How Can Protected Area Managers Deal with Nonnative Species in an Era of Climate Change?

Authors: Ohsawa, Takafumi, and Jones, Thomas Edward

Source: Natural Areas Journal, 37(2) : 240-253

Published By: Natural Areas Association

URL: https://doi.org/10.3375/043.037.0213

CONSERVATION ISSUES

How Can Protected Area Managers Deal with Nonnative Species in an Era of Climate Change?

Takafumi Ohsawa[1,3,4]

[1]School for Resource and Environmental Studies
Dalhousie University
Halifax, NS, Canada B3H 4R2

Thomas Edward Jones[2]

[2]Graduate School of Governance Studies
Meiji University, TA Jimbocho Building
Research Laboratory 501
1-1 Kanda-Surugadai, Chiyoda-ku
Tokyo, Japan 101-8301

[3] Corresponding author: aa56258@hotmail.co.jp

[4] Current address: Nature Conservation Bureau, Ministry of the Environment, Japan, Kasumigaseki 1-2-2, Chiyoda-ku, Tokyo, Japan, 100-8975

Natural Areas Journal 37:240–253

ABSTRACT: Protected areas have been established under the premise of static distribution of different ecosystems and species, but this assumption is becoming invalid due to climate change. Under non-static conditions, some adaptable nonnative species will enter into protected areas, while some native species will no longer be able to sustain ecological functions. In this case, it is a challenge to determine if species that expand their distribution due to climate change (climate-induced species) should be regarded as "alien species" and be removed or not. We approached the challenge of how to treat climate-induced species in protected areas by conducting a literature survey together with a case study in the largest terrestrial national park in Japan (Daisetsuzan National Park). According to both surveys, there is considerable difference in the attitudes of researchers and practitioners. Practitioners tend to think that climate-induced species should be removed only if they are harmful and realistically removable. Continued discussion on climate-induced species is needed to develop and implement a consistent response.

Index terms: adaptation, alien species, climate change, climate-induced species, protected areas

INTRODUCTION

The latest report by the Intergovernmental Panel on Climate Change (IPCC 2013) documented that the mean temperature of earth's surface increased by 0.89 °C between 1901 and 2012. Furthermore, the temperature may increase by 1.0 °C (95% CI, 0.3–1.7 °C) or 3.7 °C (95% CI, 2.6–4.8 °C) by 2081–2100 in comparison with 1986–2005 under the Representative Concentration Pathway (RCP) 2.6 or 8.5 scenarios, respectively (IPCC 2013). A number of studies have reported that climate change has negatively impacted forest plant species, with the associated elevation in mortality and declining reproduction leading to regional decline and dieback events (Allen 2009; Jump et al. 2009). Furthermore, climate change may influence the genetic structure of each species such as the distribution of genetic variations along elevational gradients (Ohsawa and Ide 2008). Considering its serious impacts at the species and genetic levels, many researchers have called for immediate action against climate change (e.g., Stern 2006). Such researchers have commonly placed protected areas at the core of climate-change adaptation measures (Hannah et al. 2002; Mawdsley et al. 2009; MacKinnon et al. 2011).

Protected areas were established under the premise of static distribution of different ecosystems and species, but this assumption is no longer valid due to the shifting of species distribution under changing climates (Scott et al. 2002; Suffling and Scott 2002; Lemieux and Scott 2005; Reid 2006; Thomas and Gillingham 2015). This is relevant to many nature conservation approaches. For instance, a director of the US National Park Service pointed out the potential necessity of changing their conventional policy related to species intruding from outside of national parks, because species that migrate due to climate change might not be able to find alternative habitats for their survival (Kunzig 2012). Such species are not native species at the park level, though they might need to be protected in the parks to avoid species' extinction. To tackle this new issue, there are four possible options for protected areas: (1) static management that maintains the current goals and management; (2) passive management (a laissez faire approach) that accepts some changes as a result of climate change; (3) adaptive management to climate change involving mitigation measures to minimize changes resulting from climate change; and (4) hybrid management that is a combination of (1) and (3) (Suffling and Scott 2002; Scott and Lemieux 2005). These researchers also proposed that the third option—adaptive management—is the most effective and efficient, and is, thus, a prudent way to protect biotic legacies. Fire suppression and assisted migration (species translocation to safe sites) are also examples of the third option (Suffling and Scott 2002).

Assisted migration could allow some species threatened by climate change to survive in new habitats, but such efforts could possibly alter species compositions within protected areas. Hagerman et al. (2010) collected general opinions about this issue at the World Conservation Congress (WCC) in 2008 and found great variation in views among attendees. For instance, some participants were supportive of conducting experiments in assisted migration, while others were dismissive due to the latent potential for unexpected and irreversible changes (Hagerman et al. 2010). Hajjar et al. (2014) collected opinions (acceptance/rejection) from the general public and forest community leaders about six reforestation strategies for adapting to climate change in western Canada. However, many respondents changed their opinions when they were informed about the positive or negative consequences of the strategies on forests and forest-dependent communities. Thus, Hajjar et al. (2014) concluded that the opinions collected by the study varied widely depending on the outcomes (of the strategies) that each respondent had imagined.

Likewise, unassisted migration due to climate change may allow some species to survive. Such "climate-induced species" that independently expand their range due to climate change represent a new challenge for protected areas. The focus of this article, "climate-induced species," are nonnative species that fall into four categories: (1) those that are "regionally" nonnative and (i) disperse into the protected area of interest because of climate change or (ii) move into the area due to non-climatic mechanisms; (2) species that are native to the greater area or region and (i) move into the (adjacent) protected area due to climate change or (ii) move into the area due to non-climatic mechanisms. Herein, our article focuses on the nonnative species of type (2)(i).

The term "climate-induced species" has been used by a few previous studies as complex adjectives. For instance, Munasinghe and Swart (2005) used the term "climate-induced species loss," and Walther (2010) used the expression "climate-induced species' range shifts." Nonetheless, there has been no globally used noun that specifically refers to such species, and there is much room to discuss how to treat such species. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) was supposed to assess impacts of "species native to a region that are shifting in range due to environmental change, including climate change" (i.e., climate-induced species) in its thematic assessment of invasive alien species and their control by 2019 (IPBES 2015). However, it was decided in the fourth session of the plenary of the IPBES (IPBES-4) in February 2016 that this assessment would be undertaken, subject to its funding availability (IISD 2016). In other words, the issue of climate-induced species might not be addressed by the IPBES over the next few years.

To address how protected area managers can deal with climate-induced species, we need to consider a few relevant points. First, we should consider if climate-induced species should be regarded as "alien species" at the protected area level. Second, even if such species are considered "alien," should they be eradicated or otherwise managed? We could address this issue by considering the positive and negative impacts of such species under climate change. In this article, we approached the new challenge by addressing these questions. We conducted a literature survey and carried out a case study in Daisetsuzan, the largest terrestrial national park in Japan (2268 km^2).

Located in Hokkaido, the northernmost of the four Japanese main islands (at around 43–44°N), the Daisetsuzan park hosts alpine and sub-boreal ecosystems (JME 2009). These ecosystems are vulnerable to climate change because the resident species include a mix of the following: species that indeed require cold and snowy (moist) conditions; species that are competitive in such conditions; and species whose natural range includes such conditions (Kudo 2014). A questionnaire survey was conducted on park rangers and park volunteer members in May 2014, during their annual general meeting. Forty-three Park Volunteer (PV) staff members (41% of all registered PVs) as well as three park rangers (50% of all the rangers) responded to the survey. Herein, we present a few key findings from the survey along with conceptual work on the suggested questions. We also provided details of our case study in an online Appendix. Knapp et al. (2014) reported that stakeholders' ideas and observations about climate change were significantly different among several types of stakeholders (e.g., subsistence users vs. scientists) in Denali National Park in Alaska, suggesting that consulting not only scientists but also local people who have lived there for a long time should be crucial for climate adaptation planning. Hence, in focusing on volunteers who have substantial experience in the park we investigated (1) differences in their opinions about the issue of climate-induced species and (2) the most feasible adaptation options to climate change at the protected area level.

Climate-Induced Species and Alien Species

Even though climate-induced species are nonnative with respect to the protected areas the species move into, it is still unclear if such species should be regarded as "alien species" or not. This question is important, as the concept of alien species typically entails negative associations. Alien species are defined as those species that are artificially introduced and extant, and alien species that threaten biodiversity are known as "invasive alien species" (Mack et al. 2000; Westphal et al. 2008). In support of this, the Convention on Biological Diversity (CBD) defined invasive alien species as those "whose introduction and/or spread threaten biological diversity" (SCBD 2002). Historically, according to "the tens rule," around 10% of the species introduced to new sites can establish their populations, and 10% of the established species can be pests (i.e., harmful to native species) (Williamson and Fitter 1996). According to recent studies, alien species can be categorized into casual alien species, naturalized species, and invasive (alien) species, depending on where the species lies on the "introduction–naturalization–invasion continuum" (Richardson et al. 2000; Richardson and Pyšek 2012). Thus, alien species have been notorious, given that some of them could become invasive alien species with significant impacts on native species such as competition and hybridization between alien and native species (Pyšek and Richardson 2010). Controlling invasive alien species is now one of the Aichi Biodiversity Targets according to the CBD. Some countries have already targeted them with or without legal regulations (Ohsawa and Osawa 2014). Besides, ecosystem functions have recently been reinterpreted as "ecosystem services," which contribute to human well-being or aspects of the ecosystem that are valued by humans (Harrison et al. 2014). Typical examples of such services are provisioning services (e.g., timber production), regulating services (e.g., water flow regulation), and cultural services (e.g., landscape aesthetics). These services are usually considered to be hampered by some alien species (Vilà et al. 2009; Harrison et al. 2014).

Theoretically, current climate change is the indirect result of anthropogenic activities such as burning fossil fuels and deforestation (Karl and Trenberth 2003; IPCC 2013), but not an artificial activity per se. Thus, some may think that climate-induced species are alien species, whereas others may not. Moreover, public skepticism remains regarding the idea that modern climate change has been caused by human activities (e.g., as described by Poortinga et al. 2011). In short, people's views on climate-induced species are highly diverse.

Some entities and previous studies have briefly mentioned a relationship between climate-induced species and alien species. The Standing Committee of the Convention on the Conservation of European Wildlife and Natural Habitats recommended not to consider "native species naturally extending their range in response to climate change" when interpreting the term "alien species" (COE 2009). This recommendation was made in consideration of the purpose of the implementation of the European Strategy on Invasive Alien Species (COE 2009). Because of this recommendation, the Strategy did not conflict with climate change–induced migration (Trouwborst 2012). Similarly, the new EU Regulation No. 1143/2014 applies to "all invasive alien species" but not to "species changing their natural range without human intervention, in response to changing ecological conditions and climate change" (EU 2014; Trouwborst et al. 2015). Yet, it is noteworthy that the same regulation explicitly states that "the risks such species pose may intensify due to increased global trade, transport, tourism, and climate change," where "such species" refers to invasive alien species (EU 2014). As mentioned before, the director of the US National Park Service stated that, according to their conventional policy, species coming from outside of national parks due to climate change may be regarded as exotic species (Kunzig 2012). Trouwborst (2012, 2014) mentioned that distinguishing artificial hybridization and natural hybridization is difficult, particularly when climate-induced species hybridize with native species (e.g., hybridization between African long-legged buzzard and native European common buzzards in southern Europe).

To verify the supposition that there is no single position or viewpoint that is supported by a majority of conservation practitioners, we posed the issue to experts in Daisetsuzan National Park in Japan. More than half of the respondents considered climate-induced species to be "alien species," though nearly 40% of the respondents thought the opposite. Therefore, neither of the ideas presented by the COE (2009) or Kunzig (2012) was strongly supported by our respondents. In addition, it is noteworthy that one respondent commented that climate-induced species should be regarded as alien species "for the time being," which is consistent with the relative concepts of alien versus native species both in time and space (Warren 2007).

Positive and Negative Impacts of Climate-Induced Species

Ascertaining how to manage nature during climate change should be based on information from not only the natural sciences but also the social sciences, including cultural, economic, and historical perspectives (Kueffer 2014). In particular, identifying positive and negative values associated with new species is still highly ambiguous. As mentioned before, negative impacts of nonnative species on native ones have been documented by a number of studies. Yet, new species might become important components in new ecosystems under a changing climate, possibly sustaining ecological functions and landscape beauty. For instance, according to a questionnaire survey conducted by Bardsley and Edwards-Jones (2007), erosion control was acknowledged as one of the positive impacts of exotic plant species in the Mediterranean islands. Considering the overwhelmingly rapid nature of change, approaches other than simple restoration of the historically dominant species (Hobbs et al. 2011) are required for the management of protected areas. In other words, it could be necessary to make good use of some new adaptable species in order to maintain the functions and services of ecosystems. According to "intervention ecology," some new species can be regarded as important components in new climates (Hobbs et al. 2011).

However, overemphasizing the benefits of ecosystem services for human beings (e.g., food and timber production) has led to the degradation of nature (Kareiva et al. 2007). In addition, we cannot ignore the history of preexisting natural environments even when considering such new approaches (Keenleyside et al. 2012). From the perspective of social science, people who are emotionally attached to landscapes may want to preserve them (Walker and Ryan 2008) and this attachment could also be applied in terms of native species. In other words, climate-induced species may not be welcomed by such people who are not familiar with the new species.

Even at the genetic level, introgressive hybridization between climate-induced species and other related species (e.g., congeneric species) may occur due to global changes including climate change (Krosby et al. 2015). Such hybridization is now considered to have both positive and negative impacts. It might spread adaptive genes from one species to another and possibly create novel hybrid species that show high fitness under global changes (Brennan et al. 2015). In contrast, the hybridization could result in genetic disturbances together with maladapted hybrids (Brennan et al. 2015). As such, new ecosystem components are a "double-edged sword" and it is something of a challenge to determine how to harmonize old and new ecosystem components (i.e., keeping original species' compositions vs. maintaining ecological functions and services).

How to Deal with Climate-Induced Species?

If we want to minimize the negative impacts of certain species, we may simply try to remove them as much as possible. Attitudes toward the removal and control of nonnative species, without considering climate change, have been previously investigated. For instance, in Doñana National Park in Spain, 60% of general tourists agreed with the introduction of nonnative species that are economically or recreationally beneficial, while nature tourists, as well as conservation professional groups, fervently disagreed (García-Llorente et al. 2008). In contrast, almost all respondents, regardless of stakeholder type, stated that harmful nonnative species should be eradicated. Meanwhile, a minority (8%) of the respondents to the survey by Bardsley and Edwards-Jones (2007) in some Mediterranean islands did not accept the necessity of management or control of exotic species. Furthermore, according to another survey in Belgium, 26% of nature reserve managers stated that failure to control invasive alien species would not threaten nature and natural areas (Vanderhoeven et al. 2011).

Compared with these previous studies, our survey in Daisetsuzan found a low frequency of responses supporting the removal of climate-induced species and a high frequency of answers respecting the introduction of such species. This result is partly because some respondents believed that climate-induced species were not "alien." Consequently, 63% of such respondents chose to respect natural changes that occur under changing climates. However, even the 23% of respondents who did regard such species as "alien" chose the same option, allowing the introduction of new species. One such respondent commented that even armed with the knowledge that they are alien, it would be impossible to remove such species.

Furthermore, our survey offered six specific species/vegetation examples to ask if respondents thought that they should be removed or not. We then found considerable variation in the responses depending on the species/vegetation (Appendix). For example, almost all respondents replied that beech would not need to be removed, whereas most of the respondents chose to remove cockroaches. Even though both species are native to adjacent areas south of Daisetsuzan, how does such a discrepancy occur? According to the survey in Doñana (García-Llorente et al. 2008), species that were introduced less recently were more likely to be regarded as native species. In addition, the survey by Bardsley and Edwards-Jones (2007) reported that a majority of respondents stated that native species for each island included not only species from the same island but also from anywhere in the Mediterranean. As such, many alien species were believed to be native by the general public (Davis et al. 2011). Therefore, even though certain species have arrived from elsewhere as a result of artificial factors, they may still be regarded as native species if they are from the same region or were introduced further in the past. Furthermore, Davis et al. (2011) and Shackelford et al. (2013) proposed that impact assessments of new species, including both positive and negative effects, should be conducted to decide whether a species should be removed. In light of these studies, whether climate-induced species should be removed or allowed to colonize may be judged based not only on their original distribution but also on the period of time since their introduction, as well as on a balance between their positive and negative influences and values. In terms of the introduction–naturalization–invasion continuum (Richardson et al. 2000; Richardson and Pyšek 2012), introduction of climate-induced species may be accepted, unless these species are reaching the final stage of the continuum, the invasion stage. However, the term "introduction" implies the active involvement of humans, whereas climate-induced species were not brought by humans directly. Hence, we should use other words instead, such as migration, when referring to climate-induced species. Thus, although most of our respondents may not have been familiar with the idea of the continuum, the species whose immigration was supported by many respondents (e.g., the beech) were probably considered to be casual alien species or naturalized species, but not invasive alien species.

Moreover, removal of large or aesthetically valuable nonnative species is weakly supported by the public, according to previous studies (as reviewed by Bremner and Park 2007). Thus, opinions about the presence of climate-induced species may also be affected by the general perception of certain species (Gutrich et al. 2005; Davis et al. 2011).

If some climate-induced species are beneficial rather than harmful, we may want to introduce and harness such species in protected areas. According to Hannah (2008), assisted migration and/or *ex situ* protection (e.g., captive breeding) are helpful methods when climate change is so rapid that protected areas alone cannot address the negative influences on wild species. According to Thomas and Gillingham (2015), in the United Kingdom, the United States, and China, a few species (butterfly and plant species) were actually translocated to higher altitudes or latitudes. Canada also began addressing the issue of habitat connectivity to allow species to migrate under changing climates (Nantel et al. 2014; protection of Chignecto Isthmus as well as the Ontario Ministry of Natural Resources' 50 Million Tree program in Ontario). Moreover, in Alberta, another Canadian province, seed transfer zones were extended by up to 200 m in altitude and up to 2° north latitude, while British Columbia also allowed sseed/seedling transfers to shift upward by 200 m (Nantel et al. 2014). Shoo et al. (2013) proposed a decision-making process for prioritizing vulnerable species and measures to protect them. In their process, assisted migration at a genetic level has also been proposed as "genetic assisted colonization," where certain genetic materials (e.g., adaptive genes for a new climate) are introduced to wild populations artificially (Shoo et al. 2013).

CONCLUSIONS

This article combines a theoretical and practical platform—including the technical term of climate-induced species—for discussing how protected area managers can deal with new species that expand their range due to climate change. A literature survey together with the case study revealed various ideas around this issue. For instance, there is not complete agreement as to whether climate-induced species should be regarded as "alien species." Making management decisions involving these species is relatively difficult, as our study revealed considerable variation in the respondents' attitudes, even within a single protected area. We will need to continue these discussions about climate-induced species to develop and implement a consistent response to climate change. Particularly, the use of coherent terminology in relevant concepts, such as climate-induced species, will be crucial to develop the discussion.

However, among the four approaches suggested by Suffling and Scott (2002) and Scott and Lemieux (2005), the first approach—static management that maintains conventional goals—and to a lesser degree the second approach—passive management—were favored by our respondents over the adaptive management to climate change recommended by Suffling and Scott (2002) and Scott and Lemieux (2005). Leaders in forest communities in western Canada supported the idea of planting seedlings of local lineages but not of more interventional approaches (e.g., planting genetically modified seedlings that are adapted to new climates) or passive management (Hajjar et al. 2014). We will not only need conceptual or theoretical frameworks, but also practitioners' experience in order to tackle the ongoing challenges associated with climate change.

ACKNOWLEDGMENTS

We are grateful for the collaboration of the Park Volunteers of Daisetsuzan National Park as well as a supporting park ranger, Ms. Tomoko Okubo. In addition, Nakagawa Wood Industry Co., Ltd., kindly allowed us to use their tree illustration. We highly appreciate the constructive comments of the Chief Editor as well as Associate Editor of the journal on earlier drafts of the manuscript. The views and opinions expressed in this article solely represent those of the authors and do not represent the views of any organization.

Takafumi Ohsawa majored in forest ecology and genetics in the undergraduate and graduate programs at the University of Tokyo. Subsequently, he joined the Japanese Ministry of the Environment and was mainly engaged in the issues of nature conservation. He was also dispatched from the Ministry to Dalhousie University to study issues of climate change mitigation and adaptation for two years. Currently, he works for the Ministry again, being involved in several global issues of nature conservation including the Convention on Biological Diversity.

Tom E. Jones is Associate Professor at Meiji University's Graduate School of Governance Studies in Tokyo, where he lectures on environmental policy. Originally from the UK, Jones completed a PhD in Forest Science at the University of Tokyo in 2010 before working as a researcher for a regional NGO in Matsumoto at the foot of the Japan Alps. His research interests include nature-based tourism, place branding, and regional revitalization. Field work experience includes stakeholder interviews and visitor surveys, particularly in and around the Japan Alps and Mount Fuji regions.

LITERATURE CITED

Allen, C.D. 2009. Climate-induced forest die-back: An escalating global phenomenon? Unasylva 231/232 60(1-2):43-49.

Bardsley, D.K., and G. Edwards-Jones. 2007. Invasive species policy and climate change: Social perceptions of environmental change in the Mediterranean. Environmental Science and Policy 10:230-242.

Bremner, A., and K. Park. 2007. Public attitudes to the management of invasive non-native species in Scotland. Biological Conservation 139:306-314.

Brennan, A.C., G. Woodward, O. Seehausen, V. Muñoz-Fuentes, C. Moritz, A. Guelmami, R.J. Abbott, and P. Edelaar. 2015. Hybridization due to changing species distributions: Adding problems or solutions to conservation of biodiversity during global change? Evolutionary Ecology Research 16:475-491.

[COE] Council of Europe. 2009. Recommendation No. 142 (2009) of the Standing Committee, adopted on 26 November 2009, interpreting the CBD definition of invasive alien species to take into account climate change. <https://wcd.coe.int/ViewDoc.jsp?id=1560527&Site=>.

[EU] European Union. 2014. Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species. <http://eur-lex.europa.eu/eli/reg/2014/1143/oj>.

Davis, M.A., M.K. Chew, R.J. Hobbs, A.E. Lugo, J.J. Ewel, G.J. Vermeij, J.H. Brown, M.L. Rosenzweig, M.R. Gardener, S.P. Carroll, K. Thompson, et al. 2011. Don't judge species on their origins. Nature 474:153-154.

García-Llorente, M., B. Martín-López, J.A. González, P. Alcorlo, and C. Montes. 2008. Social perceptions of the impacts and benefits of invasive alien species: Implications for management. Biological Conservation 141:2969-2983.

Gutrich, J., D. Donovan, M. Finucane, W. Focht, F. Hitzhusen, S. Manopimoke, D. McCauley, B. Norton, P. Sabatier, J. Salzman, and V. Sasmitawidjaja. 2005. Science in the public process of ecosystem management: Lessons from Hawaii, Southeast Asia, Africa and the US Mainland. Journal of Environmental Management 76:197-209.

Hagerman, S., T. Satterfield, and H. Dowlatabadi. 2010. Climate change impacts, conservation and protected values: Understanding promotion, ambivalence and resistance to policy change at the World Conservation Congress. Conservation and Society 8:298-311.

Hajjar, R., E. McGuigan, M. Moshofsky, and R.A. Kozak. 2014. Opinions on strategies for forest adaptation to future climate conditions in western Canada: Surveys of the general public and leaders of forest-dependent communities. Canadian Journal of Forest Research 44:1525-1533.

Hannah, L. 2008. Protected areas and climate change. Annals of the New York Academy of Sciences 1134:201-212.

Hannah, L., G.F. Midgley, T. Lovejoy, W.J. Bond, M.L.J.C. Bush, J.C. Lovett, D. Scott, and F.I. Woodward. 2002. Conservation of biodiversity in a changing climate. Conservation Biology 16:264-268.

Harrison, P.A., P.M. Berry, G. Simpson, J.R. Haslett, M. Blicharska, M. Bucur, R. Dunford, B. Egoh, M. Garcia-Llorente, N. Geamănă, W. Geertsema, et al. 2014. Linkages between biodiversity attributes and ecosystem services: A systematic review. Ecosystem Services 9:191-203.

Hobbs, R.J., L.M. Hallett, P.R. Ehrlich, and H.A. Mooney. 2011. Intervention ecology: Applying ecological science in the twenty-first century. BioScience 61:442-450.

[IISD] International Institute of Sustainable Development. 2016. IPBES-4 Highlights 20–28 February 2016, Kuala Lumpur, Malaysia. <http://www.iisd.ca/vol31/enb3129e.html>.

[IPBES] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. 2015. Scoping for a thematic assessment of invasive alien species and their control (deliverable 3 (b) (ii)). <http://www.ipbes.net/images/documents/plenary/fourth/working/4_10/IPBES-4-10_EN.pdf>.

[IPCC] Intergovernmental Panel on Climate Change. 2013. Climate Change 2013: The Physical Science Basis. <http://www.ipcc.ch/report/ar5/wg1/#.UlAmTj2CjIU>.

[JME] Japanese Ministry of the Environment. 2009. Daisetsuzan National Park. <http://hokkaido.env.go.jp/nature/mat/park/en/daisetsu/all.pdf>.

Jump, A.S., C. Mátyás, and J. Peñuelas. 2009. The altitude-for-latitude disparity in the range retractions of woody species. Trends in Ecology and Evolution 24:694-701.

Kareiva, P., S. Watts, R. McDonald, and T. Boucher. 2007. Domesticated nature: Shaping landscapes and ecosystems for human welfare. Science 316:1866-1869.

Karl, T.R., and K.E. Trenberth. 2003. Modern global climate change. Science 302:1719-1723.

Keenleyside, K., N. Dudley, S. Cairns, C. Hall, and S. Stolton. 2012. Ecological Restoration for Protected Areas: Principles, Guidelines and Best Practices. IUCN, Gland, Switzerland.

Knapp, C.N., F.S. Chapin III, G.P. Kofinas, N. Fresco, C. Carothers, and A. Craver. 2014. Parks, people, and change: The importance of multistakeholder engagement in adaptation planning for conserved areas. Ecology and Society 19:16. <http://www.ecologyandsociety.org/vol19/iss4/art16/>.

Krosby, M., C.B. Wilsey, J.L. McGuire, J.M. Duggan, T.M. Nogeire, J.A. Heinrichs, J.J. Tewksbury, and J.J. Lawler. 2015. Climate-induced range overlap among closely related species. Nature Climate Change 5:883-886.

Kudo, G. 2014. Vulnerability of phenological synchrony between plants and pollinators in an alpine ecosystem. Ecological Research 29:571-581.

Kueffer, C. 2014. Ecological novelty: Towards an interdisciplinary understanding of ecological change in the Anthropocene. Pp. 19–37 *in* H.M. Greschke and J. Tischler, eds., Grounding Global Climate Change: Contributions from the Social and Cultural Sciences. Springer, Berlin.

Kunzig, R. 2012. Goodbye to "Primitive America": An interview with Jon Jarvis. <http://newswatch.nationalgeographic.com/2012/08/25/goodbye-to-primitive-america-an-interview-with-jon-jarvis/>.

Lemieux, C.J., and D.J. Scott. 2005. Climate change, biodiversity conservation and protected area planning in Canada. Canadian Geographer 49:384-397.

Mack, R.N., D. Simberloff, W.M. Lonsdale, H. Evans, M. Clout, and F.A. Bazzaz. 2000. Biotic invasions: Causes, epidemiology, global consequences, and control. Ecological Applications 10:689-710.

MacKinnon, K., N. Dudley, and T. Sandwith. 2011. Natural solutions: Protected areas helping people to cope with climate change. Oryx 45:461-462.

Mawdsley, J.R., R. O'Malley, and D.S. Ojima. 2009. A review of climate-change adaptation strategies for wildlife management and biodiversity conservation. Conservation Biology 23:1080-1089.

Munasinghe, M., and R. Swart. 2005. Primer on Climate Change and Sustainable Development: Facts, Policy Analysis, and Applications. Cambridge University Press, Cambridge, UK.

Nantel, P., M.G. Pellatt, K. Keenleyside, and P.A. Gray. 2014. Biodiversity and Protected Areas. Pp. 159–190 *in* F.J. Warren and D.S. Lemmen, eds., Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation. Government of Canada, Ottawa, ON.

Ohsawa, T., and Y. Ide. 2008. Global patterns of genetic variation in plant species along vertical and horizontal gradients on mountains. Global Ecology and Biogeography 17:152-163.

Ohsawa, T., and T. Osawa. 2014. Quantifying effects of legal and non-legal designations of alien plant species on their control and profile. Biological Invasions 16:2669-2680.

Poortinga, W., A. Spence, L. Whitmarsh, S. Capstick, and N.F. Pidgeon. 2011. Uncertain climate: An investigation into public scepticism about anthropogenic climate change. Global Environmental Change 21:1015-1024.

Pyšek, P., and D.M. Richardson. 2010. Invasive species, environmental change and management, and health. Annual Review of Environment and Resources 35:25-55.

Reid, H. 2006. Climate change and biodiversity in Europe. Conservation and Society 4:84-101.

Richardson, D.M., and P. Pyšek. 2012. Naturalization of introduced plants: Ecological drivers of biogeographical patterns. New Phytologist 196:383-396.

Richardson, D.M., P. Pyšek, M. Rejmánek, M.G. Barbour, F.D. Panetta, and C.J. West. 2000. Naturalization and invasion of alien plants: Concepts and definitions. Diversity and Distributions 6:93-107.

[SCBD] Secretariat of Convention on Biological Diversity. 2002. COP 6 Decision VI/23: Alien species that threaten ecosystems, habitats or species. <https://www.cbd.int/decision/cop/default.shtml?id=7197>.

Scott, D., and C. Lemieux. 2005. Climate change and protected area policy and planning in Canada. The Forestry Chronicle 81:696-703.

Scott, D., J.R. Malcolm, and C. Lemieux. 2002. Climate change and modelled biome representation in Canada's national park system: Implications for system planning and park mandates. Global Ecology and Biogeography 11:475-484.

Shackelford, N., R.J. Hobbs, N.E. Heller, L.M. Hallett, and T.R. Seastedt. 2013. Finding a middle-ground: The native/non-native debate. Biological Conservation 158:55-62.

Shoo, L.P., A.A. Hoffmann, S. Garnett, R.L. Pressey, Y.M. Williams, M. Taylor, L. Falconi, C.J. Yates, J.K. Scott, D. Alagador, and S.E. Williams. 2013. Making decisions to conserve species under climate change. Climatic Change 119:239-246.

Stern, N. 2006. Review on the Economics of Climate Change. HM Treasury, London.

Suffling, R., and D. Scott. 2002. Assessment of climate change effects on Canada's national park system. Environmental Monitoring and Assessment 74:117-139.

Thomas, C.D., and P.K. Gillingham. 2015. The performance of protected areas for biodiversity under climate change. Biological Journal of the Linnean Society 115:718-730.

Trouwborst, A. 2012. Transboundary wildlife conservation in a changing climate: Adaptation of the Bonn Convention on Migratory Species and its daughter instruments to climate change. Diversity 4:258-300.

Trouwborst, A. 2014. Exploring the legal status of wolf–dog hybrids and other dubious animals: International and EU Law and the wildlife conservation problem of hybridization with domestic and alien species. Review of European, Comparative and International Environmental Law 23:111-124.

Trouwborst, A., M. Krofel, and J.D. Linnell. 2015. Legal implications of range expansions in a terrestrial carnivore: The case of the golden jackal (*Canis aureus*) in Europe. Biodiversity and Conservation 24:2593-2610.

Vanderhoeven, S., J. Piqueray, M. Halford, G. Nulens, J. Vincke, and G. Mahy. 2011. Perception and understanding of invasive alien species issues by nature conservation and horticulture professionals in Belgium. Environmental Management 47:425-442.

Vilà, M., C. Basnou, P. Pyšek, M. Josefsson, P. Genovesi, S. Gollasch, W. Nentwig, S. Olenin, A. Roques, D. Roy, P.E. Hulme, and DAISIE partners. 2009. How well do we understand the impacts of alien species on ecosystem services? A pan-European, cross-taxa assessment. Frontiers in Ecology and the Environment 8:135-144.

Walker, A.J., and R.L. Ryan. 2008. Place attachment and landscape preservation in rural New England: A Maine case study. Landscape and Urban Planning 86:141-152.

Walther, G.R. 2010. Community and ecosystem responses to recent climate change. Philosophical Transactions of the Royal Society of London B: Biological Sciences 365:2019-2024.

Warren, C.R. 2007. Perspectives on the 'alien' versus 'native' species debate: A critique of concepts, language and practice. Progress in Human Geography 31:427-446.

Westphal, M.I., M. Browne, K. MacKinnon, and I. Noble. 2008. The link between international trade and the global distribution of invasive alien species. Biological Invasions 10:391-398.

Williamson, M., and A. Fitter. 1996. The varying success of invaders. Ecology 77:1661-1666.

Appendix. A case study on climate-induced species in Daisetsuzan National Park in Japan.

MATERIAL AND METHODS

This case study was conducted in Daisetsuzan, the largest among the terrestrial national parks in Japan (2268 km^2), in order to supplement our discussion on climate-induced species management. The park is located in Hokkaido, the northernmost of the four Japanese main islands (at around 43–44°N), harboring alpine and sub-boreal ecosystems (JME 2009). These ecosystems are vulnerable to climate change because most of the resident species need sufficiently cold and snowy (moist) conditions (Kudo 2014).

There are three rangers as well as three supporting rangers in Daisetsuzan National Park. They are officially responsible for management, but the number of these employees is limited. In contrast, Park Volunteer staff organizations (hereafter PV) support the rangers in Japanese national parks. As of 2014, the PV in Daisetsuzan National Park consisted of 104 members who participate in several activities to support the park management. Most of the PVs have much more experience than the rangers at the park, with some having been involved for several decades; therefore, we regard them together with park rangers as park experts as explained in the Results. Contributions by similar volunteer naturalists to biodiversity policy-making are now gradually emerging globally (e.g., Ellis and Waterson 2004).

A questionnaire survey was conducted on these PV members in May 2014, during their annual general meeting. Paper copies of the questionnaire were distributed and completed forms collected on-site. Subsequently, the same questionnaire was also sent by post to PV members who did not attend the meeting. Every question was single/multiple-choice style in Japanese, and the questions asked are listed in Table 1. We did not use the specific term “climate-induced species” in the questionnaire survey. The questions ranged from the basic view of the respondents on climate change, opinions about the impacts of climate change on the vegetation/ecosystem in the park, to opinions about countermeasures. In Question 7, we asked which new species should be allowed to enter (move) into and stay (colonize) in the park. Herein, we tried to cover a wide range of species not only in terms of taxonomy but also general perception, given that respondents’ answers may be varied depending not only on species biology (e.g., species’ original distribution) but also on people’s views (Bremner and Park 2007).

We also provided a series of our expectations (hypotheses) regarding responses to our questions (Table 1). However, responses from the PV members could be different depending on how long each member has observed the park. As well, the data were subject to a further level of cross analysis in order to find patterns and attitude predictors among variables based on answers to Questions 2 and 5, assuming that each respondent’s view on climate change and alien species might be influential on responses to other questions (see Table 1 for details).

RESULTS

Forty-three PV members (41% of all registered PVs) as well as three park rangers responded to the current survey, although 12 of them skipped certain questions (typically Q1 about gender) or gave invalid answers that violated our survey instructions. The number of respondents who had climbing experience at this park for 1–10 years, 11–20 years, 21–30 years, and 31–40 years were 7, 5, 17, and 8 respectively. In addition, another eight respondents had climbing experience at the park for over 40 years.

In response to Question 2, 34 (77%) respondents chose anthropogenic factors as the main reason for climate change, while 10 (23%) of respondents chose natural factors (Table 2). Thirty-seven (80%) acknowledged feeling the impacts of climate change in Daisetsuzan National Park, while three (7%) have never experienced such impacts; six (13%) respondents were unsure (Table 3). As supporting evidence for their feelings about climate change (Table 4), “drier wetlands or smaller lakes than before” was chosen by the largest number of respondents, 20 (44%). In addition, “frequent occurrences of abnormal weather” and “introduction of lowland plant species into highlands” were chosen by a relatively large number of respondents, 15 (33%) and 14 (30%), respectively. According to a binary logistic regression analysis with three explanatory variables (gender, age, and career history in the park), only the response to the option of “drier wetlands or smaller lakes than before” could be explained by the regression with a marginal significance ($P = 0.075$). More experienced respondents in the park were more likely to agree with this option ($P = 0.025$).

Table 1. Some of the questions posed in our survey and our initial expectations about responses to the questions.

Question	Expected response	Rationales for our expectation
Q2. According to your view, what is the main reason for the currently concerned climate change (global warming)?	b. Natural factors	PVs, who are seemingly familiar with natural science (e.g., botany and zoology) to some degree, are likely to follow the basic idea of IPCC (2013) and many other climate-change studies (i.e., "current climate change is caused anthropogenically").
Q3. Have you already felt impacts of climate change (global warming) in this park based on your outside observation?	a. Yes, I have.	Recently, local people who are in charge of bus operation for autumn visitors (Kogen-Onsen bus) are often confused by late timing of foliage coloring as well as irregular weather pattern. When foliage coloring was delayed, they wondered if their bus operation period should be postponed or not. Thus, at least these two natural changes may be regarded as ramifications of climate change.
Q4. What natural changes are the reasons you felt impacts of climate change in this park?	a. Delayed timing of autumn coloring of deciduous forests than before. g. Frequent occurrences of abnormal weather.	
Q5. If any domestic species/vegetation enter into the park from the southern part of Japan (i.e., Honshu), will you regard them as alien species?	a. Yes, I will regard them as alien species.	Given that current climate change is caused anthropogenically (IPCC 2013) and that alien species were originally recognized as the species that were introduced and spread by anthropogenic activities (Mack et al. 2000; Westphal et al. 2008), most respondents (at least those who believe anthropogenically caused climate-change) would answer that nonnative species that are coming due to climate change (i.e., climate-induced species) are alien species.
Q6. If any domestic species/vegetation enter into the park from the southern part of Japan, what should we do with them?	a. Remove as much as possible.	If our assumption about Q5. is correct (i.e., if our respondents regard climate-induced species as alien species), the respondents may want to remove them from the park. According to a questionnaire survey on nonnative species, people who are familiar with or involved in nature conservation are likely to support wildlife control including removal of invasive species (Bremner and Mark 2007).
Q8. If the current vegetation/inhabiting creatures are about to be extirpated due to climate change (global warming), what should we do?	a. In situ conservation (i.e., still continue to do something for persistence of these vegetation/species in the park).	As well, if the respondents (particularly PVs who have observed the park for a long time) are emotionally attached to original state of Daisetsuzan National Park, they may dislike any changes of nature in the park (c.f. Walker and Ryan 2008). In other words, they may prefer what they have been familiar with to what they have never been familiar with.

Note, we broke our data based on answers to Questions 2 and 5, assuming that each respondent's view on climate change and alien species might be influential on responses to other questions.

Table 2. Posed question list for experts in Daisetsuzan National Park in Japan.

Q1. Basic information about each respondent.

(1) Sex

a. Male b. Female

(2) Age

a. 20s b. 30s c. 40s d. 50s e. 60s f. 70s or above

(3) Career history in this park

a. 0–1 b. 1–10 c. 11–20 d. 21–30 e. 31–40 f. 41 years or above

Q2. According to your view, what is the main reason for the currently concerned climate change (global warming)? [Single-choice]

a. Anthropogenic factors (e.g., fossil fuel combustion)

b. Natural factors (e.g., solar cycle)

Q3. Have you already felt impacts of climate change (global warming) in this park based on your outside observation? [Single-choice]

a. Yes, I have.

b. No, I have not.

c. I don't know.

Q4. What natural changes are the reasons you felt impacts of climate change in this park? If you chose "c" in Q3, just choose the last option in Q4. [Multiple-choice allowed]

a. Delayed timing of autumn coloring of deciduous forests than before.

b. Worse quality of autumn coloring of deciduous forests than before.

c. Earlier timing of fresh greening or flowering than before.

d. Introduction of lowland plant species into highlands.

e. Introduction of lowland animal species into highlands.

f. Drier wetlands or smaller lakes than before.

g. Frequent occurrences of abnormal weather.

h. I felt impacts of climate change but don't know specific reasons.

i. I do not feel any impacts of climate change or I don't know if climate change has influenced the park or not.

Q5. If any domestic species/vegetation enter into the park from the southern part of Japan (i.e., Honshu), will you regard them as alien species? [Single-choice]

a. Yes, I will regard them as alien species.

b. No, I will not regard them as alien species.

Q6. If any domestic species/vegetation enter into the park from the southern part of Japan, what should we do with them? [Single-choice]

a. Remove as much as possible.

b. Allow just the species with beautiful appearances to enter and stay in the park.

c. Allow just the species which contribute to ecological functions/services to enter and stay in the park.

d. Respect natural changes of species compositions/vegetation without any removal.

Q7. If any domestic species/vegetation enter into the park from the southern part of Japan, which species should be, do you think, allowed to stay in the park? [Multiple-choice allowed]

a. The Japanese beech (*Fagus crenata*)

b. The temperate deciduous oaks (*Quercus serrata* and *Q. acutissima*)

c. The evergreen oaks (*Cyclobalanopsis* spp. and *Castanopsis* spp.)

d. The rhinoceros beetle (*Trypoxylus dichotomus*)

e. The black-spotted pond frog (*Rana nigromaculata*)

f. The cockroaches from Honshu (Blattodea)

Q8. If the current vegetation/inhabiting creatures are about to be extirpated due to climate change (global warming), what should we do? Choose just one measure that should be prioritized for implementation. [Single-choice]

a. *In situ* conservation (i.e., still continue to do something for persistence of these vegetation/species in the park).

b. *Ex situ* conservation (i.e., bringing them to colder sites (e.g., Russia) and/or zoos/botanical gardens).

c. Respect natural changes (i.e., allow changes of vegetation and species compositions).

d. Replacing them by more adaptive species to maintain ecological functions and/or scenic beauty of this park.

Table 3. Main results of our survey conducted in Daisetsuzan National Park in May 2014. Total response and its breakdown depending on view about climate change and alien species are shown.

Question and Answer Options	Total response	Respondents of Anthr*	Respondents of Nat*	Respondents of Alien**	Respondents of Non-alien**
Q3. Have you already felt impacts of climate change (global warming) in this park based on your outside observation?					
a. Yes, I have.	37/46 (80%)	26/34 (76%)	9/10 (90%)	22/26 (85%)	13/17 (76%)
b. No, I have not.	3/46 (7%)	3/34 (9%)	0/10 (0%)	0/26 (0%)	3/17 (18%)
c. I don't know.	6/46 (13%)	5/34 (15%)	1/10 (10%)	4/26 (15%)	1/17 (6%)
Q5. If any domestic species/vegetation enter into the park from the southern part of Japan (i.e., Honshu), will you regard them as alien species?					
a. Yes, I will regard them as alien species.	26/43 (61%)	19/31 (61%)	6/10 (60%)	26/26 (100%)	0/17 (0%)
b. No, I will not regard them as alien species.	17/43 (40%)	12/31 (39%)	4/10 (40%)	0/26 (0%)	17/17 (100%)
Q6. If any domestic species/vegetation enter into the park from the southern part of Japan, what should we do with them?					
a. Remove as much as possible.	18/44 (41%)	16/32 (50%)	1/10 (10%)	15/26 (58%)	1/16 (6%)
b. Allow just the species with beautiful appearances to enter and stay in the park.	0/44 (0%)	0/32 (0%)	0/10 (0%)	0/26 (0%)	0/16 (0%)
c. Allow just the species that contribute to ecological functions/services to enter and stay in the park.	10/44 (23%)	7/32 (22%)	3/10 (30%)	5/26 (19%)	5/16 (31%)
d. Respect natural changes of species compositions/vegetation without any removal.	16/44 (36%)	9/32 (28%)	6/10 (60%)	6/26 (23%)	10/16 (63%)
Q8. If the current vegetation/inhabiting creatures are about to be extirpated due to climate change (global warming), what should we do? Choose just one measure which should be prioritized for implementation.					
a. In situ conservation (i.e., still continue to do something for persistence of these vegetation/species in the park).	20/45 (44%)	16/33 (48%)	3/10 (30%)	13/26 (50%)	5/17 (29%)
b. *Ex situ* conservation (i.e., bringing them to colder sites (e.g., Russia) and/or zoos/botanical gardens)	3/45 (7%)	3/33 (9%)	0/10 (0%)	3/26 (12%)	0/17 (0%)

Continued

Table 3. (*Cont'd*)

Question and Answer Options	Total response	Respondents of Anthr*	Respondents of Nat*	Respondents of Alien**	Respondents of Non-alien**
Q8. If the current vegetation/inhabiting creatures are about to be extirpated due to climate change (global warming), what should we do? Choose just one measure which should be prioritized for implementation (*Cont'd*)					
c. Respect natural changes (i.e., allow changes of vegetation and species compositions).	22/45 (49%)	14/33 (42%)	7/10 (70%)	10/26 (38%)	12/17 (71%)
d. Replacing them by more adaptive species to maintain ecological functions and/or scenic beauty of this park.	0/45 (0%)	0/33 (0%)	0/10 (0%)	0/26 (0%)	0/17 (0%)

* The data were broken down depending on answers to Question 2. "Respondents of Anthr" and "Respondents of Nat" refer to data of respondents who thought anthropogenic and natural factors as the main reason for currently concerned climate change, respectively.

** The data were broken down depending on answers to Question 5. "Respondents of Alien" and "Respondents of Non-Alien" refer to data of respondents who regarded new species occurring due to climate change as alien and not alien species, respectively.

Table 4. Number and frequency of respondents who chose each answer option in response to question 6 (which is about observed natural changes that could have occurred by climate change in Daisetsuzan National Park). Total response and its breakdown depending on climbing/hiking experience period are shown.

Answer Options	Total response	Climbing/hiking experience period in Daisetsuzan				
		1–10 years	11–20 years	21–30 years	31–40 years	More than 40 years
a. Delayed timing of autumn coloring of deciduous forests than before.	7/45 (15%)	1/7 (14%)	1/5 (20%)	3/17 (18%)	0/8 (0%)	2/8 (25%)
b. Worse quality of autumn coloring of deciduous forests than before.	13/45 (28%)	0/7 (0%)	0/5 (0%)	6/17 (35%)	3/8 (38%)	4/8 (50%)
c. Earlier timing of fresh greening or flowering than before.	5/45 (11%)	0/7 (0%)	0/5 (0%)	3/17 (18%)	0/8 (0%)	2/8 (25%)
d. Introduction of lowland plant species into highlands.	14/45 (30%)	0/7 (0%)	2/5 (40%)	5/17 (29%)	4/8 (50%)	2/8 (25%)
e. Introduction of lowland animal species into highlands.	13/45 (28%)	2/7 (29%)	1/5 (20%)	6/17 (35%)	2/8 (25%)	2/8 (25%)
f. Drier wetlands or smaller lakes than before.	20/45 (44%)	1/7 (14%)	2/5 (40%)	7/17 (41%)	4/8 (50%)	6/8 (75%)
g. Frequent occurrences of abnormal weather.	15/45 (33%)	1/7 (14%)	3/5 (60%)	5/17 (29%)	2/8 (25%)	3/8 (38%)
h. I felt impacts of climate change but don't know specific reasons.	3/45 (7%)	0/7 (0%)	0/5 (0%)	2/17 (12%)	0/8 (0%)	1/8 (13%)
i. I do not feel any impacts of climate change or I don't know if climate change has influenced the park or not.	5/45 (11%)	4/7 (57%)	0/5 (0%)	1/17 (6%)	0/8 (0%)	0/8 (0%)

Appendix. (*Cont'd*)

Twenty-six (61%) respondents answered that the domestic species/vegetation entering into the park from the southern part of Japan (i.e., Honshu) should be regarded as alien species (Table 2). Surprisingly, this frequency is essentially constant regardless of the respondent's view on the main causes of climate change. However, only 18 (41%) respondents thought that these species and vegetation should be removed (i.e., adaptive management). By contrast, ten (23%) respondents would allow species that contribute to ecological functions/services to remain in the park. In addition, 16 (36%) respondents agreed with the idea of respecting natural changes in species compositions/vegetation without any intervention (i.e., passive management). The attitude of allowing the introduction of new species was quite common (60%) among respondents, particularly among those who believed that climate change is mainly attributable to natural causes. In response to Question 7, almost all (97%) of the respondents agreed to allow the introduction of the Japanese beech into Daisetsuzan National Park (Figure 1). Notably, 18 respondents who thought that climate-induced species and vegetation should be removed from the park would nevertheless permit the beech to colonize the park. In contrast, only six (17%) respondents would permit the introduction of cockroaches from Honshu. In other words, the percentage of respondents agreeing with species introduction varied greatly depending on the species in question.

Finally, with respect to dealing with vulnerable species/vegetation during climate change in the park, 20 (44%) respondents chose the option of *in situ* conservation, whereas just three (7%) respondents supported the choice of *ex situ* conservation (Table 2). In addition, 22 (49%) respondents chose the option of respecting natural changes. Again, the 70% of respondents who believed that natural factors were the main reason for climate change supported the same option of respecting natural changes. No respondents chose the option of replacing native species by more adaptive species.

LITERATURE CITED

Bremner, A., and K. Park. 2007. Public attitudes to the management of invasive non-native species in Scotland. Biological Conservation 139:306-314.

Ellison, R., and C. Waterton. 2004. Environmental citizenship in the making: The participation of volunteer naturalists in UK biological recording and biodiversity policy. Science and Public Policy 31:95-105.

[JME] Japanese Ministry of the Environment. 2009. Daisetsuzan National Park. <http://hokkaido.env.go.jp/nature/mat/park/en/daisetsu/all.pdf>.

Kudo, G. 2014. Vulnerability of phenological synchrony between plants and pollinators in an alpine ecosystem. Ecological Research 29:571-581.

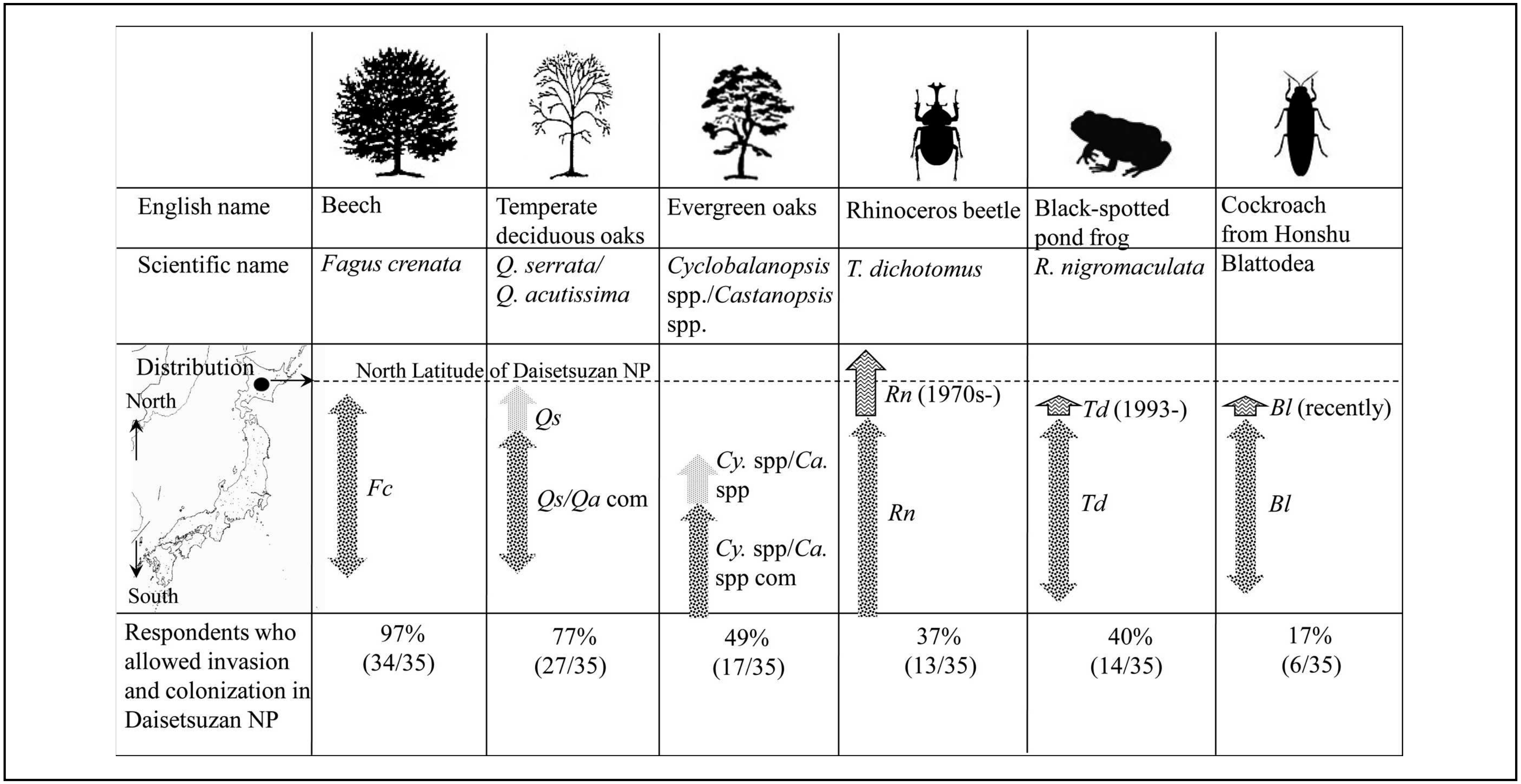

Figure 1. Outline of the result of Question 9. English name, scientific name, latitudinal distribution and percentage (number) of respondents who allowed entrance and colonization in Daisetuzan National Park of six species/vegetation are shown. For temperate deciduous oaks and evergreen oaks, distributions of these oak communities are described (as "com"), while sparse distributions of the same species are also shown. As well, northward spread of the beetle, the frog, and the cockroach have been recently found, and therefore these new distributions are shown by being hatched with wavy lines.