Aligning actions with objectives in endangered species recovery plans

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Abstract
To achieve conservation objectives for threatened and endangered species, managers must choose among potential recovery actions based on their efficacy. Yet, a lack of standardization in defining how conservation actions support recovery objectives can impede action efficacy and inhibit the efficient allocation of resources across species and projects. It is especially difficult to evaluate the effectiveness of actions in U.S. Endangered Species Act (ESA) recovery plans due to variation in how actions are described across different plans. To address this issue, we examined our ability to apply the internationally supported Conservation Measures Partnership (CMP) taxonomy to categorize existing ESA recovery plan action descriptions. Using ESA listed species in Arizona as a case study, we tested the feasibility of assigning CMP taxonomy categories to actions detailed in current recovery plans, and then used our assigned categories to assess the distribution of action categories. Pairs of researchers categorized and then compared levels of agreement between categories of recovery actions for 840 actions across 31 active recovery plans. Paired categorizations diverged for many of these actions, though confidence in action description assignments among pairs was highest in categorizing Research and Monitoring actions, which represented, on average, 53% (SD 0.9%) of actions with researcher agreement, and, on average, 42% (SD 0.08%) of classification among individual researchers. These results suggest that categorizable action descriptions most often correspond with Research and Monitoring objectives, and that other categories of actions required to delist species may be underrepresented in ESA recovery plans. We provide recommendations to support the application of the CMP taxonomy to current and future ESA recovery action descriptions using existing processes within the U.S. Fish and Wildlife Service. Our recommendations provide a roadmap for standardizing the description of recovery actions to improve decision-support for ESA-listed species.

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1 | INTRODUCTION

The number of threatened species lists has grown at local, regional, national, and global scales (Burton, 2003; Miller et al., 2007). The U.S. Endangered Species Act (ESA) is one of the most prominent and legislatively important examples (Harris et al., 2011). Under the ESA, recovery plans, which are written by either the U.S. Fish and Wildlife Service (USFWS) or National Marine Fisheries Service (NMFS), identify the actions needed to reduce threats and recover species. At least once every 5 years, USFWS or NMFS then provide a series of recommendations on the listing status of threatened and endangered species, which can include updates to recovery actions (Figure 1a). However, timely completion of 5-year reviews is often prohibitively challenging, due to resource limitations. To support iterative and regular updates of recovery documents, a three-part framework that includes recovery plans, a Species Status Assessment (SSA), and Recovery Implementation Strategies (RISs) has recently been adopted (USFWS, 2019).

ESA practitioners and the authors have noted that the conservation actions outlined in recovery plans often vary significantly in their comparability, content, and style (Boersma, Kareiva, Fagan, Clark, & Hoekstra, 2001; Clark, Hoekstra, Boersma, & Kareiva, 2002), which could contribute to vague, unbalanced, or ineffectual recovery plans (see Table 1, e.g., of the diversity of recovery plan action descriptions). In addition, the variability in action descriptions hinders opportunities for planning efficiency, such as identifying which recovery actions are shared across species or organizations.

One way to overcome inconsistencies among recovery action descriptions is to classify actions according to transparent standards. Standardization promotes rapid identification of which actions across plans support similar objectives and helps managers prioritize actions to advance conservation goals (Clark et al., 2002; Crouse, Mehrhoff, Parkin, Elam, & Chen, 2002). In addition, standardization allows organizations to more easily track how frequently different actions are recommended, implemented, or funded. When paired with effective monitoring, standardization can aid in understanding action efficacy and enable strategic resource allocation (Gerber et al., 2018; Joseph, Maloney, & Possingham, 2009). Standardizing recovery action descriptions can also enhance the usability of recovery plans for stakeholders (see NMFS, 2018), thereby enhancing adoption. Clear and standardized actions could also potentially reduce the time it takes to write and update recovery documents, supporting adaptive management. Finally, standardizing ESA recovery actions could be critical for species jointly managed by USFWS and NMFS. As such, ensuring descriptions of conservation actions are consistent and interpretable is urgently needed to support endangered species recovery at local, regional, national, and international scales.

Some large-scale efforts have helped conservation organizations standardize recovery actions, the most extensive being the Conservation Measures Partnership (CMP), a joint effort between the International Union for Conservation of Nature (IUCN) Red List Partnership and other conservation organizations. This initiative sought to create a standard classification of the threats species face and of the conservation actions decision-makers can take to counter threats (CMP, 2019; IUCN, 2020; Salasfsky et al., 2008). The IUCN Red List and other conservation initiatives employ a version of the CMP taxonomy when defining recovery actions, but usage of the taxonomy across the wider conservation community remains low and organizations still tend to describe actions for species recovery in unstandardized and varied ways (Knight et al., 2019; Redford, Hulvey, Williamson, & Schwartz, 2018; Schwartz et al., 2012). Nonetheless, the CMP taxonomy remains the premiere, globally recognized classification scheme to identify threats and actions relating to species recovery, and has obtained significant support from both government agencies and NGOs within and outside of the United States (Ban, Wilson, & Neusloss, 2020; Diaz-Campos & Vilés-Lopez, 2020; Redford et al., 2018). Additionally, research groups commonly use the CMP taxonomy to track action and threat classifications of threatened and endangered species for purposes of conservation management, planning, and decision-support (e.g., Bolam et al., 2021; Croxall et al., 2012; IUCN, 2020; McCarthy et al., 2012). As such, the CMP taxonomy is well-supported and has sufficient uptake by research groups, conservation organizations, and government agencies, making it a key choice when approaching the standardization of action descriptions under the ESA.

Since categorizing action descriptions in accordance with standards could potentially support ESA recovery objectives and conservation planning, we tested our ability to standardize existing ESA recovery action descriptions using the CMP taxonomy and Arizona species as a

| KEYWORDS |
| Arizona, conservation measures partnership, decision-support, Endangered Species Act, recovery planning, Research and Monitoring |
To support researchers and conservation managers who wish to better identify how different recovery actions align for purposes of resource allocation, conservation planning, and management, we also provide recommendations for how to write recovery actions in ESA recovery planning documents in ways that support standardization, as well as identify ways to implement guidance while building upon existing USFWS infrastructure.

2 | METHODS

2.1 | Arizona case study

We tested our ability to categorize ESA recovery action descriptions under the CMP taxonomy using Arizona species as a case study. We focused on listed species in Arizona, given the broad range of taxonomic representation and the relatively tractable number of...
| Action                      | Subaction                          | Example action with full agreement                                                                 | Example action with partial agreement                         | Example action without agreement and where otherwise placed |
|-----------------------------|------------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------|
| Land/Water Management       | Site/area stewardship              | Maintain/enhance nesting/roosting habitat                                                          | Manage for nesting/roosting recovery habitat                  | Action: Survey and enhance candidate waters Placed: Land/Water Management Research and Monitoring |
|                             | Ecosystem and natural process (re)creation | Restore natural fire regimes in the watersheds of extant populations of *Chiricahua leopard* frogs and in MAs |                                                                  |                                                                                                                      |
|                             | Species stewardship                | Reduce or eliminate threats from non-native trout and other non-native fishes within recovery portions of streams | Seed banking and ex situ research                            |                                                                                                                      |
|                             | Species reintroduction and translocation | Stock spinedace in Kehl Canyon, Beaver Creek, Turkey Creek, Willow Creek, and Gentry Creek          |                                                                  |                                                                                                                      |
|                             | Ex-situ conservation               | Rear and supply fish for recovery purposes                                                          |                                                                  |                                                                                                                      |
| Awareness Raising           | Outreach and communication          | Develop public information about the recovery program at zoological institutions, which may include (but not be limited to) informational kiosks, exhibiting red squirrels, and providing photos and video of captive-rearing efforts to the press and management agencies for educational use | —                                                              | Action: PUBLIC RELATIONS: Conduct education program in Sonora Placed: Awareness Raising Education and Training |
|                             | Protests and civil disobedience     | —                                                                                                  |                                                                  |                                                                                                                      |
| Law Enforcement and Prosecution | Detection and arrest              | Patrol habitat, cottonwood                                                                        | Enforce existing laws                                         | Action: Protect habitats occupied by natural and long-lived reestablished populations from detrimental land and water use practices. Placed: Law enforcement and prosecution Conservation designation and planning |
|                             | Criminal prosecution and conviction | Enforce grazing permits                                                                           |                                                                  |                                                                                                                      |
|                             | Noncriminal legal action            | —                                                                                                  |                                                                  |                                                                                                                      |
| Action | Subaction | Example action with full agreement | Example action with partial agreement | Example action without agreement and where otherwise placed |
|--------|-----------|----------------------------------|--------------------------------------|----------------------------------------------------------|
| Livelihood, economics, and moral incentives | Linked enterprises and alternative livelihoods | — | Develop a trade management plan | Action: Determine the feasibility of reducing collecting pressure by promoting artificial propagation program Placed: Livelihoods, Economics, and Moral Incentives Research and Monitoring |
| | Better products and management practices | — | | |
| | Market-based incentives | — | | |
| | Direct economic incentives | — | | |
| | Nonmonetary values | — | | |
| Conservation designation and planning | Protected area designation and/or acquisition | Purchase of base property for Buck Springs range allotment by Arizona game and fish department. | Develop agreements with landowners/managers and complete environmental and other compliance | Action: Return developed areas to habitat for Mount Graham red squirrel, as appropriate and supported by research (see Sections 3.6 and 3.7). Placed: Conservation Designation and Planning Land/Water Management |
| | Easements and resource rights | Permanently protect from mining | | |
| | Land/water use zoning and designation | — | | |
| | Conservation planning | Develop management plans to reduce threats and promote processes that secure, restore, and enhance currently suitable and potentially suitable habitat | | |
| | Site infrastructure | Extend improved trail system | | |
| Legal and policy frameworks | Laws, regulations, and codes | Promulgate and enforce fishing regulations to protect Gila trout populations | Law enforcement. Enforcement of all pertinent laws and regulations will provide some level of protection for food plants. Additional legal protection for forage plants, especially in Mexico, should be sought. | Action: Maintain and continue to enforce current vehicle speed restrictions to reduce Mount Graham red squirrel roadkills. Placed: Legal and policy frameworks Law enforcement and prosecution |
| | Policies and guidelines | Establish allowable-use criteria | | |
| Research and Monitoring | Basic research and status monitoring | Obtain additional information on selenium concentrations in habitat, prey base, and individuals. | Assess rationale for setting recovery goal of 700–1,000 breeding birds in the 1983 recovery plan. | Action: Survey inventory and manage populations in nonhistoric range. Placed: Research and Monitoring Species Management |
| | Evaluation, effectiveness measures, and learning | Conduct assessments to determine appropriate utilization and/or residual levels of forage. | | |
species. Of the 1,222 species listed in active US recovery plans, 72 are found in the state of Arizona (July 4, 2021—https://ecos.fws.gov/ecp/). These include an array of mammals, birds, amphibians, plants, invertebrates, and fish, including endemics of significant ecological and cultural value. Arizona also serves as an important movement corridor for several threatened and endangered species across international borders (e.g., jaguar [Panthera onca] and ocelot [Leopardus pardalis] [https://ecos.fws.gov/ecp]). Conservation actions in the region are therefore crucial to the ongoing survival of vulnerable species across ecological and sociopolitical contexts.

2.2 | Recovery plan data

We extracted a subset of 33 Arizona species recovery plans from a set of 569 active recovery plans obtained from the Environmental Conservation Online System (ECOS) database (http://ecos.fws.gov/ecp/) through a core database query on January 10, 2017 (Gerber et al., 2018). These data are publicly available via the Recovery Online Activity Reporting (ROAR) module. About half of these data come directly from published recovery plans (both draft and final versions) and include the plan title, species included in the plan, the total time and cost for recovery, and the implementation schedule.
Other items in ROAR are entered by USFWS or National Oceanic and Atmospheric Association biologists on a yearly basis. Although data in ROAR can be entered and updated in an inconsistent manner, they are the most comprehensive source of recovery plan data. Further, our aim was to identify the feasibility of categorizing a subset of ESA action descriptions in association with the CMP taxonomy, with the hope of conducting a more intensive and comprehensive follow-up study after our initial investigation. Nonetheless, we conducted spot checks on approximately one-third of randomly selected Arizona recovery plans to assess the level of variation between ROAR and written recovery plans or Recovery Plan Implementation (RPI) documents. Our spot checks confirmed that the actions pulled from the ROAR module largely corresponded with each species’ RPI document in ECOS. Active status recovery plans were the most recent version of each plan available on the query date.

We further subdivided the 33 active Arizona recovery plans to exclude two multispecies plans. Multispecies plans were excluded, since we could not identify which actions addressed the needs of which species or if differences in our comparisons could be attributed to inherent discrepancies in the kinds of actions required to recover multiple vs. single species. We also removed 23 duplicate actions found within four recovery plans to avoid unintentional distortions in our results. The final suite of single-species plans reviewed included both threatened and endangered species across 31 plans, representing 840 action descriptions.

2.3 Quantifying variation in standardizing action descriptions

Pairs of researchers manually categorized sets of ESA action descriptions in accordance with the CMP taxonomy (78–221 action descriptions per pair across 10 pairs, data available in the Appendix). Conservation researchers assessed action descriptions as opposed to conservation practitioners to capture how well a suite of relevantly trained, yet general, researchers could interpret and categorize recovery actions, as written. Researchers were placed into pairs to ensure that at least two researchers reviewed the same subset of action descriptions so that we could assess if researchers diverged in their categorizations. Described actions were then assigned by researchers according to hierarchical classifications within the CMP taxonomy (CMP, 2019; Salafsky et al., 2008) and using an action categorization protocol co-developed by the researchers (provided in the Appendix). The CMP taxonomy describes conservation actions along a hierarchy, with actions first falling within a series of three, overarching categories: actions that reduce stress or directly address conservation targets, actions that mitigate threats through behavior change, and actions that enable the required conditions for conservation (CMP, 2019). Within each of these categories, additional classifications identify how managers and policymakers might approach conservation efforts (CMP, 2019), which we define as either actions (higher-order classes within these three, broad categories, such as Land/Water Management) or subactions (more specific categories within the broader action category, e.g., Site/Area Stewardship) (Figure 1c). Many action descriptions included clear modes of action, but with a particular focus (e.g., collect data—CMP action category of Research and Monitoring—to restore key habitat—CMP focus category of Land/Water Management). We therefore also assigned action descriptions to CMP categories based on their focus and subfocus. We classified action descriptions using an adapted CMP taxonomy to address specific language in ESA recovery plans (Appendix S1).

We compared consensus in categorization by analyzing how well researcher pairs matched in their assignment of action descriptions. For each pair, we recorded the total number of matches for each level of classification (i.e., matched actions, subactions, foci, or subfoci). We also looked at the proportion of total matches across all possible combinations of these elements and identified their distributions. To quantitatively assess the variation across matches in classification, we performed one-way analyses of variance (ANOVA) and pairwise comparisons using the Tukey–Kramer post hoc test, with statistical significance set at $\alpha = .05$. Data were tested for normality and equal variance among pairs. Finally, we summarized the frequency of agreement for each action categorization across individuals and pairs of researchers. All analyses were performed in R version 3.5.1 and code and data are available in the Appendix.

3 RESULTS

The descriptions of ESA actions in recovery plans were insufficient to categorize these actions under the CMP taxonomy (Table 1). Consensus between pairs varied across action categories and decreased with category resolution (Figure 2a, Appendices S2a,b and S3). Overall, our categorization showed significant variation, both among pairs of researchers and across action, subaction, focus, and subfocus choices (Figure 2a, Figure 3, Appendices S3 and S9–S11). With a total of 556 matches and 283 mismatches (Appendix S2a,b), descriptions categorized at the action level consistently yielded a high
degree of matching, with 68% of average agreement in assignments at this level (SD 0.13). Matches at the focus level were the next most consistently agreed upon categorization ($\bar{X} = 0.57$ [SD 0.13]).

Combining higher-order and lower-order categorization schemes resulted in less agreement between researchers, with the lowest degree of matching occurring when comparing agreement across all categories collectively (i.e., action, subaction, focus, and subfocus) for any given action description ($\bar{X} = 0.16$ [SD 0.12]) (Appendix S3). Differences in agreement between these higher-order and lower-order classifications of action descriptions were statistically significant (one-way ANOVA $F_{5,24} = 10.78$, $p < .001$, $\eta^2 = 0.69$) (Figure 2a, Appendix S5). It is important to note that for this analysis, assumptions of homoscedasticity and normality bordered on failing (for more details, see Appendix S5). In addition, there were several actions that were unclear/vague or reflected multiple action categories (Table 1), and other action descriptions for which researcher pairs did not reach consensus at even the broadest level of categorization (i.e., action) (Table 2). Finally, agreement between researchers on subactions, given agreed upon action classifications, was greater than subfoci agreement.

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**Figure 2** Average proportion of matches for each category, with respect to the total number of elements analyzed per pair (i.e., of the total category elements assessed per pair, how many were on average matched). (a) Average proportion of matches corresponding to each hierarchical category under the CMP taxonomy relative to the total matches per scorer pair; (b) average proportion of matches for each action type, with respect to the total matches per scorer pair; and (c) average proportion of matches corresponding to Research and Monitoring. The left graph shows the average proportion of matches of action and focus that fell under Research and Monitoring, while the right graph shows the average proportion of matches of subaction and subfoci that fell under Basic Research and Status Monitoring. The statistical analyses are based on one way-analysis of variance (ANOVA) and pairwise comparisons using the Tukey–Kramer test ($p < .05$); whiskers represent SDs and the different lowercase letters signal statistically significant results.
under similar conditions (one-way ANOVA, $F_{1,8} = 8.02$, $p = .02, \eta^2 = 0.50$) (Appendices S8 and S11).

Most actions were categorized as Research and Monitoring (Figure 2b, Table 2). The high frequency of Research and Monitoring classification was consistent across researcher pairs, representing an average of 53.04% ($SD = 0.09\%$) of the total action descriptions agreed upon. Agreement among researcher pairs significantly differed between Research and Monitoring and other action categories (one-way ANOVA $F_{9,35} = 41.26$, $p < .001, \eta^2 = 0.91$) (Figure 2b, Appendix S6). This pattern was also observed for descriptions assigned to the Basic Research and Status Monitoring subaction category, although with a higher deviation from the average..
In contrast, the agreement on action descriptions assigned as Research and Monitoring under the focus and subfocus categories remained below 10% (7.21%, SD 8.16% and 5.35%, SD 5.40%, respectively). Differences in these groups were also statistically significant at alpha = .05 (one-way ANOVA $F_{3,16} = 36.46, p < .001, \eta^2 = 0.87$) (Figure 2c, Appendix S7).

Action categories other than Research and Monitoring were not often agreed upon by researcher pairs, with no other category achieving consensus with more than ~10% frequency, on average (Figure 2a,b, Appendix S4). Similarly, individual researchers most frequently categorized action descriptions as reflecting Research and Monitoring objectives (41.90%, SD 7.6%). After Research and Monitoring, individual researchers most often assigned action descriptions to Species Management (9.7%, SD 3.4%) and Conservation Designation and Planning (9.5%, SD 3.5%) (Table 3).

4 | DISCUSSION

Overall, we were unable to reliably categorize existing descriptions of ESA actions in Arizona recovery plans using the CMP taxonomy. Categorization of action descriptions using the CMP taxonomy varied across pairs of researchers, although the magnitude of variation corresponded with the resolution of categorization and the categories considered. These results suggest that adoption of a structured action classification scheme is needed to improve consistency and comparability of recovery action descriptions. Despite variation, we were able to quantify differences in the types of action descriptions across Arizona recovery plans, with action descriptions relating to Research and Monitoring most frequently agreed upon.

These results suggest that considering the balance among the kinds of actions outlined may be necessary when writing recovery plans, since both Research and Monitoring and other conservation-based actions are needed to recover species. Similarly, adequate representation of the subactions within Research and Monitoring and other conservation-based action categories could support species recovery by addressing the different ways in which actions address the threats species face.

When quantifying our ability to standardize the descriptions of recovery plan actions, we reached consensus most often at the highest-level of classification, with agreement of descriptions on average of 68% (SD 0.13) at the action level. However, the proportion of action descriptions agreed upon decreased at other levels of classification (Figure 2a, Appendix S3). Although some variability in the categorization of recovery action descriptions is inevitable, the lack of consensus achieved in our study suggests that the interpretation of recovery plan action descriptions may serve as a barrier to decision-support. Of the 11 possible categories to assign action descriptions, the fourth-highest assignment across researchers was Unclear, representing on average 9% (SD 0.08) of surveyed action descriptions (Figure 2b, Appendix S4). Unclear action descriptions were often vague or could fit within multiple categories, making it difficult to achieve consensus. Additionally, researchers were asked to assign action descriptions to a single category, even when the action description itself may have reflected multiple possible categories. This may have contributed to researcher disagreement and to the underrepresentation of non-Research and Monitoring actions. Finally, many actions that were interpretable (i.e., matched in assignment between researchers) were not necessarily actionable. Unactionable, but
interpretable, descriptions were vague and often lacked specificity (Table 1), potentially limiting their efficacy.

Our analysis suggests that actions relating to Research and Monitoring are by far the most commonly prescribed within the state of Arizona, with 53% (SD 0.09) of average researcher agreement (Appendix S4) and 41.9% (SD 0.08) of average individual researcher assignment falling into this category (Table 3). The comparative ease in classification of these actions may be due, in part, to keywords that made categorization of Research and Monitoring clearer than other groupings (i.e., “monitor,” “measure,” “examine,” “develop,” “assess,” or “study,” Appendix S1). Nonetheless, individual researchers assigned action descriptions as Research and Monitoring 3.5 times more frequently on average than the next highest category of Unclear (Table 3), suggesting most actions in Arizona recovery plans reflect research and monitoring needs.

These results are consistent with other work identifying an overrepresentation of Research and Monitoring in conservation actions (Buxton et al., 2020; Lindenmayer, Piggott, & Wintle, 2013). While collecting research and monitoring data is essential to understand, manage, and recover at-risk species, the extent to which Research and Monitoring actions appear to be overrepresented in Arizona recovery plans suggests that most conservation actions listed may not provide proactive measures to reduce extinction risk (Lindenmayer et al., 2013). Identification of this pattern could help managers restructure how to write and prioritize actions to improve species recovery. It also underscores the importance of shifting the focus from research actions to strict conservation actions after completing research and monitoring.

### 4.1 Recommendations for future recovery plans

Our results suggest that retroactively attempting to categorize actions described in published recovery plans is an onerous process and not realistic for decision-support. To improve the comparability, representation, and interpretability of recovery action descriptions while using the widely supported CMP taxonomy, we provide a series of recommendations that build upon current updates to ESA recovery planning (Figure 1d). USFWS has recently begun reevaluating its approach to recovery planning and implementation. The recovery plan is now just one component of a three-part framework that includes a SSA and is implemented via RISs (USFWS, 2019). SSAs seek to integrate the best available science surrounding a species’ endangerment status using the biodiversity principles of species resilience, recovery, and representation (the 3Rs) (Shaffer & Stein, 2000; Smith et al., 2018;
needed categories, we then recommend authors of recovery plans and RISs clearly separate Research and Monitoring actions and all other actions needed to recover species. The IUCN Red List does this by categorizing actions as either Conservation Actions Needed or Research Needed (IUCN, 2020). Separating Research and Monitoring and other conservation-based actions may support more focused, clear, and directed conservation activities, could lead to more cohesive monitoring by ensuring that research and monitoring efforts support conservation actions (NMFS, 2018), and could also reinforce determinations of how actions support the 3Rs for each species. For this reason, Research and Monitoring actions should still be given the same priority as other actions, potentially by cross-referencing how Research and Monitoring actions will inform conservation actions (NMFS, 2018).

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For species with existing recovery plans, we suggest categorizing actions using the CMP taxonomy when updating or revising recovery plans, such as following 5-year reviews (Figure 1d). After a species is listed under the ESA for 5 years, USFWS is charged with reevaluating the status of the species. In most 5-year reviews, a section at the end entitled Recommendations for Future Actions provides suggestions for advancing species recovery. We recommend that USFWS format these future actions in accordance with the CMP taxonomy and 3Rs, as previously outlined, to help improve standardization across recovery protocols for all species. Aligning recovery actions with the CMP taxonomy and connecting actions to how they support the 3Rs could also make 5-year reviews more precise and comparable to the recovery plans and RISs of newly listed species, helping to guide managers towards clear, tangible actions.

Finally, we recommend that these revisions, and our specific suggestions for writing actions (see below), be incorporated in USFWS and NMFS’ Interim Endangered and Threatened Species Recovery Planning Guidance document (NMFS, 2018), under Section 5.1.9.3. Recovery Action Narrative. This Section could also be revised to
include our recommendation for separate Research and Monitoring and other recovery actions. The rationale for standardizing action descriptions could further be described in Section 1.4. Opportunities for Streamlining and Flexibility of NMFS (2018). However, this may need to be reviewed for statutory adherence by the Interior Solicitor’s Office.

4.3 Recommendations for writing actions

In addition to aligning recovery actions with the 3Rs and CMP taxonomy, improving the interpretability of action descriptions could also support action efficacy (e.g., of current actions, see Table 1 under “Example Action with Partial Agreement”). Whether in a recovery plan, revised recovery plan, 5-year review, SSA, or RIS, we recommend writing or updating actions in ways that allow the reader to understand the (a) kind of action and subaction to which the action description refers, (b) focus of the action, and (c) key players and/or needs required to follow-through with said action (e.g., raise awareness [action] through outreach activities [subaction] to promote site stewardship [focus] among landowners [players] by supporting the clean-up of streams on their properties [needs]). Organizing action descriptions in this way could allow for easier implementation, clearer descriptions of to whom actions refer, and what is needed to achieve conservation objectives.

We also found some action descriptions in our analysis could be attributed to multiple categories under the CMP taxonomy. Reasons for this included action descriptions that were ambiguous or that reflected more than one goal (see Table 1). We also experienced occasional confusion in how to distinguish among similar kinds of categories (e.g., Site/Area- vs. Species Stewardship were often used interchangeably, since they reflect similar objectives). For ambiguous actions, we recommend writing clearer descriptions. If an action is attributable to multiple categories, we suggest separating descriptions into multiple, discrete actions that reflect each CMP category to which it belongs. Finally, for overlap in interpretation of similar CMP categories, we recommend having authors explicitly identify the category to which an action description belongs. In this way, the intent behind a particular action can be more interpretable to those fulfilling recovery plans.

4.4 Future directions

Given the breadth of species represented and types of actions described in Arizona recovery plans, as well as recent global evidence suggesting over-representation of Research and Monitoring actions (Buxton et al., 2020), our conclusions can be applied to other regions and institutions. Although a standard taxonomy of conservation actions is not yet the norm, entities around the world are already familiar with the classification system used by the IUCN, which, although evolving in nature, is similar to the approach discussed herein (IUCN, 2020). Standardized action descriptions could also help funding entities and government agencies determine how resource allocation corresponds with conservation outcomes, as well as with identifying which kinds of actions require more funding or focused activity. Future research endeavors could also seek to identify differences in how researchers and conservation practitioners categorize or interpret recovery action descriptions. Our recommendations also come at a prime time for USFWS, as they are currently revising recovery planning guidelines through interim documents.

Our research can also advance the prioritization of recovery actions and support more actionable conservation planning. In general, once a species is listed under the ESA, it can often take over 5 years to develop a recovery plan (Malcom & Li, 2018). While USFWS’s recently revised Recovery Planning and Implementation approach should reduce this number, the CMP taxonomy provides a template with ready-made categories for actions, instead of having managers write them from scratch. Therefore, not only would the standardized actions make the plans clearer and more easily comparable, but could help speed the writing and adoption of recovery plans (a problem already defined by the USFWS, USFWS, 2019). Review panelists in a 2016 NMFS recovery program review suggested that a database including recovery actions could help provide more detailed information on a species’ progress (CBI, 2016). In the future, building an online database of recovery actions that allows for coding of multiple categories could therefore streamline and improve recovery efforts. Such a database could also support USFWS’ recently launched Information for Planning and Conservation (IPaC) system, which seeks to advance the dissemination of conservation and recovery information to agency members and the public when planning projects (https://ecos.fws.gov/ipac/).

In summary, our results suggest that standardizing actions in species recovery documents requires urgent attention. Globally, biodiversity is lost at an alarming rate, with 1 million species worldwide threatened with extinction (IPBES, 2019). Negotiations have started to develop new targets for the Convention on Biological Diversity's Post-2020 Global Biodiversity Framework (CBD, 2020). To achieve these new targets, plans and projects involving tangible and effective conservation actions are urgently needed.
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CONFLICT OF INTEREST
The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS
Katherine C. B. Weiss, Gwenllian D. Iacona, and Leah R. Gerber: Conceived and designed the study.
Katherine C. B. Weiss, Gwenllian D. Iacona, Olivia N. Davis, Krista Kemppinen, and Katie C. Surrey: Performed the research. Álex Tuñas Corzón: Analyzed the data. Katherine C. B. Weiss, Gwenllian D. Iacona, Olivia N. Davis, Krista Kemppinen, Katie C. Surrey, Álex Tuñas Corzón, and Leah R. Gerber: Developed recommendations. Katherine C. B. Weiss, Gwenllian D. Iacona, Olivia N. Davis, Krista Kemppinen, Katie C. Surrey, Álex Tuñas Corzón, and Leah R. Gerber: Wrote the paper.

DATA AVAILABILITY STATEMENT
Our data and R code are publicly available on GitHub: https://github.com/alexunascorzon/ESA.

ETHICS STATEMENT
The research reported herein did not involve working with animals or vulnerable populations.

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REFERENCES
Ban, N. C., Wilson, E., & Neasloss, D. (2020). Historical and contemporary indigenous marine conservation strategies in the North Pacific. Conservation Biology, 34, 5–14.
Boersma, P. D., Kareiva, P., Fagan, W. F., Clark, J. A., & Hoekstra, J. M. (2001). How good are endangered species recovery plans? Bioscience, 51, 643–649.
Bolam, F. C., Mair, L., Angelico, M., Brooks, T. M., Burgman, M., Hermes, C., … Butchart, S. H. M. (2021). How many bird and mammal extinctions has recent conservation action prevented?. Conservation Letters, 14(1). http://dx.doi.org/10.1111/conl.12762.
Burton, J. A. (2003). The context of red data books, with a complete bibliography of the IUCN publications. In H. de Iongh, O. Bänkì, W. Bergmans, & M. van der werf ten Bosch (Eds.), The harmonization of red lists for threatened species in Europe (pp. 291–300). Leiden: The Netherlands Commission for International Nature Protection.
Buxton, R., Avery-Gomm, S., Lin, H.-Y., Smith, P. A., Cooke, S., & Bennett, J. R. (2020). Half of resources in threatened species conservation plans are allocated to research and monitoring. Nature Communications, 11, 4668.
CBD. (2020). Report of the open-ended working group on the post-2020 global biodiversity framework on its second meeting. Rome. https://www.cbd.int/doc/c/b14d/6af5/a97c4f2c9d58203f5e2e059c/wg2020-02-04-en.pdf.
CBL. (2016). National Marine Fisheries Service National Recovery Program Review.
Clark, J. A., Hoekstra, J. M., Boersma, P. D., & Kareiva, P. (2002). Improving U.S. Endangered Species Act recovery plans: Key findings and recommendations of the SCB recovery plan project. Conservation Biology, 16, 1510–1519.
CMP. (2019). Threats and actions classifications.
Crouse, D. T., Mehrhoff, L. A., Parkin, M. J., Elam, D. R., & Chen, L. Y. (2002). Endangered species recovery and the SCB study: A U.S. Fish and Wildlife Service perspective. Ecological Applications, 12, 719–723.
Croxall, J. P., Butchart, S. H. M., Lascelles, B. E. N., Stattersfield, A. J., Sullivan, B., Symes, A., & Taylor, P. (2012). Seabird conservation status and threats: A global assessment of priorities. Bird Conservation International, 22, 1–34.
Diaz-Campos, C. A., & Vilés-Lopez, K. (2020). Financial structuring of protected areas according to the conservation measures partnership classification system of actions. Parks, 26, 89–98.
Gerber, L. R., Runge, M. C., Maloney, R. F., Iacona, G. D., Drew, C. A., Avery-Gomm, S., … Zablan, M. A. (2018). Endangered species recovery: A resource allocation problem. Science, 362, 284–286.
Harris, J. B. C., Leighton Reid, J., Scheffers, B. R., Wanger, T. C., Sodhi, N. S., Fordham, D. A., & Brook, B. W. (2011). Conserving imperiled species: A comparison of the IUCN red list and U.S. Endangered Species Act. Conservation Letters, 5, 64–72.
IPBES. (2019). Brondizio, E. S., Settele, J., Díaz, S., & Ngo, H. T., (editors). Global assessment report on biodiversity and ecosystem services of the intergovernmental science-policy platform on biodiversity and ecosystem services. Bonn, Germany: IPBES secretariat.
IUCN. (2020). Classification schemes.
Joseph, L. N., Maloney, R. F., & Possingham, H. P. (2009). Optimal allocation of resources among threatened species: A project prioritization protocol. Conservation Biology, 23, 328–338.

Knight, A. T., Cook, C. N., Redford, K. H., Biggs, D., Romero, C., Ortega-Argueta, A., ... Keene, M. (2019). Improving conservation practice with principles and tools from systems thinking and evaluation. Sustainability Science, 14, 1531–1548.

Lindenmayer, D. B., Piggott, M. P., & Wintle, B. A. (2013). Counting the books while the library burns: Why conservation monitoring programs need a plan for action. Frontiers in Ecology and the Environment, 11, 549–555.

Malcom, J. W., & Li, Y. W. (2018). Missing, delayed, and old: The status of ESA recovery plans. Conservation Letters, 11, 1–9.

McCarthy, D. P., Donald, P. F., Scharlemann, J. P. W., Buchanan, G. M., Balmford, A., Green, J. M. H., ... Butchart, S. H. M. (2012). Financial Costs of Meeting Global Biodiversity Conservation Targets: Current Spending and Unmet Needs. Science, 338(6109), 946–949. http://dx.doi.org/10.1126/science.1229803.

Miller, R. M., Rodríguez, J. P., Aniskowicz-Fowler, T., Bambaradeniya, C., Boles, R., Eaton, M. A., ... Pollock, C. (2007). National Threatened Species Listing Based on IUCN Criteria and Regional Guidelines: Current Status and Future Perspectives. Conservation Biology, 21(3), 684–696. http://dx.doi.org/10.1111/j.1523-1739.2007.00656.x.

NMFS. (2018). Interim endangered and threatened species recovery planning guidance. Silver Spring, MD. https://www.fws.gov/endangered/esa-library/pdf/NMFS-FWS_Recovery_Planning_Guidance.pdf.

Redford, K. H., Hulvey, K. B., Williamson, M. A., & Schwartz, M. W. (2018). Assessment of the Conservation Measures Partnership’s effort to improve conservation outcomes through adaptive management. Conservation Biology, 32, 926–937.

Salafransky, N., Salzer, D., Stattersfield, A. J., Hilton-Taylor, C., Neugarten, R., Butchart, S. H. M., ... Wilkie, D. (2008). A Standard Lexicon for Biodiversity Conservation: Unified Classifications of Threats and Actions. Conservation Biology, 22(4), 897–911. http://dx.doi.org/10.1111/j.1523-1739.2008.00937.x.

Schwartz, M. W., Deiner, K., Forrester, T., Grof-Tisza, P., Muir, M. J., Santos, M. J., ... Zylberberg, M. (2012). Perspectives on the open standards for the practice of conservation. Biological Conservation, 155, 169–177.

Shaffer, M. L., & Stein, M. A. (2000). Safeguarding our precious heritage. In B. Stein, L. Kutner, & J. Adams (Eds.), Precious heritage: The status of biodiversity in the United States (pp. 301–321). New York, NY: Oxford University Press.

Smith, D. R., Allan, N. L., McGowan, C. P., Szymanski, J. A., Oetker, S. R., & Bell, H. M. (2018). Development of a species status assessment process for decisions under the U.S. Endangered Species Act. Journal of Fish and Wildlife Management, 9, 302–320.

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