley until present. In the early 1900s, families took camping trips through the Wash via horse and wagon (Nevada Archeological Survey 1975). The Wash continued to draw visitors on horseback or on foot. The loose sandy soils and open spaces are popular with off-road enthusiasts driving four-wheel drive vehicles and riding motorbikes. Groups or clubs such as Boy and Girl Scouts take advantage of the open land for outdoor games.

The desire to explore these wild spaces has not changed, but the character of the land has changed. When the wastewater discharge in the 1950s expanded the wetlands, it created a unique riparian ecosystem that also expanded the recreational uses and values of the wash. The wetlands offered food, water and respite for migratory birds. In turn, bird watching and hunting gained popularity in the wash. In 1974, the Nevada Department of Fish and Game reported the Las Vegas Wash was a popular spot for recreational hunting for doves, waterfowl, quail and cottontail. Hunters in this area put in 26% of the hunting days to harvest 7% of the County's total for all species. "In other words, this area is popular regardless of hunter success rate" (BCC 1974: Appendix 8). The City of Henderson opened a Bird Viewing Preserve in 1998 as part of a public and private joint venture to use their wastewater facilities for wildlife habitat. The value of the Las Vegas Wash for recreation use is supported by the actions of Clark County Parks and Recreation in development of the Wetlands Park with bird viewing areas, interpretive trails and horseback riding trails.

Education

The use of the wash for education has really taken hold in the last decade. When the Las Vegas Valley Water District began work on the pollution problems related to the Wash in the

early 1970s, they were “frustrated in their attempts to find data on the flora and fauna” in the Las Vegas Wash because little information was available (LVVWD 1971). The creation of a unique wetland ecosystem in the valley and its subsequent deterioration have afforded valley residents of all ages an opportunity to learn about water, wildlife, geology and archeology. The Las Vegas Wash Coordination Committee (LVWCC), in a public outreach effort, has developed media releases, informative brochures and educational programs about the Wash that are directed at elementary, middle and high school participants. The LVWCC offers environmental education programs and tours for groups, clubs and community leaders as well.

Managing the Wash

Management issues vary with the type of resource use. For sustenance uses, ensuring the quantity and quality of the mesquite forest, water, or land that provides food, fuel, water or shelter is key. For infrastructure, moving water through the system quickly is the goal. For recreation and education, users want to maintain the wetland ecosystem, stop erosion, and minimize pollution. Some management objectives are incompatible. Moving water through the channel quickly increases erosion, which straightens and deepens the channel, moving water through the channel more quickly. But a deeper and swifter channel lowers the water table, drains the land, kills wetland vegetation, makes soil more unstable, and more prone to erosion.

Management issues are further complicated, therefore, by the multiple uses of the Wash, together with the interconnections in and around the Wash ecosystem. These multiple uses and interconnections lead to indirect subtractability, in which one person’s use of a given resource may not affect another person’s potential use of the same resource (direct subtractability), but it decreases the potential use of a different resource. One discharger’s use of the Wash as a conduit for wastewater may not affect another discharger’s use, but it has the potential to erode the channel and alter the wetland ecosystem used by others. On the other hand, the use of one resource can also enhance a different resource in the system. Initial increases in discharge, for example, increased soil moisture and wetland vegetation. Wetland vegetation, though it slows the progress of water through the Wash, can reduce nutrient loads and remove sediment from the water, increasing its quality at the Wash outlet.

As the characteristics of the physical system and the desired uses of the system have evolved, approaches to managing the Wash have evolved as well. Several entities have jurisdiction over the Wash (USBR and CCPR 1999). Some of these are land owners and some are non-owner government agencies. The land is primarily owned by federal agencies, the State of Nevada, and Clark County. A small amount is privately held, most of which is in the Wash floodplain and not open for development. Wash management issues today include optimizing the volume of wastewater discharge, preventing pollution from wastewater discharge, controlling salinity contributed to Lake Mead by the Las Vegas Wash, controlling erosion, maintaining wildlife habitat, minimizing flood damage in the Valley and the Wash, providing recreational opportunities, and increasing public education about the Wash. These resource concerns involve

management agencies that include the Clark County Sanitation District, Regional Flood Control District, and Department of Parks and Recreation; U.S. Bureau of Reclamation, and U.S. Fish and Wildlife Service, among others.

Until the 1960s and 1970s, management of the Wash was mostly a matter of benign neglect. The primary uses of the Wash between the mid-1950s and 1970s were for wastewater discharge and individualized recreation such as hiking and hunting. In 1973, a Sewage and Wastewater Advisory Committee (SWAC) was organized to advise the Clark County Board of Commissioners on wastewater issues (LVWCC 1999). It was composed of technical employees from municipalities or districts actively engaged in operation or management of sewer or water facilities in Clark County. At around the same time, Las Vegas citizens began noticing that the extent of wetland vegetation was beginning to decline in the Wash as erosion worsened and the headcut began to advance up the channel. Support was building for the idea of restoring wetlands in the Wash. In 1973, the Las Vegas Wash Development Advisory Committee organized to make recommendations to the Board of County Commissioners on how to restore wetlands to the Wash, composed of citizens and representatives from different agencies (LVWCC 1999). It had no decision-making authority, however. The Advisory Committee recommended a Task Force be formed, but this was not formed until 1986. The Board of County Commissioners apparently recognized the importance of the possible future development of the Las Vegas Wash as a park or bird sanctuary (BCC 1974), but was not quick to act on the Committee's recommendations.

In the late 1970s, the emphasis on managing water quality in the Wash grew (US EPA 1971, LVVWD 1971, LVVWD 1972). The Section 208 Water Quality Management Plan issued in 1977-78 contained reports dealing with coordination of Las Vegas Wash development with wastewater treatment plants, salinity control, recreation, flood control (LVWCC 1999). In 1978, the Board of County Commissioners transferred water quality planning from the Clark County Sanitation District to the Clark County Department of Comprehensive Planning, reflecting a broadened view of the uses and value of Wash resources. In 1979, a Water Quality Study Board and Las Vegas Valley Water Quality Program were formed.

The idea of creating a wetland park in the Wash, though promoted in the late1960s and early 1970s, and recommended in 1974 and 1986 by advisory committees. A resource survey of the Wash was done in 1976 to evaluate the potential for a 5,000 acre recreation and education area (CCCD 1976), but no further action was taken until nearly 20 years later. In 1992, a $13.2 million bond was approved by Clark County voters to support the creation of the wetland park, and in 1995 the Clark County Board of Commissioners approved the idea to make the Las Vegas Wash a wetland park. But in 1996, students organizing clean-up days in the Wash to promote the idea of the Wash as a park got no response to their invitations from any county officials. County interest in making the park a reality was lukewarm at first. Efforts to create a wetlands park continued to be promoted by the Department of Parks and Recreation, however, and finally momentum built. As Bruce Sillitoe, Principal Planner with the Department of Parks and Recreation, explained, "it took one agency putting some energy into the idea and getting things

going. Now that it looks like it is really going to happen, the other agencies have jumped on board." Public support has also grown. One hundred and fifty people participated in community Wash clean-up efforts in 1996. In 1997, the first year the annual effort was sponsored by the Southern Nevada Water Authority, 500 people participated. By 1998, 1000 people turned out; in 1999, 1500 people, and by the Fourth Annual Las Vegas Wash Clean-up, over 2000 participated. Public response to the event was so great that the sponsors stopped advertising it two weeks before the event because they were afraid they would have more volunteers than they could handle.

At the same time, efforts to coordinate the activities of diverse entities involved with water quality management in the Las Vegas Valley led to the creation of the Las Vegas Wash Coordination Committee, a team of representatives from 28 local, state, and federal stakeholder groups with different responsibilities, authorities, and activities in or around the Wash (LVWCC 1999). The LVWCC was the result of two public processes begun in 1997. First, The Nevada Department of Environmental Protection initiated the Lake Mead Water Quality Forum in February 1997 to address water quality issues in Lake Mead and the Las Vegas Wash. Second, the Southern Nevada Water Authority (SNWA) established a Water Quality Citizens Advisory Committee (WQCAC) in July 1997. Both groups recommended development of a comprehensive plan for managing the Las Vegas Wash. The SNWA contributed resources in the form of a project coordination team for administration and technical support. The LVWCC completed a Comprehensive Adaptive Management Plan which recommends establishment of a single oversight body to manage the wash. They followed the lead of the Southern Nevada Strategic Planning Authority, "which recommended that regional issues in southern Nevada be addressed locally and that local agencies employ mechanisms such as interlocal agreements, when necessary, to organize themselves for such activities" (LVWCC 1999:9).

Summary

Human uses of the Wash ecosystem have evolved in type and magnitude over the last 150 years. Desired resources have shifted among the channel, water, vegetation, wildlife and land. Potential uses have changed as the characteristics of the ecosystem have changed; desired uses have changed as the characteristics of the social system, and perceptions and valuation of Wash resources by people in the Valley and regional context have changed. From the mid-1800s to about 1900, the Wash was a sink for discharge of wastewater (infrastructural), a source of food and fuelwood (sustenance), and a place for recreation. From 1900 to about 1970, infrastructural use of the Wash grew as population grew and wastewater discharge increased. Sustenance uses and recreation decreased. The primary management interest was maximizing discharge to the Wash. As the riparian area developed its wetland characteristics, the desirability of maintaining this new type of ecosystem increased. In the 1970s, recreational uses began to increase, but so did concerns about Wash contributions to pollution in Lake Mead. Increased flow through the Wash generated concerns that the Wash was contributing too much salinity and sediment to Lake Mead. When increased flow led to increased erosion and threatened to destroy the wetland area,

concerned citizens began to lobby for measures to protect the wetlands. Management issues broadened to include water quality management and wetland protection along with wastewater discharge. In the 1980s, wastewater treatment plant technology was improved to address point-source water quality concerns. Erosion worsened, however, as the growing Valley population generated more wastewater, and the extent of wetland vegetation decreased. In the 1990s, erosion in the channel continued to worsen, but continued urban growth added pressure to address the range of resource use issues. As the population of Las Vegas has grown, more people visit the Wash for off-road vehicle use and other forms of recreation. The dumping of trash in the Wash area has increased and, as urban growth encroaches on the Wash, become more visible and undesirable to people who live near as well as visit the Wash. Growing water demand has increased pressure for maximizing return flow through the Wash. Increasing urbanization in the Valley increases the value of open space and parkland. The focus of formal and informal management institutions has shifted again, this time to encompass the whole set of resources uses. Most recently, the Las Vegas Wash Coordination Committee has been raising public awareness about the Wash by showing a video about the Wash on local television and running public service announcements. The Las Vegas Wash clean-ups not only increase public awareness of Wash resources, but also set a high public value on keeping/making it clean, growing a public tradition of respect for the Wash.

Discussion

Examining the Las Vegas Wash as a commons highlights the importance of taking a systems viewpoint. The changes over time in the characteristics, use and management of Wash resources illustrate that ecosystem changes in the Wash are linked to the larger ecological and social system around it and that the characteristics, perception, valuation, use, and management of Wash resources are dynamically linked. As Botkin (1990), Zimmerer and Young (1998) and others argue, nonequilibrium conditions are the norm in ecosystems, particularly those in which human activity plays a major role. Rather than trying to explain why a given human-environment system is not in equilibrium, these authors argue we should instead expect and be trying to understand change. To understand change in this commons system, we need to look at it holistically and dynamically.

A systems perspective includes both a whole-system view of the components and connections in a system, and analysis of the way interactions play out in response to change. Thinking of a commons as a dynamic system emphasizes the processes of evolution in resource use and resource management, rather than the state of the system at a given time. A systems view of a commons seeks to identify the static structure of the system: what resources are available in what form, who has access to the resources, the structure of that access (when, how much, how it is enforced), and the connections between resource use and resource condition. This is not enough, however. The static view assumes several things, namely: that the desired use of the resources remains the same (that people don't change their minds about what is desirable), that there is no feedback between the resource condition and the desired resource use

(that users will still want to use as much of it even as the quality or availability decreases), that no resource substitution is possible (as one resource degrades another cannot be found to fill its function), that use of one resource does not affect the condition of other resources in the system. As the history of the Las Vegas Wash ecosystem and other cases show, however, these assumptions simplify the world too much. Resources (either commodities or waste processing capabilities) do not exist in isolation. They are parts of ecosystems in which changes in one component in turn change other components. And changes in the set of resources available feed back to affect the way resources users perceive, value, and desire to use resources in the set. Those perceptions and valuations are dependent not only on the biophysical characteristics of the resource ecosystem, but also on the social system in which the resource users are located.

Commons Degradation is not Inevitable

Taking a systems view strengthens the case made by many (e.g. Feeny et al. 1990, Berkes and Folke 1998, Burger and Gochfeld 1998) that degradation of common pool resources is not inevitable as Hardin (1968) argued. Hardin posits each user of resources held in common will use the maximum they can because the individual receives the full benefit from his use, but distributes the cost, or consequence, among all other shareholders. As this scenario plays out, we see the resource user continuing to value the resource at a high level, and using the resource at the maximum desired rate, while the availability or the quality of the resource degrades. Feeny et al. (1990) and Burger and Gochfeld (1998) challenge Hardin's thesis as overly simplistic and deterministic. In particular, they criticize Hardin's view of resource users as individuals seeking to maximize only their own utility. A more realistic view, say Feeny et al. (1990) and Burger and Gochfeld (1998) is to consider the resource users as a group, a collective that can respond to changes in the resource and regulate individual resource use behavior, that is, to account for feedback from resource condition to user behavior. With this feedback, the commons management system can evolve as the resource condition changes, and complete destruction – tragedy – is not inevitable. As Baden and Noonan (1998:xvi) observe, management mechanisms are dynamic:

> "As commons become imperiled, overexploited, or otherwise degraded, entrepreneurs and managers see opportunities to implement creative conservation rules. ... Political entrepreneurs frequently promulgate laws and regulations in response to the onset of the tragedy. ... Also, business entrepreneurs, community leaders, and other private parties create value for themselves, their community, and society at large by inventing new practices in the commons."

Such feedback processes have been at work in the evolution of approaches to managing the Las Vegas Wash. Ecosystem changes in the Wash motivated different agencies with different resource interests to pay attention to the management of Wash resources over time. This could have led to conflict among resource users and resource degradation, but instead led to a cooperative management process that recognizes connections among different resource uses. As the Las Vegas Wash Coordination Committee says:

"The Wash has proven to be a complex, valuable system that requires a combination of solutions to preserve its value into the future. ... As a collaborative management process, the Las Vegas Wash Coordination Committee has succeeded in bringing together a diverse group of technical experts and decision-makers, and uniting them in a common cause: the stabilization and enhancement of Las Vegas Wash" (LVWCC 1999).

The development of the LVWCC is simply the latest cycle in the long-term cycling of a feedback loop linking perception, valuation, use, environmental change, and evolution of management mechanisms. This feedback, illustrated in Figure 2 below, shows that as the actual conditions of the environment change, that is, as resource users perceive the availability or

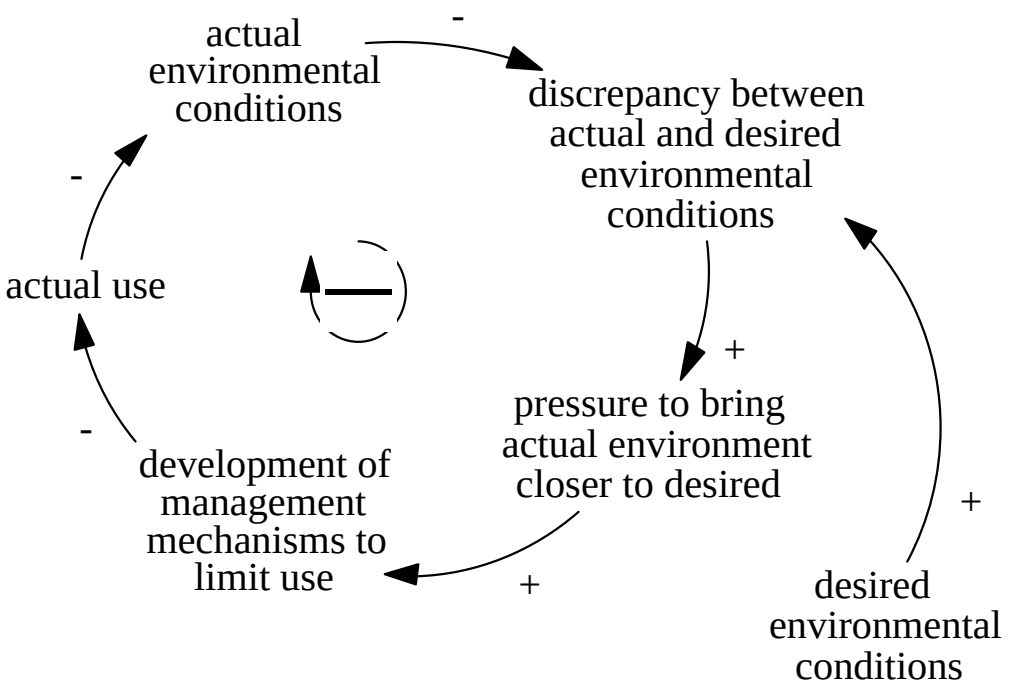

Figure 2. Feedback from Environmental Degradation to Development of Management Mechanisms to Address Degradation. ("+" indicates a posited change in the same direction; "-" indicates a change in the opposite direction. E.g., the model proposes that as actual use increases, environmental conditions related to that use would decrease/ degrade, or, conversely, as actual use decreases, related environmental conditions would improve.)

quality of the resource they value degrading relative to the conditions they desire, pressure to act to do something about the degradation increases. This pressure leads to the development of management strategies to control use, use of the resource decreases, and eventually the condition of the resource improves. This is a balancing, or negative feedback loop, in which a change in one direction in one of the variables in the loop, such as a decrease, or degradation in the condition of the resource, feeds back around the loop to counteract the degradation. Multiple users and indirect subtractability in the Las Vegas Wash ecosystem strengthen this feedback by increasing pressure to change management mechanisms.

System Dynamics: Understanding the Evolution of Resource Use and Management

The feedback loop described above is incomplete. It depicts desired environmental conditions as unchanging. Because changes in perception, valuation, and desired resource use are threaded throughout the Las Vegas Wash story, the feedback structure has to be expanded to account for them. Figure 3 proposes a more accurate representation of the system. This representation builds on Loop 2, described in Figure 2, adding a feedback from changes in the actual conditions of the environment to potential resource uses (Loop 1), and proposing that such changes in potential use contribute to changes in desired resource use and, therefore, desired environmental conditions. The characteristics of the environment bound the potential uses that can be made of it. Before wastewater discharge led to the development of a wetland ecosystem in the Wash, for example, preserving the wetland was not a possible resource use. Actual environmental conditions are a function of both resource use and larger biophysical processes including climatic regime, topography and geology. Actual uses, what people actually do with the resources, are a function of what they want to do and the constraints on use imposed by the management regime. Desired uses are a function of both the potential uses and the values and incentives for resource use that are shaped by the social context of resource users. Cultural norms, economic markets, and political realities are aspects of the social context affecting motivating resource use desires. Others include the demographic pressures affecting valuation of Las Vegas Wash resources. Desired resource uses require certain environmental conditions, against which users assess the adequacy of actual environmental conditions. This assessment then feeds back to the development or adjustment of management mechanisms (Loop 2). One change that appears to be emerging in Las Vegas is an increase in public valuation of open space such as the Wash. As urban area, population and population density increase in Las Vegas more pubic attention is turning to the issue of preserving and creating open space in the Valley. This may account for the increase in turnout for events like the Wash clean-up, which has been growing at a rate far greater than the population has been growing.

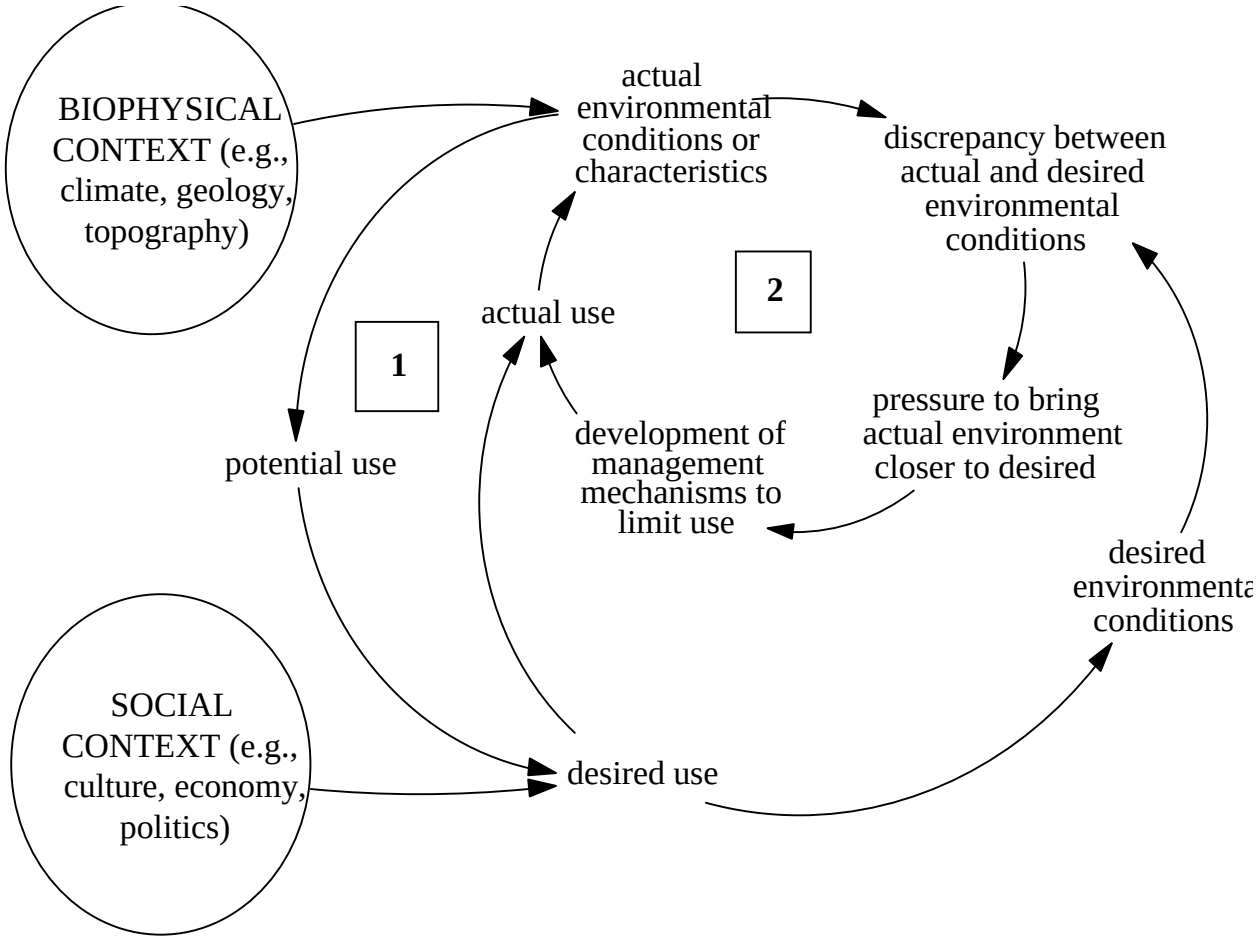

Figure 3. Influence diagram of relationship between environmental conditions, resource use and management mechanisms.

Conclusion

The Las Vegas Wash system and the resources now valued in it are both biophysically and socially constructed, and must be understood in their larger, dynamic context. The wetland would not exist if the city did not exist. Gans (1986) calls the Wash an "accidental environment." As Morris (1983:9) points out:

> "The Las Vegas Wash is somewhat of an anomaly for purposes of classification as a wetland. Because principal inflows of water are provided by a stream or river, these wetlands would be described as "riverine". However, because dominant vegetation and required hydrologic conditions are foreign to the immediate locale, these wetlands also

qualify as being classified as "artificial". The Las Vegas Wash lies somewhere between classification of either a natural or artificial wetland. Historically, riparian or wetland conditions have existed within the drainage of Las Vegas Valley but it was not until the discharge of wastewater from a growing population that the present cattail wetland developed. On the other hand, this discharge of wastewater and subsequent wetland development has not been managed or purposeful."

Further, the wetland would not be threatened with destruction by erosion if the city was not growing as it is. The open space of the wetland would not be now valued as a park if the city were not growing, and thus making open space at last a perceived good in short supply. Protective management mechanisms would not be so strongly supported if the wetland were not perceived as a scarce resource.

The Wash is a system in transition, a system that has been in transition for perhaps all of its history. Examining the changes in its biophysical characteristics over time together with the changes in the way the Wash environment has been viewed, valued, and used also force a re-examination of the concept of commons degradation. Throughout the course of the Wash's history, the characteristics of the Wash environment have changed in response to biophysical and human activity in and around the Wash. While some of these changes reduced the availability and desirability of Wash resources, other changes created new environmental conditions that then became new resources. To understand the evolution of the resources, environmental conditions, and mechanisms for managing this commons requires seeing the tight links between the Wash ecosystem and the Valley social system both as they are today and as they have changed through history.

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