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Comparison of conservation policy benefits for an umbrella and related sagebrush-obligate species

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Abstract: Many conservation strategies promote the potential of multiple species benefitting from protection of large areas necessary for the continued viability of 1 species. One prominent strategy in western North America is Wyoming's Sage-grouse Core Area Policy, which was designed to conserve greater sage-grouse (*Centrocercus urophasianus*; hereafter, sage-grouse) breeding habitat, but may also serve as an umbrella to conserve other sagebrush (*Artemisia* spp.)-obligate wildlife, including songbirds. Sagebrush-obligate songbirds and sage-grouse have undergone population declines throughout the western United States attributed to similar habitat issues. We compared trends of sagebrush-obligate songbirds from the Breeding Bird Survey and sage-grouse lek counts in 2 sage-grouse populations in Wyoming (Powder River Basin and Wyoming Basins), USA from 1996–2013. Our evaluation was focused on similarities among population performance of the umbrella species and the species under that umbrella. Sagebrush-obligate songbird and both sage-grouse populations occupied habitat within and outside of protected core areas. Trends of sagebrush-obligate songbirds were not parallel or consistently similar in trajectory to sage-grouse in either core or non-core areas. Our results indicated core areas were successful at maintaining higher sage-grouse trends compared to areas not protected under the core area policy. However, sagebrush-obligate songbird trends did not follow the same pattern. This suggests that protection of only the best sage-grouse habitat may not be a sufficient conservation strategy for other sagebrush-obligate birds.

Key words: Brewer's sparrow, *Centrocercus urophasianus*, conservation policy, greater sage-grouse, population trends, sagebrush sparrow, sage thrasher, umbrella species concept, Wyoming Core Area Strategy

Conservation strategies aimed to protect large areas of high quality habitat necessary for a sensitive species may have additional benefits to similar species, especially when that species' life history is highly dependent on the ecosystem shared by these co-occurring species (Lambeck 1997, Rowland et al. 2006, Runge et al. 2019). For example, the umbrella species concept was proposed as a surrogate means of conserving numerous species within an ecosystem by directing management and conservation practices to a species that epitomized the essential aspects of that ecosystem (Lambeck 1997, Roberge and Angelstam 2004). Greater sage-grouse (*Centrocercus urophasianus*; hereafter, sage-grouse) have been reported to be an umbrella species for sagebrush (*Artemisia* spp.)-dependent species (Rowland et al. 2006, Hanser and Knick 2011). The overlap of sagebrush-obligate songbird habitat requirements with sage-grouse has been established (Rowland et al. 2006, Hanser and Knick 2011, Gamo et al. 2013, Carlisle et al. 2018). Donnelly et al. (2017) found a positive association of sagebrush-obligate songbird abundance with the distribution of sage-grouse—the focal species. However, population trends of sagebrush-obligate songbirds have not been compared between areas of greater abundance and protections for sage-grouse to areas with fewer sage-grouse and fewer protections.

Conservation actions, such as the Wyoming Sage-grouse Core Area Policy, have been implemented throughout the western United States in efforts to prevent an Endangered Species Act listing decision of warranted for sage-grouse (State of Wyoming 2008, 2011). Protective measures within sage-grouse core areas (core areas) were established by the State of Wyoming to sustain the focal species (sage-grouse), which may also benefit sagebrush-obligate songbirds. Protections from the core area policy officially started in 2008; however, core areas functioned as areas with lower human disturbance for many decades as core areas were primarily selected based on sage-grouse population size and were areas of existing intact habitat. These core areas have subsequently been shown to benefit sage-grouse (Fedy et al. 2012, Smith et al. 2016, Dinkins et al. 2017, Gamo and Beck 2017, Spence et al. 2017).

Populations of desert and Great Basin obligate songbirds, including Brewer's sparrow (*Spizella breweri*), sagebrush sparrow (*Amphispiza nevadensis*), and sage thrasher (*Oreoscoptes montanus*), have declined from 1958–2011 by 39.7% (Sauer et al. 2013). Annual weather (drought), seasonal weather (e.g., precipitation and temperature), wildfire, human disturbance (fragmentation), and abundance of common ravens (*Corvus corax*) are known factors that have negatively affected sage-grouse (Aldridge and Boyce 2007, Coates and Delehanty 2010, Blomberg et al. 2012, Dinkins et al. 2014, Coates et al. 2016, Dinkins et al. 2016, Foster et al. 2019). Many of these factors have also been negatively associated with populations of Brewer's sparrow, sage-brush sparrow, and sage thrasher (Knick and Rotenberry 2002, Knick et al. 2005, Noson et al. 2006, Gilbert and Chalfoun 2011). While sage-grouse have been identified as a species of conservation concern and an umbrella species, it is unknown whether core areas in Wyoming resulted in higher long-term population trends for sagebrush-obligate songbirds compared to areas not designated within core areas.

We aimed to compare population trends of sagebrush-obligate songbirds and sage-grouse lek trends to assess the association of the potential focal species (sage-grouse) to 3 other species (Brewer's sparrow, sagebrush sparrow, and sage thrasher) speculated to be under the umbrella of sage-grouse. While these songbirds are long-distance migrants and sage-grouse are not, the common breeding ecosystem among sage-grouse and these songbirds provides an opportunity to evaluate whether these species population trends are limited by similar issues in their breeding habitats. The state of Wyoming implemented a core area strategy in 2008, assigning restrictions to development and use on lands crucial to sage-grouse breeding—many of these landscapes did not exceed 5% surface disturbance at that time (Executive Order 2011-5, https://wgfd.wyo.gov/web2011/wildlife-1000382.aspx). Both sage-grouse and sagebrush-obligate songbird populations may have benefitted from habitat protections for the umbrella species—sage-grouse in this case. Thus, we also compared sagebrush-obligate songbird and sage-grouse population trends within and outside of core areas to assess the effectiveness of sage-grouse conservation actions for conserving sage-grouse and sagebrush-obligate songbirds. Sage-grouse could be considered an exemplary umbrella species if the population performance of the species under the umbrella were in the same direction or parallel to the focal species.

Materials and methods

Study areas

Our study was conducted in Wyoming and a small portion of Utah, USA as a retrospective analysis of population trends of sage-grouse and sagebrush-obligate songbirds within the Powder River Basin and Wyoming Basins sage-grouse populations (Garton et al. 2011). We refined the population boundaries delineated by Garton et al. (2011) for each of these areas as the area within 8 km of all active sage-grouse lek locations (≥2 male sage-grouse counted in at least 1 year from 1996–2013; Figure 1). Our use of 8-km buffers around leks was based on results from Doherty et al. (2010), Fedy et al. (2012), and Coates et al. (2013). The area within 8 km of all active leks also aligned with Wyoming's delineation of core areas (conservation reserve). This resulted in study areas encompassing 33,542 km^2 and 92,773 km^2 for the Powder River and Wyoming Basins, respectively. While shrub cover varied among study areas, Wyoming big (*A. tridentata wyomingensis*) and mountain big (*A. t. vaseyana*) sagebrush were the dominant shrubs in the Powder River Basin and Wyoming Basins study areas.

Breeding Bird Survey and sage-grouse lek data

We used Breeding Bird Survey (BBS) count data from 1996–2013 for Brewer's sparrow, sagebrush sparrow, and sage thrasher, and sage-grouse lek counts to compare population

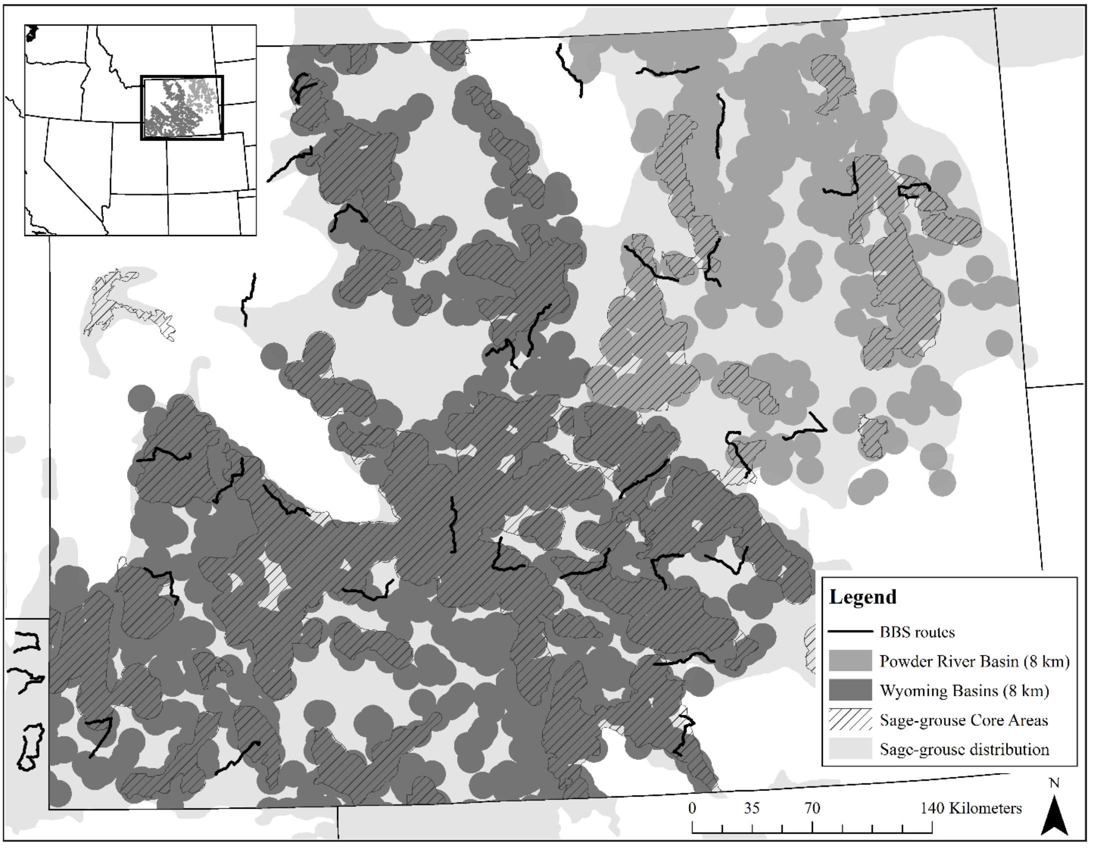

Figure 1. Map of Powder River Basin and Wyoming Basins study areas. Inset map of western United States. Study areas represent 8 km around greater sage-grouse (*Centrocercus urophasianus*) leks that were active during at least 1 year from 1996–2013. Hatched polygons depict sage-grouse core areas in Wyoming. Lek data were collected in Wyoming, 1996–2013, and Breeding Bird Survey data were collected in Wyoming and Utah, USA.

trends among these species. The BBS counts were a sum of all counted birds during 3-minute point counts by species from 50 stops along each 39.4-km route (Ziolkowski et al. 2010, Pardieck et al. 2016). The BBS counts were conducted each year during the nesting season, which was primarily June for Wyoming. Due to the length and varying shape of the BBS routes, we restricted our analysis to include BBS routes with >25% of the route within 8 km of active sage-grouse leks. Those BBS routes with >25% within a core area and that had no major anthropogenic development were classified as core area routes. Lek counts were obtained from the Western Association of Fish and Wildlife Agencies and Wyoming Game and Fish Department. We used methods and criteria from Nielson et al. (2015) to determine which lek data to include in our analysis. In addition, we further restricted leks used in this analysis by requiring each lek to have ≥15 counts across our 18-year timeframe.

Data analyses

We used generalized additive models (GAMs) with a Poisson error distribution to estimate cyclic population trends of sage-grouse, Brewer's sparrow, sagebrush sparrow, and sage thrasher using package "mgcv" (version 1.8-6) in R (version 3.1.3). We compared trends within and outside of core areas over time with GAM predictions of estimated trend where the y-axis was the centered trend (i.e., trend value minus the mean count value of leks or BBS routes; Wood 2006). The x-axis shows the spline of 18 years of count data for leks and BBS routes. We used year as the smooth term with a penalized cubic regression spline and the amount of smoothing was specified as degrees of freedom = 0.3 × total number of years rounded to the nearest whole number (Fewster et al. 2000, Robinson et al. 2005, Hewson and Noble 2009, Wright et al. 2009, Fedy and Aldridge 2011, Fedy and Doherty 2011). All models included a random smooth for individual sage-grouse leks or BBS routes.

We compared each sagebrush-obligate songbird's trend to the sage-grouse trend in each of the 2 sage-grouse populations with categorical variables and visualization of predicted trends. Sagebrush-obligate songbird and sage-grouse trends could be shifted by a few years due to different timeframes of population response to changes on the ground. Thus, we visually examined predicted trends of sage-grouse and each sagebrush-obligate songbird for parallel trends 1–3 years asynchronous from each other (i.e., parallel trends after accounting for a shifted timeframe). In addition, we compared trends of sage-grouse leks within and outside of core areas for the Powder River Basin and Wyoming Basins sage-grouse populations. We evaluated comparisons of species trends with categorical variables formatted as ordered factors for the difference in predicted counts among 5 model parameterizations: (1) sage-grouse and a sagebrush-obligate songbird (SPP); (2) core area sage-grouse, non-core area sage-grouse, and a sagebrush-obligate songbird (SG_{CORE}_BBS); (3) sage-grouse, a core area sagebrush-obligate songbird, and a non-core area sagebrush-obligate songbird (SG_BBS_{CORE}); (4) core area sage-grouse, non-core area sage-grouse, a core area sagebrush-obligate songbird, and a non-core area sagebrush-obligate songbird (SG_{CORE}_BBS_{CORE}); and (5) no difference among species or conservation protections.

Sage-grouse or core area sage-grouse was the reference level for all ordered factors. By formatting categorical variables as ordered factors, we were able to directly assess whether the reference level followed a different trend compared to all other levels in the ordered factor (Wood 2006). Thus, informative ordered factors as smooths represented the reference smooth (sage-grouse or core area sage-grouse) and difference smooths for all other levels of the ordered factor (e.g., smooth of songbird – sage-grouse or smooth of core area sage-grouse – non-core area sage-grouse). We computed a difference trend (plot) to show the relative years of higher or lower trends compared to the trend estimate of the reference trend (Wood 2006). In difference trends, values above zero indicate the population being compared to the reference had a higher trend during those years compared to the reference trend, and values below zero indicate lower trend values for the population being compared to the reference trend. We concluded that songbirds and sage-grouse or core area and non-core area followed different trends when a corresponding ordered categorical variable was predictive of trends with parameter estimate 95% confidence intervals not overlapping zero, and the relevant centered difference smooth was different than zero in the GAM plots.

Powder River Basin and Wyoming Basins yielded 5 possible models for each combination of sage-grouse and sagebrush-obligate songbird: no differences, SPP, SG_{CORE}_BBS, SG_BBS_{CORE}, and SG_{CORE}_BBS_{CORE}. We ranked models for each combination of sage-grouse and sagebrush-obligate songbird for the 2 sage-grouse populations with Akaike's information criterion corrected for small sample sizes (AIC_c) and Akaike weights (w_i; Burnham and Anderson 2002). Comparing population trends of sagebrush-obligate songbirds with sage-grouse allowed us to identify the potential benefits of the core area policy for conservation of both sage-grouse and sagebrush-obligate songbirds relative to population performance.

Results

Our analyses included 72 (n = 26 in core areas) and 446 (n = 353 in core areas) sage-grouse leks in the Powder River Basin and Wyoming Basins study areas, respectively. These leks were paired with 9 (n = 5 in core areas) and 25 (n = 14 in core areas) BBS routes in the Powder River Basin and Wyoming Basins study areas, respectively. In general, sage-grouse and all sagebrush-obligate songbirds exhibited oscillating trends across time.

The best models for the Powder River Basin and Wyoming Basins study areas were generally those that stratified by species and core and non-core areas. In the Powder River Basin study area, our best model for sage-grouse compared to Brewer's sparrows and sage thrashers were SG_{CORE}_BBS_{CORE} and SG_{CORE}_BBS (w_i = 1.00), respectively (Table 1).

Table 1. Ranking of generalized additive models comparing sage-grouse to Brewer's sparrow (*Spizella breweri*), sagebrush sparrow (*Amphispiza nevadensis*), or sage thrasher (*Oreoscoptes montanus*). Competing models were ranked with Akaike's information criterion corrected for small sample sizes (AIC_c) and Akaike weights (w_i). Modeling was stratified by data collected within the Powder River Basin and Wyoming Basins sage-grouse populations. All stratifications compared sage-grouse lek trends to analogous Breeding Bird Survey (BBS) route trends. Lek count and BBS route data were collected in Wyoming, USA from 1996–2013.

Models	df	AIC_c	ΔAIC_c	w_i
Powder River Basin				
Sage-grouse and Brewer's sparrow				
SG_{CORE}_BBS_{CORE}	100	9042.4	0.00	1.00
SG_{CORE}_BBS	94	9066.4	23.93	0.00
SG_BBS_{CORE}	97	9187.7	145.24	0.00
SSP	91	9211.7	169.24	0.00
Null	79	11204.6	2162.20	0.00
Sage-grouse and sage thrasher[a]				
SG_{CORE}_BBS	95	8596.7	0.00	1.00
SSP	92	8741.1	144.47	0.00
Null	79	10715.4	2118.74	0.00
Wyoming Basins				
Sage-grouse and Brewer's sparrow				
SG_{CORE}_BBS_{CORE}	490	97349.6	0.00	1.00
SG_{CORE}_BBS	484	97367.4	17.77	0.00
SG_BBS_{CORE}	484	98148.1	798.51	0.00
SSP	478	98165.9	816.32	0.00
Null	466	118637.0	21287.72	0.00
Sage-grouse and sagebrush sparrow[a]				
SG_{CORE}_BBS	489	95147.0	0.00	1.00
SSP	477	95966.4	819.25	0.00
Null	465	116298.0	21150.90	0.00
Sage-grouse and sage thrasher				
SG_{CORE}_BBS_{CORE}	490	96677.3	0.00	1.00
SG_{CORE}_BBS	484	132420.3	41.24	0.00
SG_BBS_{CORE}	484	133323.8	944.72	0.00
SSP	478	133365.2	986.14	0.00
Null	466	117914.0	23403.43	0.00

[a]The SG_{CORE}_BBS_{CORE} and SG_BBS_{CORE} models were excluded from this stratification because the BBS stratified by core and non-core areas did not converge.

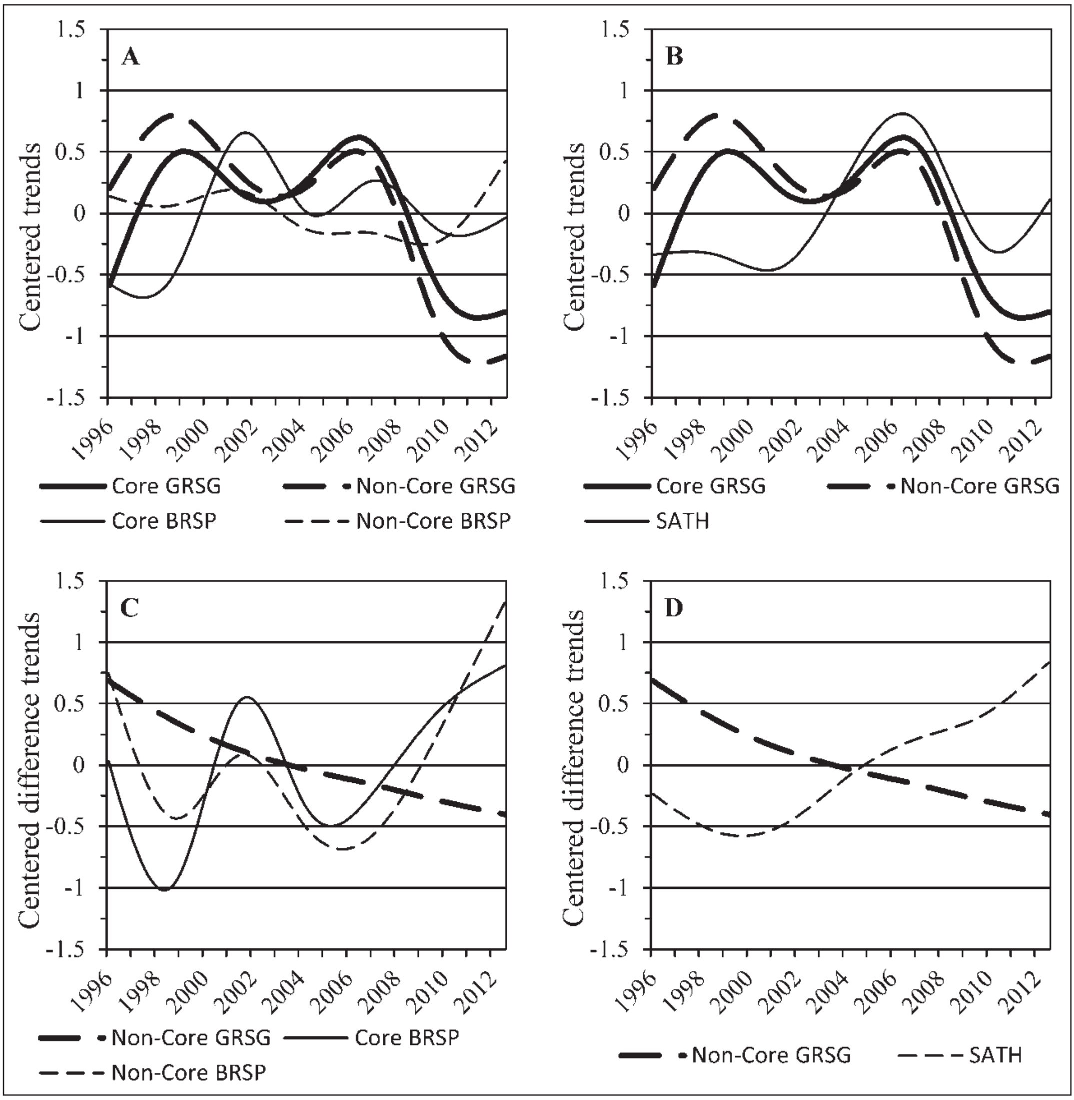

Figure 2. Sage-grouse (*Centrocercus urophasianus*) lek and sagebrush-obligate songbird trend models for the Powder River Basin estimated as centered trends (A and B) and centered difference trends (C and D) using generalized additive models. The reference trend for the Powder River Basin sage-grouse population was sage-grouse leks (GRSG; bold in A and B) in core areas compared to GRSG leks in non-core areas (bold dash in A–D), Brewer's sparrow (BRSP; *Spizella breweri*), sagebrush sparrow (SASP; *Amphispiza nevadensis*), and sage thrasher (SATH; *Oreoscoptes montanus*). The difference trends (C and D) represent the GRSG in non-core areas or sagebrush-obligate songbird trends minus GRSG in core areas trend. Sage-grouse lek and sagebrush-obligate songbird Breeding Bird Survey route data were collected in Wyoming, USA from 1996–2013.

We could not assess sagebrush sparrow trends in the Powder River Basin study area because all BBS counts were zero. In the Wyoming Basins study area, our best model was SG_{CORE}_BBS_{CORE} for Brewer's sparrow and sage thrashers (w_i = 1.00) and SG_{CORE}_BBS for sagebrush sparrows (w_i = 1.00). We excluded the SG_{CORE}_BBS_{CORE} and SG_BBS_{CORE} models from consideration for the sage-grouse comparison to sage thrasher in the Powder River Basin study area and sagebrush sparrow in the Wyoming Basins study area because the smooth for these models did not converge when stratified by core area.

Our results indicated that sage-grouse in the Powder River Basin and Wyoming Basins had similar oscillating lek trends between 1996 and 2013 with relatively higher population abundance around 1999 and 2007 (Figures 2A–B and 3A–C). While general trend patterns for sage-grouse were similar across time, the

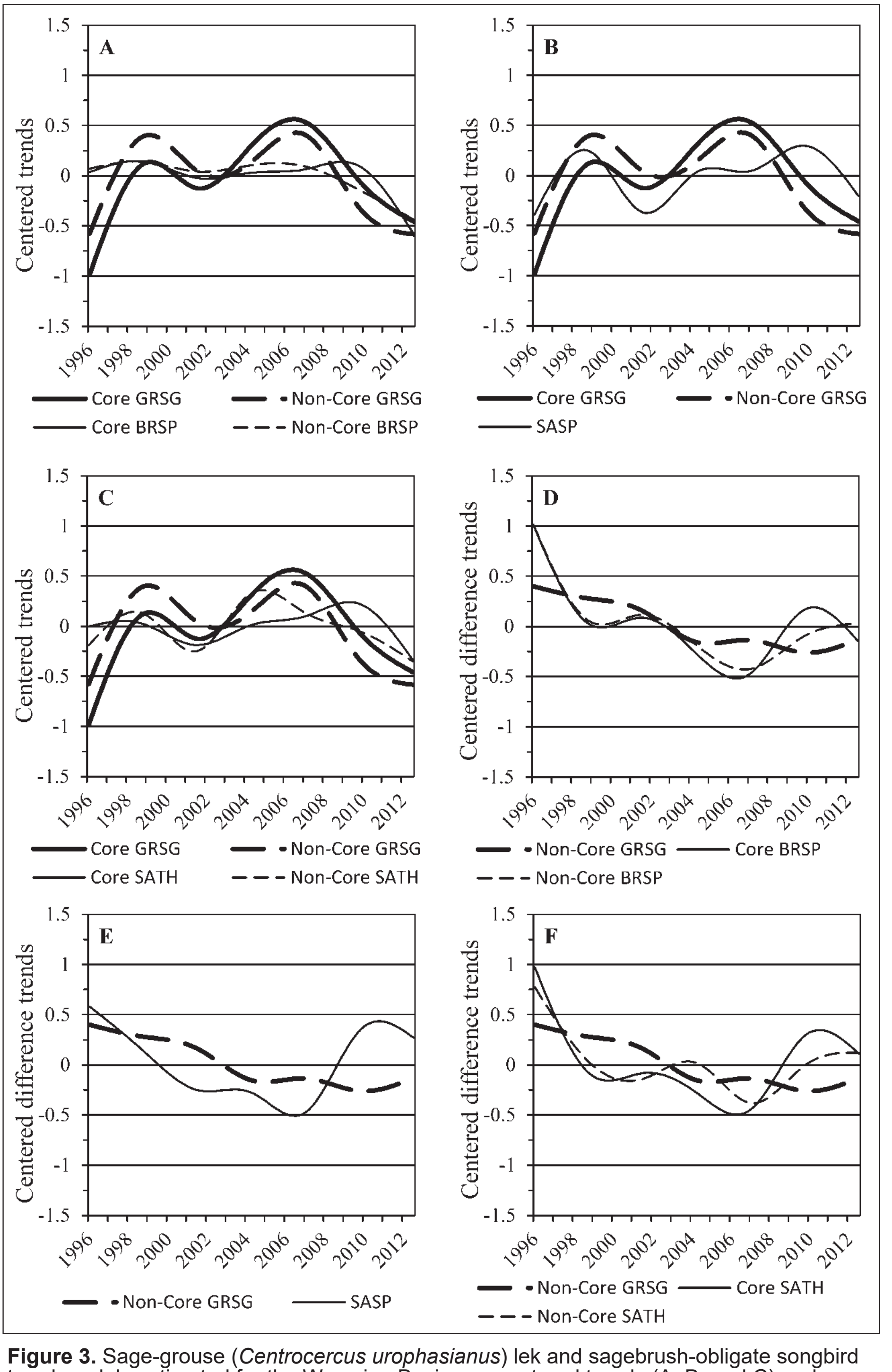

Figure 3. Sage-grouse (*Centrocercus urophasianus*) lek and sagebrush-obligate songbird trend models estimated for the Wyoming Basins as centered trends (A, B, and C) and centered difference trends (D, E, and F) using generalized additive models. The reference trend for the Wyoming Basins sage-grouse population was sage-grouse leks (GRSG; bold in A, B, and C) in core areas compared to GRSG leks in non-core areas (bold dash in A–F), Brewer's sparrow (BRSP; *Spizella breweri*), sagebrush sparrow (SASP; *Amphispiza nevadensis*), and sage thrasher (SATH; *Oreoscoptes montanus*). The difference trends (D, E, and F) represent the GRSG in non-core areas or sagebrush-obligate songbird trends minus GRSG in core areas trend. Sage-grouse lek and sagebrush-obligate songbird Breeding Bird Survey route data were collected in Wyoming, USA from 1996–2013.

amplitude of high and low trend values and overall trajectory was different for core and non-core areas (Figures 2A and 3A). Non-core area sage-grouse had relative trend values that steadily decreased in the Powder River Basin and Wyoming Basins study areas relative to core areas (Figures 2C–D and 3D–F).

In the Powder River Basin and Wyoming Basins, sagebrush-obligate songbirds followed different trends than sage-grouse with no consistent indication of parallel trends with or without a shifted time frame. In the Powder River Basin, the difference trends indicated that Brewer's sparrows and sage thrashers increased relative to sage-grouse, 1996–2013 (Figures 2C and 2D). Similar to sage-grouse in non-core areas from 1996–2007, sagebrush-obligate songbird trends in the Wyoming Basins declined relative to sage-grouse in core areas; however, we found that sagebrush-obligate songbirds increased relative to sage-grouse from 2008–2013 in the Wyoming Basins (Figures 3D–F). We did not find any difference in sagebrush sparrow trend within or outside core areas (Table 1). Even though Brewer's sparrows and sage thrashers had different trends within and outside core areas, none of the 3 sagebrush-obligate songbirds exhibited higher trend projections in core areas compared to non-core areas (Figures 2C–D and 3D–F). Our results indicate that sagebrush-obligate songbirds in the Powder River Basin and Wyoming Basins study areas had trends that were more similar to each other than to sage-grouse (Figures 2A–B and 3A–C).

Discussion

We evaluated trends between sage-grouse and sagebrush-obligate songbirds to assess parallel population performance of sagebrush obligates in core areas and non-core areas of the Powder River and the Wyoming basins of Wyoming from 1996–2013. We did not find a consistent parallel pattern of oscillation or overall trajectory (growth, decline, or stability) between sage-grouse trends and Brewer's sparrow, sagebrush sparrow, or sage thrasher trends. In addition, sagebrush-obligate songbird trends did not appear to benefit from greater protections for the potential umbrella species (i.e., sagebrush-obligate songbird trends did not exhibit higher growth in sage-grouse core areas compared to non-core areas; Figures 2–B and 3A–C). Many other studies assessing the umbrella species concept for conservation of non-target species have also found a lack of beneficial population trend for non-target species (Andelman and Fagan 2000, Roberge and Angelstam 2004, Carlisle et al. 2018). Evidence from our analyses suggested that protection of the best remaining sage-grouse habitat is not a suitable holistic conservation strategy for other sagebrush-obligate birds. However, core areas were well placed for population centers of sage-grouse with core areas maintaining higher lek counts compared to non-core areas from 1996–2013.

Fedy and Doherty (2011) found that sage-grouse and cottontail rabbit (*Sylvilagus* spp.) trends in Wyoming were correlated as a 1-year lag with r = 0.69. The premise of our comparisons of parallel trends or similar trajectories of sagebrush-obligate songbirds and sage-grouse was as a validation of sage-grouse as a robust umbrella species with conservation actions correlated with demographics rather than simple area overlap. We expected sage-grouse and sagebrush-obligate songbirds to be more tightly correlated as their breeding habitat requirements are more similar than sage-grouse and cottontails. Contrary to our expectation, we did not find any evidence of consistent parallel trends among the sagebrush obligate songbirds or sage-grouse regardless of visually inspecting shifted time frames (Figures 2 and 3). Sagebrush-obligate songbird trends were more similar to each other within each study area, which indicated sagebrush-obligate songbirds may serve each other better as indicators of respective trends. Management agencies should incorporate measures of specific habitat needs of benefitting species (sagebrush-obligate songbirds) to improve the effectiveness of the umbrella species concept in practice (Martikainen et al. 1998, Suter et al. 2002, Carlisle et al. 2018). For example, capercaillie (*Tetrao urogallus*) were found to be a good umbrella species when consideration of vegetation structure was incorporated into identification of benefitting species (Suter et al. 2002). For sagebrush ecosystems, this likely includes assessing habitat requirements of sagebrush-obligate songbirds at smaller spatial scales than sage-grouse (the umbrella species).

Overlapping area alone has not been found to provide exceptional connection among umbrella species and benefitting species with regard to population performance across time (Andelman and Fagan 2000, Roberge and Angelstam 2004, Carlisle et al. 2018, Runge et al. 2019). However, our findings do not disqualify the information gained from overlap of habitat requirements among sagebrush-dependent species found in previous studies (Rowland et al. 2006, Hanser and Knick 2011, Carlisle et al. 2018, Runge et al. 2019). Protection of sagebrush-obligate songbird habitat in any form may have benefits in the future. For example, we did not find better songbird population performance in core areas compared to non-core areas, but as non-core areas are more highly developed, sagebrush-obligate songbirds may procure more benefits of the additional protections provided in core areas. The lack of similar population performance based on counts of adult sagebrush-obligate songbirds may also be confounded by carry-over effects from songbird winter range, as these songbirds are long-distance migrants that do not winter in sagebrush.

Even though differential trends of sage-grouse within and outside core areas were likely a relic of historically higher habitat quality within core areas, our results indicated the conservation policy enacted by Wyoming has been successful at maintaining higher sage-grouse trends compared to areas not protected under the core area policy. While core areas were placed for sage-grouse to perform better in areas with more protections, sagebrush-obligate songbird trends did not exhibit the same pattern of higher trend trajectories across time. This suggests that more species-specific information needs to be incorporated into conservation strategies for other sagebrush-obligate birds. However, the quantification of habitat overlap or co-occurrence of multiple species with a focal species (potential umbrella) yields value as the focal species is an indicator of potentially suitable habitat for the species under the potential umbrella (Fleishman et al. 2000, 2001; Roberge and Angelstam 2004). Using umbrella species as a means of identifying and informing conservation actions in response to specific habitat disturbances may be a more useful approach for the umbrella species concept. Research on the appropriateness of any aspect of the umbrella species concept should be implemented on a case-by-case basis. Likewise, multi-species umbrella schemes where >1 focal species is identified to define the umbrella for a multitude of benefitting species may better encapsulate the idea of conservation of a few to benefit many (Miller et al. 1998; Fleishman et al. 2000, 2001; Carroll et al. 2001; Roberge and Angelstam 2004).

Management implications

Management of sensitive species relies on implementing conservation measures that promote quality habitat and population stability or increases. Managers often prefer conservation measures that benefit numerous species. While these conservation measures are popular, there are often mismatches in conservation benefits among species, and monitoring of numerous species is difficult. One prominent strategy in western North America is Wyoming's Sage-grouse Core Area Policy, which was designed to conserve sage-grouse. Our results suggest that conservation actions aimed specifically at 1 species do not guarantee good results for similar species—there is no proverbial getting your cake and eating it too. While this points to the necessity of monitoring for all species of conservation concern, Carlisle et al. (2018) found that large conservation reserves within an ecosystem were positive for numerous species reliant on that ecosystem regardless of the shape and exact location; even though core areas are targeted at sage-grouse, they currently serve as large conservation reserves for other sagebrush-associated species. Thus, the sum area of conservation for sage-grouse is still a positive direction for all species dependent on sagebrush ecosystems. To best confer conservation benefits for numerous species of conservation concern, we suggest targeted monitoring of as many sensitive species within the sagebrush ecosystem as possible.

Acknowledgments

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Literature cited

Aldridge, C. L., and M. S. Boyce. 2007. Linking occurrence and fitness to persistence: habitat-based approach for endangered greater sage-grouse. Ecological Applications 17:508–526.

Andelman, S. J., and W. F. Fagan. 2000. Umbrellas and flagships: efficient conservation surrogates or expensive mistakes? Proceedings of the National Academy of Sciences of the United States of America 97:5954–5959.

Blomberg, E. J., J. S. Sedinger, M. T. Atamian, and D. V. Nonne. 2012. Characteristics of climate and landscape disturbance influence the dynamics of greater sage-grouse populations. Ecosphere 3(6):article 55.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference. Second edition. Springer, New York, New York, USA.

Carlisle, J. D., D. A. Keinath, S. E. Albeke, and A. D. Chalfoun. 2018. Identifying holes in the greater sage-grouse conservation umbrella. Journal of Wildlife Management 82:948–957.

Carroll, C., R. F. Noss, and P. C. Paquet. 2001. Carnivores as focal species for conservation planning in the Rocky Mountain Region. Ecological Applications 11:961–980.

Coates, P. S., M. L. Casazza, E. J. Blomberg, S. C. Gardner, S. P. Espinosa, J. L. Yee, L. Wiechman, and B. J. Halstead. 2013. Evaluating greater sage-grouse seasonal space use relative to leks: implications for surface use designations in sagebrush ecosystems. Journal of Wildlife Management 77:1598–1609.

Coates, P. S., and D. J. Delehanty. 2010. Nest predation of greater sage-grouse in relation to microhabitat factors and predators. Journal of Wildlife Management 74:240–248.

Coates, P. S., M. A. Ricca, B. G. Prochazka, M. L. Brooks, K. E. Doherty, T. Kroger, E. J. Blomberg, C. A. Hagen, and M. L. Casazza. 2016. Wildfire, climate, and invasive grass interactions negatively impact an indicator species by reshaping sagebrush ecosystems. Proceedings of the National Academy of Sciences of the United States of America 45:12745–12750.

Dinkins, J. D., M. R. Conover, C. P. Kirol, J. L. Beck, and S. N. Frey. 2014. Greater sage-grouse (*Centrocercus urophasianus*) select habitat based on avian predators, landscape composition, and anthropogenic features. Condor 116:629−642.

Dinkins, J. D., M. R. Conover, C. P. Kirol, J. L. Beck, and S. N. Frey. 2016. Effects of common raven and coyote removal and temporal variation in climate on greater sage-grouse nesting success. Biological Conservation 202:50–58.

Dinkins, J. B., K. J. Lawson, K. T. Smith, J. L. Beck, C. P. Kirol, A. C. Pratt, M. R. Conover, and F. C. Blomquist. 2017. Quantifying overlap and fitness consequences of migration strategy with seasonal habitat use and a conservation policy. Ecosphere 8:e01991.

Doherty, K. E., J. D. Tack, J. S. Evans, and D. E. Naugle. 2010. Mapping breeding densities of greater sage-grouse: a tool for range-wide conservation planning. Completion report to the Bureau of Land Management for Interagency Agreement L10PG00911.

Donnelly, J. P., J. D. Tack, K. E. Doherty, D. E. Naugle, B. W. Allred, and V. J. Dreitz. 2017. Extending conifer removal and landscape protection strategies from sage-grouse to songbirds, a range-wide assessment. Rangeland Ecology and Management 70:95−105.

Fedy, B. C., and C. L. Aldridge. 2011. The importance of within-year repeated counts and the influence of scale on long-term monitoring of sage-grouse. Journal of Wildlife Management 75:1022–1033.

Fedy, B. C., C. L. Aldridge, K. E. Doherty, M. O'Donnell, J. L. Beck, B. Bedrosian, M. J. Holloran, G. D. Johnson, N. W. Kaczor, C. P. Kirol, C. A. Mandich, D. Marshall, G. McKee, C. Olson, C. C. Swanson, and B. L. Walker. 2012. Interseasonal movements of greater sage-grouse, migratory behavior, and an assessment of the core regions concept in Wyoming. Journal of Wildlife Management 76:1062–1071.

Fedy, B. C., and K. E. Doherty. 2011. Population cycles are highly correlated over long time series and large spatial scales in two unrelated species: greater sage-grouse and cottontail rabbits. Oecologia 165:915–924.

Fewster, R. M., S. T. Buckland, G. M. Siriwardena, S. R. Baillie, and J. D. Wilson. 2000. Analysis of population trends for farmland birds using generalized additive models. Ecology 81:1970–1984.

Fleishman, E., D. D. Murphy, and P. F. Brussard. 2000. A new method for selection of umbrella species for conservation planning. Ecological Applications 10:569–579.

Fleishman, E., D. D. Murphy, and P. F. Brussard. 2001. Empirical validation of a method for umbrella species selection. Ecological Applications 11:1489–1501.

Foster, L. J., K. M. Dugger, C. A. Hagen, and D. A. Budeau. 2019. Greater sage-grouse vital rates after wildfire. Journal of Wildlife Management 83:121–134.

Gamo, R. S., and J. L. Beck. 2017. Effectiveness of Wyoming's sage-grouse core areas: influences on energy development and male lek attendance. Environmental Management 59:189–203.

Gamo, R. S., J. D. Carlisle, J. L. Beck, J. A. C. Bernard, and M. E. Herget. 2013. Greater sage-grouse in Wyoming: an umbrella species for sagebrush dependent wildlife. Wildlife Professional 7:56–59.

Garton, E. O., J. W. Connelly, J. S. Horne, C. A. Hagen, A. Moser, and M. A. Schroeder. 2011. Greater sage-grouse population dynamics and probability of persistence. Pages 293–381 *in* S. T. Knick and J. W. Connelly, editors. Greater sage-grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology Series 38, University of California Press, Berkeley, California, USA.

Gilbert, M. M., A. D. and Chalfoun. 2011. Energy development affects populations of sagebrush songbirds in Wyoming. Journal of Wildlife Management 75:816–824.

Hanser, S. E., and S. T. Knick. 2011. Greater sage-grouse as an umbrella species for shrubland passerine birds: a multiscale assessment. Pages 475–488 *in* S. T. Knick and J. W. Connelly, editors. Greater sage-grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology Series 38, University of California Press, Berkeley, California, USA.

Hewson C. M., and D. G. Noble. 2009. Population trends of breeding birds in British woodlands over a 32-year period: relationships with food, habitat use and migratory behaviour. Ibis 151:464–486.

Knick, S. T., A. L. Holmes, and A. F. Miller. 2005. The role of fire in structuring sagebrush habitats and bird communities. Pages 63–75 *in* V. A. Saab and H. D. W. Powell, editors. Fire and avian ecology in North America. Studies in Avian Biology Series 30, University of California Press, Berkeley, California, USA.

Knick, S. T., and J. T. Rotenberry. 2002. Effects of habitat fragmentation on passerine birds breeding in Intermountain shrubsteppe. Pages 130–140 *in* T. L. George and D. S. Dobkin, editors. Effects of habitat fragmentation on birds in western landscapes: contrasts with paradigms from the eastern United States. Studies in Avian Biology Series 25, University of California Press, Berkeley, California, USA.

Lambeck, R. J. 1997. Focal species: a multispecies umbrella for nature conservation. Conservation Biology 11:849–856.

Martikainen, P., L. Kaila, and Y. Haila. 1998. Threatened beetles in white-backed woodpecker habitats. Conservation Biology 12:293–301.

Miller, B., R. Reading, J. Strittholt, C. Carroll, R. Noss, M. Soulé, O. Sánchez, J. Terborgh, D. Brightsmith, T. Cheeseman, and D. Foreman. 1998. Using focal species in the design of nature reserve networks. Wild Earth 99:81–92.

Nielson, R. M., L. L. McDonald, J. Mitchell, S. Howlin, and C. LeBeau. 2015. Analysis of greater sage-grouse lek data: trends in peak male counts 1965–2015. Western EcoSystems Technology, Inc, Cheyenne, Wyoming, USA.

Noson, A. C., R. A. Schmitz, and R. F. Miller. 2006. Influence of fire and juniper encroachment on birds in high elevation sagebrush steppe. Western North American Naturalist 66:343–353.

Pardieck, K. L., D. J. Ziolkowski, Jr., M. A. R. Hudson, and K. Campbell. 2016. North American Breeding Bird Survey dataset 1966–2015, version 2015.1. Patuxent: U.S. Geological Survey, Patuxent Wildlife Research Center, Beltsville, Maryland, USA, <http://www.pwrc.usgs.gov/BBS/RawData/>. Accessed April 15, 2016.

Roberge, J., and P. Angelstam. 2004. Usefulness of the umbrella species concept as a conservation tool. Conservation Biology 18:76–85.

Robinson, R. A., G. M. Siriwardena, and H. Q. P. Crick. 2005. Size and trends of the house sparrow (*Passer domesticus*) population in Great Britain. Ibis 147:552–562.

Rowland, M. M., M. J. Wisdom, L. H. Suring, and C. W. Meinke. 2006. Greater sage-grouse as an umbrella species for sagebrush-associated vertebrates. Biological Conservation 129:323–335.

Runge, C. A., J. C. Withey, D. E. Naugle, J. E. Fargione, K. J. Helmstedt, A. E. Larsen, S. Martinuzzi, and J. D. Tack. 2019. Single species conservation as an umbrella for management of landscape threats. PLOS ONE 14(1): e0209619.

Sauer, J. R., W. A. Link, J. E. Fallon, K. L. Pardieck, and D. J. Ziolkowski, Jr. 2013. The North American Breeding Bird Survey 1966–2011: summary analysis and species accounts. North American Fauna 79:1–32.

Smith, K. T., J. L. Beck, and A. C. Pratt. 2016. Does Wyoming's Core Area Policy protect winter habitats for greater sage-grouse? Environmental Management 58:585–596.

Spence, E. S., J. L. Beck, and A. J. Gregory. 2017. Probability of lek collapse is lower inside sage-grouse core areas: effectiveness of conservation policy for a landscape species. PLOS ONE 12(11): e0185885.

State of Wyoming. 2008. Greater sage grouse area protection. 2008-02. Office of Governor Freudenthal, State of Wyoming Executive Department Executive Order.

State of Wyoming. 2011. Greater sage grouse area protection. 2011-05. Office of Governor Mead, State of Wyoming Executive Department Executive Order.

Suter, W., R. F. Graf, and R. Hess. 2002. Capercaillie (*Tetrao urogallus*) and avian biodiversity: testing the umbrella-species concept. Conservation Biology 16:778–788.

Wood, S. N. 2006. Generalized additive models: an introduction with R. CRC Press, Boca Raton, Florida, USA.

Wright, L. J., R. A. Hoblyn, R. E. Green, C. G. R. Bowden, J. W. Mallord, W. J. Sutherland, and P. M. Dolman. 2009. Importance of climatic and environmental change in the demography of a multi-brooded passerine, the woodlark (*Lullula arborea*). Journal of Animal Ecology 78:1191–1202.

Ziolkowski, Jr., D., K. Pardieck, and J. R. Sauer. 2010. On the road again for a bird survey that counts. Birding 42:32–40.

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