

Missing the bandwagon: Nonnative species impacts still concern managers

Sara. E. Kuebbing^{1,2}, Daniel Simberloff¹

1 Department of Ecology & Evolutionary Biology, 569 Dabney Hall, University of Tennessee, Knoxville, TN 37996 **2** Current Address: School of Forestry & Environmental Studies, Yale University, 205 Prospect Street, New Haven, CT 06511

Corresponding author: Sara. E. Kuebbing (sara.kuebbing@yale.edu)

Academic editor: L. Foxcroft | Received 10 November 2014 | Accepted 19 February 2015 | Published 14 April 2015

Citation: Kuebbing SE, Simberloff D (2015) Missing the bandwagon: Nonnative species impacts still concern managers. NeoBiota 25: 73–86. doi: 10.3897/neobiota.25.8921

Abstract

Recent critics of invasion biology advocate reduced efforts against nonnative species, arguing that attempts to manage invasions are often costly and futile and that managers are indiscriminately managing species regardless of their impact. Whether this criticism has affected ground-level operations is unknown. A survey of land stewards of a major conservation NGO reveals that this plea has not been heeded; in fact, managers report that they would increase nonnative species management if more resources were available. While respondents overwhelmingly listed nonnative, invasive species as their highest priority for management, we found little evidence supporting the criticism that practitioners focus on nonnative species with minimal ecological impact. Additionally, we found that more conservation practitioners reported managing problematic “weedy” native species over nonnative species that are not invasive. Our results indicate that these managers are selective rather than profligate, targeting species that are having a demonstrable impact or are likely to do so. They feel hamstrung by resource shortages despite their rigorous target selection. Why the increasing literature calling for changed treatment of nonnatives has not led to changed operations is uncertain. Possible reasons are that the critics are not prescriptive or unified about management prioritization, or that these managers simply reject the proposed new paradigm.

Keywords

New conservation science, nonnative species, nonnative invasive species, management

Introduction

The past decade has seen vocal critics of invasion biology and management (Davis 2009, Davis et al. 2011, Valéry et al. 2013, Thompson 2014) argue that attempting to redress invasions is often costly and futile. A recurring criticism of management programs is that too much time and money are expended managing nonnatives that have minimal impact and that managers' should focus on those species with the largest impact, regardless of the species' origin. However, most critics agree that species—native or nonnative—that negatively affect ecosystems should be managed. Complaints against invasion biology and management vary, but our primary concern here is the argument that management is wasteful and that managers are indiscriminately managing species regardless of their impact.

This barrage of criticisms raises concern that policymakers and managers could lessen or even stop successful (Simberloff 2013) but frequently costly, arduous campaigns to counter invasions (Simberloff and Vitule 2014). There is precedent (e.g., the anthropogenic climate change “debate”) for policymakers to use scientific “controversies” to stop or delay environmental measures (Oreskes and Conway 2010). The increase in both academic publications (Davis 2009, Davis et al. 2011, Valéry et al. 2013, Thompson 2014) and public media attention (Chew and Carroll 2011, Zimmer 2011, Marris 2013) warrants concern that public support for invasive species management may decrease.

These criticisms of invasive species management distill into two major suggested revisions of current invasive species management practices: first, that managers should distinguish between nonnative species that are invasive and those that are not (Davis 2009, Davis et al. 2011, Chew and Carroll 2011), and second, that managers should be concerned with native problematic species as much as nonnative invasive species (Warren 2007, Davis 2009, Davis et al. 2011, Shackelford et al. 2013). A frequent response to these management critiques is that they are straw man arguments because managers already prioritize among nonnative species to target those deemed harmful to specific conservation goals (Simberloff et al. 2011, Richardson and Ricciardi 2013). This debate over current management practices has stagnated, in part, because it is unknown whether these calls to change management paradigms have any influence on ground-level management philosophies or activities.

The call to de-emphasize management of nonnative species is related to a larger crusade that invokes an even stronger call to revise “traditional” conservation management practices. In the past decade, the “new conservation science” (NCS) movement has sought to refocus conservation biology on protecting nature for services it provides to humans rather than on saving nature for its own sake (Doak et al. 2014). NCS advocates often argue that traditional conservation is inadequate for preserving biodiversity and that some degrading natural forces (such as nonnative species) are so powerful and inexorable that certain strategies and goals of traditional conservation should simply be abandoned. This view has led to heralding of a “new world order” (Hobbs et al. 2006, 2009) in which restoration ecologists will abandon the

goal of returning an ecosystem to a semblance of its historical reference condition. In this new world, removing or managing nonnatives is futile after ecosystems pass an irreversible “restoration threshold” to become “novel ecosystems” (Hobbs et al. 2009). Instead, its advocates seek to harness “novel ecosystems” that arise because of invasions and global climate change to produce services to humankind (Hobbs et al. 2009, Lalasz 2011, Schlaepfer et al. 2011). Again, results of calls to reform nonnative species management practices in response to these broader conservation paradigm shifts are unknown.

To address how managers are selecting and prioritizing species for management on conservation properties, we surveyed land stewards from one of the largest international conservation organizations. The Nature Conservancy (TNC), one of the largest landowners in the United States, owns approximately 6 million hectares and assists in management decisions for tens of thousands more hectares (TNC, www.nature.org). In previous IUCN threat classification assessments, “Invasive & Other Problematic Species” were listed as one of the greatest threats to conservation priorities for TNC conservation projects (Kuebbing et al. 2012). Conservation managers at TNC provide an ideal group for testing how recent debates on nonnative species management philosophy have affected on-the-ground operations because recent critiques of current invasive management programs have garnered an upswell of responses from TNC staff (Chadderton 2011, Gordon 2011, Jacquart 2011, Serbesoff-King 2011, Zimmerman 2011) and its Chief Scientist (Kareiva 2011, Kareiva et al. 2011, Kareiva in Dunkel 2011, Lalasz 2011, Kareiva and Marvier 2012, Voosen 2012), which indicates that the organization is actively debating the role of nonnative species management within its larger conservation mission. Additionally, because of the large amount of land owned by TNC, it employs many conservation practitioners who are actively making management decisions for conservation.

Here, we are interested in the attitudes and on-the-ground actions of TNC staff who manage TNC preserves. We queried TNC land stewards and support staff on their attitudes about nonnative species, management of them, and specifically how they prioritize management activities among species, whether native and nonnative as well as invasive or not invasive. We asked to what extent a drumbeat of academic publications (Davis et al. 2001, Hobbs et al. 2009, Valéry et al. 2013) and publications and talks by TNC’s Chief Scientist (e.g., Kareiva et al. 2011, Kareiva in Dunkel 2011, Kareiva and Marvier 2012) has changed TNC management activities.

Materials and methods

We created an online survey (Suppl. material 1) containing a mixture of closed-ended questions, including yes/no, Likert scale, check-all-that-apply, and ranked response options. Many questions included an “other” option for open-ended responses. Options for check-all-that-apply and ranked response questions were randomized to avoid effects of option order on answers. The survey was divided into five sections:

impacts, management, selection of species for management, TNC Global Invasive Species Team (GIST), and debate on nonnative species impacts. Although the GIST was dismantled in 2009 owing to budget cuts, we included questions about it in the survey because this resource was a widely-used aggregation of resources and communication pathway for TNC employees making decisions regarding nonnative species (Serbesoff-King 2011). For those TNC employees whose tenure overlapped with the GIST, we can gauge how managers have adapted to finding information on nonnative species management and whether their assessment of nonnative species management needs have changed, based on whether they feel the need for the GIST to be resurrected. For questions designed to determine whether managers distinguish between nonnative species and invasive nonnative species, we defined each species type (Suppl. material 2). Our software allowed us to move respondents through the survey depending upon answers (e.g., a respondent who did not manage nonnatives skipped all management questions). Each respondent answered between 10 and 18 questions.

We emailed 206 employees through TNC's "Stewardship" internal listserv. This listserv represents employees who manage conservation lands owned or monitored by TNC and employees who provide research and guidance on management. We emailed the survey on February 24, 2014 and sent a reminder on March 31, 2014.

Results

Respondent demographics

Eighty-eight employees – 43% of the total listserv – completed the survey. Over three-quarters of respondents were highly involved in nonnative species management decisions, either sharing decision-making (60%) or making decisions themselves (17%). Thirteen percent made some decisions, and 6% had no substantial management input. Many respondents have worked over 10 years for TNC (39%), and nearly one-quarter 6–10 years. Most respondents had a college or university bachelor's (45%) or master's degree (47%).

Impacts of nonnative species

Nearly all respondents thought a proportion of nonnative species caused ecological or aesthetic impact (Figure 1a–d). For all impacts, the majority of managers felt only "some" (defined in the survey as < 25%) nonnative species caused impact, and managers were unlikely to report that they believed "all" (defined in the survey as 100%) nonnative species caused impact. Likewise, very few managers described nonnative species as having "no (0%)" impact (Figure 1).

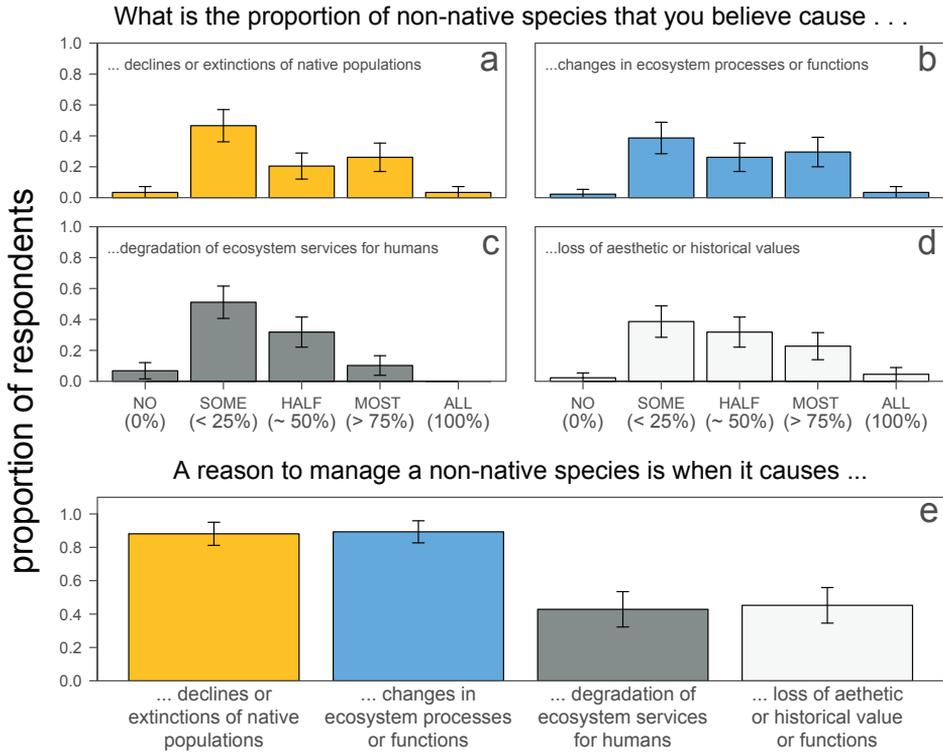


Figure 1. Impacts of nonnative species. Managers thought a lower proportion of nonnative species were likely to degrade ecosystem services for humans (c Fisher’s Exact Test, $P < 0.05$) compared to other ecological or aesthetic impacts (a, b, d), and nonnative species impacts on native species populations or ecosystem processes were more likely to be cited as justification for managing them (e Fisher Exact Test, $P < 0.001$). Error bars represent 95% confidence intervals.

Management of nonnative species

Almost all respondents managed nonnative species (95%). Of respondents who did not currently manage them (5%), three reported they had managed nonnatives on TNC properties in the past but no longer do so because other goals have higher priority.

Ecological impacts of nonnative species motivated management for respondents who managed for nonnative species (Figure 1e). Respondents were more likely to manage nonnatives because they believe they cause changes in ecosystem processes or functions or declines or extinctions of native species populations than because nonnatives decreased aesthetic or historical value or degraded ecosystem services for humans (Fisher Exact Test, $P < 0.0001$). Some respondents provided additional reasons for managing nonnatives, including additional ecological impacts (e.g., nonnatives changing the condition of rare ecological communities or ecosystems, promoting other nonnative spe-

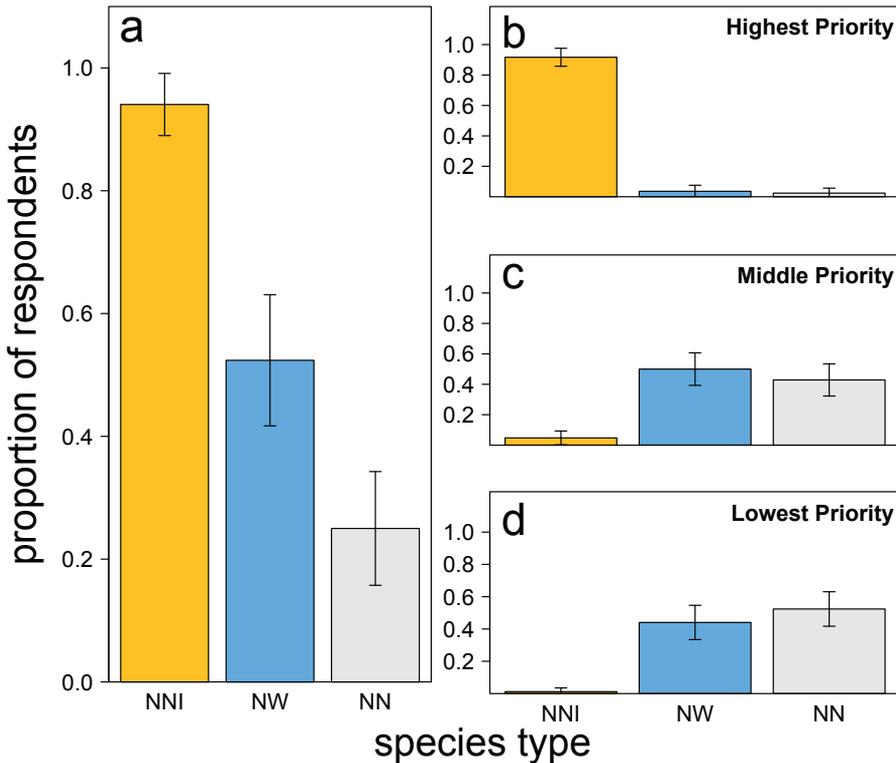


Figure 2. Selection of species for management. Managers were most likely to report that they managed nonnative invasive species (NNI, gold **a**) on conservation properties, and managers ranked NNI as the highest priority for management (**b**) compared to native weedy species (NW, blue) or nonnative species that are not invasive (NN, gray). Error bars represent 95% confidence intervals.

cies, or decreasing ecological resilience), philosophical grounds (e.g., the “precautionary principle”), or contractual requirements (e.g., in-lieu fee mitigation program).

Most respondents who managed for nonnative species allocated less than half their resources (time, money, labor, etc.) to management, but nearly all reported they would increase allocation if more resources were available (Figure 4). Approximately half of the managers reported resources for nonnative species management increased, and one-quarter reported decreases. Over the past 5–10 years, one-quarter of respondents have had stable resource allocation (Figure 4).

Selection of species for management

Nonnative invasive species were the most frequently reported management target (Figure 2a), and 92% of managers ranked nonnative invasive species as the highest priority (Figure 2b). Managers were twice as likely to report they managed native weedy species than that they managed nonnative species that are not invasive

(Figure 2a). Native weedy species and nonnative species that are not invasive were equally likely to be ranked as middle and lowest priority (Figure 2c, d; Fisher's Exact Test, $P > 0.1$).

TNC Global Invasive Species Team (GIST)

Approximately half of the stewards worked for TNC when the GIST was operating, and of these respondents nearly all reported that over 75% of their interactions with the GIST had aided their nonnative species management activities. Two-thirds of respondents familiar with the GIST indicated that it would aid their management activities if TNC revived the GIST, and the remaining one-third were "not sure" whether reviving the GIST would be helpful. Currently, respondents find information on nonnative species management from colleagues who manage nonnatives, other websites (e.g., Global Invasive Species Database, Center for Invasive Species and Ecosystem Health, Center for Invasive Species Management, Delivering Alien Invasive Species Inventories for Europe, etc.), and the primary literature (i.e., peer-reviewed publications).

Debate on the impact of nonnative species

Almost all managers agreed that nonnative species often cause ecological problems and should be of ecological concern (Figure 3b) and disagreed that people who think nonnatives are often a problem are xenophobic (Figure 3a). However, managers were split on whether "native weedy species cause ecological problems as much as nonnative species" (Figure 3e). Approximately one-quarter of respondents agreed and one-third disagreed with the sentiment that native weedy species and nonnative species were equally likely to cause ecological impacts. Respondents more frequently cited personal (74%,) or peer (60%) knowledge and first-hand experiences as more influential than academic research and journal publications focusing on the current nonnative species management debate (34%) in affecting their opinions about nonnatives.

Discussion

Our survey shows that nonnative species management remains an important component of conservation strategies at The Nature Conservancy. We found little evidence supporting the recent criticisms that managers do not distinguish between "nonnative" and "nonnative invasive" species, or that managers are more concerned with nonnative species over problematic native species. Managers responsible for protecting conservation properties believed a proportion of nonnative species cause ecological impact and reported that managing nonnatives species that cause these impact was justified. Generally, respondents dedicated a sizeable fraction of resources to nonnative manage-

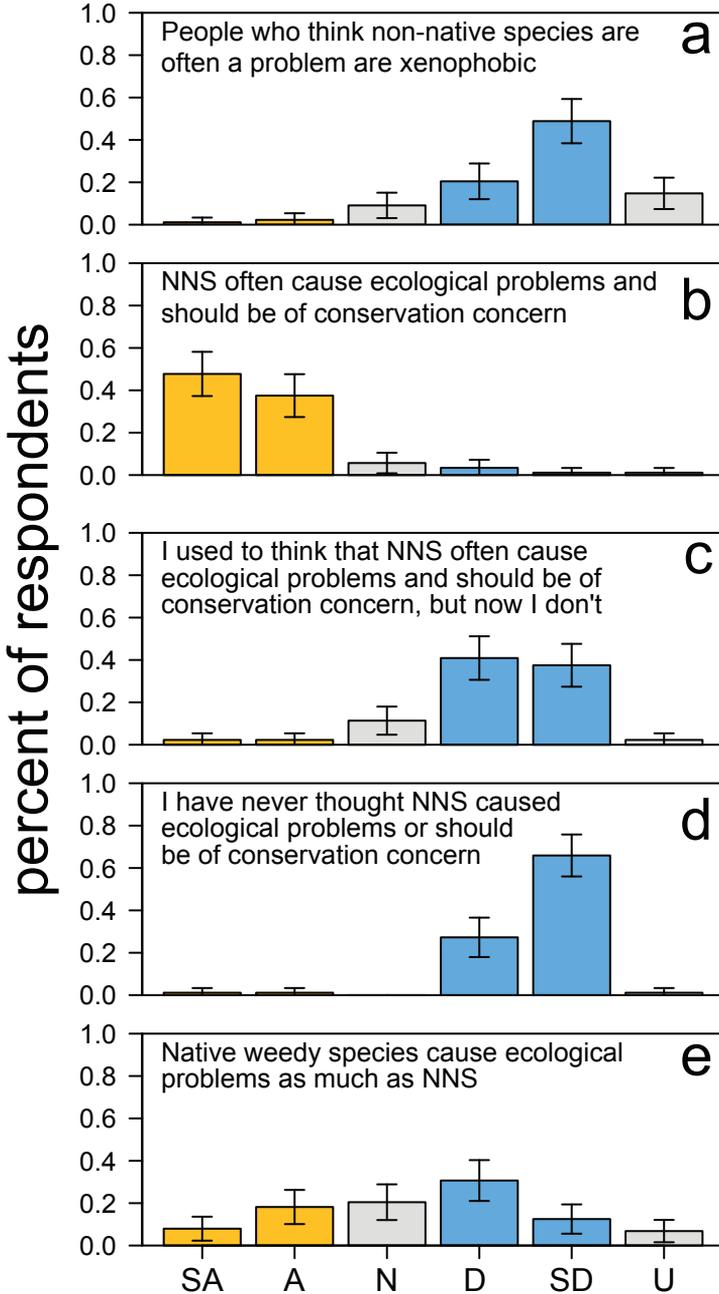


Figure 3. Debate on the impact of nonnative species. Managers rank how strongly they agree or disagree with the following statements regarding non-native species (NNS) management. Abbreviations represent the following: SA = strongly agree, A = agree, N = neutral, D = disagree, SD = strongly disagree, U = uncertain.

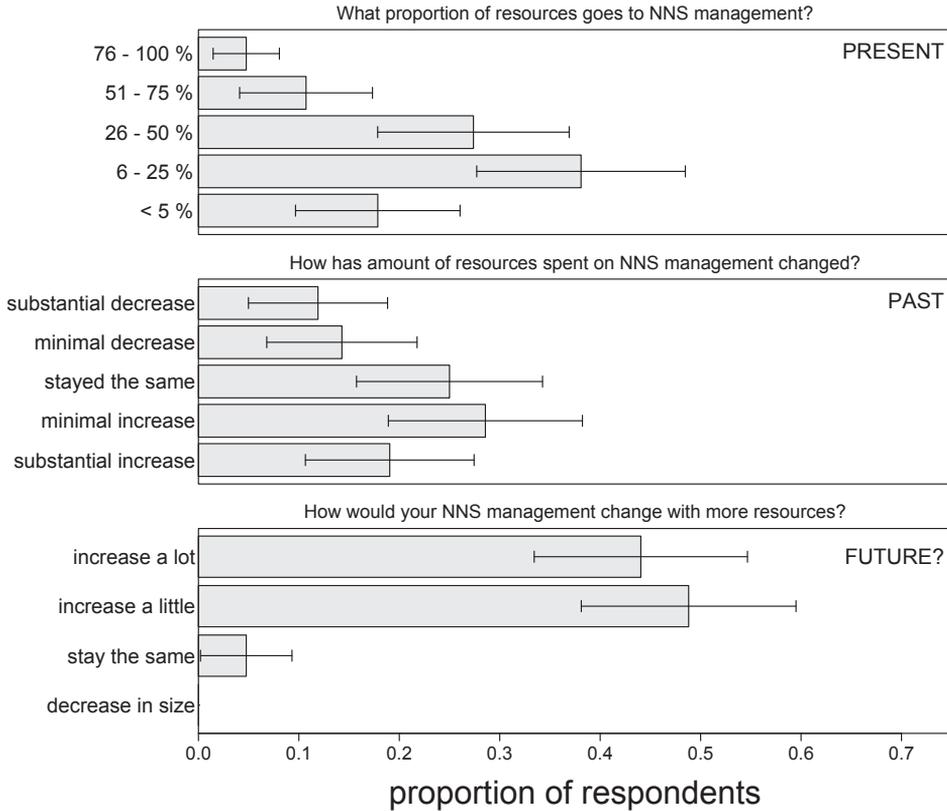


Figure 4. Resource allocation for species management. The majority of respondents who managed for non-native species (NNS) allocated less than half their total resources (time, money, labor, etc.) to management and have seen minimal to no change in resource expenditure in the past 5–10 years. Nearly all respondents would increase non-native species management if more resources were available. Error bars represent 95% confidence intervals.

ment activities, but nearly all respondents would increase such management if given more resources. Most managers reported their motivations for nonnative species management were based upon personal and peer first-hand experiences and not academic journal publications. This may explain why, despite the flurry of prominent academic publications calling for the “end of invasion biology” or fundamental shifts in management strategies, TNC managers have not adopted a new modus operandi with respect to nonnative species.

Although managers spend a sizeable amount of resources managing nonnatives, we detected no indications of profligacy. Respondents indicated that they lacked the resources necessary to manage nonnative species adequately, which suggests they are not likely to be wasteful of the limited resources currently available. Though critics suggest that managers “vilify” *all* nonnatives (Davis 2009, Davis et al. 2011, Chew and Carroll 2011), we found evidence that managers are scientifically savvy and

thoughtful in their definition of what makes a species “problematic” and in their management approach. For example, less than 5% of respondents indicated that “all (100%)” nonnatives have impact, and 95% of respondents ranked “nonnative invasive” species rather than all nonnative species as the highest management priority. This indicates an ecological “triage” for managing nonnatives with perceived impact. Perhaps there is a nuanced distinction in how managers target species; managers must prioritize based on “realized” impact (i.e., a widespread species on a property) and “possible” impact (i.e., a species with known impact elsewhere), but if managing a species is inexpensive (i.e., new to an area) and has high possible impact, they should manage for it even if it has not been found “guilty” on their preserve (Pyšek and Richardson 2010, Helzer 2011, Zimmerman 2011). These results also suggest that perhaps the best academic course of action is to continue studying nonnative impacts and prioritization tools to aid species prioritization.

Respondents seem skeptical about academic research, and the invasion management controversy in particular, with respect to their actions on the ground. They were more likely to value personal and peer knowledge and first-hand management experiences than academic research and journal publications. This finding concurs with recent surveys concerning the “knowing-doing” gap in invasive species management, which show that limited access to scientific publications, limited time to peruse literature, and limited overlap in utility of theoretical research to applied issues contribute to infrequent reliance on academic publications for management (Matzek et al. 2014).

The tenet of both the “novel ecosystem” (Hobbs 2006, Hobbs et al. 2009) and the “New Conservation Science” (NCS) movements (Lalasz 2011, Schlaepfer et al. 2011) is that managers should prioritize all management strategies, including dealing with nonnative species, around the concept of “ecosystem services for humans” has not carried the day among TNC managers. Although 41% of respondents listed impact on ecosystem services as a motive for managing nonnatives, this was nearly equivalent to the number listing changes to aesthetic or historical value (43%) and far less than those listing impacts on native species (84%) or ecosystem processes (85%) that may or may not directly affect ecosystem services to humans. This may be a result of the overarching mission of TNC (i.e., “to conserve the lands and waters on which all life depends”), which dictates priority to land protection and all forms of biodiversity (not just humans). Additional possible reasons for TNC managers’ focus on native species and ecosystem processes could be a research bias (i.e., fewer studies on ecosystem service impacts), or that nonnatives are less likely to cause these impacts, or simply that this focus reflects managers’ personal preferences. However, because ecosystem processes are intimately connected to several ecosystem services (Millennium Ecosystem Assessment [MEA] 2005), the substantial number listing ecosystem processes could have been at least partly motivated by concern for ecosystem services, but the relevant survey question listed ecosystem processes and ecosystem services separately and permitted positive responses to both. Certainly there is no doubt that nonnative species can greatly affect ecosystems services, both negatively (e.g. bush honeysuckle, *Lonicera*

spp., increasing human Lyme disease risks, Allan et al. 2010) and positively (e.g., pollination services by nonnative European honeybees, *Apis mellifera*, Potts et al. 2010). Although there has been an effort to frame nonnative species impacts in terms of ecosystem services (Vilà et al. 2010), perhaps invasion biologists should be more explicit about how nonnative species impacts fit into the MEA framework.

Although the overall tone of those seeking a new paradigm for invasion management can only suggest a deemphasis of the entire project, there is a mixed message. For example, even the most vocal critics agree that preventative measures, such as policies that reduce introductions of new nonnatives or early detection and rapid response measures for small invasions, should be promoted and prioritized within conservation programs (Chew and Carroll 2011, Davis et al. 2011, Lalasz 2011). Additionally, many critics concur that the management of widespread nonnative species is justifiable when there is “good” evidence that those species are impacting native species or ecosystems. Thus, the critiques regarding current nonnative species management programs boil down to whether managers indiscriminately target nonnative species regardless of impact—an allegation that these data strongly reject—or that conservation managers and the critics disagree on what constitutes “good” evidence for justifying the management of particular nonnative species.

Conclusion

The management of nonnative, invasive species remains a priority for land stewards and managers at a leading international conservation organization. Contrary to recent accusations, land stewards at The Nature Conservancy distinguish between nonnative and nonnative invasive species and dedicate a substantial proportion of their conservation resources to management of the latter. Managers feel justified in their management choices because of the ecological and aesthetic impacts of nonnative, invasive species and would increase management if resources allowed. For whatever reason – skepticism, mixed messages, inertia – TNC operations on the ground are not yet substantially modified. We found that anti-invasion activities continue apace, and resource expenditures have even increased in some instances. Particular campaigns are featured in TNC’s Magazine and website (e.g., Reimers 2014, Smith 2014). Perhaps it is too early for management changes to be manifested in response to NCS and the New World Order, or perhaps its mandates for activities on the ground are not yet clear. Or possibly the critics are unconvincing and the paradigm is not actually shifting.

Acknowledgments

We thank the TNC staff for their time and responses to the survey, and two anonymous reviewers for their comments.

References

- Allan BF, Dutra HP, Goessling LS, Barnett K, Chase JM, Marquis RJ, Pang G, Storch GA, Thach RE, Orrock JL (2010) Invasive honeysuckle eradication reduces tick-borne disease risk by altering host dynamics. *Proceedings of the National Academy of Science* 107: 18523–18527. doi: 10.1073/pnas.1008362107
- Chadderton L (2011) The cutting edge of invasive species control: starting small but thinking big. *The Nature Conservancy Science Chronicles*, October 2011, 21–26. <https://www.conservationgateway.org/News/Pages/cutting-edge-invasive-spe.aspx>
- Chew MK, Carroll SP (2011) Opinion: the invasive ideology. *The Scientist*. <http://www.thescientist.com/?articles.view/articleNo/31143/title/Opinion--The-Invasive-Ideology/>
- Davis MA (2009) *Invasion biology*. Oxford University Press, New York, USA, 288 pp.
- Davis MA, Chew MK, Hobbs RJ, Lugo AE, Ewel JJ, Vermeij GJ, Brown JH, Rosenzweig ML, Gardener MR, Carroll SP, Thompson K, Pickett STA, Stromberg JC, Del Tredici P, Suding KN, Ehrenfeld JG, Grime JP, Mascaro J, Briggs JC (2011) Don't judge species on their origins. *Nature* 474: 153–154. doi: 10.1038/474153a
- Doak DF, Bakker VJ, Goldstein BE, Hale B (2014) What is the future of conservation? *Trends in Ecology & Evolution* 29: 77–81. doi: 10.1016/j.tree.2013.10.013
- Dunkel T (2011) Can we move beyond man vs. nature? *Nature Conservancy Magazine Spring*, 32–45. <http://my.nature.org/nature/posts/public/conservation-for-nature-or.html>
- Gordon D (2011) An ounce of prevention: Should TNC do more about invasives? *The Nature Conservancy Science Chronicles*, October 2011, 16–20. <https://www.conservationgateway.org/News/Pages/ounce-prevention-should-t.aspx>
- Helzer C (2011) Purist or pragmatist? Identifying and addressing non-native vs. invasive species in Prairies. *The Prairie Ecologist*. <http://prairieecologist.com/2011/09/13/purist-or-pragmatist-identifying-and-addressing-non-native-vs-invasive-species-in-prairies/>
- Hobbs RJ, Arico S, Aronson J, Baron JS, Bridgewater P, Cramer VA, Epstein PR, Ewel JJ, Klink CA, Lugo AE, Norton D, Ojima D, Richardson DM, Sanderson EW, Valladares F, Vilà M, Zamora R, Zobel M (2006) Novel ecosystems: theoretical and management aspects of the new ecological world order. *Global Ecology and Biogeography* 15: 1–7. doi: 10.1111/j.1466-822x.2006.00212.x
- Hobbs RJ, Higgs E, Harris JA (2009) Novel ecosystems: implications for conservation and restoration. *Trends in Ecology & Evolution* 24: 599–605. doi: 10.1016/j.tree.2009.05.012
- Marris E (2014) Opinion: It's time to stop thinking that all non-native species are evil. *National Geographic Daily News*. <http://news.nationalgeographic.com/news/2014/07/140724-invasive-species-conservation-biology-extinction-climate-science/>
- Kareiva P, Marvier M, Lalasz R (2011) Conservation in the Anthropocene; beyond solitude and fragility. *Breakthrough Journal*. <http://thebreakthrough.org/index.php/journal/past-issue/issue-2/conservation-in-the-anthropocene>
- Kareiva P, Marvier M (2012) What is conservation science? *Bioscience* 62: 962–969. doi: 10.1525/bio.2012.62.11.5
- Lalasz R (2011) Fighting invasive species. Worth the costs? Forum with Mark Davis, Daniel Simberloff, and Peter Kareiva. *The Nature Conservancy Science Chronicles*, September

- 2011, 2–8. <https://www.conservationgateway.org/News/Pages/fighting-non-natives-wort.aspx>
- Matzek V, Covino J, Funk JL, Saunders M (2014) Closing the knowing-doing gap in invasive plant management: accessibility and interdisciplinarity of scientific research. *Conservation Letters* 7: 208–215. doi: 10.1111/conl.12042
- Millennium Ecosystem Assessment (2005) *Ecosystems and human well-being: current state and trends: findings of the condition and trends working group*. Island Press, Washington, DC, USA. <http://www.unep.org/maweb/en/Condition.aspx>
- Oreskes N, Conway EM (2010) *Merchants of doubt*. Bloomsbury Press, New York, USA, 1–355.
- Potts SG, Biesmeijer JC, Kremen C, Neumann P, Schweiger O, Kunin WE (2010) Global pollinator declines: trends, impacts, and drivers. *Trends in Ecology and Evolution* 25: 345–353. doi: 10.1016/j.tree.2010.01.007
- Pyšek P, Richardson DM (2010) Invasive species, environmental change and management, and health. *Annual Review of Environment and Resources* 35: 25–55. doi: 10.1146/annurev-environ-033009-095548
- Reimers F (2014) Python patrol. *Nature Conservancy Magazine*. February/March, 50–59. <http://magazine.nature.org/features/python-patrol.xml>
- Richardson DM, Ricciardi A (2013) Misleading criticisms of invasion science: a field guide. *Diversity and Distributions* 19: 1461–1467. doi: 10.1111/ddi.12150
- Schlaepfer MA, Sax DF, Olden JD (2011) The potential conservation value of non-native species. *Conservation Biology* 25: 428–437. doi: 10.1111/j.1523-1739.2010.01646.x
- Serbesoff-King K (2011) Recapturing a TNC Internal Forum for Invasives. *The Nature Conservancy Science Chronicles*, October 2011, 27–30. <https://www.conservationgateway.org/News/Pages/recapturing-tnc-internal-.aspx>
- Shackelford N, Hobbs RJ, Heller NE, Hallett LM, Seastedt TM (2013) Finding a middle-ground: The native/non-native debate. *Biological Conservation* 158: 55–62. doi: 10.1016/j.biocon.2012.08.020
- Simberloff D (2011) Non-natives: 141 scientists object. *Nature* 475: 36. doi: 10.1038/475036a
- Simberloff D (2013) Biological invasions: What’s worth fighting, and what can be won? *Ecological Engineering* 65: 112–121. doi: 10.1016/j.ecoleng.2013.08.004
- Simberloff D, Vitule JRS (2014) A call for an end to calls for the end of invasion biology. *Oikos* 123: 408–413. doi: 10.1111/j.1600-0706.2013.01228.x
- Smith J (2014) Cutting a clear path. *Nature Conservancy Magazine*. April/May, 32–45. <http://magazine.nature.org/features/cutting-a-clear-path.xml>
- Thompson K (2014) *Where do camels belong? The story and science of invasive species*. Profile Books, London, United Kingdom, 262 pp.
- Valéry L, Fritz H, Lefeuve JC (2013) Another call for the end of invasion biology. *Oikos* 122: 1143–1146. doi: 10.1111/j.1600-0706.2013.00445.x
- Vilà M, Basnou C, Pyšek P, Josefsson M, Genoves P, Gollasch S, Nentwig W, Olenin S, Roques A, Roy D, Hulme PE, DAISIE partners (2010) 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. doi: 10.1890/080083

- Voosen P (2012) Myth-busting scientist pushes greens past reliance on “horror stories.” Greenwire, April 3. <http://www.eenews.net/greenwire/stories/1059962401>
- Warren CR (2007) Perspectives on the ‘alien’ versus ‘native’ species debate: a critique of concepts, language and practice. *Progress in Human Geography* 31: 427–446. doi: 10.1177/0309132507079499
- Zimmer C (2011) Alien species reconsidered: finding value in non-natives. *Yale Environment* 360. http://e360.yale.edu/feature/alien_species_reconsidered_finding_a_value_in_non-natives/2373/
- Zimmerman C (2011) To control or not to control? An invasive plant management decision analysis tool. *The Nature Conservancy Science Chronicles*, October 2011, 31–34. <https://www.conservationgateway.org/News/Pages/control-or-not-control-in.aspx>

Supplementary material 1

TNC Non-native Species Management Survey

Authors: Sara. E. Kuebbing, Daniel Simberloff

Data type: Adobe PDF file

Explanation note: Online survey to assess land managers nonnative species management strategies.

Copyright notice: This dataset is made available under the Open Database License (<http://opendatacommons.org/licenses/odbl/1.0/>). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Supplementary material 2

Survey Responses by Question

Authors: Sara. E. Kuebbing, Daniel Simberloff

Data type: Adobe PDF file

Explanation note: Survey responses for all questions.

Copyright notice: This dataset is made available under the Open Database License (<http://opendatacommons.org/licenses/odbl/1.0/>). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.