Chapter 7 : HABITATS FOR GROUPS OF SPECIES

Introduction

Regional assessment of vast areas such as an ecoregion typically requires evaluation of many species of conservation concern, such as the 40 species evaluated here. Regional assessments can include hundreds or even thousands of species (e.g., Thomas et al. 1993*a*, 1993*b*; Marcot et al. 1998; Nachlinger et al. 2001). For land managers, individual attention to large numbers of species can be impractical. To address these inefficiencies, various "shortcut" methods have been proposed to eliminate or reduce the number of individual species that are explicitly considered in an assessment and subsequent management (Andelman et al. 2001; Fleishman et al. 2000, 2001; Wisdom et al. 2003).

One shortcut method is the use of species groups, as defined by Wisdom et al. (2000, 2003). Species groups can be used to address the needs of both single and multiple species in a hierarchical fashion (Wisdom et al. 2000, 2003). At best, the use of species groups, in combination with individual species, may enable managers to (1) address either single- or multi-species needs, depending on objectives; (2) identify regional habitat patterns that affect multiple species similarly; (3) address the needs of many species efficiently and holistically with the use of regional strategies for the groups; (4) determine how well the regional strategies for groups of species meet the needs of individual species within the groups; and (5) summarize results for species and groups at multiple spatial extents to maximize flexibility in the design and implementation of regional management strategies. At worst, use of species groups may not reflect robust patterns among species, may fail to account for key requirements of individual species, and may provide a false sense of confidence for managers unwilling to consider the unique needs of individual species.

Federal agencies need information about habitats for groups of species at spatial extents that are typically used for land management planning. The Great Basin Restoration Initiative, led by USDI Bureau of Land Management (BLM), is committed to plan and implement sagebrush restoration management at the watershed extent (USDI Bureau of Land Management 1999). Moreover, the watershed extent, or 5th Hydrologic Unit Code (Gravenmier et al. 1994), is a spatial extent increasingly used by the USDA Forest Service to manage National Forests and Grasslands in the sagebrush ecosystem (Clint McCarthy, personal communication, Region 4, USDA Forest Service, Ogden, UT).

Consequently, in this chapter we describe the use of 5 groups of species to generalize the habitat patterns represented by the 40 species of conservation concern in watersheds of the Great Basin Ecoregion (Great Basin) and the state of Nevada. Our objectives were to (1) place species in groups by similarity among habitat associations and amounts of these habitats, as a means of generalizing the habitat patterns of the 40 species; and (2) characterize habitat conditions in watersheds for each group of species, for use in land management planning.

Methods

Establishing the Groups of Species—Species can be grouped in many ways (Marcot et al. 1994; Wisdom et al. 2000, 2001, 2003). Two general steps are required. First, the type of data

must be identified that will be used as the basis for forming the groups. For example, species can be grouped based on commonality of habitat associations, similarity of environmental threats, or varying degrees of home range size or body size (Wisdom et al. 2001). And second, algorithms must be developed or identified to analyze these data for establishing the number of groups, and membership of species in each group. For example, algorithms for grouping species can vary from simple rule sets to formal analyses such as hierarchical cluster analysis (Wisdom et al. 2000, 2001).

For the first step, we used similarity among the species' habitat associations and the amounts of these habitats as the basis for forming groups. For the second step, we explored a variety of algorithms, starting with cluster analysis and ending with a customized rule set, to establish the number and type of groups. Our specific process follows.

We began our analysis by using the dichotomous list of habitats versus non-habitats identified for each of the 40 species of concern in the Great Basin (Table 6.1, Chapter 6). This list was composed of land cover types (referred to as cover types) designated as either source habitats (i.e., contributing to population persistence) or non-source habitats (i.e., not contributing to population persistence) for each species in Nevada and the Great Basin (see Chapter 6). We used this list to conduct a hierarchical cluster analysis (SAS Inc. 1989) of the 40 species, using the methods described by Wisdom et al. (2000). Because this analysis gave equal weight to all cover types, regardless of the amount of each type, the results did not reflect large differences in abundance of many cover types in the Great Basin, and how these differences might affect species membership in groups.

To address this problem, we combined the cover types into 6 categories (Table 7.1). With the exception of several miscellaneous cover types placed in 1 category (see "Other" category, Table 7.1), each category represented a set of cover types that have similar life forms, taxonomic relations, site requirements, or land management considerations. For example, all cover types of sagebrush were combined in a sagebrush category. Similarly, the cover types that typically occur in arid, salt desert environments were included in a salt desert scrub category (Table 7.1). In establishing the 6 categories of cover types, our intention was to conduct the cluster analysis in a manner that minimized the effect of the less abundant cover types in forming species groups. Cover types occupying <0.1% of the Great Basin were not included in the 6 categories, and thus were not included in our subsequent analyses for grouping the species.

Results from the cluster analysis, based on species' associations with the 6 categories of cover types, gave us insight about potential ways to group species, and several potential groups were identified. Some species, however, did not fit well in any of the potential groups; that is, some species had divergent habitat associations or habitat amounts within the same group. Consequently, we developed additional rule sets to further explore ways to improve species membership in the groups, and to finalize the number of groups. Our intention here was to minimize the number of groups, but ensure that enough groups, and types of groups, were established to accommodate species with divergent habitat associations and amounts.

We ultimately placed each of the 40 species in 1 of 5 groups: (1) sagebrush; (2) salt desert scrub; (3) shrubland; (4) sagebrush-woodland; and (5) generalist (Fig. 7.1). The name of each group denotes the primary habitat associated with species in the group. The 5 groups were established with a rule set based on 2 criteria: (1) the percentage of each species' habitats within each of the 6 cover type categories; and (2) the amount of these habitats within each of the 6 categories relative to the species' total amount of habitat in the Great Basin. That is, for a given species, we first calculated the percentage of its habitats in each of the 6 categories of cover

types (criterion 1). We then calculated the amount of the species' habitats in each of the 6 categories in the Great Basin, divided this amount by the total amount of the species' habitat in the Great Basin, and multiplied by 100 to express the results as a percentage for the species and category (criterion 2).

The maximum value of these calculations was 200 for a given species in a given category. That is, a species' habitats could compose 100% of the cover types within a given category, and these cover types would then equal 100% of its overall habitat amount in the Great Basin, summing to a "score" of 200 for the species and category. Alternatively, a species might be associated with 25% of the cover types within a category, and those cover types might compose 50% of the species' overall habitat amount in the Great Basin, summing to a "score" of 75 for the species in that category of cover types. We used these scores for each species and category in the following rule set (Fig. 7.2):

1) If a species' score for the sagebrush category of cover types was >80 and the species' score for the pinyon-juniper category was >40, the species was placed in the sagebrush-woodland group of species.

2) For the remaining species, if a species' score for either the sagebrush or the salt desert scrub categories was >100, and the species' score for all other categories was <60, then the species was placed in the sagebrush group or the salt desert scrub group, respectively.

3) For species not placed in sagebrush-woodland, sagebrush, or salt desert scrub groups, if a species' score was >80 for the sagebrush and the salt desert scrub categories, the species was placed in the shrubland group.

4) All other species were placed in the generalist group.

The percent area of the categories of cover types associated with each of the 5 groups of species is shown in Fig. 7.3. These patterns illustrate the key differences in habitat associations among the groups (see Results and Discussion sections).

Characterizing Habitat Conditions by Watershed for each Group--Our purpose in developing the species groups was to use them to characterize habitat conditions in watersheds in an efficient manner for the 40 species, with conditions defined in ways that have direct implications for management. Conservation planning and management, such as done through the Great Basin Restoration Initiative, is being conducted at the spatial extent of watersheds, with focus on habitats associated with species of concern, particularly sagebrush habitats (USDI Bureau of Land Management 1999).

Accordingly, we characterized habitat conditions for the 5 groups of species at the watershed extent in Nevada and Great Basin, using digitized watershed maps currently available from federal agencies for Nevada (Dave Pickel, dpickel@nv.nrcs.usda.gov), California (Lori-Peltz-Lewis, lpeltzlewis@mp.usbr.gov), and Utah (Karen Hanson, khanson@usgs.gov). The watershed maps for California and Nevada are in draft form, and will be refined and finalized by federal agencies in late 2003 or early 2004. The watershed map for Utah was completed recently; documentation is available at http://www.ftw.nrcs.usda.gov/huc_data.html and http://www.crwr.utexas.edu/giswr/events/122000nhda/11/nwbd.html.

In Nevada, 446 watersheds occur in the state or intersect the state's boundaries (Fig. 7.4). The mean size of the 343 watersheds occurring entirely within Nevada is 73,586 ha, and these

watersheds range in size from 548 ha to 541,875 ha. The Great Basin is composed of 521 watersheds that occur within the Ecoregion or intersect its boundaries (Fig. 7.5). Mean size of the 367 watersheds occurring entirely within the Ecoregion is 65,666 ha, and these watersheds range in size from 549 ha to 542,055 ha. These estimates of mean size and range exclude a handful of watersheds that are <3 ha, and that are likely to be subsumed within adjacent watersheds when maps for California and Nevada are finalized by federal agencies.

For each watershed and group, we estimated and mapped 2 habitat variables: (1) habitat abundance (low, moderate, or high); and (2) habitat risk (none to low; low to moderate; or moderate to high risk of habitat displacement by cheatgrass). We used these 2 habitat variables to characterize the composite habitat conditions in each watershed for each group.

The purpose of characterizing watersheds in this manner was to provide spatial estimates of habitat conditions for a comprehensive set of species, such that the information has direct utility for management. For example, watersheds with high habitat abundance and none to low risk of displacement by cheatgrass may require little or no management change. By contrast, watersheds with habitats of low abundance and moderate to high risk may require careful management to mitigate the risk of losing the existing habitats. See Discussion for details regarding this rationale.

Classifying Watersheds by Habitat Abundance—We used the following steps to classify habitat abundance in each watershed as low, moderate, or high for each group of species in both Nevada and the Great Basin. First, for each species, we calculated the amount (ha) of habitat in each watershed, and calculated the percent area (0%-100%) of this habitat in the watershed. See Chapter 6 regarding methods used to identify species' habitats and quantify habitat amount. Second, we calculated the mean area (ranging from 0%-100%) of habitat in each watershed among all species in each group, using the percent area calculated for individual species. Only those species whose ranges overlapped a given watershed were included in the calculation of mean area for a group in that watershed. For example, if the range of 2 of 5 species in a group overlapped a watershed, habitats for just those 2 species were used for estimating habitat characteristics for that group and watershed.

From these calculations, we classified a watershed as having low habitat abundance when mean area was <25% for a group. We classified a watershed as having moderate or high habitat abundance when mean area was 25%-50% or >50%, respectively, for a group. Use of these classes was based on an exploratory analysis designed to understand the patterns of habitat abundance across the watersheds for each group. This exploration was done to ensure that the number of classes, and class intervals, reflected the underlying frequency distribution of habitat area among watersheds and groups.

Classifying Watersheds by Habitat Risk—We estimated habitat risk for each group and watershed. First, we calculated the percentage of each species' habitat that was none, low, moderate, and high risk of displacement by cheatgrass in each watershed. Chapters 4 and 6 describe how risks were estimated for cover types and species' habitats, respectively. Second, we calculated the mean percentage of habitats that were none, low, moderate, and high risk among all species in a group and watershed. Only those species whose ranges overlapped a given watershed were included in these calculations for the group in that watershed.

We then characterized a watershed as having none to low habitat risk for a group if that watershed was dominated by habitats (i.e., >50% of the group's habitat area) with these 2 risk classes. In the same way, we classified a watershed as low to moderate risk, or moderate to high risk, if habitats for a group were dominated by either of these risk combinations.

Before we finalized this approach, we estimated and mapped the risk of cheatgrass displacement in a variety of ways by watershed and group. We ultimately settled on the use of the combinations of risk classes described above as an acceptable method of indexing the more complex compositional patterns of the 4 risk classes (none, low, moderate, and high) within each watershed. See Chapter 9 regarding limitations and guidelines for management application.

Deriving a Composite Habitat Condition for each Group and Watershed—We used the 2 variables, habitat abundance and habitat risk, to characterize the composite habitat conditions for each watershed and group. We did this by summarizing and mapping all combinations of habitat abundance (3 classes) and habitat risk (3 classes) across the watersheds for each group of species at both spatial extents (i.e., Nevada and the Great Basin). Thus, any of 9 conditions (i.e., 9 combinations of habitat abundance and habitat risk) were possible for a watershed and group.

This approach was conceptually similar to the matrix of environmental conditions established by Ricketts et al. (1999) for use in conservation planning for terrestrial ecoregions in North America. The approach also was similar to the characterization of habitat conditions for groups of species in watersheds of the Interior Columbia Basin, based on combinations of habitat abundance and quality (Wisdom et al. 2002).

Results

Species Membership in Groups--Each of the 5 groups (Figs. 7.1, 7.2; Table 7.2) had distinctive associations with cover types, and amounts of these cover types, in each category (Fig. 7.3). The sagebrush and salt desert scrub groups were associated with large areas of sagebrush or salt desert scrub. By contrast, the shrubland group was associated with a mosaic of both sagebrush and salt desert scrub types, while the sagebrush-woodland group was associated with a mosaic of sagebrush and pinyon-juniper (Fig. 7.3). Moreover, the generalist group was associated with a combination of sagebrush and a myriad of other cover types that occur in Nevada and the Great Basin.

Habitat Abundance—Abundance of habitats varied widely by species group and watershed in both Nevada and the Great Basin (Tables 7.3, 7.4). The sagebrush and salt desert scrub groups had the highest percentages (25% and 34%) of Nevada watersheds with low habitat abundance. The sagebrush and salt desert groups also had the lowest percentage of watersheds (39%) in Nevada with high habitat abundance. By contrast, nearly all watersheds for the shrubland and generalist groups in Nevada had high habitat abundance (91% and 95%, respectively), with few watersheds of low abundance (2% for shrubland group; 1% for generalist group). Habitat abundance for the sagebrush-woodland group was more variable; for this group, 56% of Nevada watersheds were classified as high, 41% as moderate, and 3% as low. We found similar patterns of habitat abundance for the 5 groups across Great Basin watersheds (Table 7.4).

Spatial distributions of habitat abundance also varied widely among the groups. Watersheds of high habitat abundance for the sagebrush group were concentrated in northern and east-central Nevada (Figs. 7.6, 7.7). In opposite manner, watersheds of high abundance for the salt desert scrub group were concentrated in southern and southwestern Nevada (Fig. 7.8) and western Utah (Fig. 7.9). Watersheds with high abundance were mostly in northern and eastern Nevada and southwestern Utah for the sagebrush-woodland group (Figs. 7.10, 7.11), and dominated all areas for the shrubland and generalist groups (Figs. 7.12 - 7.15).

Habitat Risk--The shrubland and salt desert groups had almost one-half (44% and 48%) of the watersheds in Nevada with habitats dominated by moderate to high risk of displacement by cheatgrass (Table 7.3). By contrast, the sagebrush-woodland and sagebrush groups had relatively low percentages (14% and 19%) of Nevada watersheds that were composed mostly of habitats at moderate to high risk. Results for the generalist group in Nevada were intermediate to the other 4 groups in terms of watersheds dominated by habitats at moderate to high risk (Table 7.3).

These patterns were similar but substantially stronger in the Great Basin. Here, a majority of watersheds (63% and 71%) for the shrubland and salt desert shrub groups were dominated by habitats at moderate to high risk of displacement by cheatgrass. Watersheds with habitats dominated by moderate to high risk for the other 3 groups also occurred in substantially higher percentages in the Great Basin (sagebrush-woodland group, 26%; sagebrush group, 32%; and generalist group, 43%) in contrast to Nevada.

Percentage of Nevada watersheds with habitats dominated by none to low risk did not vary much among the 5 groups (sagebrush, 37%; salt desert scrub, 27%; shrubland, 26%; sagebrush-woodland, 29%; and generalist, 31%). Percentage of Great Basin watersheds with habitats dominated by none to low risk varied more among the groups, and was generally lower (sagebrush, 24%; salt desert scrub, 14%; shrubland, 11%; sagebrush-woodland, 15%; and generalist, 18%), which mirrored the substantially higher percentage of Great Basin watersheds at moderate to high risk compared to Nevada.

Spatial distributions of habitat risk were concentrated in different areas for each group. For the sagebrush group, watersheds with higher classes of habitat risk were concentrated in parts of northern and western Nevada, as well as in southeastern Nevada and western Utah (Figs. 7.6, 7.7). Watersheds at higher risk for the salt desert scrub group occurred across vast areas of Nevada, with the exception of the extreme northern part of the state where little habitat exists for the group (Figs. 7.8, 7.9). Moreover, nearly all watersheds for the salt desert scrub group in western Utah were dominated by habitats at moderate to high risk of displacement by cheatgrass (Fig. 7.9).

Most watersheds at moderate to high risk for the sagebrush-woodland group were found in parts of north-central or western Nevada, southern Nevada, and western Utah (Figs. 7.10, 7.11). For the shrubland and generalist groups, watersheds with higher risk were found throughout all of western Utah and most of Nevada except portions of central Nevada (Figs. 7.12, 7.13).

Composite Habitat Conditions—Any of 9 composite conditions, based on 9 combinations of habitat abundance (3 classes) and habitat risk (3 classes), were possible for a watershed and group. In both Nevada and the Great Basin, the percentage of watersheds in each of these 9 conditions was relatively even for the sagebrush and salt desert scrub groups (Tables 7.3, 7.4). None of the 9 conditions for these 2 groups occurred in more than 30% of watersheds (Table 7.4).

The other 3 groups of species had substantially more habitat in 1 or 2 of the 9 conditions. For the shrubland group, the percentage of watersheds composed of high habitat abundance with moderate to high habitat risk was 40% and 51% in Nevada and the Great Basin, respectively. For the sagebrush-woodland group, the percentage of watersheds made up of high habitat abundance with low to moderate habitat risk was 32% for both spatial extents (Tables 7.3, 7.4). Most watersheds in Nevada for the generalist group were in 1 of 3 conditions: high habitat abundance with each of the 3 classes of habitat risk (30% or more watersheds in each condition).

Most watersheds in the Great Basin for the generalist group were in 1 of 2 conditions, either high habitat abundance with low to moderate risk, or high abundance with moderate to high risk (Table 7. 4).

Spatial distribution of the composite habitat conditions varied widely among the groups. Watersheds with habitats of higher abundance and lower risk were scattered across northern Nevada for the sagebrush group (Figs. 7.6, 7.7) and concentrated in southern Nevada for the salt desert scrub group (Fig. 7.8). Watersheds of higher habitat abundance and lower habitat risk for the sagebrush-woodland group were found in parts of northeastern and northwestern Nevada, small portions of west-central Nevada, and across larger areas of southern Nevada (Fig. 7.10). Because the shrubland and generalist groups had high habitat abundance throughout Nevada and the Great Basin, the distribution of watersheds with high abundance and low risk reflected spatial differences in risk; in this case, watersheds with habitats of high abundance and low risk were concentrated in northern and southern Nevada for both groups (Figs. 7.12, 7.13, 7.14, 7.15).

Watersheds with habitats of lower abundance and higher risk were scattered throughout Nevada and concentrated in southwestern Utah for the sagebrush group (Figs. 7.6, 7.7), and were found in central Nevada and parts of northwestern and southwestern Utah for the salt desert scrub group (Figs. 7.8, 7.9). For the sagebrush-woodland group, watersheds with lower abundance and higher risk were concentrated in larger areas of northwestern Nevada and western Utah, and in smaller areas of southern Nevada (Figs. 7.10, 7.11). The shrubland and generalist groups had watersheds with lower habitat abundance and higher habitat risk in small portions of western Nevada and northwestern and southwestern Utah (Figs. 7.12, 7.13, 7.14, 7.15).

Discussion

Distinctiveness of Groups--Each of the 5 groups had distinctive habitat associations (Fig. 7.3) that resulted in clear differences in watershed conditions for species of concern in different groups. This was shown in the strongly contrasting spatial distributions of habitat conditions between the sagebrush and salt desert scrub groups. For the sagebrush group, watersheds with high habitat abundance and low habitat risk were concentrated in northern Nevada (Fig. 7.6), while these same conditions for the salt desert scrub group were concentrated in southern Nevada (Fig. 7.8).

By contrast, the shrubland group was associated with a mosaic of both sagebrush and salt desert scrub habitats. Consequently, watersheds conditions for this group often resembled a combination of the conditions observed for the sagebrush and salt desert scrub groups. For example, watersheds with high habitat abundance and low habitat risk for the shrubland group were concentrated in both northern Nevada (similar to sagebrush group) and southern Nevada (similar to salt desert scrub group)(Fig. 7.12). Moreover, spatial patterns of watershed conditions for the sagebrush-woodland and generalist groups were distinctly different from all other groups. These patterns indicated that the 5 groups met our objective to generalize the broad habitat patterns represented by the 40 species of conservation concern. The 5 groups represent 5 distinct sets of habitat associations that appear to provide a coarse but meaningful index of the more specific patterns of habitat associations among the 40 species of conservation concern.

Management Use of Watershed Conditions--Our characterization of habitat abundance, risk, and composite conditions by watershed and species group was designed for efficient

management planning at regional scales for species of concern in Nevada and the Great Basin. For example, results could be used to develop regional conservation and restoration strategies by watershed condition and group. Spatial priorities for allocating limited resources for conservation and restoration of each group's habitats could be mapped for various watershed conditions.

Such an approach is similar to regional management direction established for species of concern in the Interior Columbia Basin (USDA Forest Service and USDI Bureau of Land Management 2000), based on the characterization of watershed conditions of habitat quantity and quality for groups of species (Wisdom et al. 2002). Identifying spatial priorities for each watershed condition and group also would complement recent mapping of portfolio sites of high ecological importance in the Great Basin (Nachlinger et al. 2001). Root et al. (2003) also characterized habitat conditions in a manner highly similar to our approach, for each of 40 species in California. In Root et al.'s analysis, areas were classified by habitat abundance, by habitat threats, and by using a combination of habitat abundance and threats to map a multispecies "conservation value," quite similar to our characterization of composite conditions for each group of species.

By design, different combinations of habitat abundance and habitat risk have different implications for conservation and restoration. Watersheds with habitats of higher abundance and lower risk may represent habitat "strongholds" (i.e., optimal habitat amount, quality, and arrangement for a group of species) that are likely to persist in the future. The degree to which these conditions represent habitat strongholds deserves further scrutiny with follow-on field evaluations.

Similarly, watershed conditions with habitats of lower abundance and higher risk may denote areas that are substantially sub-optimal or degraded in relation to a group's requirements. Sub-optimal or degraded habitats in a watershed would likely be of smaller amount, smaller patch size, lower quality, and lower connectivity in relation to the group's needs. The degree to which watersheds with lower abundance and higher risk represent areas of sub-optimal or degraded habitats also deserves further scrutiny with field evaluations. These field evaluations would provide additional, empirical insights about interpretations and uses of the watershed conditions for management.

These points suggest that regional strategies could be developed for watersheds in each condition to identify the appropriate conservation and restoration prescriptions needed to meet management goals for each group of species. Such a watershed-based strategy for groups of species was developed for the Interior Columbia Basin (USDA Forest Service and USDI Bureau of Land Management 2000), based on the characterization of watershed conditions in a habitat network for groups of species in the Basin (Wisdom et al. 2002).

Management Use of Species Groups--The 5 groups of species used in our analysis appear to provide a meaningful but coarse index of the more specific habitat associations of the 40 species of concern. Each group has distinctive associations with habitats, and amount of these habitats, which provides clear discrimination among groups. That is, species within each group have substantial similarities in habitat associations and amounts, and species across groups do not. Moreover, when habitats at risk are plotted for individual species, a tight cluster of species is naturally formed for each group of species used here (see Chapters 6 and 8), even though habitat risk was not used as a criterion for establishing the species groups. Consequently, these patterns suggest that management use of our watershed characterizations for a group would provide similar, but not necessarily equal, benefits for most or all species in the group.

Any management direction based on groups of species, however, requires management verification of the assumed benefits to individual species in each group (Wisdom et al. 2003). Management verification is needed to demonstrate that the use of species groups is an efficient way to manage and benefit individual species in a given watershed in which the regional management direction will be applied. Management verification can be done by (1) identifying which species in the group occur in the watershed where the management direction will be applied, using species' range maps or similar data; (2) identifying which cover types in the watershed are the focus of the management direction; (3) calculating the percentage of each species' habitats in the watershed that are composed of the cover types of management focus; and (4) summarizing these percentages for all species in each group, for the watershed.

For a given watershed, the benefits of applying the regional management direction for a group of species will not result in equal benefits to all species within the group. The above verification exercise will provide insights about the degree of benefits among species in a group that would be derived from regional management direction applied to a given watershed. In some cases, particular species in the group may not occur in the watershed, as the ranges of many species vary substantially across Nevada and the Great Basin (see Chapter 4 and maps in Appendix 4). And in other cases, the specific cover types of management focus in a watershed may not encompass a species' habitats, as each species in a group has unique habitat associations (see Chapter 6).

Results of the verification exercise could then be used to adjust the management direction for a given watershed, or set of watersheds, to derive additional benefits for the overall set of species in a group or groups. In this way, the use of species groups is hierarchical and adaptive, as described by Wisdom et al. (2000, 2003). That is, species groups can be used to address the needs of both single and multiple species by first setting management direction for groups, then verifying the benefits of that direction for individual species within groups, and finally adjusting the management direction, if needed, to maximize benefits for all species of conservation concern (Wisdom et al. 2000, 2003).

Assumptions and Limitations

- Although species in each group had strong similarities in habitat associations, we did not account for other differences in environmental requirements among species within the groups. For example, species in a group may vary in their use of space, food, or response to habitat change. We did not assess such factors. Consequently, use of species' groups is most appropriate as an aid for efficient development of management strategies to maintain or restore habitat types at regional scales. Additional factors beyond habitat types, however, must be accounted for in the implementation of such strategies at local scales. See Wisdom et al. (2003) and Chapter 9 for additional discussion.

- Patterns of habitat amount, habitat risk, and composite habitat conditions for each group of species will vary by the spatial extent chosen. We used watersheds as the spatial extent for our analysis because this extent is the one currently of most interest to managers in the Great Basin (USDI Bureau of Land Management 1999). Other spatial extents can be used to summarize habitat patterns for each group of species, and to develop regional management strategies, but the patterns will vary from those

documented here for watersheds. The choice of spatial extent is best determined by management objectives, and more than 1 spatial extent may be appropriate for applications of the concepts illustrated here.

- We assume that management applications of the species' groups will include verification of the degree to which the presumed benefits of a management strategy is shared among all species in the group. Verification of management benefits from the use of species' groups is needed to ensure that habitats for all species in each group are addressed holistically. If management verification is not done, the use of species' groups may provide a false sense of confidence for managers unwilling to consider the unique needs of individual species.

Key Findings

- We characterized habitat conditions in watersheds for 40 species of concern with the use of 5 species groups: (1) sagebrush; (2) salt desert scrub; (3) shrubland; (4) sagebrush-woodland; and (5) generalist. Our purpose was to use the groups as a general index of the more specific habitat associations of the 40 species, for efficient use in land management planning at the spatial extent of watersheds.

- For each watershed and group, we estimated and mapped 3 habitat variables: (1) habitat abundance (low, moderate, or high); (2) habitat risk, (none to low; low to moderate; or moderate to high risk of habitat displacement by cheatgrass); and (3) the composite habitat conditions based on integration of variables 1 and 2.

- The salt desert scrub group of species had the highest percentage (34%) of watersheds in Nevada with low habitat abundance (watersheds with habitat area <25%), followed by the sagebrush group (25%). The generalist group had only 1% of watersheds classified as low habitat abundance, and <3% of watersheds for the shrubland and sagebrush-woodland groups were classified as low.

- The generalist and shrubland groups had 90% or more of Nevada watersheds classified as high habitat abundance (watersheds with habitat area >50%). The sagebrush-woodland group had 56% of Nevada watersheds classified as high, while the salt desert scrub and sagebrush groups each had 39% in the high class. Similar patterns of habitat abundance were found in Great Basin watersheds for all groups.

- The salt desert scrub and shrubland groups had the highest percentages (47% and 44%, respectively) of Nevada watersheds dominated by habitats at moderate to high risk of displacement by cheatgrass. The sagebrush group of species had 19% of Nevada watersheds at moderate to high risk, 44% at low to moderate risk, and 36% at none to low risk.

- Higher habitat risk was found in Great Basin watersheds compared to Nevada watersheds. The majority of Great Basin watersheds (63% and 71%) for the shrubland

and salt desert shrub groups, respectively, were dominated by habitats at moderate to high risk of displacement by cheatgrass. Percentage of watersheds with habitats mostly at moderate to high risk for the other 3 groups also was substantially higher in the Great Basin (sagebrush-woodland group, 26%; sagebrush group, 32%; and generalist group, 43%) compared to Nevada.

- None of the 9 composite watershed conditions (3 classes of habitat abundance combined with 3 classes of habitat risk) were particularly common for the sagebrush or salt desert scrub groups, with <30% of watersheds in any 1 condition for these groups. The other 3 species groups had substantially more watersheds in 1 or 2 of the 9 conditions. For example, watersheds with low habitat abundance and moderate to high habitat risk made up 40% of Nevada watersheds for the shrubland group and 32% for the sagebrush-woodland group. The generalist group also had 30% or more of Nevada watersheds with high habitat abundance in combination with each of the 3 classes of habitat risk.

- Our characterization of habitat abundance, habitat risk, and composite conditions by watershed and group is designed for efficient and credible use in management planning for species of concern at regional scales in Nevada and the Great Basin. Regional strategies could be developed to conserve and restore habitats by watershed condition and group. Regional strategies designed to benefit groups of species requires verification of like benefits to individual species in each group. This verification is needed to demonstrate that use of species groups is an efficient way to manage and benefit individual species.

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Table 7.1. Placement of land cover types into 6 categories that were used in the rule set for establishing groups of the 40 species of conservation concern. Only those land cover types that occupied ≥0.1% of the Great Basin were included in the cover type categories.

Land Cover Type[1]	Percent Area of Great Basin	Cover Type Category
Wyoming and basin big sagebrush	17.9	Sagebrush
Black sagebrush	5.1	Sagebrush
Mountain big sagebrush	3.7	Sagebrush
Low sagebrush	1.1	Sagebrush
Bitterbrush	0.5	Sagebrush
Low sagebrush-mountain big sagebrush	0.4	Sagebrush
Low sagebrush-Wyoming big sagebrush	0.2	Sagebrush
Rabbitbrush	0.1	Sagebrush
Pinyon-juniper	6.1	Pinyon-Juniper
Pinyon pine	4.4	Pinyon-Juniper
Utah juniper	2.4	Pinyon-Juniper
Salt desert scrub[2]	25.2	Salt Desert Scrub
Shadscale	2.8	Salt Desert Scrub
Black greasewood	4.4	Salt Desert Scrub
Blackbrush	0.7	Salt Desert Scrub
Spiny hopsage	0.4	Salt Desert Scrub
Winterfat	0.3	Salt Desert Scrub
Saltbush	0.1	Salt Desert Scrub
Mojave mixed scrub	0.1	Salt Desert Scrub
Bunchgrass	3.3	Grassland
Desert grassland	0.4	Grassland
Agriculture	2.8	Ag_Urban
Urban	0.8	Ag_Urban
Recently burned	4.1	Other
Barren/rock/lava	4.1	Other
Water	2.9	Other
Forest	1.7	Other
Playa	1.5	Other
Mountain shrub	1.1	Other
Marsh/wetland	0.5	Other
Riparian	0.4	Other
Aspen	0.2	Other
Mountain mahogany	0.1	Other
Dunes	0.1	Other

[1] Land cover types established by Comer et al. (2002) and Reid et al. (2002); see Chapter 3.
[2] Generic land cover type that can include any of the other cover types listed for the salt desert scrub category; see Chapter 3.

Table 7.2. Membership of the 40 species of conservation concern in 5 groups. See Figure 7.1 and methods for a description of the rule set used to group the species and the habitat associations of species in each group. See Chapter 6 for species-habitat associations.

Common Name	Scientific Name	Group
Greater sage-grouse	*Centrocercus urophasianus*	Sagebrush
Sage thrasher	*Oreoscoptes montanus*	Sagebrush
Sage sparrow	*Amphispiza belli*	Sagebrush
Vesper sparrow	*Pooecetes gramineus*	Sagebrush
Brewer's sparrow	*Spizella breweri*	Sagebrush
Wyoming ground squirrel	*Spermophilus elegans nevadensis*	Sagebrush
Pygmy rabbit	*Brachylagus idahoensis*	Sagebrush
Desert collared lizard	*Crotaphytus insularis*	Salt Desert Scrub
Longnose leopard lizard	*Gambelia wislizenii*	Salt Desert Scrub
Desert horned lizard	*Phrynosoma platyrhinos*	Salt Desert Scrub
Desert spiny lizard	*Sceloporus magister*	Salt Desert Scrub
Longnose snake	*Rhinocheilus lecontei*	Salt Desert Scrub
Ground snake	*Sonora semiannulata*	Salt Desert Scrub
Merriam's kangaroo rat	*Dipodomys merriami*	Salt Desert Scrub
Chisel-toothed kangaroo rat	*Dipodomys microps*	Salt Desert Scrub
Gray flycatcher	*Empidonax wrightii*	Sagebrush-Woodland
Green-tailed towhee	*Pipilo chlorurus*	Sagebrush-Woodland
Merriam's shrew	*Sorex merriami*	Sagebrush-Woodland
Sagebrush vole	*Lemmiscus curtatus*	Sagebrush-Woodland
White-tailed jackrabbit	*Lepus townsendii*	Sagebrush-Woodland
Sagebrush lizard	*Sceloporus graciosus*	Shrubland
Northern harrier	*Circus cyaneus*	Shrubland
Prairie falcon	*Falco mexicanus*	Shrubland
Short-eared owl	*Asio flammeus*	Shrubland
Western burrowing owl	*Speotyto cunicularia*	Shrubland
Loggerhead shrike	*Lanius ludovicianus*	Shrubland
Black-throated sparrow	*Amphispiza bilineata*	Shrubland
Kit fox	*Vulpes macrotis*	Shrubland
Pronghorn	*Antilocapra americana*	Shrubland
Ord's kangaroo rat	*Dipodomys ordii*	Shrubland
Dark kangaroo mouse	*Microdipodops megacephalus*	Shrubland
Little pocket mouse	*Perognathus longimembris*	Shrubland
Northern grasshopper mouse	*Onychomys leucogaster*	Shrubland
Great Basin spadefoot	*Scaphiopus intermontanus*	Generalist
Night snake	*Hypsiglena torquata*	Generalist
Striped whipsnake	*Masticophis taeniatus*	Generalist
Ferruginous hawk	*Buteo regalis*	Generalist
Swainson's hawk	*Buteo swainsoni*	Generalist
Lark Sparrow	*Chondestes grammacus*	Generalist
Brewer's blackbird	*Euphagus cyanocephalus*	Generalist

Table 7.3. Percentage (number) of watersheds in Nevada by all combinations of the classes of habitat abundance with the classes of risk that habitats will be displaced by cheatgrass, summarized for each of the 5 groups of species of conservation concern.

Species Group	Habitat Abundance	Risk of Habitat Displacement by Cheatgrass			
		None-Low	Low-Moderate	Moderate-High	**All Risk Classes Combined**
Sagebrush	Low	16% (69)	5% (23)	4% (17)	25% (109)
	Moderate	10% (42)	18% (78)	8% (36)	36% (156)
	High	11% (48)	21% (93)	7% (31)	39% (172)
	All Habitat Abundance Classes Combined	37% (159)	44% (194)	19% (84)	100% (437)
		None-Low	Low-Moderate	Moderate-High	**All Risk Classes Combined**
Salt Desert Scrub	Low	8% (33)	15% (66)	12% (51)	34% (150)
	Moderate	6% (24)	6% (28)	15% (64)	27% (116)
	High	14% (61)	3% (15)	22% (95)	39% (171)
	All Habitat Abundance Classes Combined	27% (118)	25% (109)	48% (210)	100% (437)
		None-Low	Low-Moderate	Moderate-High	**All Risk Classes Combined**
Shrubland	Low	1% (4)	1% (2)	1% (3)	2% (9)
	Moderate	1% (4)	15% (14)	4% (16)	7% (34)
	High	24% (107)	32% (118)	40% (176)	91% (401)
	All Habitat Abundance Classes Combined	26% (115)	30% (134)	44% (195)	100% (442)
		None-Low	Low-Moderate	Moderate-High	**All Risk Classes Combined**
Sagebrush Woodland	Low	2% (7)	1% (2)	1% (4)	3% (13)
	Moderate	11% (50)	15 (67)	15% (65)	41% (182)
	High	17% (74)	32% (141)	8% (36)	56% (251)
	All Habitat Abundance Classes Combined	29% (131)	47% (210)	24% (105)	100% (446)

Species Group	Habitat Abundance	Risk of Habitat Displacement by Cheatgrass			
		None-Low	Low-Moderate	Moderate-High	**All Risk Classes Combined**
Generalist	Low	0% (0)	<1% (1)	1% (2)	1% (3)
	Moderate	1% (5)	1% (2)	6% (10)	4% (17)
	High	30% (135)	30% (133)	35% (158)	95% (426)
	All Habitat Abundance Classes Combined	31% (140)	31% (136)	38% (170)	100% (446)

Table 7.4. Percentage (number) of watersheds in the Great Basin by all combinations of the classes of habitat abundance with the classes of risk that habitats will be displaced by cheatgrass, summarized for each of the 5 groups of species of conservation concern.

Species Group	Habitat Abundance	Risk of Habitat Displacement by Cheatgrass			
		None-Low	Low-Moderate	Moderate-High	**All Risk Classes Combined**
Sagebrush	Low	14% (73)	10% (51)	9% (44)	32% (168)
	Moderate	7% (37)	21% (108)	18% (91)	46% (236)
	High	2% (12)	14% (70)	7% (33)	22% (115)
	All Habitat Abundance Classes Combined	24% (122)	44% (229)	32% (168)	100% (519)
		None-Low	Low-Moderate	Moderate-High	**All Risk Classes Combined**
Salt Desert Scrub	Low	6% (30)	8% (42)	21% (108)	35% (180)
	Moderate	4% (20)	4% (20)	23% (116)	31% (156)
	High	5% (23)	3% (15)	26% (133)	34% (171)
	All Habitat Abundance Classes Combined	14% (73)	15% (77)	71% (357)	100% (507)
		None-Low	Low-Moderate	Moderate-High	**All Risk Classes Combined**
Shrubland	Low	2% (8)	1% (3)	2% (12)	4% (23)
	Moderate	3% (14)	4% (23)	10% (51)	17% (88)
	High	7% (34)	21% (111)	51% (265)	79% (410)
	All Habitat Abundance Classes Combined	11% (56)	26% (137)	63% (328)	100% (521)
		None-Low	Low-Moderate	Moderate-High	**All Risk Classes Combined**
Sagebrush Woodland	Low	7% (38)	9% (47)	9% (48)	26% (133)
	Moderate	3% (17)	18% (93)	8% (43)	29% (153)
	High	5% (24)	32% (168)	8% (41)	45% (233)
	All Habitat Abundance Classes Combined	15% (79)	59% (308)	26% (132)	100% (519)

Species Group	Habitat Abundance	Risk of Habitat Displacement by Cheatgrass			
		None-Low	Low-Moderate	Moderate-High	**All Risk Classes Combined**
Generalist	Low	1% (6)	<1% (1)	1% (3)	2% (10)
	Moderate	3% (15)	1% (5)	5% (28)	9% (48)
	High	14% (73)	37% (195)	37% (195)	89% (463)
	All Habitat Abundance Classes Combined	18% (94)	39% (201)	43% (226)	100% (521)

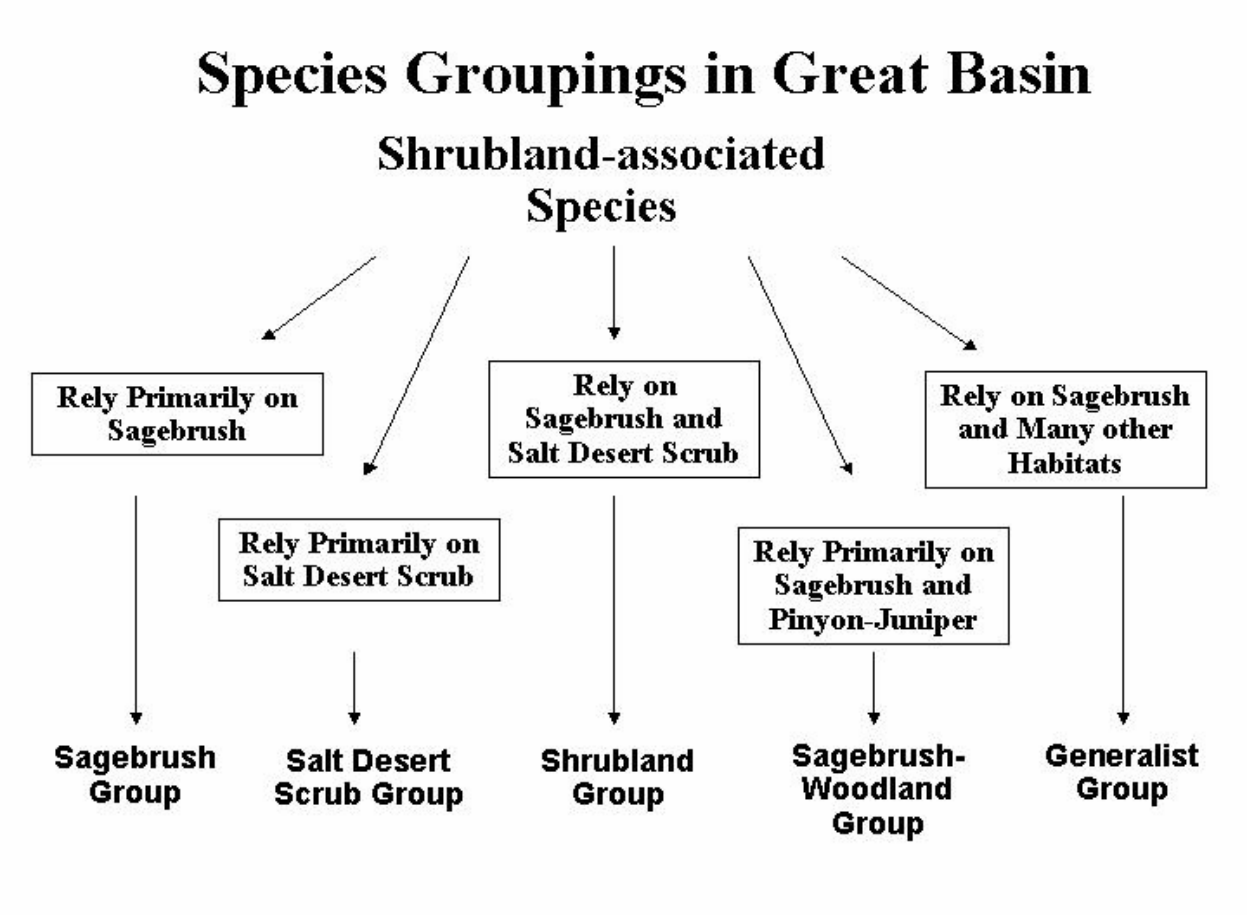

Figure 7.1. Five groups of the 40 species of concern, based on their primary habitat associations and amounts of these habitats. The name of each group denotes the primary habitat association for the group.

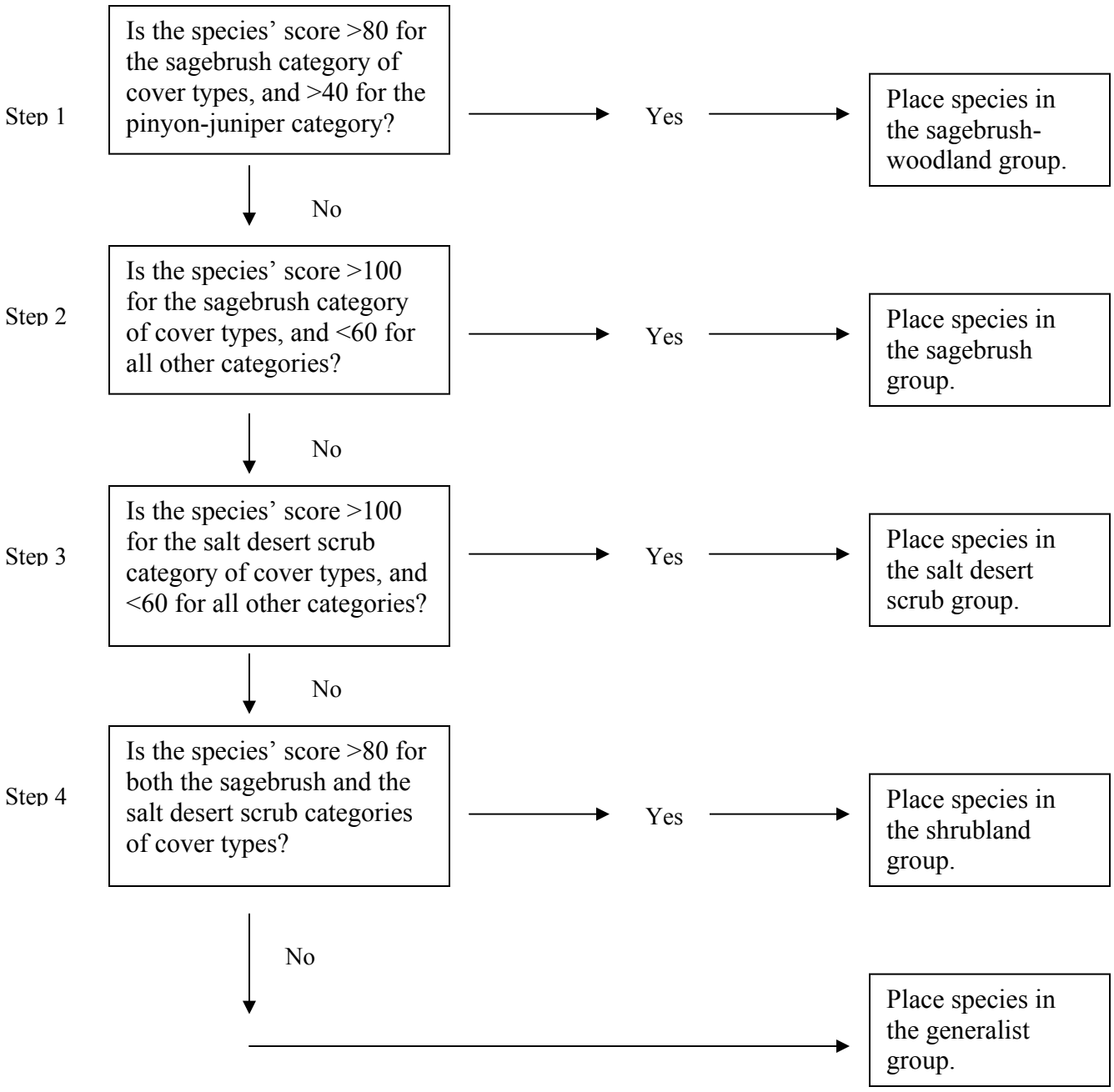

Figure 7.2. Decision diagram incorporating the final rule set used to place each of 40 species of conservation concern into 1 of 5 groups for habitat analysis in Nevada and the Great Basin.

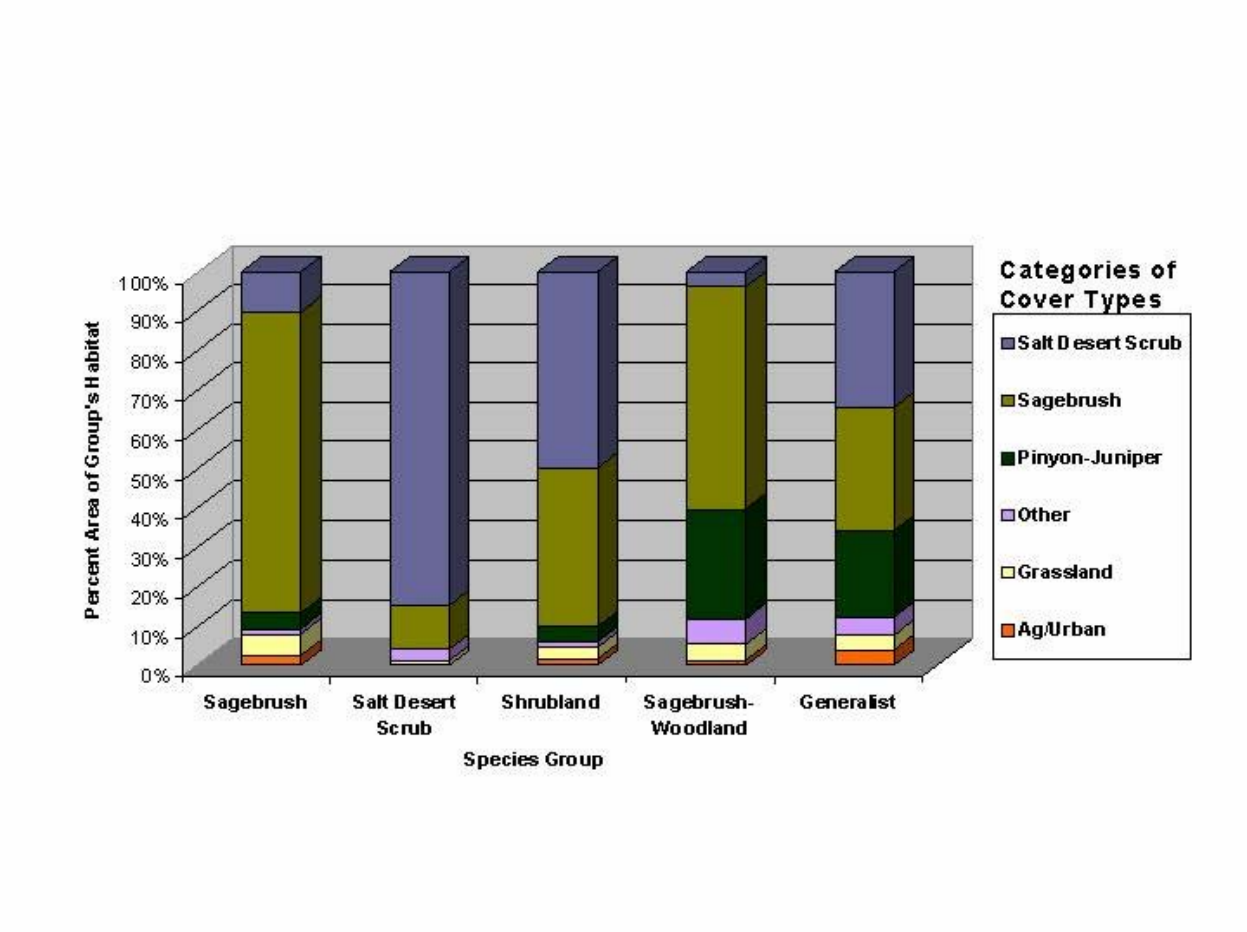

Figure 7.3. Percent area of the categories of land cover types associated with each of the 5 groups of species of conservation concern, as estimated for the Great Basin.

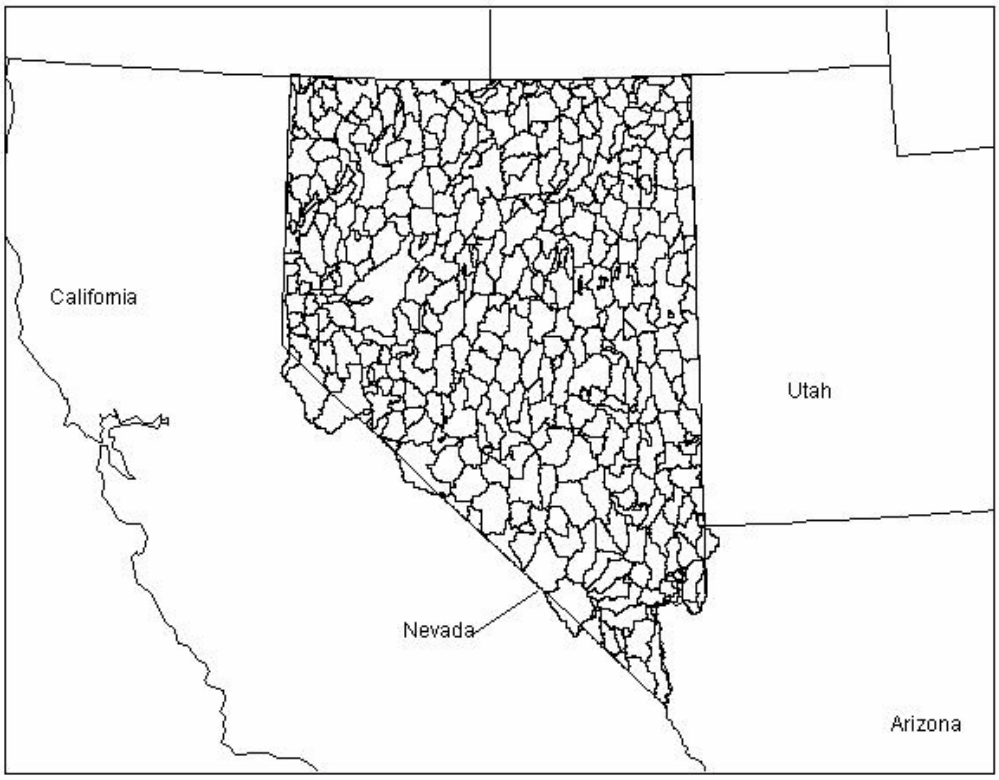

Figure 7.4. Watersheds (n = 446) in Nevada in which habitat abundance, cheatgrass risk, and composite conditions were estimated for each of the 5 groups of species of conservation concern.

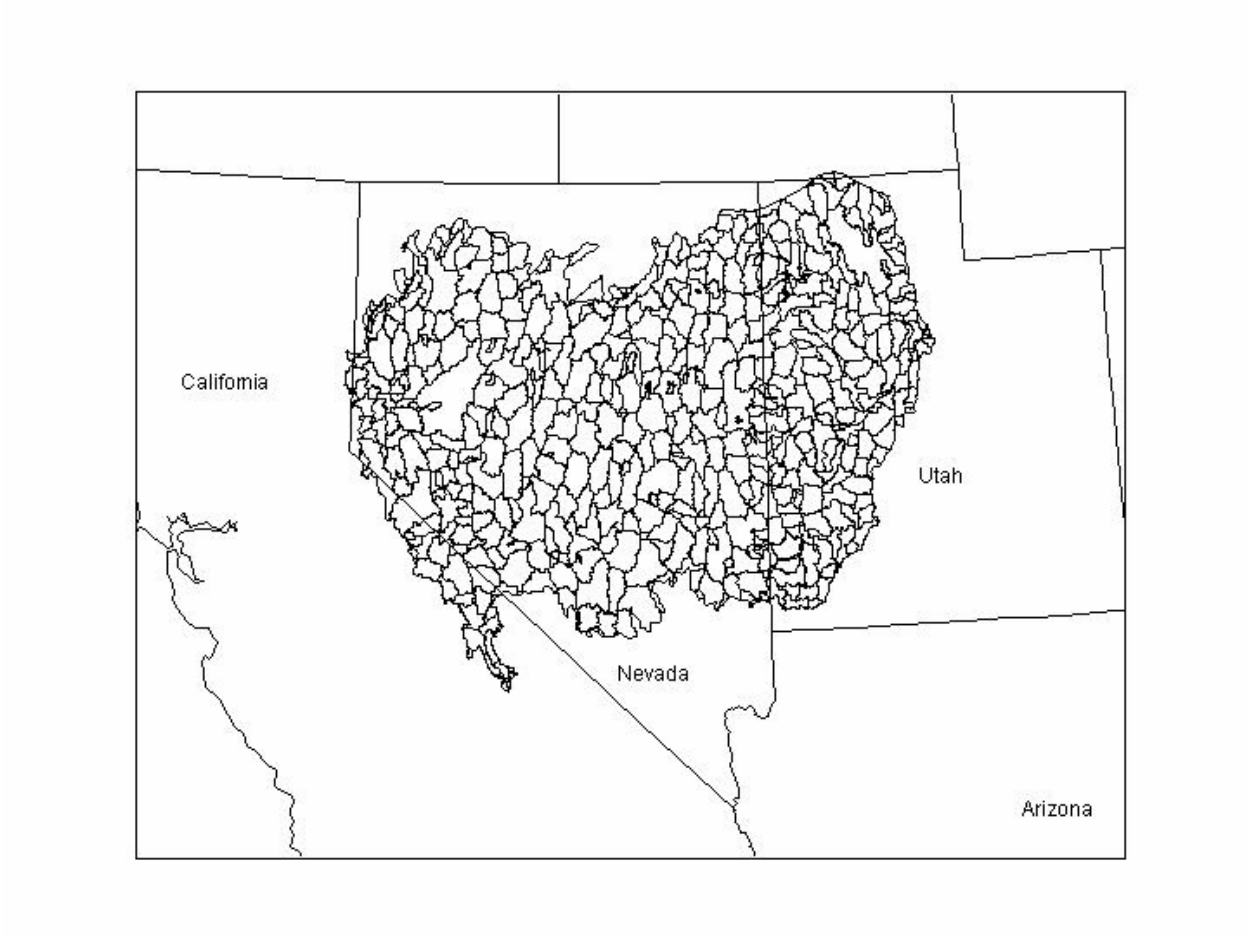

Figure 7.5. Watersheds (n = 521) in the Great Basin in which habitat abundance, cheatgrass risk, and composite conditions were estimated for each of the 5 groups of species of conservation concern.

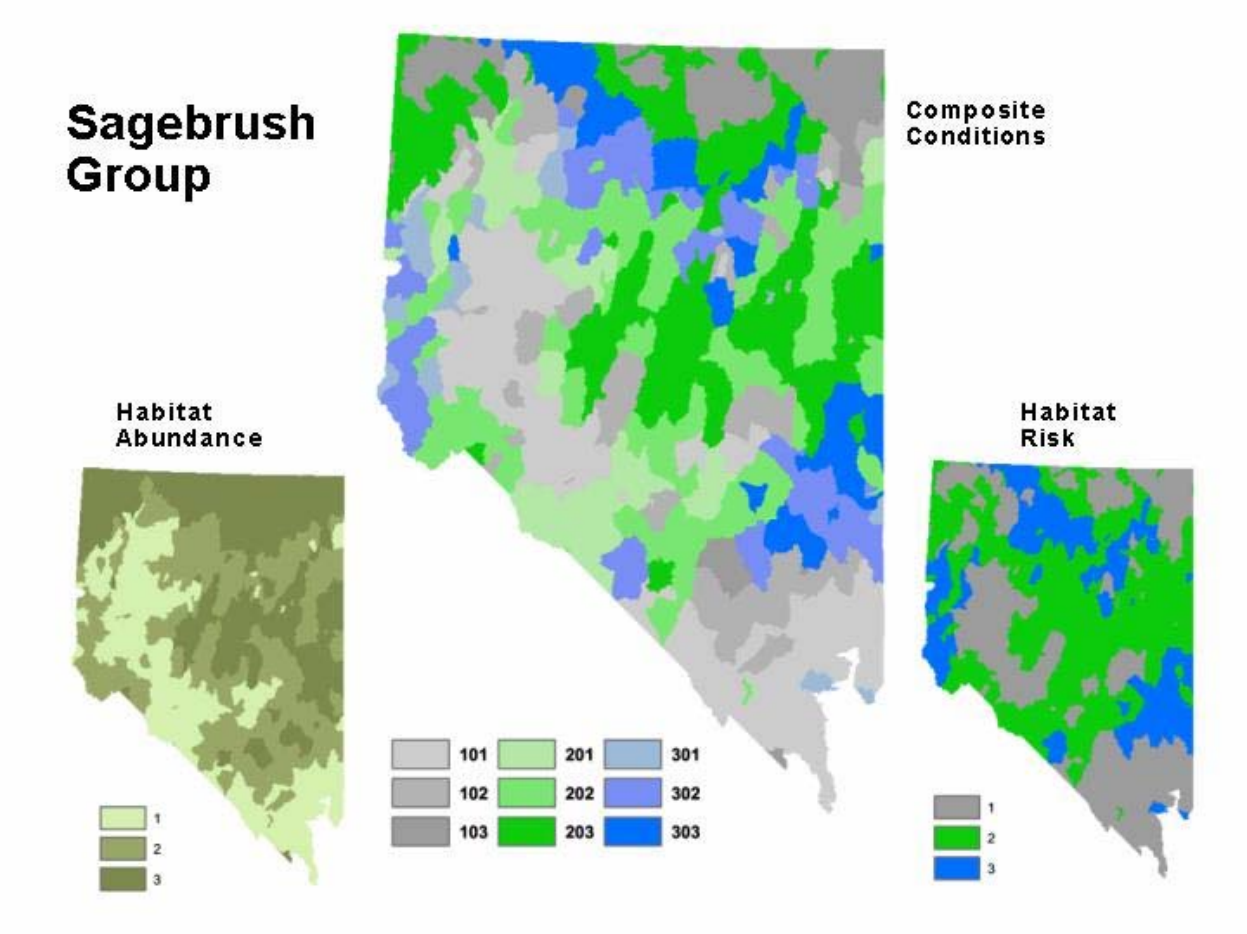

Figure 7.6. Habitat abundance (lower left), habitat risk (lower right), and composite conditions (all combinations of habitat abundance and risk, top center), mapped for the sagebrush group of species in watersheds of Nevada. For the map of habitat abundance, 1 = low (<25% of the watershed is habitat), 2 = moderate (25%-50% of the watershed is habitat), and 3 = high (>50% of the watershed is habitat). For the map of habitat risk, 1 = watersheds with habitats dominated by none-low risk of displacement by cheatgrass, 2 = watersheds with habitats dominated by low-moderate risk, and 3 = watersheds with habitats dominated by moderate-high risk. For the map of composite habitat conditions, the first number is that for abundance, and the last number is that for risk, using the same definitions given above for maps of habitat abundance and risk. For example, 101 denotes watersheds with habitats of low abundance and none-low risk, whereas 303 denotes watersheds of high habitat abundance and moderate-high risk. In addition, map colors on the composite map follow those for the map of habitat risk (blue = moderate-high risk, green = low-moderate risk, and gray = none-low risk), and intensity of colors follow those for the map of habitat abundance (darkest shade = high habitat abundance, intermediate shade = moderate, and lightest shade = low).

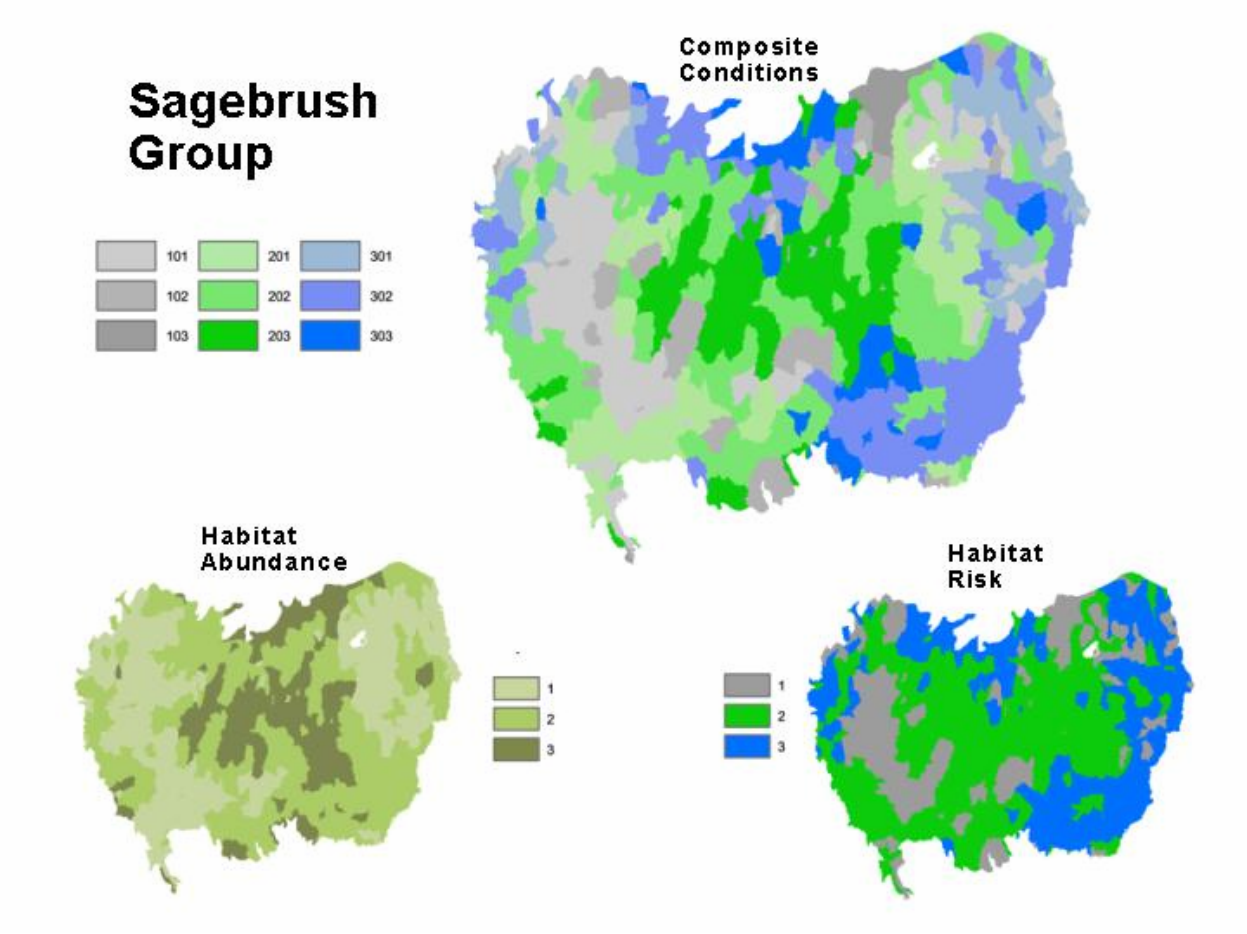

Figure 7.7. Habitat abundance, habitat risk, and composite conditions for the sagebrush group of species in watersheds of the Great Basin. Legends and details of each map are explained in the caption for Figure 7.6.

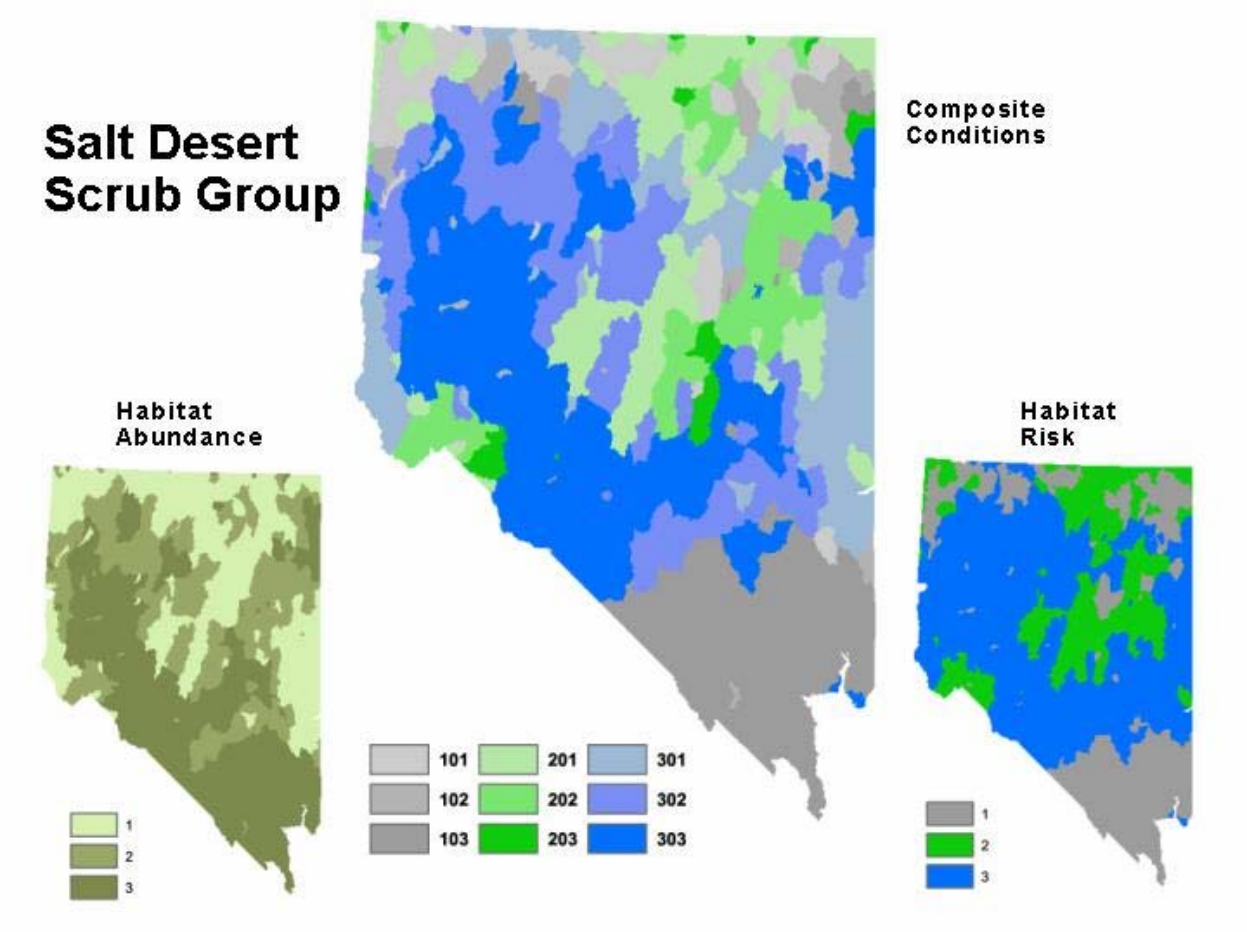

Figure 7.8. Habitat abundance, habitat risk, and composite conditions for the salt desert scrub group of species in watersheds of Nevada. Legends and details of each map are explained in the caption for Figure 7.6.

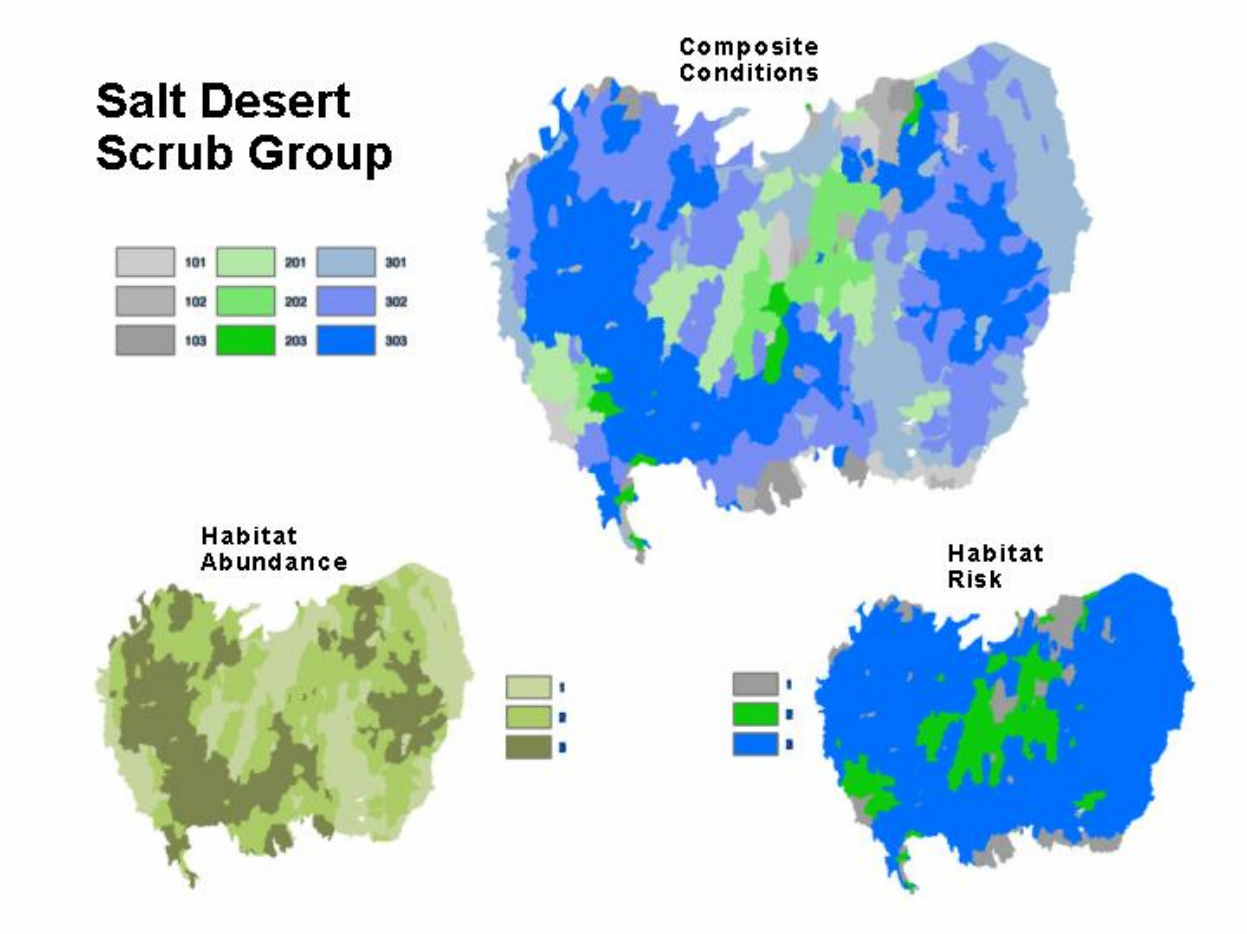

Figure 7.9. Habitat abundance, habitat risk, and composite conditions for the salt desert scrub group of species in watersheds of the Great Basin. Legends and details of each map are explained in the caption for Figure 7.6.

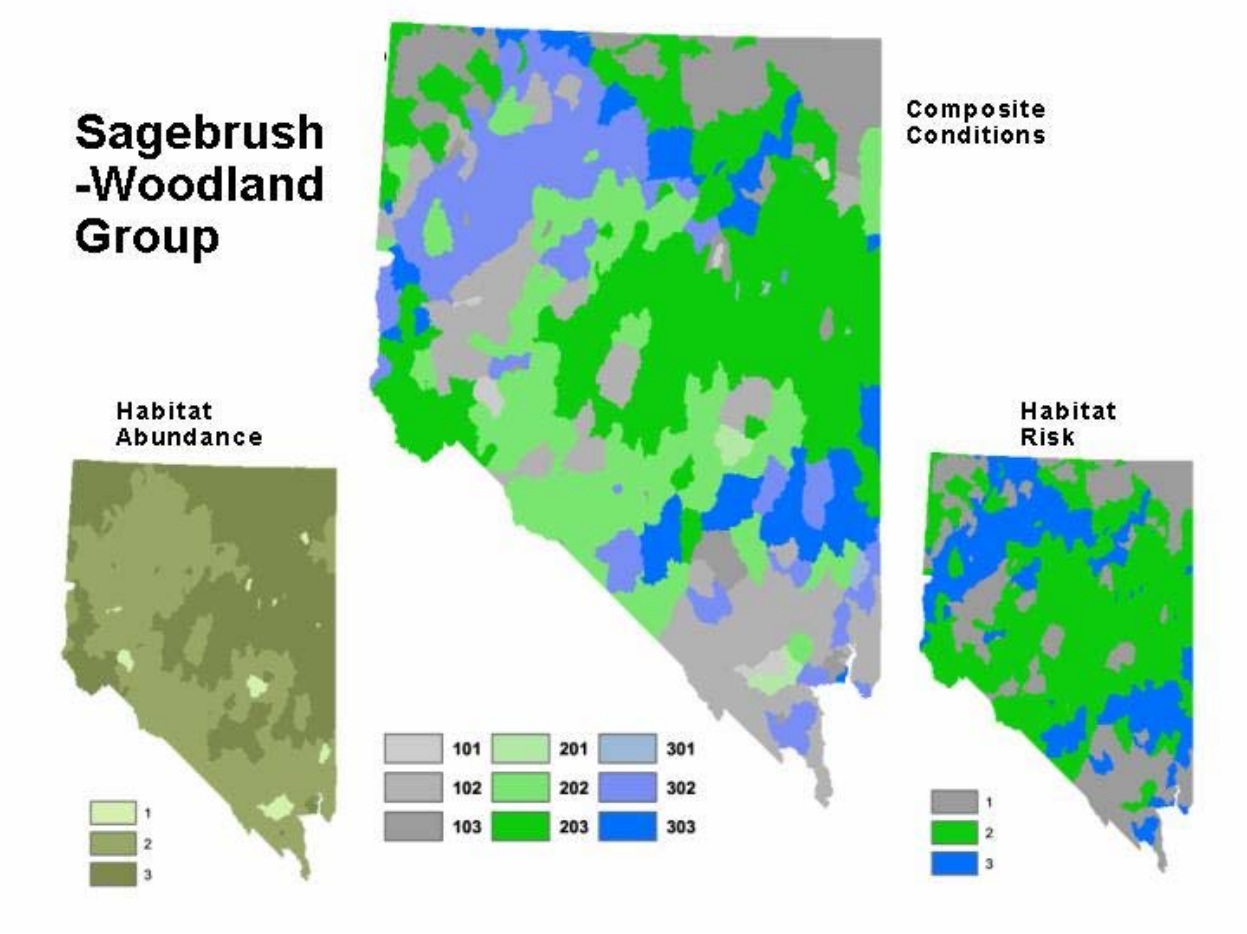

Figure 7.10. Habitat abundance, habitat risk, and composite conditions for the sagebrush-woodland group of species in watersheds of Nevada. Legends and details of each map are explained in the caption for Figure 7.6.

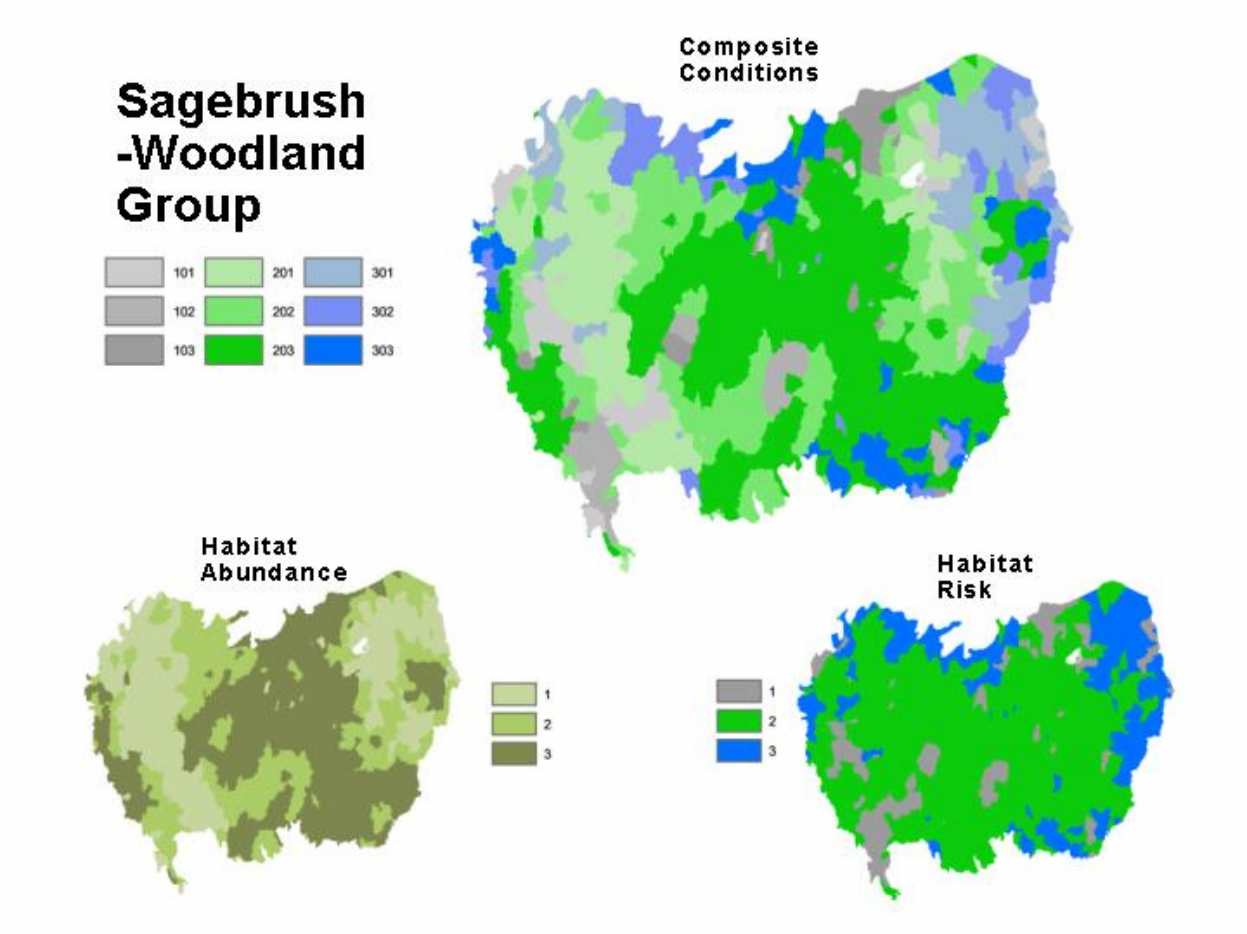

Figure 7.11. Habitat abundance, habitat risk, and composite conditions for the sagebrush-woodland group of species in watersheds of the Great Basin. Legends and details of each map are explained in the caption for Figure 7.6.

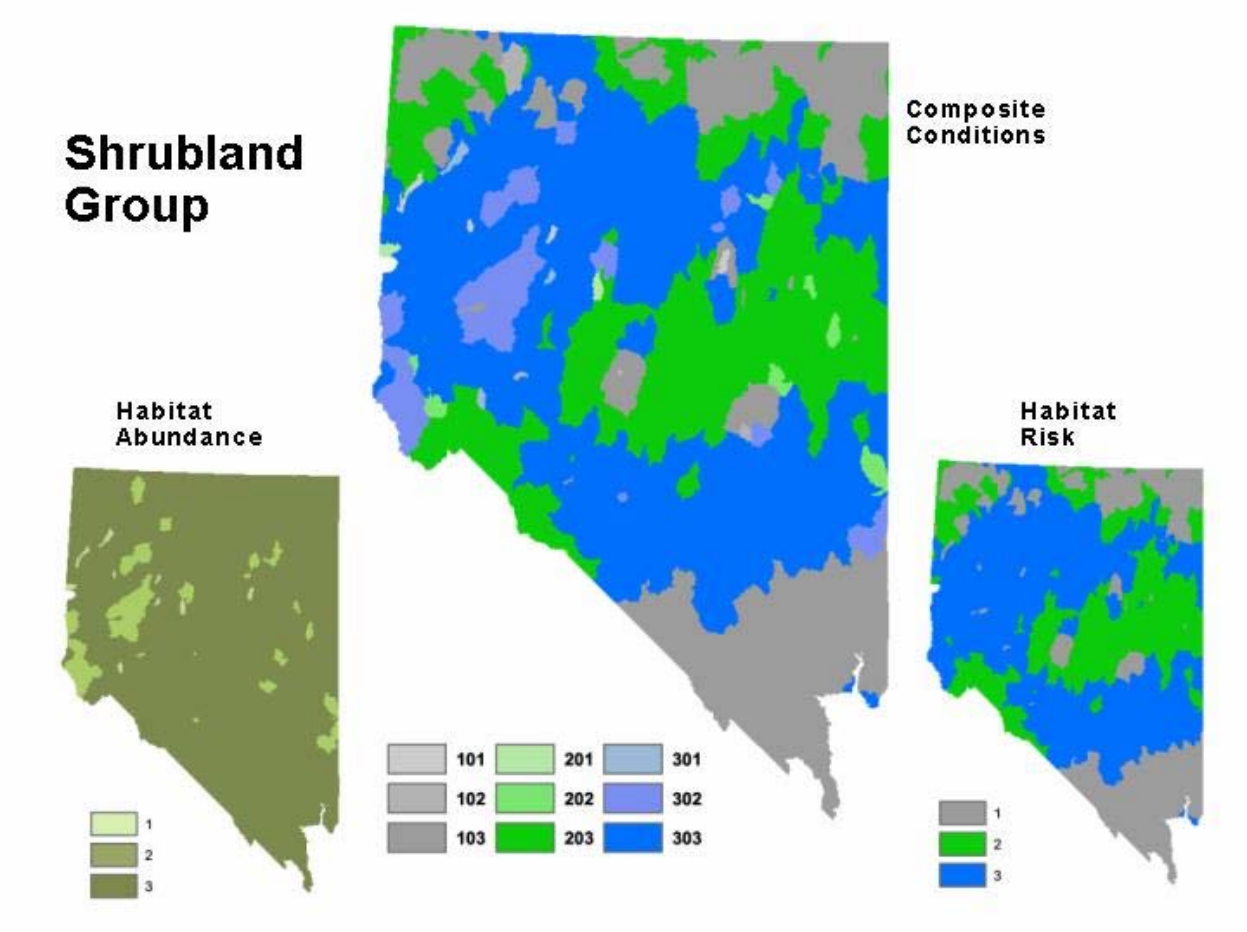

Figure 7.12. Habitat abundance, habitat risk, and composite conditions for the shrubland group of species in watersheds of Nevada. Legends and details of each map are explained in the caption for Figure 7.6.

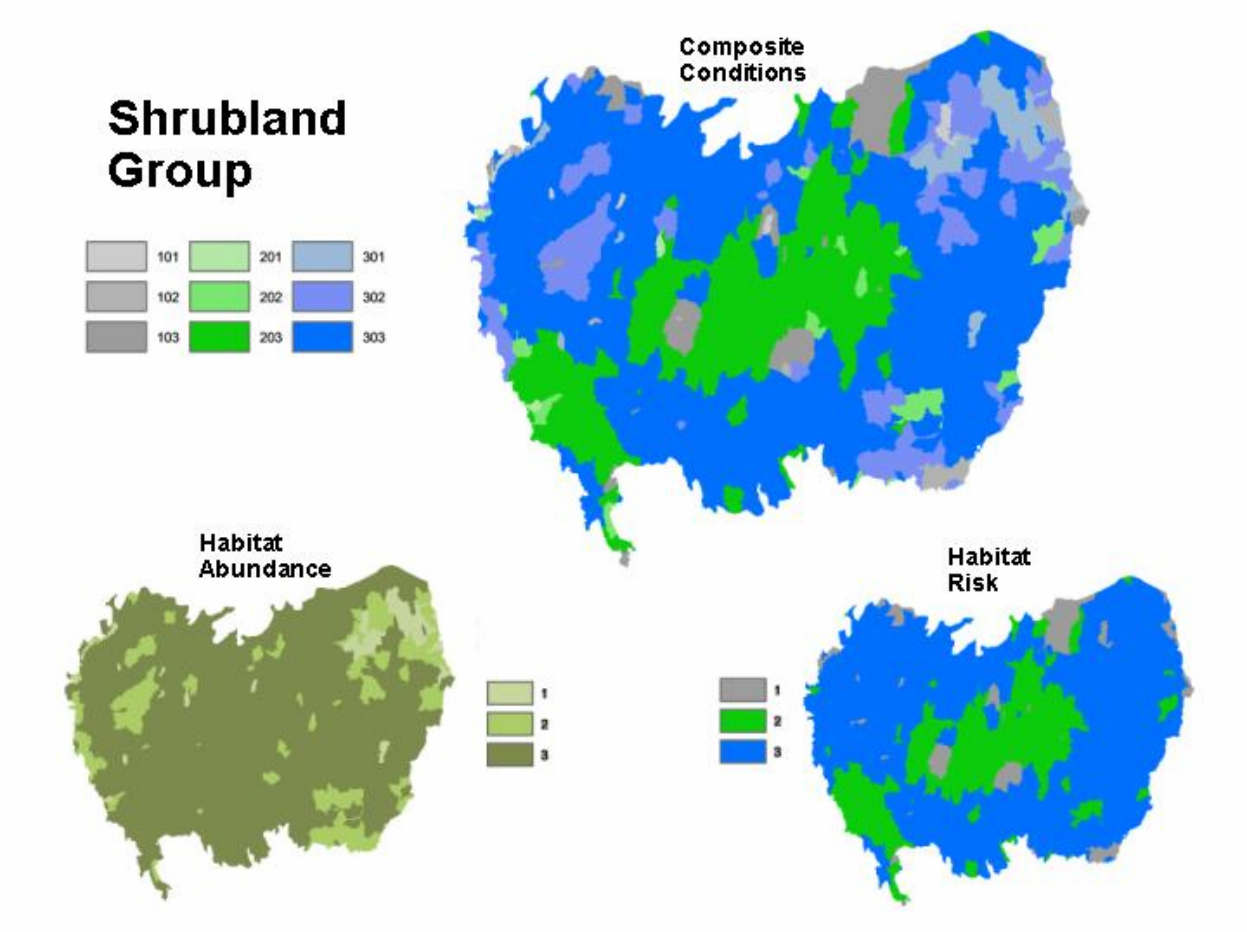

Figure 7.13. Habitat abundance, habitat risk, and composite conditions for the shrubland group of species in watersheds of the Great Basin. Legends and details of each map are explained in the caption for Figure 7.6.

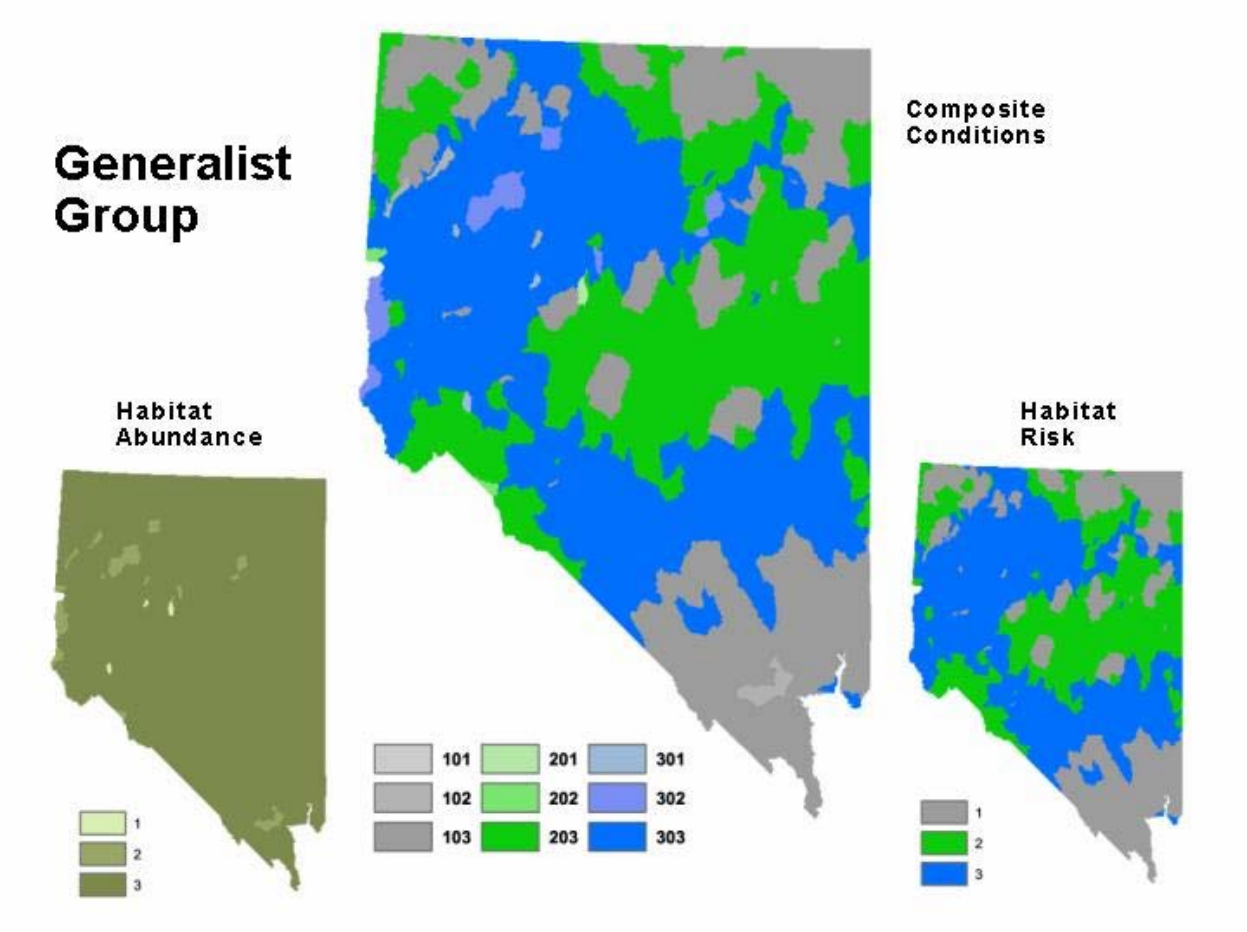

Figure 7.14. Habitat abundance, habitat risk, and composite conditions for the generalist group of species in watersheds of Nevada. Legends and details of each map are explained in the caption for Figure 7.6.

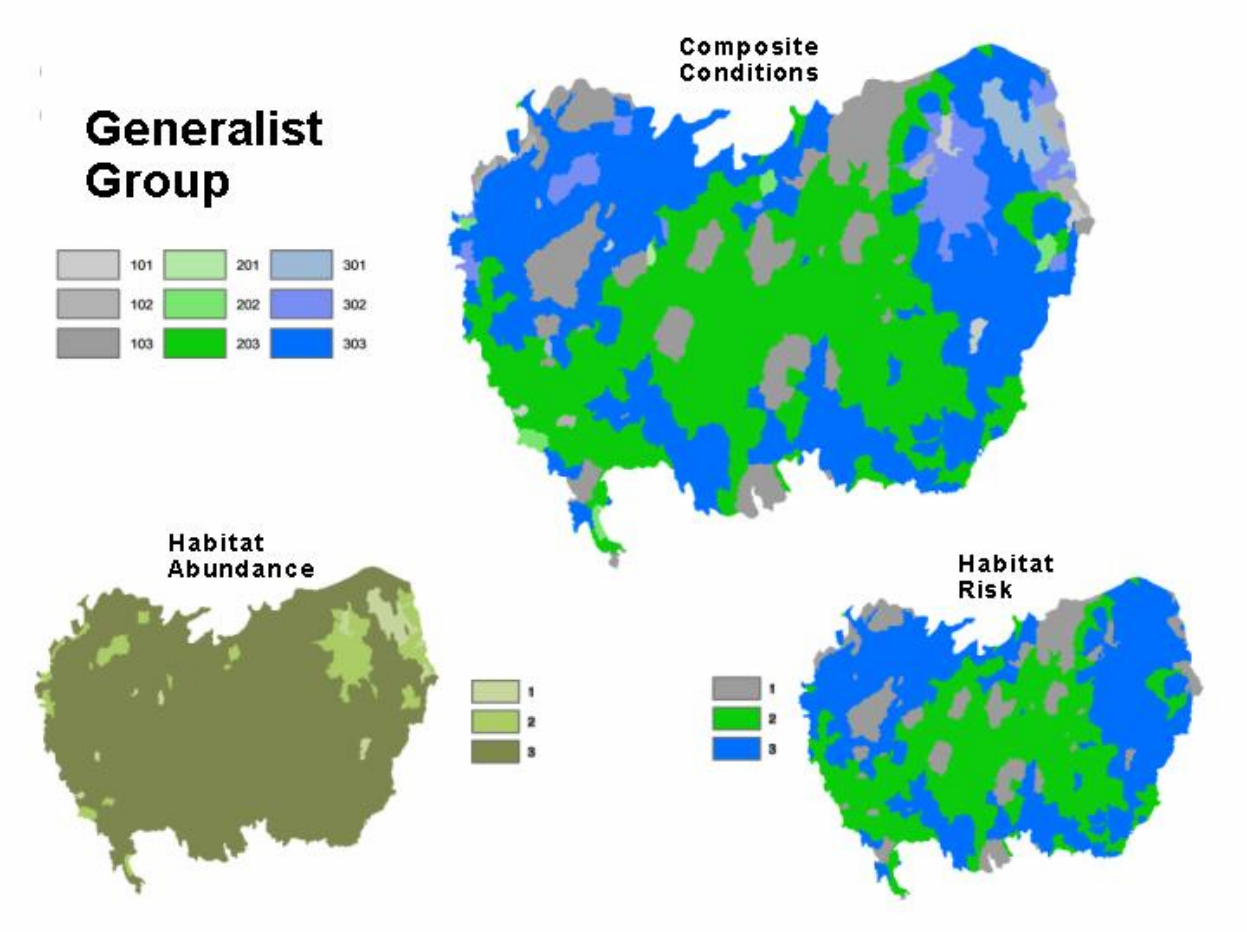

Figure 7.15. Habitat abundance, habitat risk, and composite conditions for the generalist group of species in watersheds of the Great Basin. Legends and details of each map are explained in the caption for Figure 7.6.