Multispecies approaches to status assessments in support of endangered species classifications

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Abstract
Multispecies risk assessments have developed within many international conservation programs, reflecting a widespread need for efficiency. Under the United States Endangered Species Act (ESA), multispecies assessments ultimately lead to species-level listing decisions. Although this approach provides opportunities for improved efficiency, it also risks overwhelming or biasing the assessment process and would benefit from clear guidance for practitioners.

We reviewed multispecies assessments conducted between 1993 and 2019 for ESA listing decisions to identify the ecological basis for combining species, the assessment approach used, and the policy factors influencing their efficacy. We identified 42 cases covering 359 species. Most assessments (81%) included two to five species, although the maximum was 82. A common theme involved grouping narrow endemics or habitat specialists based on taxonomic relatedness, similar distributions, and common threats to persistence. All assessments included a combined threats analysis, but few employed a common species’ response model or expert elicitation process. Although ESA risk assessments are distinct from policy decisions, most assessments (50%) supported decisions that all species warranted endangered status. Available guidance has generally emphasized ecological similarity as the key attribute leading to successful multispecies assessments. The challenge with consistently selecting species based on qualitative proxies such as common distributions or threats to persistence is that ecological patterns and processes are scale dependent. Focusing instead on the assessment methods and their potential for bias and increased efficiency may provide a stronger basis for developing consistent and transparent guidance.

Keywords
decision making, ESA, extinction risk, multi-species, species status assessment, surrogate species, threatened
1 | INTRODUCTION

The accelerating pace of extinctions combined with the resources required to evaluate species’ extinction risk has often triggered debate about whether approaching conservation on a species-by-species basis can keep pace with societal needs (Carroll et al., 1996; Clark & Harvey, 2002; Franklin, 1993; LaRoe, 1993; Nicholson et al., 2009; Simberloff, 1998). As a result, multispecies approaches to extinction risk assessments have developed in many national and international species-at-risk programs (Appendix S1). NatureServe and Australia have adopted procedures for listing ecological communities, with 90 threatened ecological communities currently listed under Australia’s Environment Protection and Biodiversity Conservation Act (Commonwealth of Australia, 2020; Nicholson et al., 2009). Several countries and the International Union for Conservation of Nature (IUCN) have established procedures for assessing entire ecosystems or habitat types, which are inherently multispecies and implement similar criteria to the IUCN Red List of Ecosystems (Keith et al., 2015). Risk assessments focused on communities or ecosystems face a variety of challenges, including lack of agreement on the characteristics that define an ecological community or ecosystem (LaRoe, 1993; Ricklefs, 2008) and difficulty identifying changes in functional properties that indicate community or ecosystem extinction (Keith, 2009). The fact that such assessment approaches exist, however, suggests that it is possible to develop consistent criteria for extinction risk at levels above individual species and emphasizes the perceived need for these approaches (Nicholson et al., 2009).

Ecosystem and community-based conservation programs have not replaced the need for species-level assessments, as key procedures and conservation efforts remain focused on individual species. Many of the programs previously mentioned operate independently of similar species-oriented legislation within each governing body (e.g., IUCN Red List of Species and Red list of Ecosystems), and other countries lack robust approaches for determining threatened status above the species level. Although the U.S. Fish and Wildlife Service (USFWS) has expressed a commitment to incorporate ecosystem-level approaches into Endangered Species Act (ESA) management (USFWS, 1994) and researchers have called for ecosystem-level assessments (Noss et al., 2021), the cornerstone of the ESA remains listing determinations for individual species or populations because these establish all subsequent protections under the Act. At the same time, the recent USFWS methodology for prioritizing the large number of candidate species and the resulting multi-year national listing workplan (USFWS, 2016b) suggest an urgent need to find efficiencies in the assessments that support these decisions.

Multispecies assessments geared toward species-level status determinations offer one approach to address this need for efficiency and present a range of potential benefits and risks similar to community and ecosystem approaches (Table 1). Managers responsible for implementing endangered species legislation often cite efficiencies gained by not duplicating costly data collection, analyses, or legislative processes (Jewell, 2000). Researchers generally point to potential gains in statistical power or improved model predictions when data-rich species are combined with functionally similar, data-poor species (Kindsvater et al., 2018; Ovaskainen & Soininen, 2011). On the other hand, there is great risk of overwhelming an assessment process with too many dissimilar species or overlooking important functional differences in species’ response to threats (Caro et al., 2005). Reviews of ESA recovery plans indicate that species included in multispecies plans may be less likely to show improving trends compared with those covered under single-species plans (Boersma et al., 2001; Taylor et al., 2005). These tradeoffs suggest that careful consideration and clear guidelines would help weigh the potential benefits and risks of multispecies assessments before implementing such approaches.

Multispecies approaches to status assessments under the ESA have been occurring for decades as part of assessments to support listing decisions (e.g., Brainard et al., 2011; USFWS, 2016a, 2018), recovery plans (Hoeckstra et al., 2002), and habitat conservation plans (Rahn et al., 2006). The USFWS has expressed a commitment to pursue multispecies approaches to improve efficiency, including grouping multiple species by taxon, anticipated threats, geographic location, or similar considerations (editor’s note following LaRoe, 1993; USFWS, 1994, 2016b). Guidance for multispecies recovery plans is perhaps the most developed, with USFWS recommending this approach be considered when two or more species of the same genus and geographic areas share common threats or ecosystems (Jewell, 2000). Specific guidelines on how to perform multispecies recovery plans, select multiple species for habitat conservation plans, or incorporate multispecies approaches into assessments supporting individual listing decisions are generally lacking (Clark & Harvey, 2002; Rahn et al., 2006). Guidance would be especially useful for assessments supporting listing decisions, which determine subsequent ESA protections (Waples et al., 2013), may affect whether species remain grouped in the future, and face challenges not present in other ESA contexts. For example, the available data and pool of potential candidates for multispecies processes may be more limited for assessments...
supporting listing decisions compared with recovery and habitat conservation plans that may rely on information generated after listing or combine species listed at different times.

The recent implementation of the Species Status Assessment (SSA) framework by the USFWS established a transparent and reproducible process for the scientific assessments supporting ESA decisions (Smith et al., 2018). Within that framework multispecies approaches entail choices about how species are combined and then assessed. To aid development of transparent guidance, we reviewed past multispecies assessments in support of ESA listing decisions to evaluate the previous approaches and assumptions used when combining species. Specifically, this study seeks to identify the ecological basis for combining species, the assessment approach used, and the policy factors that may influence the usefulness of multispecies assessments under the ESA. Our hypothesis was that the data available for many at-risk species are insufficient to generate repeatable groupings when focusing exclusively on ecological similarities or shared threats, and that these similarities do not necessarily result in increased efficiency on their own. We focus instead on identifying best practices related to specific assessment methods, which are the basis for achieving efficiencies and may provide a more tractable means for the USFWS to develop repeatable and transparent guidance. Although previous studies have reviewed the use of multispecies approaches to ESA

| Benefits | Examples | Source | Risks | Examples | Source |
|----------|----------|--------|-------|----------|--------|
| Efficiency | Increase cost-effectiveness by not duplicating analyses or sampling | LaRoe (1993); USFWS (2016b) | Overwhelm | Including too many or dissimilar species can become overly burdensome or impede interpretation | Authors’ personal observations |
| Streamline public comment, report writing, and filing processes | Jewell (2000) | Combining species at varying ESA stages (e.g., listing and recovery) or with differing levels of taxonomic certainty can lead to bottlenecks | | Authors’ personal observations |
| Data sharing | Using data from multiple species can improve predictions of distributions, occurrence, or abundance | Ovaskainen and Soininen (2011); Fithian et al. (2015); Kindsvater et al. (2018) | Data misapplication | Missing important differences among species’ functional responses to environmental change | Caro et al. (2005) |
| Response of surrogate species can serve as a guide for data-limited species | Wenger (2008) | Overlooking critical habitat or resource needs if species’ ranges are overlapping, but patchily distributed | | Hitt and Frissell (2004) |
| Consistency | Common modeling framework can lead to consistent criteria and presentation of results | McClure et al. (2003) | Loss of specificity | Assessments become too generalized and unable to focus on specific, isolated threats or species needs | Authors’ personal observations; Clark and Harvey (2002) |
| | | | | | |
| Integration | Inclusion of community dynamics that impact viability, such as mutualisms or competitive exclusion | Sabo (2008) | Scale dependency | Population and community trends may lead to conflicting interpretations | Dornelas et al. (2019) |
| | | | | | |

**Table 1: Potential benefits and risks of multispecies approaches to status assessments for endangered species act listing decisions**
recovery and conservation planning (Clark & Harvey, 2002; Hoekstra et al., 2002; Rahn et al., 2006), we are not aware of reviews focused on the listing stage and the SSA framework does not explicitly address multispecies approaches.

2 | METHODS

Past multispecies assessments were identified by reviewing the U.S. Federal Register, the USFWS Service Catalog (i.e., ServCat), and National Oceanic and Atmospheric Administration (NOAA) Fisheries Documents in October 2019. Federal Register search terms included: (endangered and threatened wildlife and plants) or (endangered species status) or (species status assessment) or (status review). Results were further refined by limiting the type of document to rules and the topic to endangered and threatened species. NOAA Fisheries and USFWS ServCat searches were limited to ESA status review and species status assessment documents, respectively. These search criteria returned 975 documents, including proposed and final listing rules, critical habitat designations, and species status review and status assessment reports.

Multispecies assessments were defined as any process where data or resources were shared among more than one species. For example, the reliance on generalized demographic parameters of congeners, an expert elicitation approach that involved the same experts for multiple species, and a single threat assessment applicable to several species were all considered a form of multispecies assessment. For each case matching this definition, we recorded the number of species included, lead agency and region, assessment type, assessment approach, and listing outcome. Assessment type was classified as similarity in their distributions, habitat requirements, life history strategies, threats to persistence, or listing petition history. Because these factors are scale dependent, we did not attempt to define criteria for considering species ranges, life history traits, or other characteristics as similar (e.g., >75% overlap in ranges). Classifications were instead based on whether data were shared or information was presented jointly for multiple species within the assessment (e.g., presenting multiple range maps in one figure). Assessment approach refers to the methods used and was classified as either a common species response model, threat assessment, or expert elicitation approach, where common response model refers to any common framework for evaluating changes in extinction probability beyond a threat assessment (e.g., species distribution or population models). Neither assessment types nor approaches were considered mutually exclusive. Listing outcome was classified as all endangered, all threatened, mixed listing (i.e., endangered and threatened), mixed (i.e., warranted and not warranted), none listed, or pending based on the ESA decision presented in the final listing rule. The lowest major taxonomic level that contained all species (i.e., domain, kingdom, phylum, class, order, family, genus, species) was recorded based on taxonomy referenced in the assessment or the Integrated Taxonomic Information System (ITIS, 2020) if sufficient information was not available in the assessment.

To compare the geographic scope and similarity of species’ ranges among assessments, we calculated the extent of occurrence following IUCN (2019) and percentage overlap in distributions for all species with range information available in USFWS Environmental Conservation Online System (USFWS, 2019). The spatial resolution of distribution maps varies among assessments based on available data (e.g., county-level, watershed-level, or point localities); however, data for species within an assessment were always available at a similar resolution. While spatial resolution clearly impacts estimates of geographic extent and overlap of distributions, we use these data only to demonstrate the broad variation across assessments (e.g., single site endemics compared with wide-ranging, partially overlapping species) and caution against direct comparison. Area calculations were performed using data referenced to the Albers Equal Area North American Datum 1983 Coordinate Reference System (EPSG 42303) for species in the conterminous U.S. using QGIS version 3.12.2 (QGIS, 2020). Calculations for species occurring outside of the conterminous U.S. were performed using data referenced to the Mollweide Equal Area Coordinate Reference System (EPSG 54009), but were excluded from extent of occurrence estimates reported below due to the small number of assessments.

Cases were limited to assessments supporting listing decisions because of their unique challenges, ability to impact future ESA contexts, and the lack of previous studies synthesizing trends. Multispecies assessments regularly occur during recovery planning, consultations under section 7 of the ESA, and habitat conservation plans and these have been reviewed elsewhere (Clark & Harvey, 2002; Hoekstra et al., 2002; Rahn et al., 2006). The two exceptions were an SSA in support of a 5-year review process and an SSA that combined species at both the listing and recovery planning stages, which were included because few multispecies SSAs have been completed to date and a major goal of this study is to provide information useful for adapting multispecies approaches to the SSA framework.
Multispecies assessments in support of ESA listing determinations have been occurring since at least 1993 (earliest date of online Federal Register documents). Forty-two unique cases were identified, covering 359 individual species (Appendix S2). Most assessments (81%) included two to five species, although several assessments contained as many as 38–82 species. Assessments covered a wide range of taxonomic groups, including birds, mammals, reptiles, amphibians, fishes, terrestrial plants, and both aquatic and terrestrial invertebrates. Numerous cases were also identified where multiple species were combined within a proposed or final rule in the U.S. Federal Register, but no information or analyses were shared during the assessments. Although this approach may provide certain publishing efficiencies when communicating results, these cases were excluded from the present analysis.

Multispecies assessments most frequently combined species within the same genus (Figure 1a); however, 36% combined species at the level of class or higher, including 10% that grouped species at the level of Domain (i.e., combining plants with vertebrate and invertebrate animals). Most assessments grouped species based on perceived similarities in distributions and threats to persistence (Figure 1b), although the estimated overlap in distributions ranged from zero to nearly 100% (Figure 2). For example, multiple assessments of species from the pine rocklands ecoregion in Southern Florida revealed nearly complete overlap in ranges, whereas an assessment of yellow-legged frogs in the genus *Rana* included species with largely non-overlapping ranges in montane regions of the Sierra Nevada of California. All cases reviewed appeared to combine species for multiple reasons (e.g., similar distributions, habitat requirements, and threats to persistence), and 26% suggested that limited species-specific data were a factor for grouping species (Appendix S2). No assessments combined species based on host–parasite, predator–prey, or competitive interactions. Surprisingly few assessments (26%) explicitly referenced the reasons or assumptions behind the decision to combine multiple species into a single document or analysis.

A common theme among the cases reviewed was grouping narrow endemics or habitat specialists. For example, the Edwards Plateau salamanders in the genus *Eurycea* are endemic to Central Texas (Figure 2) and highly specialized for cave, spring, and groundwater habitats in karst areas. Similarly, several assessments grouped species based on endemism to either the Hawaiian or Mariana Islands, including all but one of the assessments with greater than 20 species. Half of the cases reviewed had combined extents of occurrence less than 100,000 km² (roughly the size of the state of Indiana), but numerous assessments grouped species spanning much larger areas, including near global distributions of some sharks and rays (e.g., *Alopias* spp., *Manta* spp.).

All multispecies assessments included some form of a combined threats analysis, reflecting a key component of extinction risk assessments (Figure 3). Interestingly, relatively few assessments employed a similar species’ response model or expert elicitation process (Figure 1c), and only two cases were identified that could be defined as using a joint modeling approach (a multivariate ordination describing shifts in community structure and a population trend analysis based on timeseries data.

3 RESULTS

Multispecies assessments in support of ESA listing determinations have been occurring since at least 1993 (earliest date of online Federal Register documents). Forty-two unique cases were identified, covering 359 individual species (Appendix S2). Most assessments (81%) included two to five species, although several assessments contained as many as 38–82 species. Assessments covered a wide range of taxonomic groups, including birds, mammals, reptiles, amphibians, fishes, terrestrial plants, and both aquatic and terrestrial invertebrates. Numerous cases were also identified where multiple species were combined within a proposed or final rule in the U.S. Federal Register, but no information or analyses were shared during the assessments. Although this approach may provide certain publishing efficiencies when communicating results, these cases were excluded from the present analysis.

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collected when two recently split species were considered a single species). All other assessments employing a common response model used a parallel approach in which similar methods or model structure were used, but model fitting or expert judgments were conducted individually for each species. Although ESA status assessments are distinct from the eventual policy decision, most multispecies assessments (50%) resulted in a decision that all species included in the assessment warranted listing as endangered (Figure 4). Less than 10% of reviewed cases resulted in a mixed decision where only some species were listed as threatened or endangered.

4 | DISCUSSION

Multispecies assessments in support of ESA listing decisions have been occurring for nearly three decades; however, the approach has become more prevalent in recent years following a trend in large, multispecies petitions. Indeed, 36 of the 42 identified assessments were conducted after 2010 and nearly half included species that were petitioned together (Figure 1b). While the ability to simultaneously petition multiple taxonomic units ended following a 2016 rule (81 FR 66461), the commitment expressed to pursue multispecies approaches suggests this trend will continue (USFWS, 2016b). Fewer multispecies assessments appear to support listing decisions compared to other ESA contexts. For example, 82 multispecies
recovery plans were approved between 1982 and 1998 (Clark & Harvey, 2002) compared with the 42 assessments identified between 1993 and 2019 in the present study. Because not all listing assessments were documented in a status review report or SSA, the number of multispecies cases identified is likely an underestimate, particularly for not-warranted decisions. Whatever the actual number, these assessments may have disproportionate effects on conservation policy by determining future ESA protections and influencing whether species remain grouped in later stages (Waples et al., 2013).

Perhaps the most important decision for any multispecies risk assessment is how to select species. Ideally, this would be based on similarities in functional traits or functional responses (Caro et al., 2005), and a growing body of literature explores whether large-scale trait databases and multivariate statistical methods can aid the identification of ecological groups or surrogate species (e.g., Cooke et al., 2019; Diaz et al., 2016; Kopf et al., 2017; Sofaer et al., 2018; Winemiller et al., 2015). The reality is these data are unavailable for most at-risk species, forcing assessments to rely on available proxies. A large percentage of assessments grouped species based on geographic and taxonomic proximity (Figure 1), consistent with attempts to predict IUCN Red List categories for data-deficient species using similar factors (Jetz & Freckleton, 2015). The most common assessment type grouped narrowly endemic and closely related habitat specialists, where the limited range of conditions necessary for survival may make assumptions of similar functional responses across species more credible. For species-rich assessments (23–49 species), geography and threats were the primary reasons for grouping. This reflects the previous threats-based approach used within USFWS; however, it seems unlikely that such large and taxonomically diverse assessments will lead to similar gains in efficiency under the more species-centric SSA framework (Smith et al., 2018). Not all cases that grouped species based on habitat contained species using a single habitat type. For example, an assessment of 49 species from Hawaii used an ecosystem/habitat approach to organize species, but covered species occurring in several different ecosystems (USFWS, 2016a). All assessments combined species for multiple reasons, highlighting how reliance on multiple proxies may lead to more ecologically relevant and efficient groupings. For example, focusing only on taxonomic relatedness ignores complex patterns of evolutionary convergence and diversification (McGhee, 2011), but in combination with similar patterns of habitat use and life history strategies may indicate that joint assessment approaches are appropriate.

The challenge with developing guidance for selecting species based on qualitative proxies such as common geographies, threats, or ecosystem dependence (Jewell, 2000; Noss et al., 2021) is that ecological patterns and processes are scale dependent (Levin, 1992). At what point are species’ habitat requirements similar enough to expect that a multispecies assessment may achieve an agency’s objective to maximize efficiency? For example, while many aquatic species can be described as riffles- or rapids-adapted, this coarse similarity in habitat use overlooks widespread patterns of niche partitioning and diverse life history strategies among co-occurring species (Lujan & Conway, 2015). Combining rapids-adapted species in an assessment may be appropriate, however, if the primary threat is loss of swift-water habitat as rivers become increasingly fragmented and impounded. Similar issues of scale, choice of methods, and the specific management objectives can lead to variation in how species are selected even when using multivariate clustering methods as a basis (e.g., Bal et al., 2018; Sofaer et al., 2018). Identifying best practices for selecting species may depend less on whether species are true ecological surrogates (sensu Caro et al., 2005; Wenger, 2008) than whether they are similar enough given the resolution of available data and known threats to persistence to be efficiently combined in a joint process.

Guidance for multispecies assessments will support attempts to increase efficiency with reduced risk of compromising species-based decision making. Because qualitative proxies of ecological similarity are unlikely to generate consistent groupings on their own, and do not capture potential procedural efficiencies, we argue instead for an approach that focuses on the assessment methods and their varying degrees of potential bias and gains in efficiency (Table 2, Figure 3). Creating initial groupings of species around the potential methods used, in addition to the species’ biological characteristics, may allow managers developing the ESA listing workplan to directly identify the expected approach for increasing efficiency. It will be challenging to assess potential methods during workload planning because the available data for each species is often compiled during the assessment process. In practice, this may require that species groupings are developed in collaboration with analysts conducting the assessments, as well as a willingness from managers to later separate species into individual assessments if the analyst finds the initial grouping needs revision. This approach may also increase transparency by allowing external stakeholders to evaluate the potential risks associated with each combination of methods.

Some multispecies assessment methods provide a clearer path for achieving efficiencies than others. For example, joint data collection for co-occurring species poses low risk of biasing decisions, while undoubtedly increasing efficiency in the assessment process due to
TABLE 2  Best practices for multispecies approaches to status assessments for endangered species act listing decisions

| Method                        | Conditions for success                                                                                                                                                                                                 |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Initial grouping on workplan  | Groupings are developed in collaboration with assessors and based on potential methods used in addition to biological characteristics. The reasons for grouping are clearly identified to allow for ongoing evaluation. The groupings remain flexible to splitting as further details of the species are uncovered during the assessment process. |
| Joint data collection         | Species occur over a similar range and are generally collected in the same surveys, or the assessment will rely on the same data sources (i.e., literature review, museum collections, experts). Gains in efficiency will likely increase with greater overlap in the area of occupancy, not the extent of occurrence. |
| Combined threat assessment    | The same primary threats are affecting each species and the assessment will use the same resolution analysis units (e.g., watersheds, counties, standardized grid) for summarizing threat data.                                      |
| Parallel response models      | The resolution of available species data (e.g., single snapshot of occurrence, time series of abundance) leads to a similar model structure and analysis unit for each species, allowing the model fitting procedure to be easily repeated.       |
| Joint response model/ data sharing | Sufficient data and resources are available to fit hierarchical models for at least some species. The species are part of an interacting assemblage where distributions or demographics are correlated and functional responses related. |
| Joint publication             | The reasons for grouping species into a single assessment are clearly identified. Reports are well organized and distinguish shared methods from the species-specific results of the risk assessment.                                         |
| Joint decision meeting        | A description of shared methods is followed by species-specific risk summaries and policy application. Sufficient time is provided for each species, with breaks in between decisions or separate sessions. Careful consideration is given to the ordering of species relative to risk profiles to avoid common cognitive biases such as anchoring effects (i.e., only comparing a species risk relative to the previous species). |
| Joint rulemaking              | Procedural efficiencies (e.g., lower publication costs, fewer rules) are clearly distinguished and pursued independently from scientific reasons for grouping species during the risk assessment.                                                               |

reliance on similar data sources and experts (e.g., Fitzgerald et al., 2021; Lacher et al., 2012). In this context data collection refers to more than field-based sampling, including activities such as compiling or digitizing locality data, eliciting expert judgments, or any other attempt to synthesize existing knowledge of the species (Table 2). Although we were unable to assess the frequency of joint data collection processes based on the information provided in the assessments, we suspect this approach is common. Many IUCN species specialist groups use processes that can be viewed as forms of multispecies assessment in which workshops are used to streamline data collection and expert knowledge elicitation for sometimes hundreds of species grouped based on taxonomic and geographic similarities (Lacher et al., 2012; Stuart et al., 2004). This makes efficient use of financial resources, experts’ time, and promotes consistency in the assessment process for a particular region, while still generating the classifications needed for individual species determinations. The fact that joint data collection processes are widely used for species-level IUCN classifications suggests that this approach provides gains in efficiency and that similar methods could be successfully applied under the ESA.

A single threats analysis describing the extent, magnitude, or probability of impact was used in all reviewed cases (e.g., based on land use patterns or timeseries analysis of commercial harvest data). This method may benefit assessments of multiple species facing common threats to persistence with low risk of biasing the analysis if species functional responses are evaluated individually (e.g., Burgess et al., 2013). Although this method is widely used in ESA assessments, it is not always implemented under the conditions that likely lead to increased efficiency (Table 2). For example, qualitative descriptions of threats can become difficult to follow when there are site-specific differences in exposure and species’ ranges overlap only partially. Combined threat assessments may prove most effective for variables that can be summarized quantitatively, such as climate or land cover projections, and used as input to a similar modeling framework for each species.

Apart from using surrogate species to inform response of data-poor species, the greatest risk of biasing decisions or impacting downstream ESA processes likely occurs during the communication stage. For example, the large percentage of assessments leading to identical decisions among species (i.e., all endangered, all threatened, none listed) could suggest either assessments are grouping species with similar risk profiles or that cognitive biases are causing decision makers to anchor on previous decisions while evaluating subsequent species (Kahneman...
et al., 2021; Tversky & Kahneman, 1974). The prevalence of assessments for narrowly endemic habitat specialists may mean that similarity in risk profiles is driving this pattern, but it is not possible to distinguish between these alternative interpretations for many past assessments. Careful consideration of the ordering of species in joint decision meetings may guard against some cognitive biases (Table 2). Similar to best practices for expert knowledge elicitation (Dias et al., 2018), decisions could start with the lowest and highest risk species to provide two opposing anchor points when evaluating subsequent species with intermediate risk profiles. The SSA framework’s focus on species response will also provide some clarity going forward. SSAs are intended to be living documents supporting multiple ESA contexts (Smith et al., 2018), and careful organization may be required to facilitate future 5-year reviews or recovery plans if listing outcomes are mixed or species are subsequently separated. Clearly distinguishing shared methods from species-specific results in joint publications provides one way to help support ESA contexts beyond listing and may provide more clarity on decision outcomes (Table 2). Viewing multispecies assessments as a flexible collection of methods may help differentiate efficiencies gained during the scientific risk assessment from considerations surrounding policy decisions or procedural efficiencies such as decreased repetition, publication costs, or need for expert reviewers (Doremus, 1997). Indeed, the many cases excluded from this review where species were assessed individually, but combined within a proposed or final rule (i.e., joint rulemaking in Table 2), represent an approach to increase efficiency after the risk assessments and policy decisions are complete.

Most assessments may not require or be able to support joint modeling efforts or the use of surrogate species for data sharing (Table 2); however, taking a methodological focus may highlight other opportunities for increased cost-effectiveness and consistency while minimizing the risk of bias. Because nearly all reviewed assessments used a parallel modeling approach where analyses were conducted individually for each species, the risk of biased results is expected to be low. This also suggests that assessments supporting listing decisions have not realized the increased predictive power that multispecies approaches may afford (Ovaskainen & Soininen, 2011; Wenger, 2008). The benefit of adopting a methods-focused approach is that it can be tailored to the available data for specific listing packages or the comfort level of biologists and decision makers, while remaining flexible to changing circumstances as assessments develop. For example, species could be separated if a joint data collection process reveals that distributions or threats vary such that different modeling frameworks are required or that continuing the multispecies assessment may impede interpretation by decision makers. Importantly, this change to the initial multispecies grouping could occur without losing any efficiencies gained during previous data compilation.

The ESA presents several unique challenges and opportunities for implementing multispecies risk assessments. The petitioning process and subsequent listing timelines may represent the greatest challenge. While the systematic approach or independent advisory panels used in other legislation provide flexibility in prioritizing species (Lacher et al., 2012; Waples et al., 2013), assessments under the ESA are practically limited to species on the national workplan and appropriate ecological analogs may not be readily available. Multispecies packages are often grouped early in the planning process, creating the potential for public petitions or internal procedure to drive selections rather than biologists’ expertise on the species and available data. Similar concerns have been raised about the lack of biological information supporting multispecies recovery plans (Clark & Harvey, 2002). A major advantage of implementing multispecies assessments under the ESA is flexibility in selecting species. While many community and ecosystem approaches are strictly based on co-occurrence (Keith et al., 2015; Nicholson et al., 2009), multispecies assessments for ESA listing decisions may not require geographic overlap to realize potential efficiencies (e.g., allopatric habitat specialists facing common threats). Because ESA listing decisions ultimately occur at the species level, multispecies assessments are not required to meet specific criteria for combining species. This is in contrast to Australia’s Environment Protection and Biodiversity Conservation Act where, for example, a petition to list the lower Murray-Darling fish community was declined threatened status because the ecological community was not adequately defined (Commonwealth of Australia, 2020). In the absence of specific criteria, it will be important that assessments clearly state the assumptions used when combining species in order to maintain the goals of transparency and reproducibility outlined in the SSA framework (Smith et al., 2018).

Multispecies approaches to recovery and habitat conservation plans have been criticized in part for providing insufficient detail for individual species (Clark & Harvey, 2002; Rahn et al., 2006). These concerns are perhaps even more important to avoid during the listing stage and could be reduced through future SSAs that clearly define how and when multispecies approaches are used to support ESA listing decisions. Because the methods used in an assessment represent both the mechanism for achieving efficiency and the potential source of bias, they may provide a stronger and more transparent
basis for evaluating these tradeoffs than focusing solely on ecological similarities or shared threats to persistence when combining species in an assessment process.

**AUTHOR CONTRIBUTIONS**

Daniel B. Fitzgerald and David R. Smith designed the study. Daniel B. Fitzgerald conducted the reviews, performed data analysis, and wrote the initial draft of the manuscript. All authors provided input on study design and manuscript revisions.

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**CONFLICT OF INTEREST**

The authors declare no conflicts of interest.

**DATA AVAILABILITY STATEMENT**

The data recorded during the review process are provided as supporting information and all original assessments are publicly available.

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**SUPPORTING INFORMATION**

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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