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Civic and natural place attachment as correlates of resident invasive species control behavior in Hawaii

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1. Introduction

Invasive species pose a significant threat to native biodiversity, as well as local economies and the provisioning of ecosystem services (Asner et al., 2008; Funk et al., 2013; Russell et al., 2015). To achieve biodiversity gains and socio-economic benefits, conservation organizations are expanding invasive species control efforts beyond public reserves to private lands (Gardener et al., 2010; Russell et al., 2015; Stokes et al., 2006). Such expansion of control efforts will require motivating residents to become involved in a variety of different control behaviors on their private properties and in their communities (Epanchin-Niell et al., 2010; Stokes et al., 2006). Graham (2013), for example, suggests that effective control of invasive species on a landscape scale will require motivating residents not only to remove invasive species on their property and in their community, but also to apply peer pressure to neighbors related to removing invasive species and to share information about proper control techniques.

Typically, education and outreach programs developed to motivate resident engagement in invasive species control behaviors have focused on providing information about proper control techniques, often coupled with financial subsidies for engaging, or penalties for not engaging, in control efforts (Graham, 2013; McLeod et al., 2015). However, such programs have often failed to bring about widespread, lasting, or effective behavior change and landscape-level reductions in invader populations (Gardener et al., 2010; Graham, 2013).

Recent literature has, therefore, sought to understand additional factors, besides knowledge of control techniques and financial costs or benefits, which might influence citizen engagement in invasive species control efforts (García-Llorente et al., 2008; Graham, 2013; Howell et al., 2014; Hu and Gill, 2015; Niemiec et al., 2016; Prinbeck et al., 2011). Citizens' decisions to engage in control efforts may be influenced by their attitudes toward control tactics (Prinbeck et al., 2011), the perceived difficulty of engaging in efforts to control invaders (Howell et al., 2014), perceptions of social norms regarding invasive species control (Howell et al., 2014; Niemiec et al., 2016; Prinbeck et al., 2011), environmental values and attitudes (Sharp et al., 2011), and time pressure (Hu and Gill, 2015).

Although this recent literature provides greater insight into the barriers as well as social and structural factors influencing residents' decision-making related to invasive species control, relatively little research has considered the affective, or emotional, drivers of invasive species control behavior (McLeod et al., 2015). Considering the role of place attachment, an affective driver that has been found to influence other types of environmental behaviors (Anton and Lawrence, 2015; Raymond et al., 2011; Scannell and Gifford, 2010b), may further understanding of residents' invasive species control decision-making.

Place attachment refers to the emotional bonds that develop between individuals and their environments. It is a multi-dimensional concept (Raymond et al., 2010) that considers the person, the psychological process, and various place dimensions (Scannell and Gifford,

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2010a). In this article we focus on two specific dimensions of place attachment: connections to the biophysical or natural environment in a place, or *natural attachment* (also referred to as natural bonding); and connections to the community or other inhabitants in a place, or *civic attachment* (also referred to as neighborhood attachment or social bonding). These dimensions of attachment may be somewhat fluid, differing over time and within the same individuals. They also may have varied relationships to and impacts on behavior (Oakes et al., 2016; Scannell and Gifford, 2010a; Scannell and Gifford, 2010b; Raymond et al., 2011).

Place attachment has been found to help predict resident engagement in wildfire mitigation behavior (Anton and Lawrence, 2015; Kyle et al., 2010), flood preparedness (Mishra et al., 2010), sustainable farming practices (Lincoln and Ardoin, 2015), and native vegetation planting (Raymond et al., 2011). Civic and natural place attachment have been found to have different impacts on environmental behavior; Scannell and Gifford (2010b), for example, found that attachment to the natural or biophysical aspects of place predicted engagement in variety of environmental behaviors, such as carpooling and recycling, but attachment to the civic or social aspects of place did not. While recent studies have examined the relationship between various dimensions of place attachment and environmental behaviors, place attachment has generally been overlooked in the literature on invasive species control behavior.

Place attachment may provide a useful framework for analyzing resident engagement in invasive species control behavior because different forms of attachment may provide different motivations for or barriers to engaging in individual or collective efforts to combat invasion. Civic attachment, for example, may lead to improved relations with neighbors and thus may empower people to address shared community problems (Chavis and Wandersman, 1990). The benefits of civic attachment may be particularly important for motivating resident behavior to combat invasive species, given that reducing invasive species across private lands typically requires the collective actions of numerous and diverse residents (Epanchin-Niell et al., 2010; Graham, 2013; Klepeis et al., 2009). Improved neighbor relations and enhanced conceptions of community empowerment may motivate residents to approach their neighbors about control efforts, share information about control techniques, and organize efforts with neighbors to combat invasion in a collective manner (Graham, 2013). Residents' invasive species control decisions may also be influenced by their connections to the biophysical components of place, i.e., their natural attachment. Because invasive species can transform a landscape and threaten native flora or fauna, natural attachment may motivate engagement in invasive species control efforts due to residents' desire to maintain the biophysical aspects of a place and return it to a state closer to the one that existed before those invaders arrived.

Given the potential ways in which place attachment may influence invasive species control behavior, combined with the lack of prior literature on this topic, we examined the extent to which place attachment helped predict various types of invasive species control behavior among residents in the Puna District of Hawaii. In particular, we examined the question: to what extent, and how, are residents' natural attachment and civic attachment related to various forms of invasive species control behavior in their community? Our case study provided an opportunity to explore, in depth, the relationship between place attachment and invasive species control in order to understand how this factor may influence conservation practices on private lands.

2. Methods

2.1. Case study

We examined the role of place attachment in understanding residents' engagement in invasive species control through a case study of the invasive albizia tree (*Falcataria moluccana*) in the 320,000 acre Puna District on the island of Hawaii. *Albizia* is a nitrogen-fixing tree native to the Moluccas, New Guinea, New Britain, and the Solomon Islands (Wagner et al., 1999). The tree, which was brought to Hawaii in 1917 and planted as part of reforestation efforts, is commonly found in forest reserves throughout the Puna District, as well as on private residential properties (Hughes et al., 2011). The tree threatens both the native flora of Hawaii and the safety and well-being of residents by crowding out native species, such as ʻōhiʻa lehua (*Metrosideros polymorpha*), and facilitating the growth of other invasive species, such as strawberry guava (*Psidium cattleianum*; Hughes et al., 2011). In addition, *Albizia* in one of the fastest growing trees in the world when it is in Hawaii, growing up to 2.5 cm a day; due to its low wood density and lofty height, in high winds, *Albizia* falls onto roads, powerlines, and buildings (Hughes et al., 2011). In the 2014 Tropical Storm Iselle, for example, much of the $50 million in estimated damage was caused by *Albizia* and similar invasive trees falling on infrastructure (Butler, 2014).

The case of *Albizia* in the Puna District is ideal for exploring the relationship between place attachment and invasive species control for three reasons. First, most of the Puna District residents are aware of *Albizia*'s negative socio-economic impacts due to *Albizia*-related power losses and infrastructure damage incurred during tropical storms. Despite this widespread awareness of the species' impacts, however, only a portion of residents have begun engaging in *Albizia* control behaviors in their community (Niemiec et al., 2016). *Albizia* in Puna thus provides the opportunity to examine factors beyond awareness of the negative impacts of the species that might be related to residents' *Albizia*

Table 1
A summary of independent variables included (and how they are measured); these were hypothesized to influence resident engagement in invasive species control behavior.

Predictor variable	Indicator on survey
Natural place attachment	The green areas here are very special to me (agree/disagree 7-point scale)
	I am attached to the green areas here (agree/disagree 7-point scale)
Civic/social place attachment	I feel connected to this community (agree/disagree 7-point scale)
	I am attached to this community (agree/disagree 7-point scale)
Albizia risk perception	How great of a risk do you believe *Albizia* poses to Hawaii's native plants in your community? (5-point risk scale)
	How great of a risk do you believe *Albizia* poses to residents in your community? (5-point risk scale)
Knowledge on how to control	I have the knowledge to kill an *Albizia* tree safely and effectively (agree/disagree 7-point scale)
Herbicide attitudes	I feel uncomfortable using herbicides (agree/disagree 7-point scale)
Perceived behavioral control	I do not have the money to engage in control (agree/disagree 7-point scale)
	I do not have the time to engage in control (agree/disagree 7-point scale)
Social norms (subjective)	Most people in my community believe that I should take actions to reduce *Albizia* (agree/disagree 7-point scale)
Time on property	How long have you lived on this property?
Income	What was the estimated annual income for your household for 2014? (<$10,000, $10,000–$30,000, $30,001–60,000, $60,001–$90,000, $90,001–$100,000, >$100,001)
Education	What is your highest level of education? (elementary or some high school, high school, associate degree, college degree, graduate degree)
Property ownership	Do you own this property? Y/N
Years on property	How many years have you lived on this property? (years)
Property size	How large is your property? (acres)

control decisions. Second, because *Albizia* causes both social and ecological damage, residents' actions may be motivated by both civic and natural attachments. This case, thus, allows examination of whether, and to what extent, these different forms of attachment may be related to invasive species control. Third, and finally, the Puna District consists of around a dozen housing subdivision communities, which vary in demographics, the presence and activeness of community associations, property size, and vegetation. Therefore, it is possible that, within these diverse communities, residents may have developed different degrees of attachment to the social and natural aspects of their community.

2.2. Survey design

We conducted a survey of residents throughout the Puna District, using various measures of civic and natural place attachment adapted from Scannell and Gifford (2010b) that were originally adapted from Williams and Vaske (2003) (Table 1). These measures ask about residents' connections with their community. We equated "community" with the specific subdivision in which residents live because pilot interviews with residents, conducted in June 2015, indicated that residents view the subdivisions as distinct from each other as well as from other parts of the island. In our survey, we informed participants that any reference to "community" in the survey referred to the subdivision in which they lived. In addition to place attachment items, we also included as covariates numerous demographic measures that have been related to place attachment in previous studies, including whether residents own their property (Brown et al., 2003), residents' length of residence (Knez, 2005), and residents' level of educational attainment (Mesch and Manor, 1998). We also included property size, which may influence neighbor interaction and the visibility of invasive species (Alexander and Lee, 2010).

Because we wanted to examine whether natural and civic place attachment helped explain invasive species control behavior when we controlled for other, more commonly examined predictors, we also incorporated elements of Ajzen's (1991) theory of planned behavior (TPB). The TPB has been used in numerous studies to explain environmental behavior more generally (Bamberg and Möser, 2007), as well as resident engagement in invasive species control behaviors, more specifically (Howell et al., 2014; Hu and Gill, 2015; Prinbeck et al., 2011). The TPB assumes that a person's intentions to engage in a behavior are influenced by his/her: 1) attitudes toward the behavior, defined as his/her like or dislike of the behavior; 2) subjective norms, defined as the extent to which s/he believes others would approve or disapprove of the behavior; and 3) perceived behavioral control, defined as the perceived ease or difficulty of engaging in the behavior (Ajzen, 1991). These variables have been found to be important for understanding citizens' invasive species control behavior. Howell et al. (2014), for example, found that subjective norms were important for explaining bait shop owners' intentions to educate their customers to engage in behaviors to reduce the spread of aquatic invasive species, while perceived behavioral control was important for predicting actual engagement with customers. To measure subjective norms, we included an item about whether others in one's community believe one should be taking action to control *Albizia* (Table 1). To measure behavioral control, we included perceptions of time and funds available for controlling *Albizia*.

We also included as independent variables knowledge of effective control techniques, as well as risk perceptions related to the social and ecological impacts of *Albizia* (Table 1); previous studies have found these independent variables to be important for understanding citizens' actions toward invasive species (Aslan et al., 2009; Estevez et al., 2015). We included a question about attitudes toward herbicides, given that the most effective *Albizia* control technique requires the use of the herbicide, Milestone ® (Hughes et al., 2011). Concerns over the potential negative impacts of herbicides on the environment and human health have been identified as a key barrier to engaging citizens in invasive species control efforts (Estevez et al., 2015). A variety of other perceptions related to invasive species control were also measured on the survey (described in Niemiec et al., 2016), but were not used in this study and, as such, are not reported in this paper. All perceptions were measured on a seven-point Likert-type scale, with the exception of risk perceptions, which were measured on a 5-point risk scale (Table 1).

As our dependent variables, we included various measures of residents' self-reported *Albizia* control behaviors. These included: killing *Albizia* on their own property; killing *Albizia* elsewhere in the community (such as along roads or in neighbors' property); contacting neighbors to convince them to control *Albizia*; teaching neighbors how to kill *Albizia*; or organizing efforts with neighbors to kill *Albizia* throughout the community. All dependent variables were measured as a count of the number of times an individual had ever engaged in the behavior (0, 1, 2, ≥ 3 times).

In addition, to add depth and nuance to the survey findings regarding how residents' place attachment may relate to *Albizia* control, we conducted semi-structured interviews with residents. During interviews, we asked residents about their reasons for moving to the area, what three words they would use to describe where they lived, and the perceived motivations and/or barriers to engaging in efforts to combat *Albizia* (Appendix). Our interview questions were developed based on pilot interviews with conservation practitioners and community leaders as well as mixed method studies on place attachment and environmental behavior (Ardoin, 2014). Interviews were transcribed verbatim. We analyzed interviews by coding sections of the interviews in which residents mentioned feeling connected with, or disconnected from, the residents or natural areas in their community. After calculating the results from our regression analyses, we also developed emergent codes, related specifically to natural place attachment, which are described in further detail in the appendix and qualitative results section of this paper.

2.3. Participant recruitment

We collected survey responses by recruiting residents in person at a variety of locations and community events in the Puna District. We used purposive sampling (Teddlie and Yu, 2007),[1] to allow comparison of perceptions of place attachment among residents who were and who were not highly involved in *Albizia* control. Our sampling involved recruiting residents from events where we would find residents who were highly engaged in *Albizia* control and locations where we would likely find some residents who were not as engaged. Those locations included grocery stores, hardware stores, farmer's markets, and gas stations; the events included *Albizia* control workshops run by the Big Island Invasive Species Committee, a project of the University of Hawaii, and community association meetings. We also used purposive sampling to recruit residents for follow-up interviews after they completed the survey; specifically, we selected interview participants from among the population of residents who had and had not engaged in high levels of *Albizia* behavior, as indicated on surveys. We approached individuals between the hours of 7:30 am and 7:30 pm during 22 separate recruitment events between June 11 and July 25, 2015.

2.4. Surveyed population

We distributed paper surveys or links to the online Web-based survey to 1048 people and received 285 responses from the Puna area, representing a response rate of 27%. This response rate is similar to other studies examining resident engagement in conservation behaviors on private lands (Aslan et al., 2009; Hu and Gill, 2015). These responses were completed by mail (72%), in person (8%), or online (19%). A small proportion (11%) of respondents reported receiving the

[1] Described in greater detail in Niemiec et al. (2016).

survey from a friend, neighbor, or family member, while 83% reported being recruited in person by a researcher. We conducted supplementary interviews with a total of 17 residents. Of the initiated surveys, 7 respondents were missing all or all but one of the measured independent variables shown in Table 1. We removed those respondents from the analysis, resulting in a total of 278 surveys for analysis.

Before we ran any analyses, we created the following independent variables as an average of two factors (Table 1): We measured civic place attachment as the average of the two questionnaire items: "I feel connected to my community" and "I am attached to my community" (Cronbach's Alpha = 0.79); natural place attachment as the average of the two metrics: "The green areas here are very special to me" and "I am attached to the green areas here" (Cronbach's Alpha = 0.83); risk as the average of the risk posed by *Albizia* to both biodiversity and community safety (Cronbach's Alpha = 0.72); and perceived behavioral control as the average of perceptions of lack of time and lack of money for engaging (Cronbach's Alpha = 0.73).

Additionally, before we ran analyses, we examined the distribution of each of the five dependent variables. Nearly all (90%) of the 42% of participants who had *Albizia* on their property had attempted to control it at least once, so we removed this dependent variable from analysis due to the small variation in responses. Over half (52%) of those surveyed had attempted to remove *Albizia* from somewhere in their community at least once before; 23% had removed *Albizia* three or more times. Fewer than half (31%) of the residents had attempted to convince a neighbor to engage in *Albizia* control, and only 9% had tried to convince a neighbor three or more times. Thirty percent of residents reported having taught a neighbor how to engage in *Albizia* control. Residents reported organizing efforts with their neighbors the least often; 76% of residents had never organized with their neighbors to combat *Albizia*, and only 4% had organized three times or more.

Surveyed residents had slightly lower median income than the general population; the median income reported by respondents was between $10,000 and $30,000, compared to $33,993 overall in the Puna District (US Census Bureau, American Community Survey, 2009–2013). Residents were slightly more educated and older than the general Puna population: 38% of surveyed respondents reported having a bachelor's or graduate degree compared to 22% of Puna residents. The median age of respondents was 54, compared to 41 in the Puna District overall.

Residents generally reported high perceptions of natural and civic place attachment: 56% of those surveyed averaged a "6" (moderately agree) or higher for the civic place attachment scale, and 73% averaged a "6" (moderately agree) or higher for the natural place attachment scale. Only 4.6% of those surveyed slightly, moderately, or strongly disagreed with the natural attachment statements, compared to 8.4% for the civic attachment statements. Because of the high degree of skewness for both natural (skewness = −1.36) and civic (skewness = −1.024) place attachment, we ran regression analyses both with and without those variables transformed into a three-point scale based on the 25th and 75th percentiles to reduce skewness. For natural attachment, we assigned those respondents with an average of <5.5 (or disagree to somewhat agree) a "1", those with an average of 5.5–6.5 (moderately agree) a "2", and those with an average of "7" (strongly agree) a "3". For civic attachment, we assigned those respondents with an average of <5 (or disagree to neither agree nor disagree) a "1", those with an average of 5–6.5 (slightly to moderately agree) a "2", and those with an average of "7" (strongly agree) a "3".

2.5. Analysis

To examine the extent to which civic and natural place attachment related to various *Albizia* control behavior behaviors, we first examined correlations among all independent variables to check for collinearity. We used Spearman's rank correlation coefficients because we were examining correlations between ordinal, not continuous, variables. We then ran a Poisson regression analysis predicting to each of the dependent variables, using all independent variables from Table 1. Poisson regression analysis was used because each of our dependent variables was a count of the number of times a resident had engaged in a behavior, with many (48–76%) of the respondents indicating that they had never engaged in the behavior (Coxe et al., 2009). Coxe et al. (2009) discusses how Poisson regression analysis avoids the problems posed by OLS regression when using count variables with a low mean, as is true for our *Albizia* behavior metrics. Furthermore, the mean and variance were similar for all of our dependent variables, which is a key assumption of Poisson regression (mean "removing *Albizia*" = 1.151, variance "removing *Albizia*" = 1.249; mean "teach neighbor" = 0.515, variance "teach neighbors" = 0.887; mean "convince neighbor" = 0.619, variance "convince neighbor" = 1.020; mean "organized efforts" = 0.396, variance "organized efforts" = 0.803).

We first ran our analysis with onlyfull cases (n = 187-190). To conduct a sensitivity analysis of the robustness of our results, we also repeated our analysis using multiple imputation techniques to account for missing data (Sterne et al., 2009). Multiple imputation has been found to result in less-biased results compared to listwise deletion and mean replacement and has been advocated for in recent behavioral science research (Boudet et al., 2014). Multiple imputation allows for uncertainty in missing data to be considered. It does this by creating multiple copies of the dataset with missing values replaced as different plausible values sampled from the distribution of the observed data (Sterne et al., 2009). Generalized linear models can then be run by averaging together estimated associations from the various imputed datasets. We implemented multiple imputation using the "mi" package in R, using the default of 30 iterations and 4 chains (Gelman and Hill, 2011). For multiple imputation, the number of missing values imputed in the 278 respondents ranged from 3 (for the "risk" variable) to 49 (for "income"). Our natural attachment variable included 17 missing values, and the community attachment variable included 16 missing values.

3. Results

3.1. Correlation and Poisson regression analyses

In the correlation analysis, we found that civic place attachment was positively correlated with natural place attachment ($r_s = 0.489$), subjective norms ($r_s = 0.200$), years on property ($r_s = 0.175$), and knowledge ($r_s = 0.183$). We found that natural place attachment was weakly correlated with years on property ($r_s = 0.157$) and property size ($r_s = 0.144$).

When we included risk perceptions, elements of the theory of planned behavior, and demographics in a Poisson regression model, in addition to place attachment metrics, civic attachment emerged as a significant (p = 0.020) and positive predictor of removing *Albizia*, but not of any behaviors that involved engaging with neighbors (Table 2). Natural attachment emerged as a significant negative predictor (p = 0.035) of removing *Albizia* in the community and organizing efforts with neighbors (p = 0.016; Table 2). Knowledge emerged as a significant predictor of all four behaviors, risk perceptions emerged as a significant predictor of all behaviors except teaching a neighbor, and subjective norms emerged as a significant predictor of teaching a neighbor, convincing a neighbor, and organizing efforts with neighbors (Table 2). Education was important for teaching and convincing a neighbor, while property size was important for organizing efforts with neighbors (Table 2). The Pearson Goodness of Fit test for our Poisson regression model of removing *Albizia* was insignificant (p = 0.096), indicating that the model was a good fit to the data.

For the model of removing *Albizia*, addition of place attachment metrics improved the pseudo-R2 from 0.149 to 0.159. Transforming the place attachment metrics to a three point scale to reduce skewness, and running the model with multiple imputation led to similar overall key findings for the removing *Albizia* model, with slightly different

Table 2
Estimated coefficients and standard errors of various predictors influencing resident *Albizia* behavior using Poisson regression with complete cases. Bolded values indicate that that coefficients are significantly associated with the outcome variable.

	Removed *Albizia* in community	Convince a neighbor to control *Albizia*	Teach a neighbor how to control *Albizia*	Organize efforts with neighbors to combat *Albizia*
Collective risk	**0.250** (**0.091**)**	**0.553** (**0.156**)**	0.285 (0.148)	**0.768** (**0.197**)**
Lack of behavioral control	−0.042 (0.044)	0.049 (0.064)	−0.054 (0.064)	−0.057 (0.071)
Civic attachment	**0.163** (**0.070**)*	0.004 (0.097)	−0.104 (0.10)	0.129 (0.126)
Natural attachment	**−0.148** (**0.070**)*	0.215 (0.131)	−0.034 (0.121)	**−0.312** (**0.130**)*
Knowledge of control tactics	**0.242** (**0.042**)**	**0.170** (**0.054**)**	**0.464** (**0.079**)**	**0.395** (**0.079**)**
Herbicide attitude	0.045 (0.032)	−0.079 (0.045)	0.005 (0.046)	0.044 (0.051)
Subjective norms	0.067 (0.043)	**0.139** (**0.066**)*	**0.220** (**0.070**)**	**0.165** (**0.079**)*
Years on property	0.004 (0.007)	0.006 (0.010)	0.019 (0.011)	0.013 (0.012)
Own property	0.192 (0.186)	−0.456 (0.253)	−0.371 (0.264)	−0.145 (0.303)
Education	−0.107 (0.067)	**0.212** (**0.095**)*	**0.237** (**0.100**)*	−0.023 (0.112)
Income	−0.051 (0.064)	0.046 (0.091)	−0.185 (0.104)	−0.096 (0.111)
Property size	−0.013 (0.014)	0.010 (0.010)	0.005 (0.011)	**0.028** (**0.010**)**
N	189	187	188	190
Pseudo R2	0.159	0.171	0.24	0.218

* $p < 0.05$.
** $p < 0.01$.

coefficients (Table A1; Table A2). Natural place attachment was no longer a significant predictor of organizing efforts with neighbors when the place attachment metric was transformed to a three point scale or when multiple imputation was used (Table A1; Table A2).

3.2. Qualitative evidence on the negative relationship between natural place attachment and control behavior

Given our surprising finding that natural place attachment was a negative predictor of removing *Albizia*, we further explored these results through our interviews (see Appendix for additional information on analysis). The interview data suggested that some residents appeared to have become attached to the *Albizia* itself as part of the biophysical landscape; this attachment to *Albizia* as part of the "green areas" of the landscape may have influenced a reluctance to engage in removal efforts.

When we asked residents to describe what they liked about their neighborhood, many residents discussed how they liked that their neighborhood was "green," "lush," and felt like a "jungle." Because *Albizia* forms thick, green canopies, residents reported that *Albizia* contributed to this feeling of living in a lush, tropical area. Many residents referred to one grove of *Albizia* trees in particular to which they had become attached; this grove of *Albizia* trees formed a tree tunnel over a main road through the Puna district, immediately next to the local Lava Tree State Monument. Residents described the tree tunnel as "beautiful" and "magical," noting that it was an iconic location in the Puna District. One resident, when discussing that particular grove of *Albizia* trees, said:

> "Yeah and that was a real pretty drive and stuff as long as you weren't aware that those were 20 year old *Albizia* trees. You thought it was an ancient rain forest."

Several residents spoke about how strong attachments to this particular grove of *Albizia* trees actually led to behavior against controlling *Albizia* before the 2014 tropical storm in which *Albizia* caused widespread damage:

> "That wonderful tree tunnel that was…you know, the one that took out the powerlines, they tried to cut some of those down in the past, I guess, but…oh no, 'no save the *Albizia*.' On Oahu, same thing, they held *Albizia* over them; people don't take out those beautiful trees."

While some residents' attachments to *Albizia* appeared to be related to their expectations for a green and lush neighborhood, other residents discussed how they felt attached to *Albizia* because it had always been there or because it served a functional purpose. One resident discussed how he was upset when he heard that many of the *Albizia* in Lava Tree Park had fallen over in the storm because they had always been there "since he was a kid." Others discussed how *Albizia* provide shade during warm days, improve soil quality by fixing nitrogen, and provide certain ecosystem services, such as carbon sequestration.

Yet, despite these emotional connections as well as the potential benefits provided by the tree, it was clear that many of the interviewees were weighing the potential societal risks posed by *Albizia* with their emotional connections to the species. For some, the damage caused by *Albizia* from the 2014 Tropical Storm Iselle appeared to enhance their support of control efforts, despite their emotional attachments. As one resident said:

> "I was saddened when I heard the tree tunnel come down… but, then again, we lost power… they're beautiful but dangerous."

Some residents dealt with this conflict between their emotional connections to and their knowledge of the negative impacts of *Albizia* by taking the stance that *Albizia* should only be managed in areas where it poses a direct threat to human safety. Several residents discussed the need to control the trees along roadsides and near buildings where *Albizia* could pose harm but leave the trees in open fields and forests where the trees did not pose a direct socio-economic threat. One resident said: "They are beautiful trees if they are in the right place." Therefore, stemming in part from these responses, one explanation for the negative relationship between natural attachment and removal behavior is that residents may have become attached to *Albizia* being a part of the biophysical landscape in their community and, as such, may have been reluctant to remove it unless the tree posed a direct threat to human safety.

4. Discussion

Within our data set, we found a positive association between civic attachment and residents' invasive species removal behavior in the community; by contrast, we found a negative association between natural attachment and residents' invasive species removal behavior. The positive relationship between civic attachment and removal behavior supports previous findings in the literature on resident engagement in behaviors to reduce natural hazards. This literature has found that civic attachment is positively predictive of resident engagement in fire hazard mitigation activities in their community (Kyle et al., 2010).

Residents with enhanced civic attachment may be more likely to attend events in which they receive information about a hazard and may be more likely to feel empowered to make a difference in their community (Brenkert-Smith, 2007).

While our findings support previous hazards research, our results are contrary to those of Scannell and Gifford (2010b), who found that natural, but not civic, place attachment positively predicted a range of general pro-environmental behaviors when controlling for the town, length of residence, gender, education, and age. This difference in findings may be due to the types of behaviors examined in our study and other hazards research, compared with Scannell and Gifford's study. *Albizia*, like fire and other natural hazards, poses a significant, direct, and immediate threat to residents' well-being in the community, as was evidenced by the damage caused by Tropical Storm Iselle. Scannell and Gifford (2010b), on the other hand, examined more general environmental behaviors, such as carpooling and recycling, which have a less-obvious impact on the safety and well-being of community residents. It is, therefore, possible that civic attachment may only be a strong motivator for behaviors that reduce significant threats to neighborhood safety and well-being; civic attachment may not be as important for predicting resident engagement in control of invasive or exotic species with less-obvious social impacts than *Albizia*. Future studies may examine how the relative importance of natural compared to civic place attachment may vary based upon threats posed by different invasive species in other systems.

The finding that civic attachment was predictive of removal of invasive species, but not predictive of the behaviors that involved engaging with neighbors, is particularly interesting, given that previous literature has suggested that civic attachment may enhance pro-social behavior via improved relationships between neighbors (Chavis and Wandersman, 1990). Residents with high civic attachment may not be engaging in *Albizia* behavior that involved convincing or teaching their neighbors due to their desire to maintain positive neighborhood relations; in fact, several studies have suggested that, in many rural areas, strong social norms exist against interfering with neighbors' land-management decisions, including invasive species control (Graham, 2013; Ravnborg and Westermann, 2002). Although residents with strong civic attachments may have felt empowered to protect their neighborhood though invasive species control behavior, they may have been reluctant to sour their neighboring relationships by breaking social norms of approaching neighbors about land-management decisions.

Natural attachment emerged as a negative predictor of *Albizia* control behavior, and our qualitative evidence from interviews with residents provided insight into a potential explanation: residents may have become attached to the *Albizia* itself as part of the biophysical landscape. It is possible that the negative relationship between natural attachment and *Albizia* removal could reflect a certain group of residents whose attachments to *Albizia* as part of the local green spaces are holding them back from engaging in *Albizia* control behavior in their community. If this was indeed the case, then simple measures of natural attachment, which refer to the "green" areas in one's community, may not be sufficient for understanding the complex role of natural attachment in invasive species management and biodiversity conservation decisions. Rather, future studies might consider dividing natural attachment into separate measures of attachment to native, exotic, invasive species or other aesthetic aspects of the landscape that people may come to value differently.

Furthermore, our findings suggest a need to examine when, and in what contexts, people come to develop attachments to invasive and exotic species. Qualitative evidence from our study indicates that people's attachments to the *Albizia* may have been influenced by how long the tree had been in their area, the extent to which they believed the tree served a functional purpose, and the extent to which the invader fit within their pre-conceived expectations for their neighborhood. Future studies could examine these various potential pathways as influencing whether residents form an attachment to an exotic or invasive species.

4.1. Study limitations

While this study provides one of the first investigations into the role of place attachment in invasive species control behavior, it has several limitations. First, we examined only two dimensions of place attachment: natural and civic attachment. Studies suggest that place attachment can be further divided into place identity, place dependence, social bonding (including family and friend bonding), and nature bonding (Raymond et al., 2010). A more nuanced investigation into how these different forms of attachment may relate to various forms of invasive species control behavior is needed. Second, our study relied on self-reported behavior; future studies might examine links between residents' perceptions and ecological data on invasive species populations to obtain more accurate measures of the impacts of place attachment on control behavior and conservation outcomes over time.

Third, the prevalence of behaviors and attitudes in our survey population may not be generalizable to the greater Puna population due to our use of purposive sampling and in-person recruitment. These sampling techniques may have favored residents who had strong views about *Albizia* control, were involved in their community, and were comfortable being approached by a stranger in a public location. The strength of this approach, however, was that it allowed us to obtain sufficient numbers of engaged and nonengaged residents, facilitating comparisons of place attachment between these populations. In addition, there are likely cultural, geographic, and social dimensions to the responses of the neighbors in our sample which might limit the generalizability of our findings to other communities; for example, our findings may not apply where there are different cultural views and norms associated with property rights or working with neighbors.

Finally, we only measured *Albizia* behavior and attachment at one spatial scale, the subdivision community. Research suggests that people may take action at the scale at which they feel most connected (Ardoin, 2014); for example, Anton and Lawrence (2015) found that attachment to homes, but not to the local area, predicted residents' engagement in wildlife preparedness behavior on their property. Because invasive species control behavior can take place at many scales, such as the property, community or regional scale, it is possible that different scales of attachment may help motivate different forms of invasive species control behavior.

4.2. Conservation implications

Our findings have implications for practitioners seeking to enhance biodiversity conservation and motivate invasive species control on private lands. First, our findings regarding the negative relationship between natural place attachment and removal behavior suggest that outreach efforts focused on motivating resident engagement in invasive species removal and restoration of native biodiversity may not be effective if people have developed emotional connections to the exotic or invasive species in their community. Rather, people may see the efforts of conservation agencies to remove exotic or invasive species, especially in areas where those species do not pose a direct threat to human safety and well-being, as threatening aspects of place to which they feel connected. Consequently, such actions may reduce trust in and support for conservation agencies. When those connections have formed to invasive or exotic species, conservation agencies may, therefore, benefit from acknowledging people's emotional connections to the invasive species and carefully developing participatory processes for engaging residents in decision-making on where, why, and to what extent the species need to be managed. Such participatory processes may enhance residents' trust in conservation agencies (Munton, 2003), enabling residents to consider various management options despite emotional connections to the detrimental species.

Our findings also suggest that, to enhance biodiversity and combat invasive species on private lands, conservation agencies may benefit from taking action to prevent such connections to exotic or invasive

species from forming in the first place. In our study, many of the people with emotional connections to *Albizia* mentioned that the tree had been widespread in their community since they moved there; thus, the tree was symbolic of their community. It is possible, then, that the longer an invader persists in an area, the more likely that people will become attached to it, especially if the invader's socio-economic impacts are not obvious. These findings emphasize the importance of initiating outreach and control efforts before an invasive species becomes widespread, facilitating attachments. Furthermore, if an invader is already widespread, then our findings emphasize the importance of targeting specific outreach and education for residents who have moved to the area after the invader has become widespread and, as such, they do not have a conception of and connection to the biophysical landscape before the invader arrived. Conservation agencies could help facilitate the formation of community groups that provide new residents with information on the exotic and invasive species in their neighborhood. In this way, new residents may immediately come to see the species as a threat to, rather than a part of, the valued aspects of their place.

Our finding that civic place attachment is a positive predictor of control efforts suggests that conservation agencies may benefit from fostering social connections among residents. Enhanced social connections may empower residents to engage in invasive species control efforts to improve their community, particularly when invasive species have negative socio-economic, as well ecological, impacts. Conservation agencies might consider holding outreach and educational events in community centers, where neighbors are likely to meet one another, and encourage discussion among residents, possibly over meals or other events. Furthermore, conservation agencies could organize workdays and action support groups to enhance social bonding and social support among residents engaging in invasive species and biodiversity conservation behaviors in their community (Staats et al., 2004).

While such efforts to enhance civic attachment may increase resident engagement in removal behavior in their community, our findings suggest that such social bonding may not necessarily lead to enhanced resident engagement in approaching other neighbors about their biodiversity conservation decisions. This lack of relationship between civic attachment and behavior that involves engaging with neighbors may be a result of residents' fear of souring their relationships with their neighbors. Interventions focused on enhancing social connections may therefore have to be coupled with interventions that change norms around approaching neighbors about land management decisions. Ravnborg and Westermann (2002), for example, discuss how, in order to change norms around approaching neighbors, one community group in southwestern Columbia ran community meetings in which they provided biological explanations for the need for farmers to coordinate their control efforts of the crop-damaging leaf-cutter ants (*Atta cephalotes*). The group also started a competition in which residents received points for convincing a neighbor to undertake control efforts; together, such activities provided residents with justification for approaching neighbors about land-management decisions.

In conclusion, we suggest that residents' emotional connections to both natural and civic aspects of place are important for understanding resident engagement in invasive species control efforts. We suggest that biodiversity conservation organizations may benefit from carefully considering the ways in which their messages and outreach efforts may interact with emotional connections to exotic and invasive species and various dimensions of place attachment. Invasive species control programs may be most effective in achieving conservation objectives if design takes into account the range of connections that people may have with their places where species invade.

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Appendix A. Supplementary data

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