Codornices Creek Corridor: Land Use Regulation, Creek Restoration, and their Impacts on the Residents' Perceptions

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Abstract

Codornices Creek, an ecological corridor located in the northern part of Berkeley, California, is among the most visible, publicly accessible, creeks in the East Bay, flowing through socioeconomically diverse neighborhoods. The current study examines the comparative influence of the following factors on the area residents' sense of community and perception of area ecology: individual-level socioeconomic conditions, the involvement of local area residents in creek restoration activities, and the existing creek-related land use regulations. Based on the data collected through field measurements and a survey of the creek area residents, the study finds the respondents' exposure to the City of Berkeley's Creek Ordinance, a key land use regulation in the Codornices Creek area, to be among the most important factors affecting their perception of the creek's role in stormwater management, while the comparative impact of socioeconomic conditions appears to be less important. In contrast, exposure to the ordinance is found to have no significant impact on the respondents' sense of community or overall perception of area biodiversity. Surprisingly, not one of the three outcomes of interest—the sense of community, perception of area biodiversity, or awareness of the creek's role in stormwater management—appear to be strongly affected by the respondents' involvement in creek-focused restoration activities.

Introduction

Forming an ecological corridor in the northern part of Berkeley, California, the Codornices Creek supports a diverse and unique ecosystem both in terms of the surrounding natural landscape as well as the local residents' socioeconomic characteristics. Starting in the Berkeley Hills in the east, the creek flows through the backyards of single-family homes, passes through underground culverts, and bisects soccer fields before finally entering the San Francisco Bay. In its path, the creek winds through both well-established, wealthy neighborhoods and low-income, racially diverse communities characterized by high residential turnover rates. Along its entire course, the creek functions as the backbone of a rich and diverse

ecology, allowing it to maintain within the urban fabric "a thread of wilderness" represented by flowing water, trees, and wildlife (Schwartz 2000), improving stormwater management in the area, and providing opportunities for recreation and involvement for the local community.

The City of Berkeley's Creek Ordinance, an important legal instrument aimed at preserving these natural functions, represents another unique aspect of the Codornices corridor. Throughout its existence, the ordinance has generated contention and debate among environmentalists, city officials, and affected private property owners. By limiting development along the corridor and establishing guidelines for improving the stormwater-management capacity of land parcels adjacent to the creek, the ordinance in several important ways complements the various creek restoration activities that a number of environmentalist groups have organized over the years with the help of the local community. Apart from sharing the goal of ecological preservation and restoration, both the ordinance and the restoration activities are also likely to raise the affected residents' awareness of the creek's ecological functions and the biodiversity characterizing the area surrounding it. At the same time, the effects of the ordinance and creek activism on the local residents' attachment to the community are possibly quite different. Specifically, the present study hypothesized that, while the latter is likely to increase the opportunities for interaction between the socioeconomically and demographically different segments of the area population, thus potentially bringing the community together and increasing the residents' shared sense of being Berkeley residents, the effect of the ordinance on the extent to which the residents in question see the Codornices Creek area as their home is more difficult to determine.

Given the area's unique socioeconomic diversity, land-use-related regulatory context (which affects some, but not all, of the local property owners), and ecological activism during the recent decades, this study seeks to identify the contribution of these factors to the area residents' sense of community, their perception of the creek area's biodiversity, and their awareness of the creek's role in stormwater management. Specifically, we hypothesize that the residents' awareness of the ecological assets of the Codornices Creek is significantly affected by their past and present involvement in creek restoration initiatives and their active exposure to the Creek Ordinance. In contrast, of these two factors, only involvement in creek restoration was hypothesized to exert a strong positive influence on the residents' connection with the community. The study combined field-based observations of both land uses and human environmental behavior in the creek areas, Census-level socioeconomic data analysis, and a survey aimed at eliciting the residents' community-related and ecological perceptions. Because of numerous potentially confounding factors that needed to be taken into account to identify causal linkages, the study relied on statistical

analysis as the primary form of data analysis. In partial confirmation of the stated hypotheses, exposure to the ordinance was indeed found to have a statistically significant and positive effect on the respondents' awareness of the creek's role in stormwater management. Also as hypothesized, ordinance exposure did not appear to have a significant causal effect on the respondents' sense of community. Perhaps surprisingly—and of particular relevance to future community planning and environmental outreach efforts—the survey data analysis did not confirm any significant linkages between creek activism and sense of community or perceptions of the local ecology and biodiversity. Instead, the statistical analysis identified the residents' socioeconomic characteristics—first and foremost, household income and length of residence in the particular neighborhood—as comparatively more important in explaining variation in the stated sense of community and ecological awareness.

Context: the Cordonices Creek and its Management

Creek Restoration Efforts

Over the years, as a result of the filling of the San Francisco Bay for the purposes of waste disposal and real estate development, the Codornices Creek estuary has shifted nearly a mile northwest, from its original termination near Third Street (Prunuske Chatham 1990). Yet, especially over the past two decades, the creek has also witnessed significant efforts at restoring its natural path and ecology. Certain parts of the creek have been daylighted, restored, and preserved through activities undertaken by the City of Berkeley and a number of local and regional non-governmental organizations, including Friends of Five Creeks, a community creek stewardship group, the Urban Creeks Council (UCC), a non-profit organization dedicated to the protection, preservation, and restoration of urban streams and their riparian habitat, and the Codornices Creek Watershed Council (CCWC), a local volunteer organization composed of stakeholders who live and work in the watershed (Urban Creeks Council 2005; Watershed Project and the Codornices Creek Watershed Council 2007).

In 1994, the Urban Creeks Council organized an initiative to plant native willows, dogwoods, and alders along the Codornices creekside; in 1997, also as part of a UCC project, the creek's banks were stabilized using soil bioengineering techniques (Urban Creeks Council 2002). A community-wide soil bioengineering workshop was also held in 2006, organized jointly by the UCC, the CCWC, and the Waterways Restoration Institute, specifically focusing on the creek's Fifth Street area. Participants ranged from local governments and environmental consultants, to high-school ecology clubs, creekside residents, and other interested citizens.

In 2001–2003, the UCC implemented the Codornices Creek Watershed Restoration Action Plan (CCWRAP) project (Kier Associates 2003), aimed at establishing the presence of steelhead in the stream, and to evaluate the amount and quality of the creek's salmonid stream habitat. In 2006 and 2007, CCWC conducted tours of the watershed to introduce community members and others to its various resources, amenities, and projects and led an initiative aimed at native plantings and invasive vegetation removal at creek restoration sites, such as along the creek corridor near St. Mary's high school. In 2009, CCWC began implementing the Codornices Creek Watershed Stewardship Project, working with key stakeholders to create an interpretive trail and a Creekside Outdoor Classroom. Most recently, in the winter of 2010–2011, CCWC planned and organized a major volunteering effort to install up to 2,000 native plants following the completion of creek restoration.

Many other activities to promote awareness of the creek and its ecological benefits have been and are being organized along different segments of the corridor; recently the focus has been along the lower Codornices path. However, the unique aspects of Codornices Creek, and in particular the efforts to restore it, have many varying facets. In particular, the geographic terrain, land use patterns, and the socioeconomic characteristics of the area residents have the potential to make creek restoration more challenging. Moreover, the multiplicity of factors just enumerated also implies that the restoration efforts and the creek itself are likely to be perceived differently by individual residents.

Overall Land Use Characteristics

For purpose of this study, the boundary of the creek corridor is defined by a one-block buffer on both sides of the creek. The creek, openly accessible, starts in the Berkeley Hills, east of Codornices Park and the Berkeley Rose Garden. As shown in the land-use map, which was created based on field observations and Google Map imagery (Figure 1), most of the housing in this area is single-family, with very few multi-family homes. The central part of the corridor also includes many commercial and institutional buildings (schools, supermarkets), while the westernmost section contains the UC Berkeley University Village, two large soccer fields, and a number of industrial and commercial units as well as parking lots.

Based on the distinct land-use and socioeconomic characteristics, the corridor was divided conceptually into three cross sections, with the lower cross section lying between the students' village and San Pablo Avenue. The middle section is between San Pablo Avenue and Martin Luther King Jr. Way, and the upper section extends from Martin Luther King Jr. Way to Codornices Park.

Figure 1: Land Use in the Codornices Creek Corridor

City of Berkeley's Creek Ordinance

Dating back to 1929, the City of Berkeley's Creek Ordinance regulates development on or near creeks in the city. The ordinance has been modified several times in consultation with the community (Sutton 2002)—most recently, in 2004. The current ordinance is part of the Berkeley Municipal Code and contains new regulations adopted by the City Council, based on the recommendations made by the Creeks Task Force. One of the goals of the amended ordinance is to protect open creeks and nearby habitat while providing more options for expansion of existing nearby homes. Effectively, the creek is divided into two categories, "open creek" and "culverted creek," the latter being defined as flow that is channeled through underground pipes or box-shaped conduits. Among others, regulations defined by the ordinance include: limits to expansion of existing buildings (allowed up to 25–30 feet from open creek segments if authorized by the Zoning Office), a requirement to use permeable pavement material on properties within 30 feet of open creek, and a requirement to provide a Department of Public Works-issued verification of the creek's location by property owners who want to develop land lying within 15 feet of a culverted creek segments.

As indicated by these examples, a property's proximity to the creek significantly affects the extent to which the property can be modified and/or used as an economic asset. On the other hand, the exposure to the ordinance may also enhance the property owners' overall awareness of the flood control, biodiversity, and other ecological issues related to the creek.

Insights from the Literature

As suggested by Chavis and Wandersman (1990), the sense of "community," a term commonly used by citizens, politicians, and social scientists to characterize the relationship between the individual and the social structure, has received relatively little theoretical or empirical attention until recently (e.g., McMillan and Chavis 1986; Newbrough and Chavis 1986). In the present study, "sense of community" refers to the residents' sense of attachment to—and feeling of safety in—their community, and the sense that the community is their home and is composed of individuals who care about it. As stated earlier, we hypothesized that a sense of community in the Codornices Creek corridor, enhanced by activities, such as creek restoration, would increase opportunities for resident interaction and their ability to contribute to the ecological health of the creek-adjacent landscape as well as generate shared concerns and goals. Similarly, we also hypothesized that "perception of area biodiversity," measuring the degree to which the residents perceive the community to be characterized by a high diversity of flora and fauna, would be positively associated with creek activism—primarily, through the enhanced amount of time and attention

spent directly interacting with the natural landscape. Likewise, we expected that biodiversity-related perceptions were also strongly related to the residents' "active" exposure to the Creek Ordinance (i.e. exposure and awareness of being exposed), as a result of the greater likelihood that ordinance-exposed residents pay attention to *all* creek-related issues; and the likelihood that objective biodiversity is indeed higher in the areas immediately adjacent to the creek. Lastly, "awareness of the creek's role in stormwater management" aims to capture whether individual local residents perceive the creek and its adjacent ecosystem to serve an important function in controlling the cycling and absorbtion of storm and flood water in the landscape. As with perceptions of biodiversity, creek activism and active ordinance exposure are hypothesized to be important explanatory factors.

As reflected in the conceptual definitions of the key variables of interest, and as implied by the proposed hypotheses, the research design and interpretation of results necessitate an interdisciplinary approach, drawing from theories and methods across the literature on sense of community, environmental perception and education, and watershed management and restoration.

Environmental and Communited-Related Perceptions

An underlying theme of literature that informs the goals and design of the present study is the idea that environmental behavior is deeply grounded in environmental perception—a process that is complex, dynamic, and active (Holahan 1982). The ways in which people feel, use, and interact with their surroundings have been reflected in so-called "place studies" (Moudon 1992), emerging in the early 1970s with the work by authors such as Appleton (1975), Hiss (1990), and Whyte (1988). Furthermore, with respect to human perception of the natural environment surrounding them, "nature-ecology studies" from the 1980s explored perceptions of natural forces in relation to the built environment. Examples of literature in this field include George and McKinley (1974), Hughes (1975), and Van der Ryn and Calthorpe (1986). The idea that the individuals' perception of—and interaction with—their environment are interrelated motivates the present study's focus on measuring ecology—and neighborhood-related perceptions.

Also informing the study's hypotheses and approach are insights from the literature that concludes that measuring and understanding the extent to which a sense of community exists in a particular neighborhood is important in providing the foundation for urban and community planners (McMillan and Chavis 1986). Moreover, feeling ties with a place and fellow residents has been linked to various community-level outcomes that directly and indirectly influence mental health and social

network formation (Berkman and Glass 2000). Using path-analysis and longitudinal models, Chavis and Wandersman (1990) have shown that sense of community can have a catalytic effect on local action by affecting the perceptions of the environment and social relations. In the case of the Codornices creek community, the sense of community is of interest as it might explain—and be expected to facilitate—certain outcomes related to the residents' willingness to support and contribute to the overall management of the watershed.

A challenge with research that aims to assess sense of community in a specific area and to identify factors that might explain it, however, lies in identifying indicators of "sense of community" that are meaningful and have reasonably high construct validity. Some authors, such as Holahan (1982), have also stressed the challenges in developing measures of perceptual responses that are able to reflect the richness of the perceptual process. While the current study defines sense of community as a composite of a number of different perceptions—such as those related to fellow community members and the extent to which the community "feels like home"—the concept in the existing literature has been operationalized in any number of ways. Similarly, different authors appear to attribute slightly different meanings to the role of sense of community. For instance, Smith (2010) defines sense of community as a feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members' needs will be met through their commitment to be together. Importantly, Gusfield (1975) distinguished between community as a *territorial* notion and community in terms of the *relational* quality of human relationship. The latter, more so than the former, is the way "community" is conceptualized also in the current study.

Of direct relevance to the study's design—in particular, the survey questionnaire—are also the findings from existing literature that relate to the specific factors that explain variation in sense of community across individuals. These include age, income, gender, the presence of children, length of residency in the community, educational attainment, stage of life, home ownership, and number of neighbors known by first name (see, for example, Nasar and Julian 1995; Glynn 1986; Haggerty 1982; Kasarda and Janowitz 1974). Indirectly referring to factors that contribute to sense of community, Bosselmann (2008) notes that place attachment, dependency, and identity necessarily depend on the individual's ongoing relationship with a physical setting that in most cases is shared with other people.

In terms of the specific methodologies that have been used to measure sense of community, for instance, Joongsub (2002) conceptualized it in terms of four domains: community attachment, pedestrianism, social interaction, and community identity. Similarly, Riger and Lavrakas (1981) studied sense of community as reflected in neighborhood attachment

and found two empirically distinct factors they called "social bonding" and "behavioral rootedness." The first factor contained items concerning the ability to identify neighbors, feeling part of the neighborhood, and number of neighborhood children known to the respondent, while the second referred to years of community residency, home ownership status, and expected length of residency. In contrast, Doolittle and MacDonald (1978) developed a 40-item Sense of Community Scale (SCS), basing it on what have been called the "critical dimension of community structure" (Tropman 1969, 215). They then used the scale to differentiate between low, medium, and high SCS neighborhoods on its five factors: informal interaction with neighbors, safety, pro-urbanism, neighboring preferences, and localism.

However, the sense of community index that most directly informs the index constructed as part of the current study is that developed by Bachrach and Zautra (1985), built on the basis of questions developed by Kasarda and Janowitz (1974). The index included several items—feeling at home in the community, satisfaction with the community, feeling of belonging in the community, attachment to the community, agreement with the values and beliefs of the community, interest in what goes on in the community, and feeling an important part of the community—of which the present study most strongly relies on the first four.

Watershed Management

As reflected in the literature on the topic, watershed management more broadly and creek restoration in particular have gained widespread popularity in recent decades. It is attributed to a number of factors, including the ease of participating in creek restoration activities like creek-bed cleanup (Schwartz 2000). Yet, while ecosystem services are increasingly recognized as essential to society and of considerable economic value, further investments in natural capital are needed to ensure delivery of ecosystem services in the present and the future (Lant 2003).

In addition to the overall environmental and community-related perceptions, of particular importance to the present study is the idea that successful long-term watershed and creek management requires an understanding of the dynamics of land-use change, of the role of watersheds in urban stormwater control, and of the impact of particular land-use patterns on the watersheds' ability to play their role as ecological corridors and aids in stormwater management. This understanding, in turn, can enhance our knowledge about ways in which proper management of environmental quality and natural resources can foster socioeconomic and ecological sustainability. Likewise, the watershed planning process and implementation of management practices at the parcel, neighborhood, and regional level must be seen as legitimate by various stakeholder groups in

the watershed, since the issue of property rights is embedded in watershed governance (Lant 2003). In the Codornices Creek example, in particular, the local residents' understanding of these various dynamics is central to the future success of the City of Berkeley's Watershed Management Plan, especially, the private property owners' readiness to adopt various forms of green infrastructure in the Creek Ordinance buffer zone in the effort to mitigate perennial flooding.

Fullmer (2008), in a paper on restoration efforts focusing on the Codornices Creek, suggests that many local and regional groups have become involved in—and initiated—restoration projects because of the direct connection that so many individuals share with the creek as well as due to the creek's visibility above ground. However, despite the importance of local efforts in moving the restoration efforts forward, Fullmer suggests that the restoration projects occurring in the Codornices watershed have also become increasingly complex and comprehensive, with many of them containing a combination of volunteer work elements, community design elements, or workshops to engage and educate the public about the needs of their watershed. Finally, he suggests that the creek should be seen as a model for successfully obtaining funding for river and stream restoration projects, because the community, community groups, landowners, and the local government have all come together and played different, but equally important roles. In light of these conclusions, the findings of the present study, related to the effect (or, lack thereof) of restoration-related community engagement on the actual sense of community among participating residents, are somewhat surprising. Other previous studies concerning Codornices Creek have addressed its water quality (Sloan and Stine 1983), erosion problems (Prunuske-Chatham 1990), and creek restoration efforts (Waterways Restoration Institute 2001).

Methodology

In order to test the hypotheses, the study design combined both field-based observation, secondary data analysis, and a mail-back survey completed by residents in the community. Available in full in the Annex, the survey questionnaire provided the bulk of data used to test the hypothesized causal linkages, while also allowing to "control for" possible confounding variables: the individual's income, length of residence in the community, and daily exposure to the creek and the parks adjacent to it, among others. The design of the survey was informed by insights from the literature summarized previously. In particular, several questions were constructed building on Bosselman (2008), including the question asking to select from a list of adjectives that best describe the individual's neighborhood

(question 8, Appendix) and the question asking how many people in the neighborhood the individual is likely to say hello to (question 4, Appendix).

A total of 160 surveys were mailed to households living in the creek corridor, in addition to 10 surveys that were distributed by hand. The addressees were selected based on the need for a balanced sample of Creek Ordinance-affected versus unaffected residents, due to the hypothesized prominent role of ordinance exposure in the residents' biodiversity and stormwater management-related perceptions. To carry out the sampling process, the study therefore made use of the City of Berkeley's website, which identifies each land parcel's status in terms of the ordinance impact. A total of 65 addresses were randomly selected from the most up-to-date list[1] of ordinance-exposed parcel addresses[2]. The remaining 95 mailing addresses within the defined study buffer area were also selected randomly.

In addition, the secondary data—gathered mostly from the 2010 Census—allowed for an examination of the survey sample against the broader population in terms of particular socioeconomic characteristics, thus providing insights as to the likely external validity of the study's findings. Data from the Census was extracted at the tract level (with a total of 11 tracts along the creek corridor), covering such variables as home ownership rates, median household income, racial composition of the population, and the degree to which the area residents not only live but also work in the area. These variables were selected due to their likely impact on residents' lifestyles, intensity of interaction, and familiarity with people in the neighborhood. In turn, these factors were considered to be potentially important in ways in which the area residents relate to the community overall and perceive it as their home and, therefore, were also inquired about through the survey.

Finally, the field-based observations, such as those focusing on the permeability of land surfaces in creek-adjacent areas, the accessibility of the creek's daylighted portions, and the use of the park spaces located near the creek, were not used to directly test the study's hypotheses but, instead, provided a richer contextual understanding of the human and the natural landscape. The relevance of measuring ground surface permeability, in particular, lies in the importance of permeability in flood control and

1. http://www.ci.berkeley.ca.us/uploadedFiles/Planning_(new_site_map_walk-through)/Level_3_-_General/20070123OpenandCulvertedCreeks.pdf

2. Judging from the respondents' own answers to the survey question inquiring about their property's exposure to the ordinance, it appears that several of them may not be aware of the actual status of their land parcel (i.e. being located very close to or along the Creek, they said that their property was not exposed to the Ordinance or that they did not know whether or not it was). Because the respondents' exact addresses were not always provided with the returned survey questionnaires (only the nearest street intersection), the exact number of such respondents could not be verified.

wastewater management. We therefore hypothesize that such factors influenced residents' perceptions of the important role of the creek and its surrounding vegetation.

Results

Insights from the Field and Census-Based Measurements

The field measurements and Census-based analyses alike revealed several stark differences in the natural and human landscape across the three areas of the creek corridor (Table 1). In terms of the areas' natural features, the field-based measurements suggested that surface permeability—potentially important in affecting the residents' exposure to seasonal floods and, in turn, awareness of the role of the creek and its surrounding vegetation in their mitigation—is significantly higher in the lower- and upper-creek areas (44% and 43%), due to the presence of two soccer fields

Characteristic	Lower Creek (%)	Middle Creek (%)	Upper Creek (%)
Born outside the U.S.	42	18	21
White population	72	77	77
Lived in the same house 1 year ago	64	85	84
Population >25 of age that has B.A.	68	72	85
Population only speaks English	46	78	77
Families with children <18 years of age	25	20	15
Live in home they own	16	67	60
Median Income (in US$)	46,459	90,330	99,664

Table 1: Summary Socioeconomic Characteristics

in the former and several parks in the latter. In contrast, the middle-creek area, which has relatively dense housing and no large recreational space, is much less permeable (14%) and therefore more vulnerable to flooding.

The measurements of creek accessibility showed the upper creek areas as having many more access points and crossings, compared to only a few in the lower part of the corridor. In the middle areas, while the creek mostly flows above ground and there are several paths crossing it, access is fenced off or hidden in several locations. Overlaying the road and bicycle route network, it appears that, overall, the existing transport infrastructure does allow for daily movement that provides opportunities for exposure to open creek.

Analysis of the Census data revealed stark socioeconomic differences between the lower- and upper-creek residents. The entire population residing in the westernmost Census tracts of the creek corridor (i.e. the University Village) was found to live in renter-occupied housing, in contrast to the middle- and upper creek residents, whose home ownership is significantly higher, reaching 80-85% in the Berkeley Hills. For the purposes of the study, home ownership is potentially important as a variable affecting the residents' sense of community. In terms of the median household income distribution along the corridor, Census data indicates a concentration of high income (>$100,000) households in the hills, middle-income households in the middle cross-section and low-income (<$50,000) at the lower cross-section. In the face of this data, it is interesting to note that most of the creek restoration activities have taken place at the lower cross-section of the corridor. Also inquired about in the survey, both income and home ownership variables were included as controls in the final statistical analysis.

Finally, the 2010 Census also shows the upper-creek areas to have the most homogeneous racial composition, with whites representing about 80% of all residents in the respective Census tracts; in contrast, 30% to 50% of the lower-creek census tract population is Asian. Both the middle- and the upper-creek areas, however, appear to be relatively homogenous as compared to the University Village area—being populated by predominantly middle-aged, white, American-born, English-speaking, college-educated residents. Based on the socioeconomic characteristics—and insights from the Sense of Community literature—it might be reasonable to expect the middle- and upper-creek residents to feel more at home in the community and have a greater sense of belonging to it.

Survey Results

A total of 60 completed surveys were returned out of the 170 distributed. In terms of the geographical distribution, the response rate was the highest

in the upper-creek area (41.5%) followed by the middle-creek area (36.7%) and the lower-creek area (24.4%). The majority of respondents for the entire sample were women (67.3%), although in the lower-creek area males were relatively more represented (54.5%). In the middle- and upper-creek areas, women represented 59.3% and 81.8%, respectively.

Respondent Socioeconomic Characteristics

Reflecting the Census figures cited previously, the data show the median income of the lower-creek respondents to be significantly lower than that of the middle- or upper-creek respondents: while half of the lower-creek respondents' household income is only $40,000 or less, the median income of the middle- and upper-creek respondents is more than twice that. The pattern generally corresponds to the overall Census-based indicators for the area.

As shown in Table 2, the length of stay in the neighborhood is most variable in the middle-creek area, ranging between 1 and 55 years. This contrasts with the lower creek, where the range is much smaller—between 0 and 4 years. Not only the ranges but also the averages are potentially important in influencing the residents' perceptions of the community and awareness of its ecological features. Table 2 also indicates the number of people in their "neighborhood" that the respondents know well enough to say hello to when seeing them on the street. As can be seen from the data, there is almost no relationship between the length of stay in the neighborhood and the number of local acquaintances a person has: on average, the lower-

Characteristic	Lower Creek	Middle Creek	Upper Creek
Years Spent in the Neighborhood			
Average	2	18	19
Lowest	0	1	0
Highest	4	55	52
Acquaintances in the Neighborhood			
Average	21	23	18
Lowest	4	3	0
Highest	50	63	50

Table 2: Characteristics of Respondents by Length of Stay and Number of Acquaintances

creek respondents—mostly graduate students—know more people in the community (21) than do the upper-creek respondents (18) who, on average, have lived there much longer.

Daily Exposure to the Creek

The survey also inquired about the respondents' daily exposure to the creek or visits to areas through which the creek flows, which presumably matters for both sense of community and, especially, perception of the creek's ecological functions and benefits. The survey results show that, as expected, in the lower-creek area most respondents cross the creek on Eighth Street, while in the middle- and upper-creek areas the crossing points are more diversified. The daily exposure to the creek is also coded and compared quantitatively, whereby, for instance, being able to see or hear the creek from one's home is each awarded a value of +1, as is the respondents' crossing of the creek in their daily route. A value of +3 is awarded if the respondents visit creek-adjacent parks and other areas at least once a day, +2 if they do so at least once a week, +1 if occasionally, and 0 if never. The aggregated results per respondent indicate that the middle- and upper-creek respondents appear to be more exposed to the creek in their daily commutes. In terms of their visits to the creek-adjacent parks, the upper-creek residents seem to diversify their park visits the most. For the sample as a whole, the most popular creekside recreational area is the Live Oak Park, visited by 60% of the respondents, with Codornices Park being the next most visited (48%). When asked about the particular features that attract them to the creek-adjacent parks, the natural/environmental characteristics and those related to the overall atmosphere and recreational opportunities appear to be about equally important.

Perceptions of Creek Restoration

The survey responses also elucidated the creek area residents' perceptions and awareness of the various watershed management initiatives that have been undertaken in the area. As mentioned in the introductory section of the study, over the past 15 or so years, a number of activities have been carried out by various creek activist groups in the area, aimed at restoring the ecological functions and biodiversity in the Codornices Creek corridor. These have included tree planting and re-introduction and monitoring of salmon and steelhead fish species, in addition to several community- and user-oriented activities, such as trail improvements and the creation of an outdoor classroom near the University Village entrance. Also the survey distributed to the residents of the area inquired about which of the initiatives they were aware of (q.34, Appendix) or had participated in (q.35, Appendix).

The survey data showed that while almost half of the lower-creek respondents had heard of trail improvements, only 5% and 15% of the middle- and upper- creek respondents, respectively, had. In contrast, the middle- and upper-creek residents appear to be more aware of the stormwater infrastructure improvements in the area as well as the introduction of fish species in the creek. When responses to awareness- and participation-related questions are aggregated, it appears that, overall, most respondents are aware and/or have been involved in only one or two restoration activities, although a few individuals have heard of or been involved in more than 10. The median number of activities is the same for all cross-sections (between 1 and 2), although the range of responses is much larger among the upper-creek respondents. Central to the hypotheses on factors significantly related to sense of community and ecological perceptions, the aggregated awareness and participation scores were used in subsequent statistical analyses.

Outcome 1: Sense of Community

In terms of the residents' comfort in and sense of belonging to the community (question 7, Appendix), one of the three outcomes of particular interest to this study, generally, the respondents from the lower-creek area indicated less positive perceptions across all indicators. In particular, a gap between the lower-creek and the middle- and upper-creek respondents emerged on the question of the extent to which other individuals in the community seem to contribute to it. On the other hand, it appears that lower-creek residents feel as safe in their community as do middle- and upper-creek residents. Another pattern that can be discerned is the comparatively less positive perception by upper-creek residents of the social/community aspects of their neighborhood—for instance, they seem to feel slightly less connected to their neighbors than do the middle-creek respondents.

Statement	Lower Creek	Middle Creek	Upper Creek
I feel safe in my neighborhood	1.4	1.4	1.4
My neighborhood is composed of individuals who contribute to the community	0.8	1.4	1.3
I feel a strong connection to people in my neighborhood	0.6	0.9	0.8
My neighborhood feels like home to me	1.2	1.5	1.6

Table 3: Perceptions of the Community (based on a 5-point Likert scale; +2 = "Strongly Agree")

The responses given to questions related to the sense of community were coded and aggregated by cross-section. The "Sense of Community" index, reflecting the definition provided earlier, is composed of the respondents' answers to survey question 7, whereby "Strongly Agree" is assigned a value of +2 and "Strongly Disagree," on the other extreme, a value of –2. Each respondent's answers to the four sub-questions are then summed. The results (Figure 2 (a)) show that the median[3] Sense of Community Index is higher in the middle- and upper-creek areas as compared to the lower creek. Surprisingly, the median Index is not higher for people with children living at home, contradicting results reported in several previous studies, including Bosselmann (2008) and Nasar and Julian (1995).

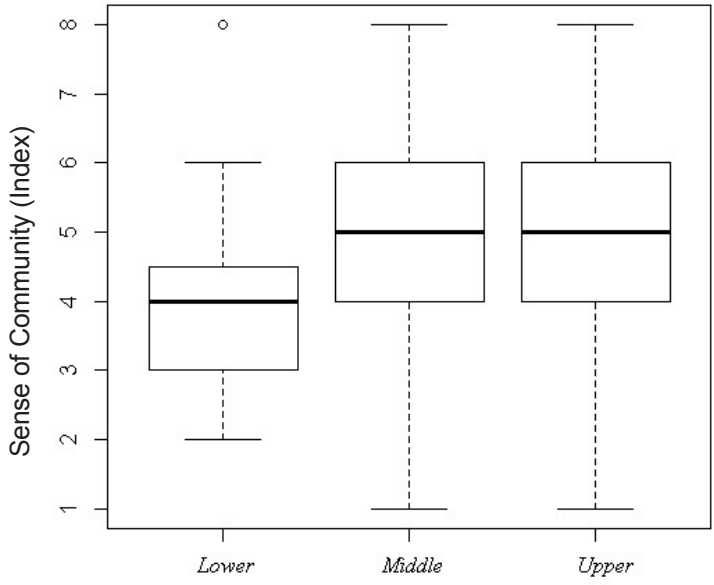

Figure 2a: Sense of Community Index

Outcomes 2 & 3: Perception of Area Ecology & Creek's Role in Stormwater Management

Another important goal of the study was to explore the creek residents' perception of the ecological assets and functions of the creek corridor, including biodiversity and the creek's role in stormwater management. The respondents' perception of the area biodiversity is captured through a composite index, consisting of responses to questions 9 and 11. As before, a value of +2 is given to "Strongly Agree." As indicated by Figure 2b, respondents in the middle- and upper-creek areas appear to perceive their neighborhood to be significantly more bio-diverse.

3. In the boxplots in Figures 2a and 2b, the median value is indicated by the thick horizontal line in the respective boxes. The upper and lower edges of each box indicate the 75th and the 25th percentiles, respectively.

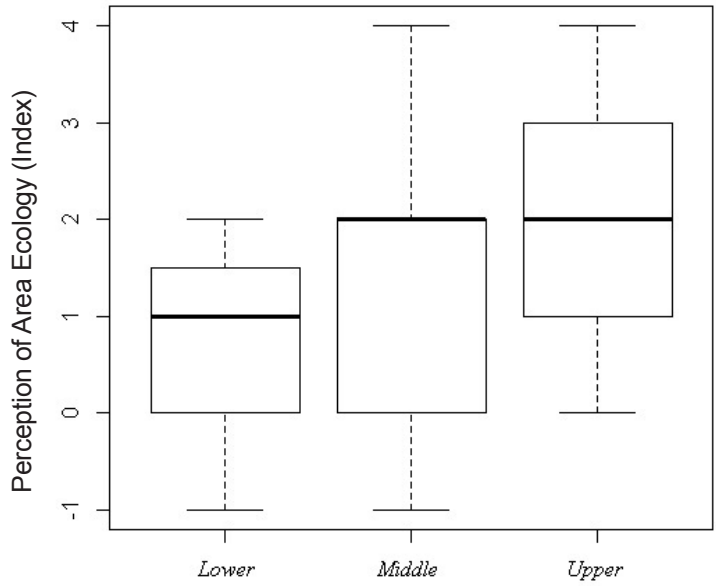

Figure 2b: Perception of Area Ecology

Data on the question inquiring about the respondents' awareness of the creek's role in stormwater management show that only 54% and 56% of the lower- and upper-creek respondents recognize that the creek plays such a role in neighborhood, while the figure is somewhat higher (64%) in the middle-creek area, perhaps due to a combination of high home ownership near the creek and exposure to annual flooding (related to the low surface permeability).

The Effect of "Active" Ordinance Exposure on Outcomes 1, 2 & 3

One of the main hypothesized influences on the creek area residents' sense of community and perception of biodiversity and ecology is their active exposure to the creek ordinance. In total, slightly fewer than one third of all those who filled out the survey indicated that they were affected by the ordinance. In addition, a large number of respondents indicated that they "Don't Know" if they are affected—these answers were coded as "Not Affected" in the final data analysis, since what matters for the study's purposes is the respondents' *awareness* of being subjected to this legal limitation on the use of their property. As indicated by the data, a respondent's active exposure to the land-use limitations specified by the ordinance clearly matters for their awareness of the various creek restoration activities being undertaken in the area. For instance, of all those who indicated that they had heard about the fish species restoration efforts, 77% were affected by the ordinance (and aware of it). Similarly, of those who had heard of the outdoor classroom, 71% were also affected by the ordinance.

Lastly, the respondents' status vis-à-vis the ordinance is also graphed against sense of community and perception of the creek area ecology and biodiversity, two of the study's three main outcome variables that are measured as a composite indices (Figures 3a and 3b). As hypothesized, those respondents who are actively exposed to the ordinance have a somewhat higher perception of biodiversity of their neighborhood. In contrast, the ordinance exposure does not seem to affect the sense of community as much, although those exposed to it seem to have a more similar perception than those not exposed.

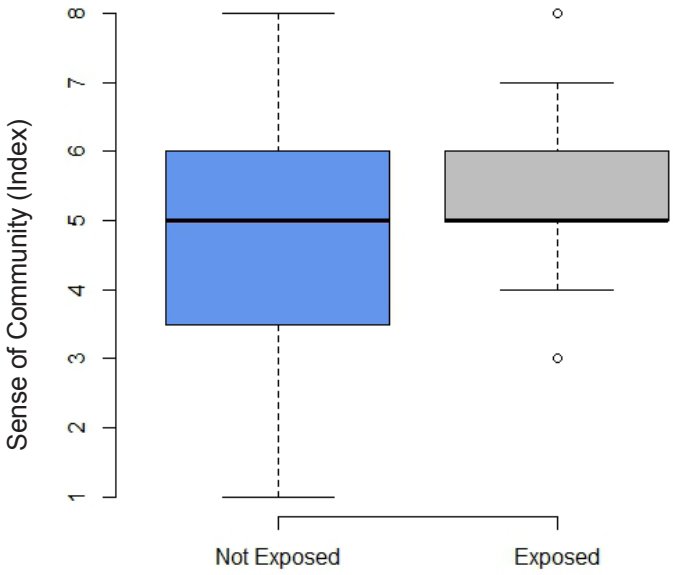

Figure 3a: Ordinance Exposure and Sense of Community (Index)

Regression Results

To test the study's hypotheses statistically, the data from the survey is analyzed through a linear regression. The main outcome variables—sense of community, perception of area biodiversity, and awareness of the creek's role in stormwater management—are regressed on the two variables hypothesized to play a significant causal role, namely, the residents' active exposure to the creek ordinance and their level of creek activism. In addition, a number of different control variables, including the respondents' gender, income, time spent in the neighborhood, and daily exposure to the creek, among others, are included in the initial linear regression models, due to their potentially confounding effect. Prior to specifying the regression, a correlation matrix was constructed to ensure that no two of the independent variables included in the model are highly correlated, thus guarding against multicollinearity. While a linear model

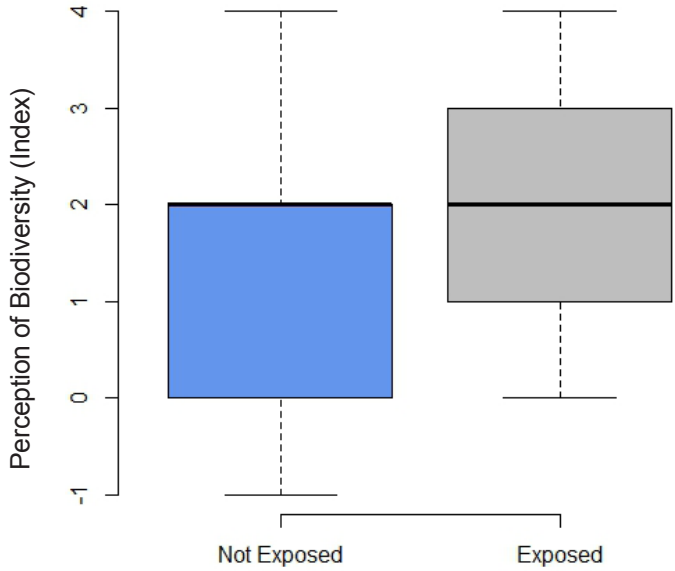

Figure 3b: Ordinance Exposure and Perception of Area Ecology (Index)

is not necessarily the best fit for the data, it is a first attempt at measuring the relative importance of the different influences on sense of community and environmental perception cited in previous literature. Thus, through a simple regression model, it is at least possible to gain insights on the likely effect of individual influences while holding the others constant. Future modeling efforts could also look at alternative functional forms as well as the potentially significant role of interaction terms.

As explained previously, all of the outcome variables—"sense of community," "perception of biodiversity," and "awareness of the creek's role in stormwater management"—are operationalized through the various *perception*-based survey questions. In contrast, control variables such as "number of acquaintances in the neighborhood" or "years spent in the neighborhood" are simply objective characteristics of the particular individual's circumstances while indicating nothing about their sense of belonging to the community or their perceptions about its ecological characteristics. As stated in the previous sections of the study, all three of the dependent variables are hypothesized to be significantly affected by the respondents' level of past and current creek activism. Ordinance exposure is hypothesized to only strongly affect the biodiversity- and stormwater management-related perceptions, with its effect on the sense of community predicted to be more ambiguous.

After regressing each of outcome variables on all of independent and control variables, it is possible to also look for a reduced form model that in each case provides not only high explanatory power but is also parsimonious

(i.e. only leaves in those variables that do contribute to explaining variation in the outcome variable). To arrive at the reduced-form model, the Akaike's Information Criterion is applied (see Burnham and Anderson 2004), which allows for iterative elimination of independent variables until arriving at the "best" model that can be constructed given the available explanatory and control variables (see results in Figure 4). Econometric modeling has also been used by other authors focusing on the topics of sense of community and environmental perception. For example, Wood, Frank, and Giles-Corti (2010) used multivariate models to examine the impact of various factors on sense of community. Mirroring the iterative model search process, they progressively adjusted for demographics characteristics, walking behavior, neighborhood design features, neighborhood perceptions, and time spent traveling in a car.

In our model, "sense of community pappears to be significantly impacted by the respondents' income as well as by the number of people they know in their neighborhood. While intuitive to some extent, the results contradict the study's initial hypothesis which posited that sense of community should be strongly tied to the respondents' past and current creek-related activism through the opportunities that such activism provides for community member interaction and creation of shared goals and values. The significant effect of income on sense of community warrants further investigation—perhaps in the form of more in-depth interviews—although one possible explanation points to the role of income in enabling other forms of social interaction.

Also contradicting the study's initial hypothesis are the results related to the respondents' "perception of area biodiversity." While assumed to be significantly affected by exposure to the Creek Ordinance and past and current involvement in creek restoration activities, this particular perception does not appear to be strongly tied to either of the two—nor, in fact, to most of the variables on which data was collected through the survey. Only the number of years spent in the neighborhood appears to have a statistically significant effect; however, the explanatory power of the model is still quite low, indicating that other factors besides those analyzed affect the perceived biodiversity. Identification of quantifiable variables for measurement in future studies, again, could be possible through more in-depth conversations with area residents.

Finally, confirming part of the initial hypothesis, exposure to the Creek Ordinance was found to have a highly significant impact on the respondents' awareness of the creek's role in stormwater management. As suggested earlier, being exposed to the ordinance is likely to increase the residents' overall sensitivity to and awareness of issues surrounding the creek, with stormwater management being a particularly important one. In addition, a number of control variables appear to have a statistically significant

a. Dependent Variable: Sense of Community

	Estimate	Std. Error	t value	Pr (>|t|)
(Intercept)	-4.7256	3.7246	-1.269	0.2097
Acquaintances in Neighborhood	0.0301	0.0160	1.879	0.0653
Ln (Income)	0.8103	0.3366	2.407	0.0193*

R^2 : 0.153

b. Dependent Variable: Perception of Area Biodiversity

	Estimate	Std. Error	t value	Pr (>|t|)
(Intercept)	1.2443	0.2445	5.090	$4.09e^{-0.6}$***
Years in Neighborhood	0.0266	0.0116	2.299	0.0251*

R^2 : 0.084

c. Dependent Variable: Perception of Creek Role in Stormwater Management

	Estimate	Std. Error	t value	Pr (>|t|)
(Intercept)	2.6026	0.9121	2.853	0.0061**
Acquaintances in Neighborhood	0.0115	0.0039	2.942	0.0048**
Years in Neighborhood	0.0064	0.0041	1.560	0.1244
Ln (Income)	-0.2253	0.0828	-2.721	0.0087**
Ordinance Exposure	0.3742	0.1311	2.855	0.0061**

R^2 : 0.372

Figure 4: Linear Regression Results

explanatory power: in particular, the individuals' "groundedness" in the community, described by the number of years spent living there and the number of acquaintances in the neighborhood, seems to enhance their awareness of the ecological functions played by the creek. Interestingly, the respondents' income appears to be significantly negatively related to the outcome of interest, perhaps explained by the fact that exposure to perennial flooding—and, possibly also the overall attention paid to the issue—is highest in the lower- and middle-creek sections that are characterized by significantly lower income levels than are the residents of the Berkeley Hills. These results can be compared with those reported in Bosselmann (2008), whereby San Francisco residents were shown to be more aware and appreciative of natural stormwater management systems in parks but were less aware of the less tangible biodiversity benefits of the parks' managed natural areas.

Conclusions

As shown through the various illustrations of the field measurements and secondary data analyses, the Codornices Creek corridor represents a high diversity of both socioeconomic and ecological conditions. Likewise, the survey of the residents along the corridor reflected a variety of personal circumstances, which then could be related to the stated perceptions and opinions about the creek ecology and community. In particular through the quantitative analysis of the survey data, several of the initially stated hypotheses were confirmed.

- The analysis showed that the respondents' exposure to the Creek Ordinance is indeed among the most important factors affecting their awareness of stormwater management.

- However, we found that ordinance exposure does not appear to have a significant effect on the overall perception of area ecology and biodiversity.

- Active exposure to the ordinance did not appear to strongly affect the respondents' sense of community.

- The respondents' socioeconomic conditions (income) appeared to strongly affect sense of community.

- Lastly, the residents' awareness of or involvement in creek restoration activities did not prove to be a statistically significant influence on either their sense of community or environmental perceptions. Instead, the income level and the length or residence in the neighborhood, respectively, mattered most in explaining variation in these two outcome variables.

Policy Relevance

Based on the above findings as well as the insights gained from conversations with people involved in the creek restoration activities and the currently proposed Watershed Management Plan, the study findings appear to be relevant for the future design and implementation of policies and initiatives in the area. Firstly, the results could inform future outreach to the community when explaining the purpose and benefits of various creek restoration initiatives. Such education and outreach may have a positive impact regarding a community's support for further stormwater management strategies. In fact, as indicated by several of the respondents, particularly in the middle-creek area, the residents of the creek corridor are quite concerned about the flooding threats posed by the existing creek infrastructure. Similarly, several respondents expressed their readiness to get more involved in the various creek restoration activities, provided more information was provided about the specific opportunities to do so. Understanding the perceptions and awareness of creek-related ecological benefits across the wide income spectrum that is present in the Codornices Creek corridor, as this study has tried to do, is helpful for future planners and designers engaging in ecological restoration work and educational outreach programs.

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