Strengths and shortcomings of habitat exchange programs for species conservation

Kristin P. Davis¹,² | Julie Heinrichs³ | Erica Fleishman²,⁴ | Pricila Iranah² | Drew E. Bennett⁵ | Joel Berger²,⁶ | Liba Pejchar²

¹ Graduate Degree Program in Ecology, Colorado State University, Fort Collins, Colorado, USA
² Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, Colorado, USA
³ Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, Colorado, USA
⁴ College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, Oregon, USA
⁵ Haub School of Environment and Natural Resources, University of Wyoming, Laramie, Wyoming, USA
⁶ Wildlife Conservation Society, Bronx, New York, USA

Correspondence
Kristin P. Davis, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Campus Delivery 1474, Fort Collins, CO 80523, USA.
Email: kristin.p.davis@gmail.com

Funding information
Strategic Environmental Research and Development Program

Abstract
Habitat exchange programs, a form of biodiversity offsetting, aim to compensate for negative impacts in one area by conservation in another. A newer subset of habitat exchange programs includes programs that have three distinct characteristics: they allow for temporary (as opposed to only permanent) credits; they are centralized and overseen by nonregulatory, independent administrators; and they exist in the absence of mandatory mitigation policy. As a result, these programs may be relatively flexible and practical in areas where environmental regulation is unpalatable politically. We synthesized gray and peer-reviewed literature to evaluate these programs’ strengths and shortcomings. On the basis of our synthesis, we suggest that temporary conservation credits in habitat exchanges could encourage participation of landowners in conservation and enable programs to respond to environmental change. However, temporary credits can lead to trade-offs between flexibility and uncertainty. Moreover, there is little evidence that these habitat exchange programs have benefited target species, and many challenges associated with offsetting programs persist. Newer forms of habitat exchange programs may have potential to achieve no net loss or net gains of biodiversity to a greater extent than other forms of offsetting, but this potential has not yet been realized.

KEYWORDS
biodiversity offsets, conservation credits, ecological monitoring, habitat credit systems, mitigation, threatened and endangered species

1 | INTRODUCTION

When avoiding or minimizing local impacts of human actions on species and ecosystems is not feasible, it may be possible to offset such impacts by conservation actions elsewhere (i.e., biodiversity offsets; Bull & Strange, 2018).

Although the structure of biodiversity offset programs varies (Koh et al., 2019), many programs include the exchange of debits and credits. Generally, entities that generate negative effects on species or ecosystems, referenced as debits, purchase credits to offset those impacts. Debts often are calculated on the basis of the affected area...
of a given ecosystem or species’ habitat. Conversely, credits usually represent conservation actions or gains, such as habitat conservation, maintenance, or restoration, at a different site (Hrabanski, 2015).

Biodiversity offsetting is a diverse and evolving practice (Bull & Strange, 2018). Almost 40 countries across every continent except Antarctica have policies relevant to or have implemented offset programs (Bull & Strange, 2018). Market-like offset approaches in particular have gained international popularity in recent decades (Koh et al., 2019). Conservation banking, for example, is a market-like offset approach that occurs globally under various names (e.g., habitat banking, biobanking) and is used to counteract the effects of development with the conservation of species, communities, or environments. Market-like offset programs have been used for mitigation that either is required by regulation or voluntary (Bull & Strange, 2018; Hrabanski, 2015). Voluntary market-like offset mechanisms have been regarded by corporations and organizations such as the Organisation for Economic Co-operation and Development and the World Bank as solutions to enacting mitigation in the absence of regulations. Market-like offsets can enable companies to improve their reputation and avoid conflict with shareholders and communities (ten Kate et al., 2004). However, the degree to which conservation goals are met through offset programs is influenced by the motivation for their use (e.g., to satisfy regulatory requirements, promote corporate social responsibility, or manage risk), and by how entities engage politically and with relevant institutions (ten Kate et al., 2004).

Here, we focus on a subset of market-like offset programs, inconsistently termed habitat exchanges. Although terms for offset programs are not standardized and habitat exchanges is sometimes used to describe a broader suite of offset programs (particularly globally), we use habitat exchange programs (sensu Bean, 2017; EDF, 2018; Galik et al., 2017) to describe programs that have three distinct characteristics. First, they allow for temporary credits, which represent time-limited agreements to generate conservation actions that may be used to offset temporary impacts or, via consecutive agreements, to offset longer-term impacts. Second, they are centralized exchanges that are overseen by independent administrators who are not regulators, but may receive approval for compensatory mitigation from regulatory entities. Third, they may exist in the absence of a mandatory mitigation policy (Bean, 2017; Galik et al., 2017; Pindilli & Casey, 2015; Wolfe et al., 2012). We focus on these habitat exchange programs because they have been touted as a more flexible and practical offset approach in the face of global environmental change (which could reduce the efficacy of permanent conservation strategies; D’Aloia et al., 2019) and in areas where environmental regulation or land-use restriction is unpalatable politically (see Section 2; Bean, 2017; Galik et al., 2017; Wolfe et al., 2012).

Little to no regulatory or policy guidance exists for this newer form of habitat exchange programs, and the use of these programs is limited (Galik et al., 2017). One such program currently operating in southern France, the Contournement Nîmes-Montpellier project, began in 2010. The program engages farmers in 5-year financial agreements to improve Little Bustard (Tetrao tetrix L.) habitat on their property to offset 25 years of impacts from the construction of a railway line (Calvet et al., 2019; Figure 1). In the United States, approximately 10 of these habitat exchange programs have been developed or implemented in the past 15 years, including three since 2016. The first—the Golden-cheeked Warbler (Setophaga chrysoparia) Recovery Credit System—was initiated in 2006 to offset effects of military training at Fort Hood (Killeen, Texas) on the warbler, which is listed as endangered under the U.S. Endangered Species Act. This program engaged private landowners in 10–25-year financial agreements, in increments of 5 years, to improve Golden-cheeked Warbler habitat on their properties (Wolfe et al., 2012; Figure 1).

Although the conservation potential of habitat exchange programs is receiving more attention, especially in the United States, there has been little formal, comprehensive evaluation of potential mechanisms of and limitations to their success (but see Robertson & Rinker, 2010 and Calvet et al., 2019). The ecological objectives of these newer habitat exchange programs are similar to those of traditional offset programs, but the use of temporary credits may have distinct advantages and drawbacks for species conservation. Furthermore, evaluations of other types of offset programs (e.g., conservation banks) suggest that such programs have difficulty achieving conservation goals and fully compensating for human impacts (Maron et al., 2016; zu Ermgassen et al., 2019). It is unclear whether the habitat exchange programs on which we focus meet these challenges or achieve positive ecological outcomes beyond those of other forms of market-like biodiversity offsets.

Here, we synthesize gray and peer-reviewed literature to assess the ability of habitat exchange programs to benefit target species. We examine current impediments to habitat exchange programs, including trade-offs between flexibility and uncertainty, quantification of ecological equivalency, and establishment of explicit and measurable objectives. We then suggest program designs to maximize ecological benefits of habitat exchange programs.
FIGURE 1  The purpose, focal species, duration, and outcomes of a sample of habitat exchange programs currently or formerly in operation. Photographs are in the public domain unless otherwise noted.

2 | TRADE-OFFS BETWEEN FLEXIBILITY AND UNCERTAINTY ASSOCIATED WITH TEMPORARY CREDITS

The duration of temporary credits in habitat exchange programs has ranged from 5 to more than 30 years (Calvet et al., 2019; State of Nevada, 2017a; Wolfe et al., 2012). Because short- or moderate-term actions incur less financial commitment and risk to credit sellers than permanent actions (Bean, 2017), programs that allow temporary credits may facilitate participation from more-diverse entities than those restricted to permanent offsets. For example, private landowners surveyed prior to implementation of the Golden-cheeked Warbler Recovery Credit System and the Contournement Nîmes-Montpellier project were resistant to permanent conservation protections, but willing to enter into temporary conservation agreements (Calvet et al., 2019; Wolfe et al., 2012).

The use of temporary credits within habitat exchange programs also could benefit species with distributions that shift in response to climate change if credit lands are chosen to align with observed or projected shifts in the distribution or quality of habitat. For instance, habitat exchange programs could use temporary credits to facilitate assisted colonization of space that is predicted to be favorable for persistence (i.e., potentially supporting net gain; Bull & Brownlie, 2017), or to conserve new habitat to which species can move unassisted, potentially supporting no net loss. Such flexibility could improve conservation outcomes as climate and land use continue to change (D’Aloia et al., 2019). However, we are unaware of such use of temporary credits within habitat exchange programs. In addition, monitoring within current habitat exchange programs rarely tracks stochastic or directional environmental change or relations between habitat quality and the demography of the target species. This limits the responsiveness of temporary credit systems to environmental change.

Despite the potential benefits of temporary credits, the ability of temporary credits to offset impacts may be less certain than that of permanent credits (Moilanen & Kotiaho, 2018). For example, some programs allow for dynamic permanent offsets, in which sequential temporary credit agreements are used to offset a long-term or permanent impact but the locations of these credits can change (Bean, 2017; Pindilli & Casey, 2015). The Contournement Nîmes-Montpellier project uses such offsets—the location of temporary credits can shift as landowners renew contracts and enroll different plots, or as new landowners join the program. However, it is unknown whether the program will be able to enroll enough landowners during each enrollment cycle to generate the mandated number of credits (Calvet et al., 2019). The availability of eligible lands from which to generate temporary credits for the duration of a long-term impact or a permanent impact always will be uncertain, and if availability is not sufficient, temporary credits could result in net loss over time (Moilanen & Kotiaho, 2018). Additionally, it may be more difficult to estimate and evaluate the cumulative effects of...
intermittent conservation actions, and the outcomes of intermittent conservation actions only may become evident given sufficient monitoring and after multiple enrollment cycles (Moilanen & Kotiaho, 2018).

Such uncertainty could be mitigated in part by requiring financial sustainability of temporary credits in advance of their use and by increasing the duration of credits. A habitat exchange program in the United States, the Nevada Conservation Credit System for Greater Sage-Grouse (Centrocercus urophasianus; Figure 1), has such restrictions on the use of dynamic permanent offsets—it requires that each temporary credit be applicable for a minimum of 30 years and that sufficient funding exists to execute new term agreements over the anticipated duration of the debit (State of Nevada, 2017a). It is unclear, however, whether such dynamic, permanent offsets have been used within this program. Increasing credit duration likely would decrease the flexibility of temporary credits and be less appealing to landowners (Calvet et al., 2019; Wolfe et al., 2012), and other habitat exchange programs in the United States do not appear to dictate the duration, transaction methods, or financial sustainability of temporary credits generated throughout the debit project. Therefore, it remains unclear whether a series of temporary offsets can mitigate a long-term impact (Moilanen & Kotiaho, 2018).

3 ECOLOGICAL EQUIVALENCY BETWEEN DEBIT AND CREDIT AREAS

Habitat exchange programs differ from many other types of market-like offset programs in that impact and mitigation sites are evaluated with standardized protocols, sometimes referenced as habitat quantification tools, that are specific to the focal ecological system and developed by nonregulatory entities (Bennett et al., 2017; EDF, 2019). For example, the habitat quantification tool for the Nevada Conservation Credit System integrates more than 15 metrics of vegetation and other habitat components across four spatial extents and three life stages of Greater Sage-Grouse to estimate the functional area of habitat. Functional area accounts for habitat amount and habitat quality, and quantifies ecological equivalency for like-for-like trades of debits and credits (Maron et al., 2016; State of Nevada, 2017a).

Although the composite metrics derived from habitat quantification tools are more comprehensive than those based solely on area of habitat, which often are used by other market-like offset programs, it is not clear whether these tools improve the ecological equivalency of debit and credit trades. It is challenging to quantify habitat area or quality comprehensively and efficiently, and the biological relevance of putatively high-quality habitat is questionable (Van Horne, 1983). Rigorous field data seldom are collected to evaluate whether composite metrics reflect the quality of species’ habitat. Composite metrics also can mask decreases in the condition or quality of some components if others increase, and therefore may not improve offset outcomes (Maseyk et al., 2016).

4 DEFINITION OF ECOLOGICAL OBJECTIVES AND MEASUREMENT OF OUTCOMES

The success of offset programs depends in part on developing and meeting objectives that relate to habitat quality, occupancy, demography, and environmental variability. Explicit ecological objectives also contribute to specification of the data necessary to evaluate debits, credits, and mitigation actions. Documentation for habitat exchange programs often states that program actions should result in a net benefit to focal species (State of Nevada, 2017a; Wolfe et al., 2012). This directive goes beyond the no net loss mandate of many biodiversity offset programs, although net gain policies are becoming more common (Bull & Brownlie, 2017). However, net benefit objectives are not clearly defined in program documentation and are not tied to explicit ecological objectives, such as increasing population viability or population growth rates. Instead, net benefit commonly is interpreted as an increase in the amount or quality of a species’ habitat via issuance of more credits than debits, and multipliers are used such that potentially impacted habitat is underestimated and ecological gains from credits are underestimated (State of Nevada, 2017a). Therefore, habitat exchange programs appear to conceptualize net benefit as overcompensating for impacts rather than increasing ecological value beyond mitigation requirements (Bull & Brownlie, 2017). This is problematic because an increase in habitat quantity or quality alone may not affect a species’ status (Heinrichs et al., 2016), and explicit, measurable ecological objectives are key to effective offsetting (May et al., 2017).

Monitoring for habitat exchange programs often focuses primarily on relatively cursory evaluation of habitat and is limited to the duration of the program; most programs are relatively new or did not operate for more than 5 years (Calvet et al., 2019; State of Nevada, 2017a). Surveys may be used to estimate species’ presence and abundance (Robertson & Rinker, 2010), but few programs collect data on demographic variables. Consequently, many programs cannot rigorously assess whether program actions improved the status of populations of focal species. For example, a third-party review of the Golden-cheeked Warbler Recovery Credit System concluded that the program’s monitor-
ing data (e.g., occupancy and abundance of the species) were insufficient to evaluate the quality of mitigation sites (Robertson & Rinker, 2010). Therefore, the extent to which the program benefited the warbler is unknown. Poor monitoring is common among offset programs (Maron et al., 2016). However, because intensive data collection may be required to evaluate no net loss (let alone net benefit; Pickett et al., 2013), rigorous monitoring may be even more relevant to programs that allow temporary credits to ensure that temporary ecological improvements are offsetting impacts.

5 | THE FUTURE OF HABITAT EXCHANGE PROGRAMS

To be effective, habitat exchange programs must achieve at least no net loss of habitat for target species (zu Ermgassen et al., 2019). Yet data generally are not collected to rigorously assess outcomes. Few habitat exchange programs have been evaluated formally (but see Calvet et al., 2019; Robertson & Rinker, 2010), and the collective ability of habitat exchange programs to offset ecological impacts and achieve conservation objectives has not been assessed. Furthermore, many challenges for biodiversity offsetting programs more broadly are applicable to habitat exchange programs. These include the difficulty of determining ecological equivalency (Maseyk et al., 2016), the absence of rigorous monitoring and explicit, measurable ecological objectives (May et al., 2017; zu Ermgassen et al., 2019), a focus on habitat gains rather than species’ demographic responses (Marshall et al., 2020), and an inability to establish that program actions benefited target species (Maron et al., 2016).

We suggest that developers or managers of habitat exchange programs take the following steps toward maximizing the ecological benefits of the program. First, define explicit, quantitative objectives that reference measures of habitat quality and population sizes and trends. Ideally, this effort will align with species-level conservation goals and population targets. However, because the reasons for engaging in these programs go beyond species conservation (e.g., corporate social responsibility, military readiness; ten Kate et al., 2004; Wolfe et al., 2012), programs (and their associated objectives and population targets) likely will continue to be developed for and operate at regional extents. Second, implement monitoring that is sufficiently rigorous and frequent to assess changes in major ecological conditions and the extent to which those reflect implementation of the habitat exchange program, especially when credits are temporary (Pickett et al., 2013). For example, data on distribution, abundance, and demography on debit lands before and after impact and on credit lands pre- and post-exchange could be used to evaluate program efficacy and avoid unintended and overlooked ecological costs of program trades. Third, monitor metrics associated with demography and population viability, which are most likely to inform the prioritization or modification of program actions, suitability of species for passive or active translocation, and evidence-based revision of equivalency metrics (Marshall et al., 2020). Many of these recommendations are not unique to habitat exchange programs (Maron et al., 2016; Marshall et al., 2020), but are applicable to diverse offset programs.

Habitat exchange programs could be a useful conservation tool given certain programmatic and ecological conditions. The option of temporary credits may broaden their appeal relative to other offset programs that require permanent offsets (Calvet et al., 2019; Wolfe et al., 2012). Temporary credits also may increase the capacity of conservation actions to adapt to environmental change (Bean, 2017; D’Aloia et al., 2019). If ecological effects of trades are not measured and reported, however, there is a risk that habitat exchange programs could increase rather than decrease the likelihood of population decline and species extirpation (Sonter et al., 2019). Advancing understanding of whether these newer types of habitat exchange programs can achieve no net loss or net gains of biological diversity beyond those of other forms of market-like biodiversity offsets remains a priority for conservation science and policy.

ACKNOWLEDGMENTS

This synthesis was funded by the Strategic Environmental Research and Development Program (RC18-1209). We are grateful to Joseph Bull for thoughtful discussion about biodiversity offsetting. We thank Jessica Perry with Creative Blue Yonder for graphic design support for the graphical abstract. We also thank three anonymous reviewers and Sarah Bekessy for comments that improved the manuscript.

AUTHOR CONTRIBUTIONS

All authors conceived of the manuscript. KPD and JH reviewed habitat exchange program literature, with help from all authors. KPD and JH drafted the initial manuscript and all authors revised the manuscript.

DATA AVAILABILITY STATEMENT

No new data were collected for this synthesis.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ORCID

Kristin P. Davis https://orcid.org/0000-0003-1204-4687
LITERATURE CITED

Bean, M. J. (2017). *Habitat exchange: A new tool to engage landowners in conservation working paper*. Madison, WI, USA: Sand County Foundation/Environmental Policy Innovation Center. https://sandcountyfoundation.org/uploads/FINAL-Habitat-Exchange.pdf

Bennett, G., Gallant, M., & ten Kate, K. (2017). *State of biodiversity mitigation 2017 - Markets and compensation for global infrastructure development*. Washington, DC, USA: USA: Forest Trends' Ecosystem Marketplace. https://www.forest-trends.org/wp-content/uploads/2018/01/doc_5707.pdf

Bull, & J.W., Brownlie, S. (2017). The transition from No Net Loss to a Net Gain of biodiversity is far from trivial. *Oryx*, 51(3), 53–59. https://doi.org/10.1017/S0030605315000861

Bull, J. W., & Strange, N. (2018). The global extent of biodiversity offset implementation under no net loss policies. *Nature Sustainability*, 1, 790–798. https://doi.org/10.1038/s41893-018-0176-z

Calvet, C., Le Coent, P., Napoleon, C., & Quétier, F. (2019). Challenges of achieving biodiversity offset outcomes through agri-environmental schemes: Evidence from an empirical study in Southern France. *Ecological Economics*, 163, 113–125. https://doi.org/10.1016/j.ecolecon.2019.03.026

D’Aloia, C. C., Naujokaitis-Lewis, I., Blackford, C., Chu, C., Curtis, J. M. R., Darling, E., Guichard, F., Leroux, S. J., Martensen, A. C., Rayfield, B., Sunday, J. M., Xureb, A., & Fortin, M.-J. (2019). Coupled networks of permanent protected areas and dynamic conservation areas for biodiversity offsetting under climate change. *Frontiers in Ecology and Evolution*, 7. https://doi.org/10.3389/fevo.2019.00027

Environmental Defense Fund (EDF). (2018, October 11). *Habitat exchanges transform conservation*. https://www.edf.org/ecosystems/habitat-exchanges-transform-conservation

Environmental Defense Fund (EDF). (2019, November 12). *Habitat Quantification Tool*. https://www.edf.org/ecosystems/habitat-quantification-tool

Galik, C. S., BenDor, T. K., DeMeester, J., & Wolfe, D. (2017). Improving habitat exchange planning through theory, application, and lessons from other fields. *Environmental Science & Policy*, 73, 45–51. https://doi.org/10.1016/j.envsci.2017.04.003

Heinrichs, J. A., Bender, & D. J., Schumaker, N. H. (2016). Habitat degradation and loss as key drivers of regional population extinction. *Ecological Modelling*, 335, 64 –73. https://doi.org/10.1016/j.ecolmodel.2016.05.009

Hrabanski, M. (2015). The biodiversity offsets as market-based instruments in global governance: Origins, success and controversies. *Ecosystem Services*, 15, 143–151. https://doi.org/10.1016/j.ecoser.2014.12.010

Koh, N. S., Hahn, T., & Boonstra, W. J. (2019). How much of a market is involved in a biodiversity offset? A typology of biodiversity offset policies. *Journal of Environmental Management*, 232, 679–691. https://doi.org/10.1016/j.jenvman.2018.11.080

Maron, M., Ives, C. D., Kujala, H., Bull, J. W., Maseyk, F. J. F., Bekessy, S., Gordon, A., Watson, J. E. M., Lentiini, P. E., Gibbons, P., Possingham, H. P., Hobbs, R. J., Keith, D. A., Wintle, B. A., & Evans, M. C. (2016). Taming a wicked problem: Resolving controversies in biodiversity offsetting. *Bioconvey*, 66, 489–498. https://doi.org/10.1093/biosci/biw038

Marshall, E., Wintle, B. A., Southwell, D., & Kujala, H. (2020). What are we measuring? A review of metrics used to describe biodiversity in offsets exchanges. *Biological Conservation*, 241, 108250. https://doi.org/10.1016/j.biocon.2019.108250

Maseyk, F. J. F., Barea, L. P., Stephens, R. T. T., Possingham, H. P., Dutson, G., & Maron, M. (2016). A disaggregated biodiversity offset accounting model to improve estimation of ecological equivalency and no net loss. *Biological Conservation*, 204, 322–332. https://doi.org/10.1016/j.biocon.2016.10.016

May, J., Hobbs, R. J., & Valentine, L. E. (2017). Are offsets effective? An evaluation of recent environmental offsets in Western Australia. *Biological Conservation*, 206, 249–257. https://doi.org/10.1016/j.biocon.2016.11.038

Moilanen, A., & Kotiaho, J. S. (2018). *Planning biodiversity offsets: Twelve operationally important decisions*. Copenhagen, Denmark: Nordic Council of Ministers/Publication Unit. https://norden.diva-portal.org/smash/get/diva2:1201285/FULLTEXT01.pdf

Pickett, E. J., Stockwell, M. P., Bower, D. S., Garnham, J. I., Pollard, C. J., Clulow, J., & Mahony, M. J. (2013). Achieving no net loss in habitat offset of a threatened frog required high offset ratio and intensive monitoring. *Biological Conservation*, 157, 156–162. https://doi.org/10.1016/j.biocon.2012.09.014

Pindilli, E., & Casey, F. (2015). *Biodiversity and habitat markets—Policy, economic, and ecological implications of market-based conservation*. U.S. Geological Survey Circular 1414. https://doi.org/10.3133/cir1414

Robertson, S., & Rinker, H. B. (2010). *Third party evaluation of the recovery credit system proof of concept*. Robertson Consulting Group, Inc.. https://denix.osd.mil/sri/policy/reports/unassigned/recovery-credit-system-proof-of-concept-march-2010-entire-report/

Sagebrush Ecosystem Technical Team (SETT). (2020). *State of Nevada Conservation Credit System 2020 Performance Report*. Nevada Conservation Credit System. http://sagebrusheco.nv.gov/uploadedFiles/sagebrushconcegov/content/Meetings/2020/NV_CCS_Performance_%20Report_12.30.2020_Draft%20Final(3).pdf

Sonter, L. J., Barnes, M., Matthews, J. W., & Maron, M. (2019). Quantifying habitat losses and gains made by U.S. Species Conservation Banks to improve compensation policies and avoid perverse outcomes. *Conservation Letters*, 12(3), e12629. https://doi.org/10.1111/conl.12629

State of Nevada Department of Conservation and Natural Resources Sagebrush Ecosystem Program (State of Nevada). (2017a). *Nevada conservation credit system manual v1.3*. South Lake Tahoe, CA, USA: Environmental Incentives, LLC. https://sagebrusheco.nv.gov/uploadedFiles/sagebrushconcegov/content/CCS/NVCCS_Manual_17.pdf

State of Nevada Department of Conservation and Natural Resources Sagebrush Ecosystem Program (State of Nevada). (2017b). *Nevada habitat quantification tool scientific methods document v1.3*. South Lake Tahoe, CA, USA: Environmental Incentives, LLC and EcoMetrix Solutions Group, LLC. https://sagebrusheco.nv.gov/uploadedFiles/sagebrushconcegov/content/CCS/Att4_CCS_HQT_Doc_v1-3.pdf
for Conservation of Nature and Natural Resources and Insight Investment Management. https://www.cbd.int/financial/offsets/g-offsets-iucn.pdf

Van Horne, B. (1983). Density as a misleading indicator of habitat quality. The Journal of Wildlife Management, 47, (4), 893–901. https://doi.org/10.2307/3808148

Wolfe, D. W., Hays, K. B., Farrell, S. L., & Baggett, S. (2012). Regional credit market for species conservation: Developing the Fort Hood Recovery Credit System. Wildlife Society Bulletin, 36, 423–431. https://doi.org/10.1002/wsb.184

zu Ermgassen, S. O., Baker, J., Griffiths, R. A., Strange, N., Strubbig, M. J., & Bull, J. W. (2019). The ecological outcomes of biodiversity offsets under “no net loss” policies: A global review. Conservation Letters, 12, e12664. https://doi.org/10.1111/conl.12664

How to cite this article: Kristin P. Davis, Julie Heinrichs, Erica Fleishman, Pricila Iranah, Drew E. Bennett, Joel Berger, Liba Pejchar. Strengths and shortcomings of habitat exchange programs for species conservation. Conservation Letters. 2022;15:e12846. https://doi.org/10.1111/conl.12846