# Getting Our Feet Wet:
# Water Management at Mt. Laguna in Cleveland National Forest

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## ABSTRACT

Integrated regional water management (IRWM) helps us to comprehend the ecological, political, and economic complexities of broad watershed regions in California. In this case study, stakeholder theory served as the framework for an assessment of water management at Mt. Laguna, CA, a rural community on the outskirts of San Diego, CA. After identifying stakeholders, I conducted interviews and surveys to gauge perspectives on water management at Mt. Laguna and to develop categories speaking to the major concerns. In addition, I used a document review to help understand the policy framework surrounding water management in this community. I created four categories: water scarcity and access, fire protection, environmental protection and recreation, and costs of infrastructure and water quality testing. A complex, fractured aquifer system led to disagreements about water scarcity in the region, which combined with rule of capture water law to illustrate how unbridled water extraction could lead to stresses and conflict. I identified fire protection as a top priority, demanding extensive water resources in the wake of the Cedar Fire of 2003. The U.S. Forest Service continues to balance conservation and recreational goals through environmental impact assessments. Finally, costs of infrastructure and water quality testing produced great strain on rural communities, particularly those less affluent than Mt. Laguna. To mitigate these conflicts, it is important that stakeholders develop an understanding of each other's priorities and the ecological realities of the surrounding region, and participate in collaborative management. Low Impact Development measures to conserve water could also help alleviate conflicts.

## KEYWORDS

Groundwater, stakeholder theory, Integrated Regional Water Management (IRWM), water scarcity, fire management

## INTRODUCTION

"Yes, as every one knows, meditation and water are wedded for ever."
–Herman Melville, *Moby Dick*

California possesses a wide array of water problems including allocation of limited resources, water rights conflicts, and regulation of water quality (California Department of Water Resources 2009a). The state, containing more than half of the population of the American West (US Census Bureau 2010), has historically adopted a variety of strategies to adapt to intermittent water scarcity resulting from the region's semi-arid climate. Various research texts have documented social strategies and policy changes used to confront these new challenges (Folk-Williams et al. 1985, Worster 1992, Reisner 1993, Hundley 2001). For example, the "Water Wars" between Los Angeles and Owens Valley show the potential for governance failures as powerful economic interests led to disproportionate gains for urban interests over rural ones (Libecap 2005). In addition, the case of Mono Lake illustrates how Los Angeles' quest for water had unforeseen environmental impacts with increasing salinity and a receding surface level of the lake (Wiens et al. 1993, Rogers and Dreiss 1995). Research on these seminal conflicts highlights how humanity's vital demand for water requires engagement with the widespread needs of communities and institutions establishing themselves in such a dry region. It also demands a thorough assessment of environmental alterations that could shift habitat dynamics and capacity to meet environmental needs. As such, water demand cases shaped policy and institutional structure, indicating that resolving water demand issues requires a policy approach that addresses social needs.

Even as growth in the American West attempted to adapt to the trials of water management, water concerns did not evaporate; complex water issues remain at the forefront of California's environmental policy concerns today (California Department of Water Resources 2009a). To help shed light on issues with water policy in California, researchers often assess various water systems individually. However, Integrated Regional Water Management (IRWM) offers a more comprehensive approach to analyzing these systems by observing how they are connected and how water users impact watersheds and regions as a whole, ecologically, economically, and politically (California State Water Resources Control Board 2008, California

Department of Water Resources 2009a, California Department of Water Resources 2012). For example, academics conducted many studies to determine how to deal with multiple conflicting biological and consumption interests in the Sacramento-San Joaquin Delta (Lund et al. 2007, Lund et al. 2008, Michael 2008). Also, a recent study discussing the Mexicali Aquifer between California and Mexico highlighted the need for regional cooperation within the framework of international groundwater collaboration (Hathaway 2011). Thus, each case presents different challenges that demand further research, particularly in less understood areas, regarding which distinct climatic, social, and political factors govern a particular area. Moreover, large-scale water policy concerns remain connected to the problems of divergent interests within specific regions.

Stakeholder theory, a theory of organizational management which aims to address the values and interests of different groups, often acts as an effective framework for analysis of complex natural resource management issues (Freeman 1984). Researchers used stakeholder theory to explore a unifying negotiation framework, outlining the six columns for how decision-making in policy is influenced: culture, institutions, agency, actor orientation and experience, cognition, and incentives (Daniels et al. 2012). Such a viewpoint attempts to take into account various factors that shape both individual players and the greater context of stakeholder negotiation. Of particular importance are broader aspects such as the structure and regulations in place, and the values and power of the various stakeholders. While individual motivators and personal psychology all factor into the analysis, one can generally bundle these into the broader framework of the culture of each stakeholder group. Stakeholder analysis may also assess societal structure and perspectives surrounding various environmental topics including public engagement in urban forestry (Pickett et al. 1997, Janse and Konijnendijk 2007), views on fire management in fire-prone areas (Cvetkovich and Winter 2008), and perceptions of environmental services from water resources (Mendoza et al. 2006). By breaking down the views of stakeholders and analyzing them individually, it can become clearer how they fit into the greater conversation of resource management. With this in mind, I collected information about communities facing potential water problems in California through interviews and surveys. I interpret this data by categorizing various stakeholder interests to begin to shed light on how to address larger scale problems that possess similar circumstances.

Mt. Laguna, California, a rural community on the outskirts of San Diego and contained within Cleveland National Forest, offers a viable opportunity for a case study of a small water system facing issues with water scarcity and tasked with allocating these resources to diverse interests. The community also faces risk of fire and exorbitant costs of water supply infrastructure replacement. The stakeholder theory framework reveals the interplay between the existing stakeholders, allowing for an analysis of how such communities work towards meeting varying objectives on water issues. Stakeholders in the region include the United States Forest Service, local firefighters, the Mt. Laguna Fire Safe Council, various small-scale water suppliers, the San Diego County Department of Environmental Health, and other water-using businesses and recreation interests (Pers Comm John Stump, Sierra Club). With different stakeholders dependent on the groundwater resources of the region, careful management becomes vital. The mountain lacks potable surface water sources and local stakeholders express uncertainty about the extent to which users share resources through a common underground aquifer (Pers Comm Department of Environmental Health representative). Forest Service research has confirmed that the geological structure of the aquifer makes it difficult to predict how much individual water extraction practices impact the supply as a whole (Pers Comm United States Forest Service representative). Intriguingly, many residents choose to ignore this ambiguity as little institutional regulation of private water obtainment and use exists (Pers Comm Department of Environmental Health representative). Various concerns involving water arise from the stakeholders. I summarize these concerns as: water scarcity and access, fire protection, environmental and recreation, and costs of infrastructure and water quality testing. However, very little is understood about how these concerns fit into the broader framework of the stakeholder process at Mt. Laguna, what conflicts emerge during this process, and what insights this might have into effective rural water policy.

My main research question is: *To what degree are stakeholders' interests regarding water resource governance being met in Mt. Laguna through policy implementation and community interactions?* To answer this I pose these sub-questions: What are the stakeholders' views and how do they interact with each other? What are the key policies in place that affect Mt. Laguna water management? How does the existing framework for decision-making impact the capacity of stakeholders to meet their goals? Answering these questions requires me to engage with stakeholders (through interviews, surveys, community meetings, etc.) to determine

their perspectives and reveal competing interests such as water consumption and water scarcity. I hypothesize that problems may arise in the form of unbalanced power dynamics between stakeholders. In addition, I believe that conflict may be rooted in existing policies and practices governing equitable allocation of water and regulation of water quality. Therefore, I trace these back to their origins to determine what changes could be made in management practices to help meet stakeholder interests. Overall, I aim to identify any gaps between stakeholder views and governance that inhibit satisfaction of water management interests at Mt. Laguna such as fair access to water.

**Study system background**

Mt. Laguna, a sparsely populated rural community located within Cleveland National Forest, is situated within San Diego County, but about 87 kilometers away from downtown San Diego. In 2010, Mt. Laguna was home to only 57 people, the majority of whom are over 50 years-old (US Census Bureau 2010).

President Theodore Roosevelt established Cleveland National Forest in 1908 as a means to protect the watershed system as an important water source for San Diego (Sakarias 1975). However, in the late 1940s, San Diego began to obtain more of its water from the Colorado River. Over time, this larger water source became a more integral part of San Diego's water supply and the importance of the Cleveland National Forest watershed system dwindled (Sakarias 1975). As such, the emphasis from the U.S. Forest Service turned away watershed protection and instead fixated on recreational purposes in addition to fire and pollution prevention (Sakarias 1975). In general, the U.S. Forest Service now focuses more on the preservation of recreational sightseeing interests, while attempting to balance environmental and local consumption needs (USDA Forest Service 2005). As a part of Cleveland National Forest, Mt. Laguna consequently manages its water with these goals in mind. It is particularly important to recognize these goals in light of the fact that while the area is sparsely populated, it does receive many visitors who stay in campsites or in cabins, which involves considerable water usage.

# METHODS

## Study population

In 2010, the majority of Mt. Laguna's 57 residents were over 50 years-old (US Census Bureau 2010). Contained in the zip code 91948, Mt. Laguna had a median income of $53,160 in 2010 (SANDAG 2012). However, the area also plays host to many visitors who come to camp and hike. Visitors and residents constitute the greater community of water users in the region, representing diverse interests of different backgrounds. My methods addressed these divergent interests through three different data collection techniques to address three key areas: interviews to reveal active stakeholder perspectives, surveys to reveal passive stakeholder perspectives, and a review of documents to better understand institutional/policy-based structures. Ultimately, I hoped to reveal the relationship between these three areas.

## Data collection

Data collection consisted of three methods: interviews, surveys, and a review of textual documents. This allowed me to triangulate my methods, combining analysis of independent sources to determine the degree of stakeholder satisfaction at Mt. Laguna.

### *Semi-structured interviews*

I conducted semi-structured interviews with water management stakeholders at Mt. Laguna. This approach allowed me to determine how key players view the issues surrounding water management and how interests are prioritized. I interviewed 8 influential figures in water management at Mt. Laguna from various community and government groups – those I identified as key stakeholders. Labeling these individuals as active stakeholders, I designated that these players possessed a direct influence over how water is managed at Mt. Laguna.

Assumptions about the uses of water at Mt. Laguna guided my selection of these stakeholders as I hypothesized that water providers, government groups, and fire protection groups would be of certain importance in the region. I also received assistance from those with

greater knowledge of the players in the area. I compiled an initial list of stakeholder groups to be included with help from my mentor from the Sierra Club, John Stump. This developed into a list of potential interviewees after meeting with some representatives from this list, who recommended further contacts. I reached out to the representatives via e-mail or telephone to schedule interviews. Participants included representatives from the Mt. Laguna Fire Safe Council, Volunteer Fire Department, major water suppliers for the region (e.g. Mt. Laguna Improvement Association, a rancher[*], and Mt. Laguna Observatory), and government agencies (e.g. United States Forest Service, Bureau of Land Management, and San Diego County Department of Environmental Health). This variety of interview subjects provided a diverse set of opinions about water management.

Interviews lasted from 20-60 minutes, conducted either in person or over the phone, depending on the subject's availability. These interviews took on an in-depth interview structure, during which I asked questions to reveal opinions about how water should be used and how this differs with the enactment of water policy (Mack et al. 2005).

Sample interview questions included:

- *What are the major issues regarding water quality and allocation facing the rural community of Mt. Laguna?*
- *How do you perceive the fairness of the allocation of water resources to various interests?*
- *What are the priorities of your group?*
- *What would you personally like to see change and what are your goals for bringing about these changes?*
- *How do you prioritize your interests in comparison to others? In other words, how would you rank the various water needs at Mt. Laguna?*
- *What would you say are the current barriers to change?*

This process involved note-taking based on verbal responses and digital recording to be referred to for later analysis. By revealing the contrasting perspectives of different groups who influence the management of water at Mt. Laguna, I identified conflict areas and connected

[*] Name of interviewee from rancher group withheld to preserve anonymity

stakeholder opinions with existing legal and institutional structures. (See Appendix A for interview questionnaire)

*Surveys*

I conducted 50 surveys on individuals familiar with the Mt. Laguna area (primarily those staying in cabins serviced by the Mt. Laguna Improvement Association) to include perspectives of all people affected by water policies. These people I deemed passive stakeholders, as they did not have direct influence over how water was managed, but were still affected by management decisions. The study population of water users in Mt. Laguna consists of widespread residents that are not easily accessible. As such, distributing surveys to everyone at their homes would have been difficult and likely not very feasible. I used snowball sampling (Goodman 1961), making use of acquaintances in Mt. Laguna to distribute the surveys to temporary residents. Data collected from surveys included demographic information, prioritization of water uses, and opinions about who had the most influence over water management. With a mixture of open-ended (i.e. write-in) responses, ranking questions, and categorical questions, the survey allowed me to draw conclusions about public concerns for water management at Mt. Laguna that may not have been addressed or emphasized by the main stakeholders. Surveys were anonymous to maintain respondent confidentiality. Surveys also afforded me an opportunity to draw subsidiary conclusions about how water issues correlate with demographic groups (e.g. income and frequency of visits/residency). (See Appendix B for survey instrument)

*Textual documents*

Finally, I collected text-based documents such as government documents, forms, meeting minutes, maps, articles, etc. to shed light on the important policies governing water management at Mt. Laguna. This allowed me to triangulate my methods across stakeholder opinion, public opinion, and institutional reality. My interview subjects provided some of these documents, which shed light on the realities of institutional regulation (through government forms) and the logistical decisions that community groups must make (through meeting minutes, maps, etc.). I then viewed this information in the context of the opinions collected through my interviews and

surveys. In addition, I searched government websites such as the United States Forest Service Pacific Southwest Research Station and California Department of Water Resources to find local, state, and national policies affecting water management at Mt. Laguna. Advice from my mentor and information from a representative at the Forest Service informed these searches. Using these online searches and connections with the various stakeholders at Mt. Laguna, I accumulated these documents for text-based analysis and comparison with survey and interview results.

## Data Analysis

### *Semi-structured interviews*

With the semi-structured interviews, I aimed to collect information about the perspectives of key stakeholders at Mt. Laguna on water management issues. This included prioritization of interests about how water should be used and regulated. Stakeholder theory (Freeman 1984), the management theory designed to observe and address the values of various groups, acted as the framework for my analysis, as I shed light on the interplay of various water management interests in order to assess stakeholder satisfaction and the effectiveness of existing policy. I extracted data from interview transcripts using an informal coding schema, highlighting trends of opinions and placing them into categories that speak to the main water management concerns. Hence, I used questionnaires to gather information, which I then parsed into relevant categories based on similar interests, priorities, and word choice. This allowed me to contrast the stakeholder groups and find potential similarities between them.

### *Surveys*

I used the same coding schema to determine public opinions regarding important water management issues at Mt. Laguna. Information from write-in responses and “check all that apply” questions offered insight into the respondent’s perspectives on water management, which I then coded into the existing categories. This also allowed survey respondents to share additional information that the close-ended questions may not have addressed. The surveys additionally demanded some statistical analysis in order to derive conclusions about how

demographics may be related to water management viewpoints and decisions. I identified correlations that exist between the ranking of priorities for water usages and personal behavior or characteristics such as frequency of visit using ANOVA tests. Specifically, I used ANOVA tests to determine how the categorical variable, frequency of visit, informed the continuous variable, average ranking of water usage prioritization. I plotted the categorical variable on the x-axis against the average rank of each of the six options for the two continuous variable questions on the y-axis. Through these means, I revealed the relationship between each demographic indicator (i.e., the categorical variable) and each attitude (i.e., the continuous variable) being ranked. I also used chi-squared tests to assess relationships between categorical variables such as expressed interest in various water issues in each coding category and frequency of visit. I conducted statistical tests with the assistance of R: A language and environment for statistical computing and R Commander (Fox et al. 2009, R Development Core Team 2009).

*Textual documents*

Again, I used the coding schema to analyze textual documents to group information about policies and their implementation into my analysis categories. This allowed me to compare policy with stakeholder perspectives about how water should be managed and draw connections between stakeholders and policy. By coding information from the three media, I could better compare the information and perspectives present in each of the major areas investigated in my study. Thus, textual analysis of these documents using coding revealed how institutional boundaries and existing policies matched or conflicted with the opinions and actions of active and passive stakeholders at Mt. Laguna.

## RESULTS

I broke down the results into four major coding categories: fire protection, water scarcity and access, costs of infrastructure and water quality testing, and environmental protection and recreation. These thematic categories represent the key interests and concerns of stakeholders at Mt. Laguna with regard to water management. The results of interviews, surveys, and document analysis are all included and grouped into these categories (Table 1).

**Table 1. Summary of stakeholder perspectives on four major thematic categories.**

| Stakeholder Group | Water Scarcity and Access | Fire Protection | Environmental Protection and Recreation | Costs of Infrastructure and Water Quality Testing |
|---|---|---|---|---|
| Mt. Laguna Improvement Association (MLIA) | -Responsible mgmt. of water (good relationship w/ USFS)<br>-Concern over rancher trucking and selling water | -Correspondence with MLFSC for fire protection<br>-Community cohesion to address fire issues | -Cooperate with Forest Service in conducting environmental impact assessments for new piping systems and infrastructure replacement | -Concerns about costs of infrastructure replacement (pipe and tanks)<br>-Concerns about excessive water tests that can be costly for some |
| Mt. Laguna Fire Safe Council (MLFSC) | -No concerns with scarcity | -High prioritization of fire safety<br>-Lobbied for emergency generators and reflective numbers for cabins | -Compliance with environmental reports for development projects<br>-Fire protection (fuel reduction) and habitat protection go hand in hand<br>-Protect watershed | -No problems with water quality |
| Mt. Laguna Volunteer Fire Department (MLVFD) | -Concerns about accessibility for fire protection after losing supply from Forest Service, but receiving water from rancher | -High prioritization of fire safety<br>-Had water supply restricted by Forest Service due to water intensive training sessions (with fire hoses) | -Frustration with USFS regulation with regard to excessive environmental protection | -More focused on fire; concerns about water quality not expressed<br>-Some issues of costs involved with purchasing water from rancher and digging own well |
| San Diego County Department of Environmental Health (SD DEH) | -Uncertainty about common aquifer at Mt. Laguna (i.e. unsure how “shared” and scarce water supply is) | -Warnings for rolling blackouts and risk of fire without power to submersible pumps (pushing for contingency plans in community) | -Tests preserve water quality, which allows for safer water provisions to recreational users | -Important for water tests to be done regularly to avoid naturally occurring contaminants (e.g. iron)<br>-Shares concern of costs, but tries to work with suppliers |
| Bureau of Land Management (BLM) | -No concerns with water scarcity | -Peripheral correspondence with Forest Service given risk of fire spreading public lands beyond Mt. Laguna | -USFS needs to to determine right balance of regulation without infringing on rights | -Acknowledges that infrastructure replacement can become very costly for private citizens and Forest Service |

| Stakeholder Group | Water Scarcity and Access | Fire Protection | Environmental Protection and Recreation | Costs of Infrastructure and Water Quality Testing |
|---|---|---|---|---|
| United States Forest Service (USFS) | -Concerns about slow aquifer recharge and excessive groundwater extraction<br>-Prioritizes improving water supply capacity | -Fire as serious problem<br>-Keeps water reserves exclusively for firefighting<br>-USFS has own fire department<br>-Recognizes that fire event would likely deplete water reserves at Mt. Laguna in 24-48 hours (need to import after that) | -Environmental impact reports when putting in new piping systems involving cost-benefit analysis of development and impact on habitat | -Water piping is old and needs replacing; much of it dates back to Civilian Conservation Corps era<br>-Difficulties acquiring funding as it is necessary to compete for grants both regionally (California wide) and nationally<br>-Concerns about iron contamination of wells |
| Mt. Laguna Observatory, owned by San Diego State University | -Generally believes that water is plentiful<br>-Wary of water supply running low if Mt. Laguna were overdeveloped<br>-Only groundwater; used to be runoff collection from rooftops, but no longer | -Facility initially designed with fire suppression system<br>-Cedar Fire came within 2.5 miles of the observatory, which heightened concern for fire protection; led to installation of user-friendly pump system<br>-Correspondence with MLFSC | -No concerns expressed | -No need to conduct water quality testing because don't provide water to public<br>-"Personal decision" whether employees drink tap water<br>-Water not for firefighting cleaned with ozone filter<br>-Funding dependent on maintaining relevance in eyes of the university (SDSU) |
| Rancher* | -No concerns about water scarcity due to lack of large development at Mt. Laguna<br>-Sells water as customers emerge; insists that it is not in large enough quantities to make impact on water table<br>-Spring operator's license from Food and Drug Branch of California Health Department | -Awareness of fire, though not focused on water resources for fighting fires<br>-Manage land as best as possible to mitigate fire risk<br>-Frustration with regulations from CA Air Resources Board restricting prescribed burns | -Prioritizes continued management of private land for raising cattle – maintaining generational links<br>-Sees regulations as detrimental to adequate management of private property | -No mention of water quality problems<br>-Focused on success of business (along with alternative sources of income such as moving firewood and selling water) to maintain control of private land for ranching |

* Name of interviewee from rancher group withheld to preserve anonymity

**Water scarcity and access**

Respondents were uncertain about how much water was available at Mt. Laguna and how it should be allocated, and many identified this as a key fire safety concern. For instance, the United States Forest Service (USFS) had concerns about excessive Volunteer Fire Department (MLVFD) water use and restricted their supply (see Appendix C for table of initialisms and acronyms). A representative from the Mt. Laguna Improvement Association (MLIA) indicated that the rancher was extracting groundwater and selling it. He also expressed uncertainty with regard to the potential existence of a common aquifer across Mt. Laguna – that is, whether the groundwater supply was shared by the whole Mt. Laguna community and whether the rancher may be significantly impacting water availability for others in the area. The representative from the San Diego County Department of Environmental Health (SD DEH) echoed MLIA's concerns and feelings of uncertainty with regard to water availability, declaring that a hydrogeologist needed to investigate the area to determine the plentitude of the groundwater supply. The representative from the Mt. Laguna Observatory and the representative from the USFS both revealed that the aquifer system contained fractured rock layers that made water availability and connectedness difficult to gauge. The USFS representative prioritized water supply capacity as a major concern at Mt. Laguna, focusing on groundwater recharge and more above ground storage.

As the representative from SD DEH indicated, and research into policy confirmed, California water policy ordains that private property cannot be regulated or restricted from accessing groundwater. Thus, the rancher's actions – drilling his own private well and receiving unrestricted access to water – are perfectly legal. The representative for the rancher (my key informant for this stakeholder group) indicated that he sells his water under a spring operator's license issued by the Food and Drug Branch of the California Department of Public Health. He sells to consumers as they become available and declared that he has not extracted water in any significant amount to impact source capacity. Specifically, the rancher has been selling water to the MLVFD because their USFS supply was cut off.

Of all survey respondents, 50% expressed interest in issues of water scarcity. 34% of survey respondents expressed interest in achieving better resident water access and 16% expressed interest in achieving better access for visitors. Survey respondents indicated their interest for these categories through a single "check all that apply" question that asked "What

local water issues interest you?" Using a chi-squared test, I determined that no significant relationship existed ($X^2$ (1, N = 50) = 1.087, $p > 0.05$) between the interest in water scarcity and the frequency of survey respondent visits to Mt. Laguna (Table 2).

**Table 2. Chi-squared test for frequency of visit and interest in water scarcity issues.**

| Frequency of visit | Interest in water scarcity | No interest in water scarcity |
|---|---|---|
| Visit "more than 5 times a year" or "resident" | 23 | 23 |
| Visit less than 5 times a year | 2 | 2 |

## Fire protection

Fire protection is a prominent issue amongst stakeholders at Mt. Laguna due to the dry climate, potentially scarce water supply, and conflict over water allocation. A representative from the MLVFD focused on fire protection as a high priority. Even if it clashed with water conservation, she viewed fire as a serious threat that should take precedence – as evidenced from past experiences with wildfires at Mt. Laguna. The representative from the Mt. Laguna Fire Safe Council (MLFSC) declared that water was not a problem at Mt. Laguna, be it in terms of quality or quantity. She also emphasized the importance of fire protection, and insisted that water was not a limiting factor for the community.

The USFS representative expressed that fire was a serious problem and explained that the USFS has its own fire department to help fight fires, and they keep water reserves exclusively for firefighting. However, the representative also indicated that a fire event would likely deplete water reserves at Mt. Laguna in 24-48 hours and the firefighting effort would require water importing after that.

The Bureau of Land Management (BLM) representative also professed in the interview that their organization has an important stake in this issue as fires are not strictly localized problems and can spread to the public lands surrounding Mt. Laguna. My interview subject representing BLM explained that they have "peripheral correspondence" with the USFS and other government agencies to ensure fire security on all fronts. In other words, they do not have direct jurisdiction over the region of Mt. Laguna, but will communicate with the USFS and take

measures necessary to assist if fire threatens the surrounding public lands they are responsible for.

Even the San Diego County Department of Environmental Health (SD DEH) has fire protection under its purview. A member of the Small Drinking Water Systems program was tasked with informing the public about the high possibility of "rolling blackouts" during the hot summer months that could lead to electricity loss and moreover, losses of power to submersible pump systems. The Department of Environmental Health sent out letters advising the local community to create contingency plans for such outages. A primary concern of the SD DEH representative is the water quality risk of power loss (see Cost of infrastructure and water quality testing), but loss of power during a fire could also have serious risks associated with it. The Department's focus is to ensure that communities are prepared to face these challenges; for instance, having adequate alternative water storage in case of power loss or having back-up generators. The MLFSC worked to install emergency generators in the case of a fire. In addition, while a fire suppression system existed at the Mt. Laguna Observatory since its inception in the 1960s, after a major wildfire, the observatory installed a more user-friendly pump switch to make their fire suppression system more accessible and efficient to fire fighters.

Interviews also revealed that tension emerged when the USFS stopped the MLVFD from accessing their water supply because of the MLVFD's water intensive training sessions for new members (e.g. learning to use powerful hoses). As such, they have opted to dig their own well and have been receiving truckloads of water from the rancher. The representative for the rancher declared that the community was lucky to have the MLVFD and questioned what the community would do without its capacity to fight fires, but explained that the transaction was conducted strictly for economic purposes to help their business. The rancher representative also expressed frustration with burdensome regulations that make fire protection a difficult task to pursue even on private property. He aimed to mitigate fire risk by keeping his land grazed during his cattle operations, but he argued that California Air Resources Board regulations prevent controlled burns as a fire prevention tactic.

In addition, 84% of survey respondents indicated an interest in conserving water for fire protection. Using a chi-squared test, I found a non-significant relationship ($X^2$ (1, N = 50) = 0.8282, $p > 0.05$) between interest in fire protection and frequency of visits to Mt. Laguna (Table 3).

**Table 3. Chi-squared test for frequency of visit and interest in fire protection.**

| Frequency of visit | Interest in fire protection | No interest in fire protection |
|---|---|---|
| Visit "more than 5 times a year" or "resident" | 38 | 8 |
| Visit less than 5 times a year | 4 | 0 |

Also, an ANOVA test (Fig. 1) showed no significant difference in the prioritization of water conservation for firefighting against other water use interests between more frequent visitors/residents and less frequent visitors ($F(1, 48) = 0.739$, $p = 0.394$).

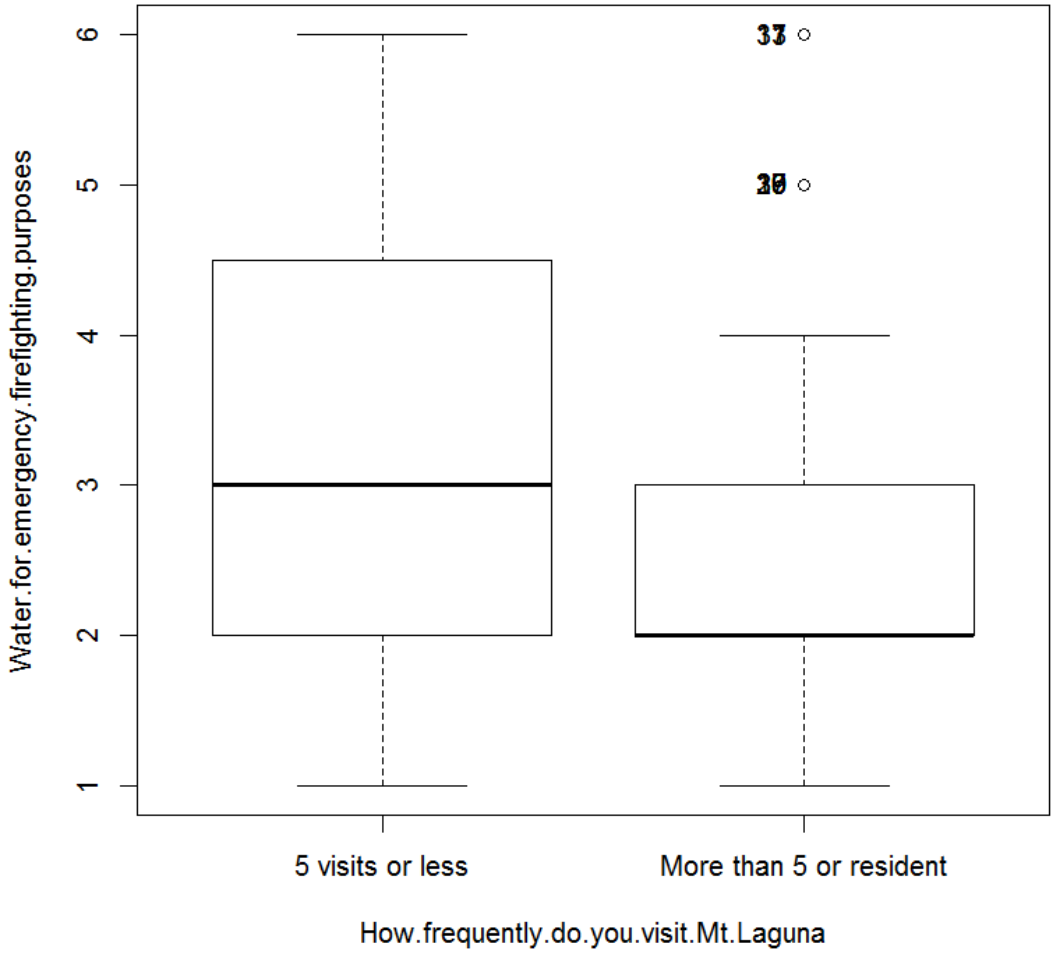


**Fig. 1.** F**requency of visit to Mt. Laguna versus prioritization of water conservation for emergency firefighting.**

The 50 survey respondents indicated their prioritization of water conservation for firefighting by ranking this against five other options. A rank of 1 was the highest prioritization, whereas a rank of 6 was the lowest. Each option for how water should be used could be given one number to designate its ranking against the other choices. Other choices included providing clean water to residents, providing clean water to visitors, conserving water to protect the natural habitats in the Mt. Laguna area, maintaining recreational sites, and providing water for economic reasons (cattle, farms, mining jobs, etc.).

**Environmental protection and recreation**

United States Forest Service policy places high priorities on resource conservation and offering recreational opportunities to the public at Mt. Laguna as the community is located under the organization's purview in Cleveland National Forest. As indicated in my introduction, there was a shift in USFS policy in Cleveland National Forest away from watershed protection to recreation. Nonetheless, the MLVFD representative expressed frustration with USFS biologists for their excessive environmental regulations in trying to protect sensitive species. The rancher also professed that regulations make it difficult to adequately manage private property. For example, he stated that clearing shrubs and managing waterways near private lands to avoid erosion and loss of property is forbidden by the Corps of Engineers.

The representative from the USFS maintained that under the National Environmental Policy Act (NEPA) they must perform cost benefit analyses of various development projects in the forest through environmental impact assessments. This, in theory, weighs environmental conservation needs against human sustenance and recreational needs. Other stakeholders, such as the MLFSC and the MLIA demonstrated understanding of these needs and have cooperated with the USFS to maintain a healthy relationship with the surrounding environment. The MLFSC additionally maintains that their goal of fire protection doubly serves as a measure to protect sensitive habitat from the threat of fire, expressing a desire to conserve and respect the natural world around them while pursuing their own goals of fire safety.

Of survey respondents, 56% indicated an interest in "conserving water for ecosystem stability." A chi-squared test to assess whether a relationship existed between interest in

"conserving water for ecosystem stability" and the frequency of survey respondent visits to Mt. Laguna (Table 4) resulted in a non-significant relationship, $X^2$ (1, N = 50) = 0.637, $p > 0.05$.

**Table 4. Chi-squared test for frequency of visit and interest in "conserving water for ecosystem stability."**

| Frequency of visit | Interest in conservation | No interest in conservation |
|---|---|---|
| Visit "more than 5 times a year" or "resident" | 25 | 21 |
| Visit less than 5 times a year | 3 | 1 |

## Costs of infrastructure and water quality testing

Some interview subjects indicated that major concerns included the costs of infrastructure replacement and water quality tests. While it was seen as very important to provide clean water in a reliable manner, the costs of routine upkeep of the water supply system can become a financial burden. Policy dictates that systems with fewer than 200 connections are regulated by San Diego County Department of Environmental Health Small Drinking Water Systems division (otherwise regulated by the State). The frequency of tests depends on sub-category classifications of water systems (i.e. how many people are serviced and how often they are present).

The MLIA representative professed that water testing becomes expensive and can be excessive at times (e.g. testing for nuclear radiation). However, the SD DEH explained that it was very important to test for naturally occurring contaminants (including some naturally occurring radiation, but also E. coli, iron, etc.). Nonetheless, a test conducted on January 31, 2012 for the MLIA water system came up absent – that is, no contaminants exceeded acceptable standard levels.

Additionally, while the SD DEH oversees the water system, the MLIA maintain responsibility for upkeep of the water delivery system to their residents. The community organization has to maintain a steady and reliable supply of water for those living in their network of cabins and therefore must keep their infrastructure from corroding and leaking. The MLIA representative reported that he had to replace a half mile of pipe each summer due to regular corrosion, amounting to approximately $15,000 in costs with labor included. In addition,

the need to replace or otherwise improve a degraded water tank represented a vital concern for the MLIA. To replace the tank would cost an estimated $1 million, very expensive for the MLIA, according to the representative. Thus, the organization started looking into other options such as placing a smaller, new tank inside the larger one or relining the old tank; both options were described as not as expensive, though still costly.

In addition, meeting minutes from August 4, 2012 indicate that the MLIA was looking to purchase a nearby smaller water system in order to acquire an extra well to supply water. The system produced 13.8 gallons of water per minute and had a permit fee of $2,500 per year. The asking price was $300,000, but the MLIA wished to investigate the upkeep and water quality of the system before negotiating further, though a deal is expected by the end of 2013.

To help account for the high costs of managing the water system for MLIA, the organization held dinners and other fundraisers. Their fundraiser report as of August 2, 2012 indicated that they had acquired over $26,000 through these means since 2002. They also helped raise money for the MLFSC to assist them in their fire protection goals.

The Department of Environmental Health, Bureau of Land Management, and United States Forest Service all recognized the burdensome costs of infrastructure replacement. In particular, the USFS representative explained that their water system is very old as much of it was installed back in the Civilian Conservation Corps era of President Roosevelt's New Deal (with projects occurring in the 1930s and 40s). She also declared that Mt. Laguna struggles to obtain funding to address natural corrosion because the USFS must request money several fiscal years in advance and compete for it, both regionally (California-wide), and nationally.

In a "check all that apply" survey, 90% of survey respondents expressed interest in water quality for private owners. 60% of survey respondents indicated that they thought that water quality was fine at Mt. Laguna and nothing needed additional needed to be done to address quality issues. 56% of survey respondents expressed interest in the monthly costs for water. 56% of survey respondents expressed interest in water quality for visitors.

A chi-squared test to assess whether a relationship existed between the proposed interest in monthly costs for water and the frequency of survey respondent visits to Mt. Laguna (Table 5) resulted in a non-significant relationship ($X^2$ (1, N = 50) = 0.0635, $p > 0.05$).

**Table 5. Chi-squared test for frequency of visit and interest in monthly water costs.**

| Frequency of visit | Interest in water costs | No interest in water costs |
|---|---|---|
| Visit "more than 5 times a year" or "resident" | 26 | 20 |
| Visit less than 5 times a year | 2 | 2 |

## DISCUSSION

My study identified a variety of factors (water scarcity, fire protection, environmental conservation, and costs of infrastructure and water quality testing) that influence stakeholder decisions for water management at Mt. Laguna – all of which should be considered in use and regulation of water resources in the community. Water scarcity in the region is complex, and it is advisable to discourage wasteful water use and to research the aquifer supply to generate greater awareness of the aquifer's fractured nature and the difficulties this poses for resource management. Fire protection is perhaps the most serious issue at Mt. Laguna, as fire is potentially life-threatening. Fire protection drew the most effective management response, as it was consistently viewed as important by active stakeholders (interview respondents). Through effective collaboration, community members satisfied various stakeholder interests despite persistent tensions over water access. Environmental protection has experienced some (arguably) wasteful and problematic management policies. For instance, preservationist practices and counter-productive regulations may be cause for concern, but the United States Forest Service (USFS) continues to seek effective ways to balance ecological values and human needs to more broadly satisfy stakeholder interests. Finally, while the community's relatively high income precluded the financial burdens of infrastructure maintenance and water quality testing from threatening livelihoods, these costs point to important lessons for collaborative management. I define collaborative management as an organizational strategy in which stakeholder groups strategize with one another, share responsibilities, and form compromises to ease tensions and satisfy multiple interests (Koontz 2006, Davies and White 2012). By pooling financial and human resources from various community and governmental groups and working together to alleviate the costs associated with providing safe water, many active stakeholders can benefit.

At Mt. Laguna, ongoing management practices and interactions between stakeholders effectively satisfied multiple interests in certain areas regarding water quality and allocation; however, lessons from successful forms of collaboration could be carried into areas of tension and conflict both here and in other rural communities (Grimble and Wellard 1997, Chipofya et al. 2009). Overall, study results highlight the need for understanding the various interests and ecological realities impacting a community and the importance of strong communication between stakeholders in any realm of resource management. Compromise and collective strategizing to develop solutions can help produce benefits that satisfy multiple stakeholders' interests.

**Water scarcity and access**

While uncertainty concerning long-term aquifer water supply prevailed, there was varying levels of concern over water scarcity at Mt. Laguna. Most active stakeholders did not express concern, but other evidence points to potential conflict over access to water. Access to water was central to the conflict between the Volunteer Fire Department (MLVFD) and the USFS. I define access as a stakeholder organization's ability to use water for their goals (e.g. firefighter training). As such, some tension existed between the MLVFD and USFS, as the two stakeholder groups differed in opinion over the severity of water scarcity. When the MLVFD was forbidden from using certain amounts of the USFS reservoir supply, the MLVFD representative felt that fire protection interests were betrayed, as they could no longer access water for trainings. This also presented financial hardship for MLVFD as they turned to purchasing water from the rancher. In the meantime, MLVFD decided to dig their own well to acquire a more secure water supply – again, with financial costs and time delays. Clearly, opportunities exist for greater communication and collaboration between MLVFD and USFS, which could bring about effective compromise and help to satisfy the USFS's water conservation goals, while not jeopardizing the MLVFD's access to water. This highlights the importance of observing trade-offs involving equitable access to resources in order to reach conflict resolution (Grimble and Wellard 1997).

With regard to surveys, the lack of significance in the chi-squared test (Table 2) implied that views of water scarcity were not impacted by time spent at Mt. Laguna. Thus, most

temporary residents believed that water scarcity was not a serious issue in the region. However, this potentially fostered belief or was based on the assumption that groundwater could be extracted without limitation, which may not have been warranted. Regardless of public and stakeholder perceptions that Mt. Laguna has a plentiful groundwater supply, some uncertainty about the water table still existed due to complex geological circumstances associated with Mt. Laguna's underground aquifer (Pers Comm USFS representative). The USFS representative also indicated that Forest Service environmental engineers prioritize improving groundwater recharge and supply capacity, suggesting that the groundwater supply may not be as reliable as some perceive. Further research on aquifer geology would help stakeholders understand the plentitude and shared capacity of water sources across California (California Department of Water Resources 2009b).

The representatives from the San Diego County Department of Environmental Health (SD DEH) and the Mt. Laguna Improvement Association (MLIA) indicated uncertainty about shared groundwater sources and quantities; this should be cause for concern because unexpectedly low water supplies at Mt. Laguna could lead to water disputes in the future. If water supply runs low or water becomes economically difficult to acquire, this would inflict severe costs on the community and put many at risk – consequences which could have been avoided with adequate planning. Rule of capture water law has led to excessive use of groundwater resources in Texas and cooperative management should be implemented to avoid overuse in private rural communities (Wagner and Kreuter 2004). In Mt. Laguna, rule of capture water law enabled the rancher to legally extract and sell water. The rancher representative declared that he did not extract a significant amount of water and only sold it as demand emerged. Nonetheless, this activity should be regulated if water supply is found to be connected to Mt. Laguna and in limited supply, in order to secure water for direct consumption instead of economic gain. If water managers could prove that water shortages exist at Mt. Laguna, it is likely that the community would be more accepting of policies restricting water use (Gilbertson et al. 2011). Such policies would reflect a guiding philosophy that values life or necessity over economic benefit. That is, while it is important to respect the right to extract water for beneficial purposes, some benefits should be valued over others, particularly when it means more immediate risk to sustenance.

**Fire protection**

With Mt. Laguna's dry climate, fire protection is a natural priority for many in the community. With some key fire protection stakeholders acknowledging that they did not believe that water management is a problem, they seemed to believe that more resources (water and financial) could be dedicated to fire protection. This placed greater emphasis on the risk of fire and the need to dedicate more water resources to fighting fires, as they did not believe it impacted other objectives such as access to drinking water. Passive stakeholders, without direct influence over how water should be used, also seemed to consider fire protection a seminal issue at Mt. Laguna. As demonstrated by the chi-squared test (Table 3), it appeared that frequency of visit to Mt. Laguna did not have a clear impact on interest in fire protection issues. It is likely that previous fire incidents in the region had an impact on the perceptions of this issue (e.g. the 2003 Cedar Fire). Knowledge of and experience with large wildfires such as the infamous Cedar Fire of 2003 makes concerns about fire all the more poignant. The testimony from the MLVFD representative indicated how immediate and life threatening the Cedar Fire was. Also, while the Mt. Laguna Observatory has long possessed a fire suppression system at its facility (indicating a general awareness of fire issues at Mt. Laguna dating back to the creation of the facility in the 1960s), the Cedar Fire drove the director to install a more user-friendly pump system to make it more efficient for fire fighters in the event of dangerous fire event. It can thereby be understood how the perception of plentiful water and the immediacy of fire threats allowed fire protection to take precedence over other water topics at Mt. Laguna.

As a result of this prioritization, active stakeholders focused on awareness and preparedness (back-up generators, reflective numbers on houses to be more visible at night or in case of fire, etc.) in the community as opposed to water issues. These stakeholders generally did not consider water a limiting factor. Therefore, many logically concluded that fire protection interests should get as much water as necessary to fight fires and train personnel. However, this mentality could be problematic if based upon a faulty premise of plentiful resources. Due to the uncertainty of supply, there is potential risk of depleting water sources and reducing access to water for drinking, economic purposes, etc. As demonstrated by the tension between USFS and MLVFD, USFS perceived water scarcity as an issue. They felt a need to conserve water to ensure reliable supply to visitors in campsites. Also, the USFS had its own fire department,

which may further justify their decision to prevent the MLVFD from using up too many resources. However, there is potential that their human resources for fire protection could be stretched thin without volunteer assistance, and that limitations via jurisdiction and other bureaucratic problems could hinder USFS's capacity to deal with fire protection.

The tension brought on by this situation indicates how the autonomy of an organization can shape negative attitudes regarding government institutions, but that these situations should be tempered via collaborative management (Davies and White 2012). Measures could be taken to estimate water needs for fire protection in order to balance appropriate quotas with firefighting and training needs (Torvi et al. 2001, Hansen 2012). Other fire management practices could be observed from an ecological perspective, such as vegetation management and fostering growth in less water intensive or fire prone plants, to ensure that water resources are not squandered (van Wilgen 2009). In fact, the rancher's concerns about regulations preventing him from adequately taking fire precautions on his own land are worth noting. If prescribed burns could be utilized to reduce fire risk without a huge detriment to air quality, then perhaps the California Air Resources Board should loosen their regulations slightly to allow for this. General vegetation management practices should be investigated to determine the best fire risk mitigation strategies without intensive water use or other risks to health or sustenance.

Despite minor tensions, there appeared to be strong cooperation regarding fire protection issues across stakeholder groups. In particular, MLIA, the Mt. Laguna Fire Safe Council (MLFSC), SD DEH, and USFS all played integral roles in heightening awareness, raising funds, and taking preparatory measures to ensure community safety in the event of a fire. Also, the teamwork of government organizations with peripheral jurisdiction such as USFS and Bureau of Land Management (BLM) – while not a major portion of the study – seemed to represent a good example of effective collaboration across stakeholder groups to secure adequate resources to satisfy common interests. Successful fire protection efforts with the MLFSC, MLIA, the MLVFD, and SD DEH showcased how collaborative management can satisfy multiple major stakeholder interests through sharing of values and resources while improving the general safety of the community as a whole.

Finally, the rancher's provision of water to the MLVFD demonstrated how cooperation can alleviate the stresses of less than ideal circumstances. The MLVFD and the rancher were able to satisfy their interests, acquiring water to fight fires and providing water in exchange for

economic benefit, respectfully, by doing business together. The rancher recognized the threat of fire on a personal level and indicated that the Mt. Laguna community was lucky to have the MLVFD, but the economic gains of having MLVFD as a customer served as the primary motivation for the transaction from which both parties benefited. The MLVFD did not find the situation desirable, as they preferred not to have to pay to have the water trucked to them, but they expressed much gratitude to the rancher for his assistance in helping them reach their goals of acquiring a decent water supply for fire protection and firefighter training. Thus, the interactions between MLVFD and the rancher mitigated the conflict regarding MLVFD's loss of access to water.

**Environmental protection and recreation**

Attitudes towards conservation for environmental purposes seemed favorable overall, but could turn sour when stakeholders perceived regulators as overstepping their bounds. Both passive and active stakeholders acknowledged the importance of environmental conservation. Such interests seemed compatible with USFS recreation goals, in that protecting the environment allows people to enjoy it more without doing it harm. USFS research of environmental and recreational compatibility has shown that striking a balance between the two goals is possible (Cerveny et al. 2011). The collaboration between USFS and community groups like MLFSC and MLIA demonstrates the potential for an efficient balance between environmental conservation and other goals such as water access and fire protection. Thus, the Mt. Laguna community illustrates how various stakeholder interests can indeed be met while conserving the natural habitat.

The main conflicts over environmental protection and recreation came from the MLVFD representative's belief that USFS biologists were too oriented toward preservation and were wasting money protecting species, as well as the rancher's concern about various regulations infringing upon the capacity of private land owners to adequately manage their lands. The resources dedicated to protecting species would likely detract from the capacity of the USFS to engage with and adequately address other goals such as fire protection, as limited funds would be allocated towards environmental protection. Though this concern did not directly relate to water issues, it is important to maintain a conversation between stakeholders about how government

money is best spent to avoid waste and to serve the needs of the community while not neglecting the environment (Davies and White 2012). As for the rancher's concerns, some valid points may have been made, but further research is required to determine the impacts of various regulations (see Limitations & future directions section).

**Costs of infrastructure and water quality testing**

Even though water providers at Mt. Laguna demonstrated resolve in dealing with the costs of providing water, specifically for quality testing and infrastructure upkeep, these costs could become very expensive and be even more problematic in less affluent communities. Such communities could face problems with contaminated water or faulty infrastructure and lack the monetary means to address these issues (California Department of Water Resources 2009a). Retired and wealthy people with holiday homes in the area comprised many of Mt. Laguna's residents. Thus, it may not have been an ideal study site to represent water management in rural areas, which generally tend to be poorer communities with fewer financial resources (Willburn 2009). However, my study did indicate that there are burdensome costs associated with tests and infrastructure replacement that require significant resources or organized action within a community to address them. Due to the need for an effective delivery system for water resources, infrastructure carried great importance, but also acted as the main source of the costs. Thankfully, MLIA mitigated these costs with fundraisers and donations. However, such monumental costs of several thousands of dollars could be problematic in less wealthy rural areas, even with the possibility of community fundraisers and similar events to address monetary concerns. Grants may also be a possibility, as a grant was provided to acquire funds for backup generators for fire protection. To help save money, regional water management can be implemented to help conserve water, avoiding the costs of overuse that may not otherwise be obvious (Varela-Ortega et al. 2011).

Concerns regarding financial resource availability to address these pressing costs could be mitigated through stronger communication between stakeholders with resources (e.g. government) and stakeholders without. The Department of Environmental Health showed great dedication to working with rural water providers to explain the importance of tests and find ways around costs (e.g. education programs for rural communities, communication and reaching deals

in extenuating circumstances, etc.). By keeping an open dialogue between regulators and those struggling to pay for infrastructure maintenance, deals can be reached to help water providers find ways to afford necessary upgrades. Also, the Small Drinking Water Systems branch of SD DEH was effective at classifying regulation needs based on size of the system and how active it was throughout the year – that is, larger systems with more frequent use warranted stricter regulation. While complaints of overregulation by MLIA are somewhat justified given their mostly clean records, SD DEH tries to reward such cases with less frequent tests. Nonetheless, there may be room for more communication perhaps making the justifications for standards more broadly known, but also hearing comments from stakeholders in the community who feel that they are paying too much.

The San Diego County Department of Environmental Health and the USFS expressed concerns about iron contamination of wells at Mt. Laguna, highlighting the need for regular water tests to ensure good quality and to avoid corrosion of pipes. Specifically, the USFS representative indicated that one of the well sources has high in iron, resulting from a water-bearing fracture above the groundwater table and cascading water falling into the well bore. The oxygen introduced from the surface into the groundwater allows iron bacteria to thrive and produces many inherent plumbing problems. The importance of water quality tests becomes clear here as a means of preventing infrastructure costs from growing even more than they would from regular wear and tear. This represents an example of communication to the general public to express the need for water quality testing.

Overall, public perceptions, as reflected in survey findings, valued clean water, particularly for private residents, but these views did not appear to be impacted by frequency of visit. Interest in water costs were seemingly not linked to residency or visit frequency either. However, these survey findings were likely related to the survey sample not adequately including infrequent visitors. Moreover, communicating concerns and stakeholders' interests could help alleviate tension between public health and economic interests.

**Limitations & future directions**

Given the nature of my research as a specific case study, possibilities for inference for water management more broadly experience some limitations. My findings cannot be applied

directly to other regions as Mt. Laguna reflects specific circumstances regarding the financial resources available and the stakeholders involved. However, with the lessons of Integrated Water Management in mind, additional studies could be conducted to draw connections between my study site and other regions experiencing similar climate, proneness to fire, and risk of water shortage. In particular, issues with water scarcity and access and infrastructure costs dominate much of California and hold potential for more research and for brainstorming solutions (California Department of Water Resources 2009a).

Other areas for further research include the role of fire management in the containment of invasive species and the potential water losses that could be incurred by non-native plants that use more water (van Wilgen 2009). The rancher also provided information about the detrimental effects of regulations on proper land management to mitigate fire risk that could be further investigated. In response to the rancher's criticisms of regulations as detrimental land management from an environmental and personal livelihood perspective, further research could be done to indicate what policies and regulations inflict more harm than good. For instance, the rancher's worry about the Corps of Engineers forbidding clearing of shrubbery in waterways (and leading to erosion and loss of private property) could be investigated to determine how to loosen these regulations or effectively implement new ones with fewer detrimental effects.

Limits to this study also included uncertainty about the views of individuals in relation to stakeholder groups as a whole. I identified key individuals to represent the active stakeholder groups at Mt. Laguna, but it is possible that these people provided biased information about their group's goals and accomplishments (Leach 2002). A more thorough and comprehensive breakdown of the players in each stakeholder group could provide a clearer and more accurate picture of the water management situation at Mt. Laguna. In addition, in using stakeholder management as the framework for my study, the research could have benefited from a more in-depth economic breakdown of the costs involved with pursuing each stakeholder's interests. Producing a cost-benefit analysis and complex models could yield useful data on how to balance priorities (Grimble and Wellard 1997, Varela-Ortega et al. 2011).

Moreover, I am unsure if the Mt. Laguna community is conducive to a collaborative management approach to dealing with multiple interests for water use. A study (Koontz and Johnson 2004) shows how circumstances of a community can make stakeholder collaboration infeasible or counterproductive. As such, it may not be best to always assume that the

collaborative approach is best for all scenarios. One needs to determine what collaboration methods are practicable between the identified stakeholders and those who could not be included in this study.

Currently, the survey sample is lopsided as a result of snowball sampling through the MLIA representative. Subjects were mainly white people above the age of 40 who have higher level incomes and spend a lot of time at Mt. Laguna as a holiday home. I used this method to ease access to residents with greater familiarity of water management in the region, but my study may have benefited from perspectives of low-income residents of Mt. Laguna.

**Broader implications**

This study demonstrates the diverse perspectives different groups and people can have regarding natural resources. While this case study does not directly scale up or provide clear insight into how we should manage water at all levels, it does provide important lessons for the kinds of issues water management presents and how all stakeholders' values should be respected in management decisions and in shaping environmental policy (Barr and Gilg 2007). Other studies support notions of identifying stakeholders and institutions and their interests and balancing these interests against each other to move toward more effective water management (McDaniels 1999, Grigg 2005, Molden et al. 2007, Chipofya et al. 2009). Water is an essential and versatile ingredient for human sustenance (for consumptive, fire protection, and environmental purposes) and needs to be shared between others in order to satisfy these interests. My study also sheds light on the clear importance of obtaining a greater understanding of the abundance and accessibility of groundwater resources in California and finding effective ways to allocate and conserve resources through Integrated Regional Water Management (Bouwer 2000, California Department of Water Resources 2009b). This case study of Mt. Laguna relates to the emerging importance of observing water management on a watershed scale, as San Diego and the State of California as a whole broaden the scope of water management to see how decisions impact other separate districts (San Diego Regional Water Quality Control Board 2001, California State Water Resources Control Board 2008). Rural areas with water shortage problems tend to demonstrate more water conservation behavior and be more accepting of conservation policies than urban areas with more water available (Gilbertson et al. 2011). If Mt.

Laguna, and other communities like it, can be shown to have water shortages then the community's stakeholders may be more likely to accept regulations from other agencies. Low Impact Development strategies such as rain gardens, soil amendments, permeable pavements, and infiltration devices could offer potential solutions to problems of water scarcity in rural regions (Weinstein et al. 2003). Notably, rainwater capture methods used to be implemented at the Mt. Laguna Observatory, but were removed once they dug a well and become more dependent on groundwater. These rainwater capture installments (e.g. gutters on rooftops) could be reintroduced at the observatory, on other buildings in the community, and abroad in other communities wherever water scarcity proves to be problematic.

In regions prone to fire, managers should be aware that water to thwart fire becomes a top priority for many, as fire is a direct threat to public safety. Water conserved for fire is likely very important in other fire-prone areas with similar climate and vegetation as Mt. Laguna (Cote et al. 1991, Grant and Drysdale 1997, Bouwer 2000, Berrahmouni 2008). Water supplies should be documented to avoid conflict between competing interests who want to use water for different purposes. While rule of capture should not be wholly replaced with restrictions on water use, it is worth looking at which regions may require some governmental management to prevent overuse of water resources in rural areas. Government agencies should continue to work with rural water providers to keep costs of testing water reasonable while avoiding serious problems such as iron contamination (damaging piping) and health risks like E. coli. Hence, a balance may be struck between public health and water provision, and financial burden. While this is not imminently a serious issue at Mt. Laguna, it is still troubling on a widespread scale because other communities have greater financial stress and California is faced with a massive widespread problem of costly infrastructure replacement (California Department of Water Resources 2009a). Conservation goals should be communicated with other stakeholders to avoid conflict where possible. With these ideas and goals in mind, water management and resource management in general could begin to improve on a widespread level.

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## APPENDIX A: Interview Questionnaire

How long have you lived here? Been visiting here, working here, etc.?

What are the major issues regarding water quality and allocation facing the rural community of Mt. Laguna? (Equity and social justice? Environmental? Property rights?)

How have these problems emerged? When did they first rise to prominence? How have they changed over time?

Which groups have the most influence over how water is managed and distributed? (government, community groups, residents, visitors, industry, etc.)

How do you perceive the fairness of the allocation of water resources to various interests? (e.g. Volunteer Fire Department losing access to Forest Service reservoir)

How do stakeholder politics play into policy-making with regard to allocation of water resources at Mt. Laguna?

How are water issues at Mt. Laguna tied to water policy at local, state, and national levels? What are your opinions about these policies?

Where is there room for improvement? Policy formation? Implementation? Public engagement? Capacity for enforcement?

What are the priorities of your group? What would you personally like to see change and what are your goals for bringing about these changes?

How do you prioritize your interests in comparison to others? In other words, how would you rank the various water needs at Mt. Laguna? (fire protection, residential consumption, visitor and camper consumption, agriculture and industry, habitat quality, etc.)

Which groups or individuals do you feel have been most beneficial in working towards progressive change in water issues at Mt. Laguna?

What would you say are the current barriers to change?

Is there anything working well with respect to current water policies?

Anything else you would like to add?

## APPENDIX B: Survey Instrument

*This survey is being conducted by William Mumby (wmumby@berkeley.edu, (858)-208-9903), an Environmental Sciences major at UC Berkeley. It is part of a senior thesis research project on rural water policy in the Mt. Laguna area in the Cleveland National Forest. Please fill in as much information as possible. The survey should take about 10-15 minutes. All information will remain anonymous and confidential. Thank you!*

1. Where do you live? (city and state or zip code) _____

2. How frequently do you visit Mt. Laguna? (select one)
   - ☐ First visit
   - ☐ Once a year or less
   - ☐ 2-5 times a year
   - ☐ More than 5 times a year
   - ☐ I live here

3. Purpose of visit to Mt. Laguna (check all that apply):
   - ☐ Nature viewing
   - ☐ Hiking
   - ☐ Camping
   - ☐ I live here/retirement
   - ☐ Work (please specify) _____
   - ☐ Other (please specify) _____
   - ☐ Horseback riding
   - ☐ Hunting

4. Please rank the importance of these issues to you from 1 to 6 (1 being most important)
   - ☐ Providing safe water at pumping stations for visitors
   - ☐ Providing safe water to residents of Mt. Laguna
   - ☐ Having water available for emergency firefighting purposes
   - ☐ Conserving water to protect the natural habitats in the Mt. Laguna area
   - ☐ Maintaining recreational sites (lakes, trails, viewpoints, camp grounds, etc.)
   - ☐ Providing water for economic reasons (cattle, farms, mining jobs, etc.)

5. Who do you think has the most influence over how water resources are used at Mt. Laguna? Please rank the following (1 being most influential; "other" does not need to be selected)
   - ☐ U.S. Forest Service
   - ☐ Fire departments
   - ☐ Community Organizations/Non-profits
   - ☐ Other (please specify) _____
   - ☐ Residents
   - ☐ Visitors and campers
   - ☐ Ranchers

6. Have you ever experienced or heard about problems with water access, quality, or health and safety at Mt. Laguna? (circle one) Yes No

   If yes, then what caused these problems? (check all that apply)
   - ☐ Residential pollution
   - ☐ Improper disposal of waste by visitors and campers
   - ☐ Agricultural runoff
   - ☐ Runoff from roads, driveways, and parking lots
   - ☐ Toilets, sewage, and other wastewater (faulty infrastructure)
   - ☐ Naturally occurring contaminants (e.g. iron, E. coli, animal waste, carcasses, radioactivity, etc.)
   - ☐ Other (please specify) _____

7. What local water issues interest you? (check all that apply)
   - ☐ Water quality for private owners
   - ☐ Water quality for visitors and campers
   - ☐ Better resident water access
   - ☐ Water scarcity
   - ☐ Maintaining water reserves for fire protection
   - ☐ Better visitor water access
   - ☐ Conserving water for ecosystem stability
   - ☐ Monthly cost of water for residents
   - ☐ Other (please specify) _____

8. What should be done to address water quality issues at Mt. Laguna? (check all that apply)
   - ☐ Stricter fines for quality violations
   - ☐ Closer or more frequent monitoring of water quality
   - ☐ Better enforcement of existing regulations
   - ☐ Better care for natural habitats (i.e. more environmental protection)
   - ☐ More community involvement/input with regard to clean water policy
   - ☐ Education for residents and visitors
   - ☐ Water quality is fine/nothing is needed
   - ☐ Other (please specify) _____

9. What should be done to address water allocation issues at Mt. Laguna? (check all that apply)
   - ☐ Rationing/limiting water access to campers
   - ☐ Rationing/limiting water access to residents
   - ☐ Charging additional fees for water usage
   - ☐ Stricter enforcement of existing laws
   - ☐ Other (please specify) _____

10. What are you willing to do to address these local water issues? (check all that apply)
    - ☐ Use water resources carefully and sparingly
    - ☐ Pick up trash seen outside of specified containers
    - ☐ Report known problems to Forest Service officials
    - ☐ Pay additional fees/taxes to improve enforcement
    - ☐ Join and participate in a community organization
    - ☐ Other (please specify) _____

11. What is your annual household income (circle one)? $0-$25,000 $25,000-$50,000 $50,000-$100,000 $100,000-$150,000 $150,000+

12. Occupation? _____

13. Gender? Male Female Age: _____

14. Ethnicity (circle all that apply)? White Hispanic/Latino Asian/Pacific Islander Black Native American Other (please specify) _____

15. Highest level of education? _____

16. Which of the following do you feel best represents your political stance? (circle one) Very liberal Liberal Moderate Conservative Very conservative

17. Anything else you would like to add?

_____
_____
_____
_____
_____

# APPENDIX C: Initialisms and Acronyms

**Table C1. Summary of initialisms and acronyms used in the study**

| Initialism/Acronym | Full Name |
|---|---|
| MLIA | Mt. Laguna Improvement Association |
| MLFSC | Mt. Laguna Fire Safe Council |
| MLVFD | Mt. Laguna Volunteer Fire Department |
| SD DEH | San Diego County Department of Environmental Health |
| BLM | Bureau of Land Management |
| USFS | United States Forest Service |
| IRWM | Integrated Regional Water Management |
| NEPA | National Environmental Policy Act |