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## Original research article

# Social challenges of spatial planning for outdoor cat management in Amami Oshima Island, Japan



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## HIGHLIGHTS

- We assessed residents' attitudes toward outdoor cats and the management across areas.
- Forest was least preferred as a cat habitat among the three areas.
- Lethal options was unacceptable, whereas trapping and adoption was acceptable in all areas.
- The attitudinal differences were found between the cat-owners and non-owners.

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## ABSTRACT

Outdoor cats pose substantial threats to native biodiversity, especially on islands. However, cats also provide benefits to people, such as companionship and the killing of pests. Thus, management of outdoor cats is controversial and can lead to conflicts among stakeholders. Although previous studies have examined stakeholders' preferences for outdoor cats and their management, little is known about the differences in their attitudes toward cat occurrences and management across habitats. Identifying these attitudinal differences would provide useful knowledge for policy makers about zoning management. We conducted structured interviews with residents in Amami Oshima Island, Japan, to evaluate the residents' attitudes to outdoor cats' occurrence and their management across habitats (Forest, Rural, and Town areas). Furthermore, we compared the attitudes of cat-owners and non-owners. The results show that the Forest was least preferred as an outdoor cat habitat. Lethal options as a management strategy were unacceptable to the residents, whereas adoption was acceptable in all areas. Cat-owners showed a significantly higher acceptance toward outdoor cats in Town and Rural areas than did non-owners; they also showed a lower acceptance of lethal options and a higher acceptance toward Trap, Neuter and Return (TNR) than non-owners. These findings imply that it is difficult to achieve consensus regarding outdoor cat management, especially in town and rural areas; however, outdoor cats from these areas move to the forests and pose a threat to the endangered species. Communication efforts with both cat-owners and non-owners should fill these attitudinal gaps among stakeholders and lead to effective management.

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## 1. Introduction

Outdoor cats (*Felis catus*), including all feral/stray cats and free-roaming owned cats, are a significant challenge to biodiversity conservation efforts worldwide (Lepczyk et al., 2004; Lohr and Lepczyk, 2014; Wald and Jacobson, 2013). One of the most serious issues is the predation of native species, which is done by cats not only in the wilderness but also in urban and rural areas. For example, May and Norton (1996) and Nogales and Medina (1996) have shown that native species are the primary food source for feral cats in the forest areas of Australia and Spain. In the UK, one cat killed 21 prey animals in two months, including five mammal and 10 bird species in urban areas (Baker et al., 2005). Lepczyk et al. (2004) have pointed out that outdoor cats are responsible for the predation of birds in rural areas, even when the population density of cats is low. They also mentioned that outdoor cats kill numerous bird species in both rural and urban areas. As a result, outdoor cats are now regarded as one of the most dangerous invasive species (Lowe et al., 2000). Particularly on islands where there are no predators, such as carnivorous mammals, and within an enclosed space, cats can cause serious disruption the ecosystem. Studies have shown that outdoor cats had a negative impact on at least 175 wildlife species in 120 islands (Bonnaud et al., 2011; Medina et al., 2011). For example, in New Zealand, it is estimated that over 16 million animals are killed each year by cats (Medina et al., 2011). About ten petrel species have gone extinct worldwide because of cats (Derenne and Mougou, 1976). It is necessary to implement management strategies, such as lethal options, for outdoor cats, to conserve biodiversity and restore native ecosystems (Bester et al., 2002). Previous studies have reported that native ecosystems and populations of endemic species (e.g., petrel species) have recovered after the elimination of outdoor cats (Bester et al., 2002; Hughes et al., 2008; Ratcliffe et al., 2009).

In addition to the above-mentioned issues, outdoor cats have a substantial negative impact on human living. For example, cats transmit diseases not only to livestock but also to people (Tenter, 2009; Torrey et al., 2007). Outdoor cats are a nuisance in urban neighborhoods because they depredate yards, cause trouble to pets, and deface property (Toukhsati et al., 2012).

On the other hand, cats are one of the most popular companion animals worldwide and have several positive roles in human lifestyles (Hall et al., 2016). Cats comfort people, and interactions with cats, including outdoor ones, relieve people from stress and improve human health (Brickel, 1979; Siegel, 1990; Wood et al., 2007). Wald et al. (2013) have reported that cats provide significant benefits to humans; they kill mice and other pests, thus reducing the risk of disease spread. As a result, many people tend to have a positive feeling about cats. In addition, pet cats provide their owners with opportunities to build social connections among themselves (Brickel, 1979; Siegel, 1990; Wood et al., 2007), and to helping children learn about responsibilities (Melson, 2003; O'Haire, 2010, 2013).

Therefore, in order to promote biodiversity conservation by managing outdoor cat populations, it is important to consider the positive and negative aspects involved; otherwise, it could pose conservation conflicts among stakeholders (Stokes et al., 2006). Area-specific, tailor-made outdoor cat management strategies should be developed, considering the ecological aspects as well as sociological situations. For instance, in New Zealand, lethal control of cats is a common approach to conserve island ecosystems (Bloomer and Bester, 1992). By contrast, Trap-Neuter-Return strategy (hereafter, "TNR") is often used in the United States (Levy et al., 2003; Loyd and Miller, 2010). Trapping and adoption of outdoor cats (i.e., finding new cat owners after live-capturing outdoor cats; hereafter, "adoption") is a common approach to conserve sea birds in Ogasawara and Teuri Islands in Japan. The ecology of cats in an area can be affected by the human behavior and customs of the place (Gramza et al., 2016; Shionosaki et al., 2016); for example, Shionosaki et al. (2016) indicated that feeding outdoor cats can change their actions and habitats in Amami Oshima Island; thus, it is necessary to obtain public support for managing outdoor cats and attitudinal gaps for the successful conservation of biodiversity.

Taking into account awareness of the aforementioned issues, some previous studies have investigated public attitudes toward cats and their management. Loyd and Miller (2010) showed that people living in rural areas preferred lethal options when compared to people living in urban areas, and women were less accepting of the lethal option than men. There have been many studies that involve comparisons between cat-owners and non-owners. Hall et al. (2016) and Thomas et al. (2012) evaluated the public attitude with respect to cats' interactions with wildlife. Their results showed that non-owners tended to affirm that pet cats were problematic if they killed wildlife species, something that the cat-owners generally did not agree with. Levy et al. (2003) investigated the proportion of people who fed free-roaming cats; they reported that about three-quarters of people fed outdoor cats and half of those that fed free-roaming cats were non-owners. Dabritz et al. (2006), Lepczyk et al. (2004), and Wald et al. (2013) found that cat-owners preferred TNR more than did non-owners. Cat-owners also tended to have a more negative opinion regarding the introduction of regulations on how to keep cats, especially people living in rural areas (Calver et al., 2007; Lord, 2008). However, very little attention has been paid to public attitudes about managing outdoor cats in different habitats.

The purpose of this study was to understand residents' preferences for management of outdoor cats in Amami Oshima Island, Japan. This island is a biodiversity hotspot; there are more than one thousand endemic species in the Amami Islands, including Amami rabbits (*Pentalagus furnessi*), which are listed as "Endangered" on the IUCN Red List of Threatened Species (Amami Oshima Island, 2015; Yamada and Sugimura, 2008). Moreover, there are no predators or carnivorous mammals in Amami Oshima Island, excluding alien species. The Japanese government will register the island as a national park in 2017 and aims for it to obtain the status of a World Natural Heritage Site in the future (Ministry of the Environment, 2016). However, so far, outdoor cats have threatened the endemic species, especially in the forest areas, and undermine the native biodiversity. Shionosaki et al. (2015) showed that cats were predators of Amami rabbits and Amami spiny rats, both endangered endemic species. Furthermore, it has been estimated by the Ministry of the Environment (2016) that there



**Fig. 1.** Example of negative and positive impact of outdoor cats in Amami Oshima Island. (a) Negative impact, outdoor cats that live in the forest are predators of wildlife. (b) Negative impact, outdoor cats cause trouble in the Town and Rural neighborhoods. (c) Positive impact, people enjoy watching outdoor cats. (d) Positive impact, our quality of life and tourist's experience are made better by cats, especially for cat lovers.

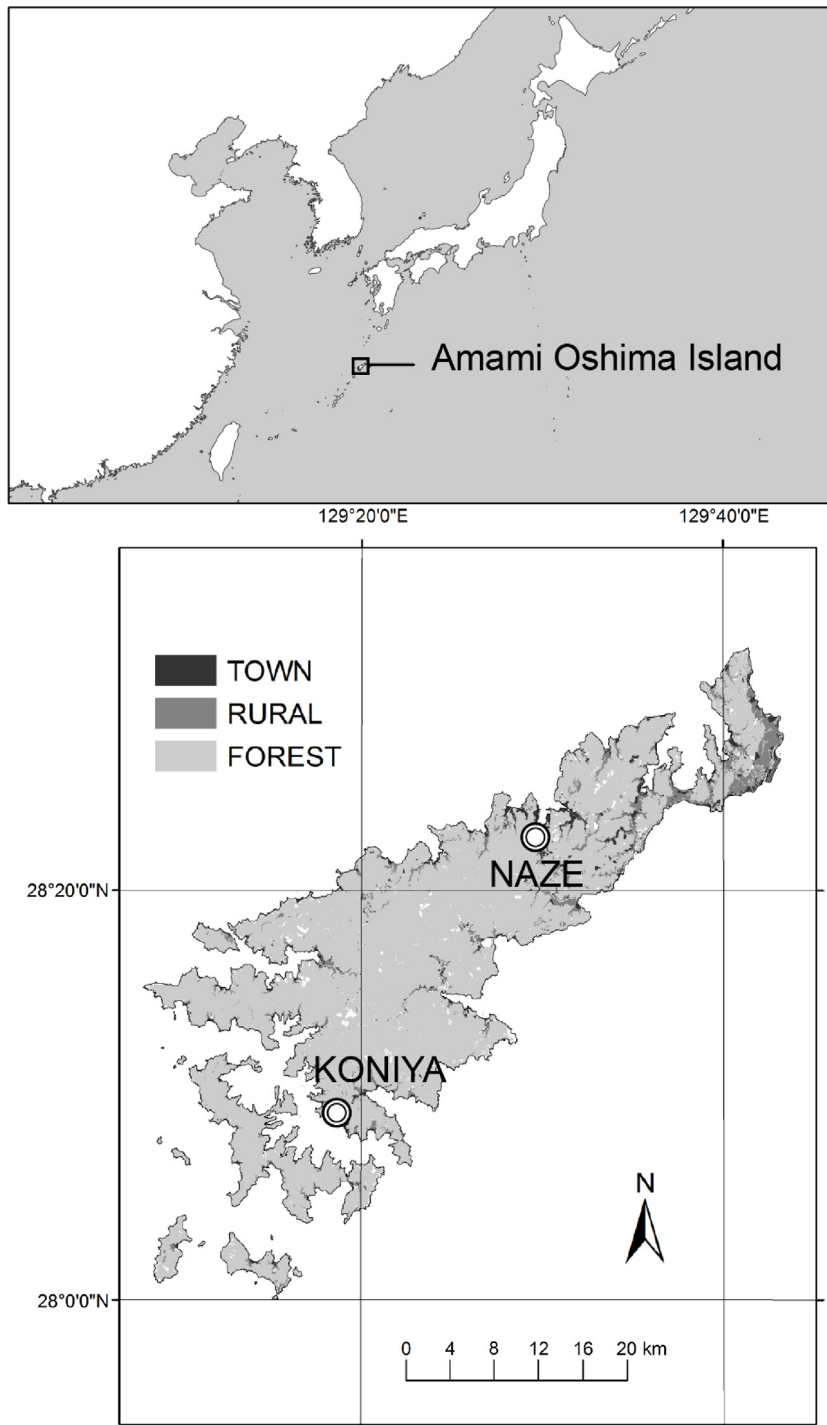
are about 600–1200 outdoor cats roaming the forest areas. Therefore, the ministry and local governments are considering proposed management options (adoption, TNR, and/or lethal options) for cats. However, some residents feel comfortable with outdoor cats because they hunt rats in the crop fields and keep away venomous snakes from residential areas. This might result in an increase in the population of outdoor cats. However, cats also have a negative impact on both biodiversity and the lives of residents. For instance, the smell of excrement, sounds in the mating season, and scavenging in garbage cans leave residents uncomfortable with outdoor cats. Therefore, it is necessary to study the residents' attitudes toward outdoor cats in order to manage them successfully on the island. This is particularly important because residents can perceive a variety of merits and demerits about cats (see examples in Fig. 1), and a uniform management strategy conducted everywhere is unrealistic, even within the island. Understanding the attitudinal differences among areas can help the decision makers devise appropriate management strategies and lead to successful zoning management, while respecting the residents' opinions. As described above, public behaviors and attitudes are important parts of the ecology of outdoor cats. Therefore, it is necessary to understand the local residents' attitudes toward outdoor cats to devise a successful management strategy. To promote consensus building among the stakeholders, we also compare the attitudes of cat-owners and non-owners, based on previous findings.

## 2. Materials and methods

### 2.1. Study context and location

Amami Oshima Island is a part of the Nansei Islands in southern Japan (28°19' N, 128°22' E; Fig. 2). It is the fifth-largest island in Japan (712 km<sup>2</sup>) and has approximately 86% forest cover (hereafter, "Forest"). The number of residents on the island is about 70,000 (Japan Censuses, 2010), who mainly live in two areas: Naze area (37,000 people) and Koniya area (5,000 people). In this paper, we refer to both these areas as "Town". In addition, there are many small villages along the coast and near the Forest (hereafter, "Rural"). For this island, three management options were considered: TNR, adoption, and lethal options. In 2015, when we conducted the survey, the local governments conducted TNR for outdoor cats, and the other two options were rarely implemented. As outdoor cats in the Forest can come from Town and Rural areas, the other two options have also been suggested for implementation.

We conducted face-to-face structured interviews with the residents using a questionnaire (Appendix 1). Our questionnaire mainly comprised questions concerning three aspects: residents' attitudes toward the occurrence of outdoor cats, their attitude toward management options (adoption, TNR, and lethal options), and individual characteristics, including experience of owning cats. Regarding the former two aspects, respondents were asked their preferences by three areas:



**Fig. 2.** Location of Japan and Amami Oshima Island, Map of Amami Oshima Island, the study site.

Forest, Rural, and Town areas, using 5-point Likert-scale questions (from 1: strongly disagree, to 5: strongly agree; see the details in Appendix 2).

To understand the regional differences in attitude toward cat occurrence and management strategies, we carried out a one-way ANOVA with Tukey's HSD test. Bartlett's test was used to check if there were any differences in the variance of data. In addition, similar to previous studies (e.g., [Hall et al., 2016](#); [Levy et al., 2003](#); [Dabritz et al., 2006](#)), we compared the attitude

**Table 1**  
Socio-demographic characteristics of respondents

Variable	Rate of respondents: This study		Population of Amami in 2010 <sup>a</sup>	
	<i>n</i>	Rate (%)	Rate (%)	
Gender	Male	38	46.3	47.8
	Female	40	48.8	52.2
	Unknown	4	4.9	–
Age	15–19	4	4.9	4.9
	20–29	7	8.5	7.5
	30–39	8	9.8	13.0
	40–49	9	11.0	13.8
	50–59	14	17.1	19.8
	60–69	18	22.0	15.4
	70–79	11	13.4	14.7
	80–89	5	6.1	10.9
	Unknown	6	7.3	–
Residence	Town	47	57.3	85.1
	Rural	35	42.7	14.9

<sup>a</sup> 2010 Japan Census.

**Table 2**  
Rate of respondents' experience of owning cats

Variable	<i>n</i>	Rate (%)	
Experience of keeping cats	Owning cats now	19	23.2
	Used to own cats	26	31.7
	Have never owned cats	37	45.1

between cat-owners and non-owners. This was done by carrying out an unpaired *t*-test with the *F*-test, assuming that there were no differences in variance. All the analyses were carried out on the 5-point Likert-scale data obtained in response to the questionnaire. The analyses were carried out using R (Version 0.99.447 and the standard equipment packages therein; R Core Team, 2016).

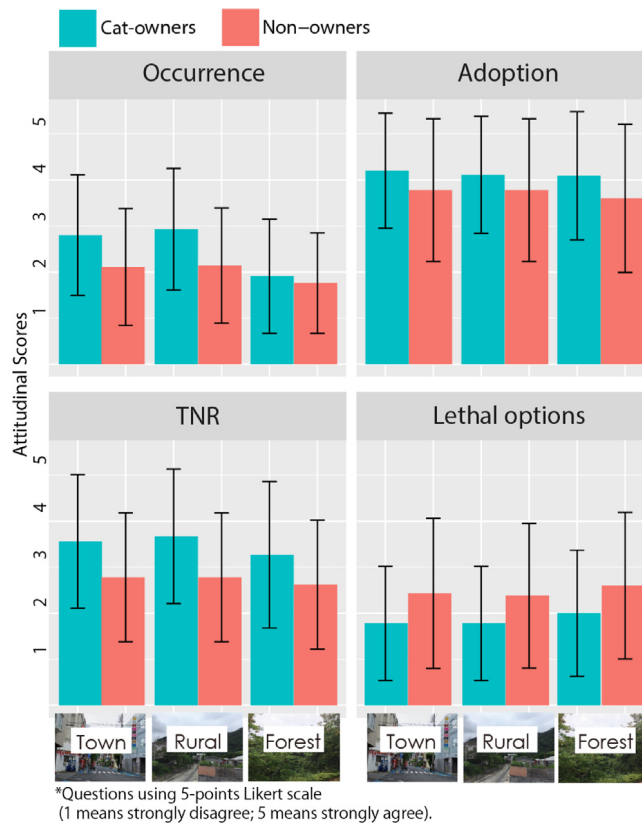
## 2.2. Sampling and data

The structured interviews were conducted with Amami Oshima residents in 2015. We recruited participants using stratified sampling for place of residence. We collected 82 completed responses from the local respondents; Table 1 shows their socio-demographic characteristics. Of the respondents, 60–70 years was the most common age group (22%), followed by 50–60 years. Males comprised about half of the respondents. Over a half of the respondents lived in the Town area (57%), whereas the others lived in the Rural area. In terms of the experience of owning cats, about one-third of the respondents were owners in the past, and about one-quarter owned cats at the time of survey. As a result, about half the respondents had experience of taking care of cats (Table 2). Thus, in this paper, we refer to respondents who had such experience as “cat-owners” and the others as “non-owners”.

## 3. Results

Table 3 shows the average attitudinal scores toward occurrence of outdoor cats, as well as the attitudinal differences between cat-owners and non-owners. According to the results of the one-way ANOVA, these average scores were significantly different by areas ( $F = 7.98$ ,  $df = 2$ ,  $p < 0.01$ ). The residents expressed a more negative attitude toward outdoor cats in the Forest area (mean = 1.84, SD = 1.17) than in the Town (mean = 2.488, SD = 1.33) and Rural areas (mean = 2.77, SD = 1.34), although there was no significant difference between the Town and Rural areas (Table 3). In the other words, Table 3 shows that, on average, residents less preferred cat occurrence in Forest compared with the other areas. In addition, there were differences between cat-owners and non-owners regarding their attitudes toward outdoor cats. The cat-owners showed attitudinal differences between the Forest and the other areas, whereas the non-owners had no area-wise differences. The cat-owners expressed a more positive attitude toward outdoor cats in the Town (mean = 2.80, SD = 1.31) and Rural areas (mean = 2.93, SD = 1.32) than in the Forest (mean = 1.91, SD = 1.24). As shown in Fig. 3, there were significant attitudinal differences toward cat occurrence between cat-owners and non-owners in the Town and Rural areas, i.e., cat-owners showed a higher acceptance of outdoor cats than did non-cat owners (Town:  $t$ -value = 2.43,  $df = 77.9$ ,  $p$ -value = 0.02; Rural:  $t$ -value = 2.80,  $df = 78.4$ ,  $p$ -value < 0.01; Forest:  $t$ -value = 0.60,  $df = 79.6$ ,  $p$ -value = 0.55).

Table 4 shows the average attitudinal scores toward each management strategy and their comparison between cat-owners and non-owners. There were no significant differences in the preference for each form of management among the areas (adoption:  $F = 0.22$ ,  $df = 2$ ,  $p = 0.80$ ; TNR:  $F = 0.87$ ,  $df = 2$ ,  $p = 0.42$ ; lethal options:  $F = 0.56$ ,  $df = 2$ ,  $p = 0.57$ ).



**Fig. 3.** Comparison of average attitudinal scores with respect to preferences for outdoor cat occurrence and management strategies between cat and non-cat owners across areas. These graphs show average attitudinal scores with respect to preferences for outdoor cat occurrence and management strategies between cat-owners and non-owners. Data was obtained using 5-point Likert scale (1: strongly disagree–5: strongly agree) and significant differences (values of mean and Tukey’s HSD test) are presented in Tables 3 and 4.

**Table 3**

The attitudinal differences in preferences for outdoor cat occurrence between cat-owners and non-owners across areas. The figure shows mean ( $\pm$ SD) of the preferences for outdoor cat occurrence based on 5-point Likert scale (1: strongly disagree–5: strongly agree).

The classification of respondents	Town	Rural	Forest	$H_0$ : No attitudinal difference in the preferences for outdoor cat occurrence across areas
All respondents	2.49(1.33) <sup>a</sup>	2.57(1.34) <sup>a</sup>	1.84(1.17) <sup>b</sup>	p-value < 0.01
Cat-owners respondents	2.80(1.31)	2.93(1.32)	1.91(1.24)	p-value <0.01
Non-owners respondents	2.11(1.27)	2.14(1.25)	1.76(1.09)	p-value = 0.33
$H_0$ : No attitudinal difference in the preferences for outdoor cat occurrence between cat-owners and non-owners	p-value = 0.02	p-value < 0.01	p-value = 0.55	

<sup>a–b</sup>: Items used to develop the attitudinal scores and results of ANOVA to test for differences between respondents, using Tukey’s HSD test, indicating differences among the management options,  $p < 0.05$ ; values followed by the same letter are not significantly different.

However, there were significant multivariate differences among the management strategies ( $F = 95.69, df = 2, p < 0.01$ ). Adoption was the most supported management strategy among the three options (mean = 3.95, SD = 1.43), whereas lethal control was the least supported strategy (mean = 2.13, SD = 1.46). Overall, 70% of the respondents preferred adoption, followed by TNR (42%) and lethal control (21%). The majority of respondents preferred the adoption strategy across all areas.

In all areas, the adoption of outdoor cats was the most desired management option, and lethal control was the least desired option among both cat-owners and non-owners (Table 4). Both cat-owners and non-owners preferred adoption, followed by TNR and lethal control; however, there are differences between them with respect to accepting TNR. That is, cat-owners preferred TNR as well as adoption in the Town and Rural areas; non-owners preferred neither TNR nor lethal control in all areas (see Appendix 2 for details). We also compared the preferences of cat-owners and non-owners using a  $t$ -test. Table 4 shows that there were no significant attitudinal differences toward adoption between cat-owners and non-owners across all areas (Town:  $t$ -value = 1.32,  $df = 68.9, p$ -value = 0.19; Rural:  $t$ -value = 1.03,  $df = 69.3, p$ -value = 0.31; Forest:  $t$ -value =

**Table 4**

The attitudinal differences in preferences for outdoor cat management strategies between cat-owners and non-owners across areas. The figure shows mean ( $\pm$ SD) of the preferences for outdoor cat management strategies based on 5-point Likert scale (1: strongly disagree–5: strongly agree).

Management options	The classification of respondents	Town	Rural	Forest	$H_0$ : No attitudinal difference in the preference for outdoor cat management strategies across areas
Adoption	ALL	4.01 <sup>a</sup> (1.40)	3.96 <sup>a</sup> (1.40)	3.87 <sup>a</sup> (1.50)	p-value = 0.80
	Cat-owners	4.20 <sup>a</sup> (1.25)	4.11 <sup>a</sup> (1.27)	4.09 <sup>a</sup> (1.39)	p-value = 0.91
	Non-owners	3.78 <sup>a</sup> (1.55)	3.78 <sup>a</sup> (1.55)	3.60 <sup>a</sup> (1.61)	p-value = 0.84
$H_0$ : No attitudinal difference in the preference for adoption between cat-owners and non-owners		p-value = 0.19	p-value = 0.31	p-value = 0.55	
TNR	ALL	3.21 <sup>b</sup> (1.47)	3.27 <sup>b</sup> (1.49)	2.98 <sup>b</sup> (1.53)	p-value = 0.42
	Cat-owners	3.56 <sup>b</sup> (1.45)	3.67 <sup>b</sup> (1.46)	3.27 <sup>b</sup> (1.59)	p-value = 0.43
	Non-owners	2.78 <sup>b</sup> (1.40)	2.78 <sup>b</sup> (1.40)	2.62 <sup>b</sup> (1.40)	p-value = 0.85
$H_0$ : No attitudinal difference in the preference for TNR between cat-owners and non-owners		p-value = 0.02	p-value < 0.01	p-value = 0.05	
Lethal options	ALL	2.07 <sup>c</sup> (1.46)	2.05 <sup>c</sup> (1.42)	2.62 <sup>c</sup> (1.40)	p-value = 0.57
	Cat-owners	1.78 <sup>c</sup> (1.24)	1.78 <sup>c</sup> (1.24)	2.00 <sup>c</sup> (1.37)	p-value = 0.64
	Non-owners	2.43 <sup>b</sup> (1.63)	2.38 <sup>b</sup> (1.57)	2.60 <sup>b</sup> (1.59)	p-value = 0.83
$H_0$ : No attitudinal difference in the preference for culling between cat-owners and non-owners		p-value = 0.05	p-value = 0.06	p-value = 0.08	

<sup>a–c</sup>: Items used to develop the attitudinal scores and results of ANOVA to test for differences between respondents, using Tukey's HSD test, indicating differences among the management options,  $p < 0.05$ ; values followed by the same letter are not significantly different.

1.48,  $df = 71.4$ ,  $p$ -value = 0.14). However, the attitudinal scores toward TNR and lethal options were significantly different between cat-owners and non-owners. Cat-owners had a significantly higher acceptance toward TNR in the Rural area than did non-owners ( $t$ -value = 2.79,  $df = 78.1$ ,  $p < 0.01$ ); they also had a lower acceptance toward lethal options in the Town area than did the non-owners ( $t$ -value =  $-2.014$ ,  $df = 66.3$ ,  $p = 0.05$ ). Fig. 3 summarizes the attitudinal differences between cat-owners and non-owners.

#### 4. Discussion

Outdoor cats are being increasingly recognized as a threat to biodiversity, especially on islands. As residents are key parts of their ecology, it is essential to obtain public support in order to carry out effective management of cats. Most previous studies have dealt with the ecology of outdoor cats exclusively with respect to their natural environment, overlooking the human aspects. The present study focused on the attitudinal differences toward cat occurrence and management strategies across cat habitats. The results should help decision makers understand the challenges in conducting effective management (e.g., zoning management), while taking into account the preferences of stakeholders.

On average, residents were more averse to cat occurrence in the Forest than in the other areas (Table 3). This implies that residents supported the elimination of cats from the Forest areas that have substantial endemic and endangered species. In other words, their perceived benefits of cats in the Town and Rural areas were higher than in the Forest. This indicates that cats, even outdoor ones, are important companion animals and pets for people. However, the kind of impact that they have on residents seems different across areas. For example, people might feel comfortable with outdoor cats when they inhabit spaces in their neighborhood, whereas, they might perceive fewer benefits of cats when they live away from the residential areas (i.e., the Forest). This is in contrast to the public's attitude toward large carnivores. For example, people show "Not-In-My-Back-Yard" (NIMBY) attitudes toward bears (e.g. Balčiauskas and Kazlauskas, 2012; Kubo and Shoji, 2014).

Furthermore, the residents showed less acceptance of outdoor cats in the Forest. This suggests that they agree with the need to eliminate cats from the Forest. Since most stakeholders enjoyed seeing cats (Lohr and Lepczyk, 2014) and forming an attachment with them in seeking companionship, and as a method of pest control, the residents were more accepting of outdoor cats in the Town and Rural areas. Although Hall et al. (2016) have indicated that Japanese people, especially those living in urban areas, regard outdoor cats as harmless to wildlife anywhere, the people who have interactions with nature, such as island residents, may be aware of the negative impact of outdoor cats on ecosystems (May and Norton, 1996; Nogales and Medina, 1996). In addition, cats on Amami Oshima have been known to prey on endangered animals (Shionosaki et al.,



2015), and publicity about these findings may have increased awareness among local residents about the ecological impacts of outdoor cats.

Furthermore, these attitudinal differences toward cat occurrence across areas were more apparent for cat-owners than for non-owners. This indicates that the benefits of having cats, such as developing companionship with them or using them to control pests, were recognized at a substantially higher level by cat-owners than non-owners. Cat-owners were also more attached to cats and worried about the implications of management on owned cats because their personal experience of owning cats made it difficult for them to extrapolate to the predatory nature of cats having an impact on wildlife. These findings support the government proposition in which outdoor cats in the Forest would primarily be eliminated; however, owned cats can go from the owners' homes and hunt endangered species (Beckerman et al., 2007; Loss et al., 2013). Thus, we need some measures to persuade cat-owners to keep the cats within their homes, especially on islands, because the impact of owned cats could be extensive.

We found that the residents' preferences for cat management did not differ across areas, which is different from the findings on cat occurrence (Table 4). Interestingly, lethal control was not accepted as an option even in the Forest, where acceptance of cat occurrence was relatively low. In all three areas, the residents preferred non-lethal management of outdoor cats: adoption was the most supported strategy, and lethal control was the least preferred option. This could be due to religious background, because Japanese people generally are less accepting of the taking of life, even of invasive species, than are people in countries, such as New Zealand and Australia, which conduct the lethal management of outdoor cats (Nogales et al., 2004). Our findings implied attitudinal differences concerning the non-lethal options for outdoor cats between Japan and other countries. However, we also found differences in the preference for cat management between cat-owners and non-owners. In particular, it is interesting that the non-owners had a more negative attitude toward TNR than did the cat-owners. Since the non-owners do not accept cat occurrence in Town and Rural areas, they do not prefer the TNR option of returning the cats to their habitats. Considering that TNR is encouraged in Town and Rural areas in the Amami Oshima Island, the government administrators need to talk with non-owners, with the aim of filling the gap between non-owners' preferences and the current policies. Communication with non-owners about the cats' potential habitat range can help them to understand the current policies. On the other hand, cat-owners had a low acceptance of lethal options and a high support for TNR. This implies that cat-owners preferred that the outdoor cats remain on the island. Therefore, using TNR could cause a conflict between cat-owners and non-owners in the Town and Rural areas. Since previous studies (e.g. Dabritz et al., 2006; Lohr and Lepczyk, 2014; Wald and Jacobson, 2013) have also pointed that TNR can cause conflicts among stakeholders, it is important to include the cat-owners and non-owners in the decision-making process, for the effective management of outdoor cats. Although adoption was the most supported option among both cat-owners and non-owners, it could be unrealistic considering the budget and human resource constraints. Thus, it is necessary to manage both these gaps: between the preferences for management and the current policies, and between cat-owners and non-owners' preferences for lethal options and TNR. Finally, we highlight the potential challenges to effective cat management in the island. To conserve native biodiversity, it is necessary to eliminate outdoor cats, at least in the Forest. Since attitudes toward cat occurrence differed between the Forest area and others, we conclude that residents agree upon the implementation of zoning management and elimination of outdoor cats in the Forest; however, their preferences for the management strategies were not consistent with their preferences for cat occurrence in each area. It is necessary to spread awareness about the advantages and roles of each management strategy in order to make the residents understand and accept the management decisions. We also note the attitudinal differences between stakeholders living on the same island. As the perceived impact of outdoor cats are different across areas, it is important to undertake communication efforts with the residents. Furthermore, to consider the outdoor cat management, understanding risk perceptions for outdoor cats and wildlife is important (Gramza et al., 2016; Wald and Jacobson, 2013). Since there could be conflicts over the management in both the Town and Rural areas, showing information about the risk of outdoor cats is essential. We believe that communication with the stakeholders, including those who do not have direct interaction with cats, should help fill the attitudinal gaps and foster effective biodiversity conservation.

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## Appendix A. Supplementary data

Supplementary material related to this article can be found online at <http://dx.doi.org/10.1016/j.gecco.2017.03.007>.

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