BIRD POPULATION RESPONSES TO PROJECTED EFFECTS OF CLIMATE CHANGE IN NEVADA: AN ANALYSIS FOR REVISION OF THE NEVADA WILDLIFE ACTION PLAN

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Abstract [To be added]

Introduction

The projected effects of climate change on bird populations fall into a variety of categories, including responses due to landscape-wide shifts in vegetation cover, shifts in migration and breeding phenologies of birds, availability of food and water resources during critical phases of life history, and direct effects of increasing temperatures and change in precipitation on birds. In Nevada, most climate models predict increasing temperatures throughout the region, decreasing snowpack in the Sierra Nevada and other high ranges in the state (Maurer 2007), increasing rainfall averages in some regions, and an overall prolonging summer drought period (Cayan et al. 2010). Our analyses presented in this report are based on projections for changes in landcover performed using state-and-transition models for current vegetation covers statewide (TNC 2011). As such, our analyses are limited by the same assumptions as necessary for the projections of change in vegetation cover, and some additional assumptions are needed to project bird responses. Vegetation cover projections for climate change are generally based on the current physical environments of plant communities, and future plant community distribution is projected using the calculated change in physical conditions across the landscape. As such, models of vegetation change generally assume a relatively gradual change in vegetation succession that allows for plant communities to degrade or shift to new locations in a continuous fashion, despite taking into account disturbance probabilities. These models generally do not try to predict highly stochastic events across large regions that have no precedence (Fitzpatrick and Hargrove 2009), such as devastating cross-regional wildfires, and they generally cannot take into account changes in other trophic levels, such as responses in herbivore populations or diseases (Araujo and Luoto 2007). These limitations apply to our attempts to model bird population changes based on predicted change in vegetation cover, as birds will most likely also respond to changes in invertebrate and other prey availability and to stochastic events, aside from their expected responses to shifts in plant community distribution (Wiens et al. 2009).

Birds are specifically expected to be also affected by (1) a decoupling of peaks in food availability and a species' brood-rearing season, (2) shifts in migration phenology toward earlier northward migration and more northern wintering grounds that may affect food availability during these life stages (Jones and Cresswell 2010), (3) and distributional shifts in response to extreme events, such as widespread wildfires, insect outbreaks, and plant disease outbreaks. These changes are extraordinarily difficult to predict in a defensible way, which is why they are generally excluded from climate change modeling, as they are in this report. Instead, we focus our efforts on predicting a "base rate" of change based on mostly gradual change in vegetation community distribution and change in habitat condition. The projected vegetation changes from the climate model consisted of averages of five model runs, with no quantification of the uncertainty in these models, but the uncertainty is estimated to be large. The uncertainty in species abundance modeling relative to vegetation is added to the uncertainty of vegetation response to climate, and to the uncertainty in the original climate models themselves. In one attempt to compare these uncertainties for fish populations, Buisson et al. (2010) concluded that species distribution modeling may be an important source of variability in the near-term, whereas climate modeling became equally important in later decades.

Future landbird monitoring will play an increasingly important role in refining climate change predictions for wildlife and implementing adaptive management to mitigate for climate change effects. Particularly long-established standard protocols for bird monitoring, such as the Nevada Bird Count and Breeding Bird Survey programs will play a key role in better understanding bird population effects from climate change.

Methods

Bird Data

For modeling landbird population change, we used data from the first ten years of the Nevada Bird Count (NBC) and from recent landbird inventory projects in Nevada that used the same point-count design as NBC for assessing bird populations. Our analyses in this report are restricted to those priority species of the Wildlife Action Plan that are diurnal landbirds with relatively small breeding territories, because point count surveys are designed to estimate densities for these species. Species with large home ranges, waterbirds, shorebirds, and secretive marshbirds are not included in our analyses, nor are landbird species that are so rare in Nevada that reasonable density estimates cannot be derived for their primary breeding habitats.

Nevada Bird Count

The Nevada Bird Count was conceptually developed by the Great Basin Bird Observatory (GBBO) in 2001-2002 and began to be implemented statewide in May 2002. It targets all landbirds of Nevada in a multi-species, habitat-stratified sampling design using primarily the point count method. Long-term trend monitoring was one objective of the program. A shorter-term objective was to generate habitat models for conservation priority species specifically to assist resource management agencies in their goal to manage habitats for bird conservation. This report is one such effort. Large-scale monitoring programs such as the Nevada Bird Count provide a wealth of information that can often be used for purposes not originally anticipated at the start of the program.

The original habitat stratification for the program used landcover types from the original GAP project (1990s), combined into 13 broad “habitat types” dominated by vegetation that correspond roughly with the Biophysical Settings used in the TNC climate change model (TNC 2011), including aspen (*Populus tremuloides*), montane riparian, lowland riparian, coniferous forest, pinyon-juniper (*Pinus* and *Juniperus* spp.), Mountain Mahogany (*Cercocarpus ledifolius*), sagebrush (*Artemisia* spp.), salt desert, Mojave scrub (including *Larrea tridentate* and *Ambrosia dumosa*), agricultural, and wetland. Random selection of NBC monitoring sites entailed a random point scatter generated for each habitat type using GIS, which served as a starting point of a 10-point survey transect. Minor adjustments were made to accommodate accessibility, and all 259 transects were surveyed at least once, and a subset multiple times, resulting in 5178 point surveys available for our analyses after 320 transects from other projects were added (see below).

Other Projects

The Great Basin Bird Observatory has conducted several projects around Nevada that provide additional point count data, doubling the sample size that was used in this report. Most of these involve random selection of transects within the region or habitat type being targeted. The sample of riparian surveys is especially enhanced by this. While these points were randomly selected within a project area, they do not, for the most part, represent point in the original statewide random point scatter. They were included here, because they represent high-priority landscapes or habitat types around Nevada that would otherwise not have been captured in our models.

Field Methods

Point count surveys are NBC's primary approach to data collection for breeding landbirds (after Ralph et al. 1993), and the same protocol was used for all other data used in this report. Survey routes consisted of habitat-based, mostly off-road walking transects of 10 survey points (300 m apart in open, expansive habitats; 250 m apart in forested, restricted habitats). During a count, all birds detected by visual or auditory cues were recorded. Each point count survey lasted 10 minutes. Most transects were visited once annually during the peak breeding season of most Nevada landbirds, from April 25 through June 30 (Mojave region) and May 25 – July 10 (Great Basin region), between dawn and 10:00 a.m. in fair weather conditions (no strong winds or heavy precipitation). Fly-over sightings and birds at distance greater than 100 m were not included in the analyses for this report. Further details about the survey protocol and sample data sheets can be obtained from the GBBO website (http://www.gbbo.org).

Current Vegetation Cover Map and Projections for 50 Years

We used two separate products provided by The Nature Conservancy (TNC 2011):

1. Statewide maps (GIS raster coverage) of potential vegetation types (Biophysical Settings, or BPS) and current vegetation classes within them (SCLASS), created from interpreted satellite or low-flying aircraft imagery.

2. Non-spatial forecast of the anticipated future condition (in 50 years) of ecological systems with climate change effects (and assumptions of minimal management), using refined computerized predictive state-and-transition ecological models.

The foundation of the mapping component was stratification of the landscape into BPSs, which represent potential vegetation types. More specifically, the BPS is the type of dominant vegetation that is expected in the physical environment under natural ecological conditions and disturbance regimes. These types were based on LANDFIRE, Southwestern Regional Gap Analysis Program, and other map sources (for more details, see TNC 2011). Within each BPS, there are several classes of current vegetation condition (SCLASS). These classes include typical successional stages of the "characteristic" natural vegetation, as well as several "uncharacteristic" classes. Uncharacteristic classes are outside of reference condition classes and are caused by anthropogenic disturbances (e.g., non-native annual grass invasion).

The raster of current conditions covers the entire state of Nevada, but only 13 of the 14 phytogeographic regions were included in the TNC modeling effort. The very small Sierra Nevada region, limited to the Carson Range under this mapping effort, was not explicitly modeled because it is small and contains many residential developments, and because TNC completed a separate assessment for the Northern Sierra Nevada reported elsewhere (Low et al. 2011).

The distribution of bird-survey transects across the 13 phytogeographic regions of TNC (2011) generally reflect the relative sizes of the regions (Table 1). Exceptions included the Tonopah region due to inaccessible Department of Defense lands, and the Mojave region which was more thoroughly covered than other regions due to strong partner support in Clark County.

Table 1. Existing bird point-count transect coverage of 13 phytogeographic regions identified in TNC (2011).

Phytogeographic Region	NBC Transects
Black Rock Plateau	59
Mojave	136
Calcareous Ranges	125
Clover-Delamar	6
Elko	88
Eastern Sierra Nevada Ranges	40
Eureka	30
Humboldt Ranges	9
Lahontan Basin	20
Owyhee Desert	3
Sierra Nevada	16
Toiyabe	38
Tonopah	5
Walker Corridor	10

Current Bird Habitat Use and Population Estimates

For modeling current bird habitat use, we used the raster map of current vegetation conditions from TNC (2011). The landbird data from the NBC and similar projects in Nevada were limited to a 100 m radius distance from each survey point, because detectability of most landbirds decreases rapidly beyond this distance. We then created a 100 m spatial buffer around each point, and calculated the percentages of each current vegetation cover type within that circle (3.14 ha).

Ideally, we would want to derive bird density estimates from points that are 100% covered by one BPS or SCLASS to make the purest estimate for each vegetation class. However, the majority of Nevada landscapes vary enough to make this impossible, particularly with our randomly selected transect locations. We therefore chose the lower threshold for the minimum area covered by one BPS or SCLASS of 25% (or 50% in more common and widespread vegetation classes). Some survey points were covered by multiple habitat types that met this minimum criterion, in which case they were used to represent each of these habitat types in our predictions.

We also largely eliminated survey points for upland vegetation classes that had riparian cover in the circle, except when the riparian habitat type was the one of interest in the analysis. In some habitat types, such as salt desert or sagebrush, areas near riparian or wetlands show differences in bird use than areas remote from mesic habitats (GBBO 2010). Therefore, if sample size was adequate for those upland habitat types we discarded the points with riparian cover within 100 m in order to get a more typical bird density estimation for the targeted habitat. For riparian habitat covers themselves, we used the 25% cover minimum for inclusion.

Inevitably, samples sizes varied among habitat types because of varying amounts of cover types in the landscape. Some rare cover types lacked survey points, and others had too few for analyses. These were either merged in with a similar type (see below) or discarded, if they were too different from other habitat types. Merging of BSPs and SCLASSes resulted in habitats (or habitat types, as they will be called hereafter) and was done using the following rules:

1. Cluster analyses on the point count data were used to combine the BPSs and SCLASSes that were similar from a bird community perspective.

2. Cover types were further merged based on similarity in vegetation structure and composition variables that are considered important to birds (based on WAP Team 2005, GBBO 2010).

3. Condition classes within a single BPS were merged more commonly than condition classes among BPSs, unless the different BPSs were closely related (e.g. different sagebrush types); in a few cases, a very rare BPS was combined with the most similar one that was more common.

4. We tried to get at least 50 survey points in each merged vegetation class, although lower sample sizes were accepted if a cover type was of high interest for climate change planning.

After merging vegetation classes, we recalculated the percent cover of each habitat type in the 100-m-radius buffers and gained some additional sampling points which now met the 25% minimum criterion. Finally, we estimated bird density for each priority landbird species in each habitat type. For this, we calculated the average number of individuals (excluding fly-over observations) detected within 10 minutes and 100 m by taking the mean of multiple visits to each point. These numbers were then averaged over all points assigned to a particular habitat type, and extrapolated to the average detectable density in 40 ha.

Because the main goal was to get the best density estimate for each habitat type (rather than to compare them), we used different minimum cover thresholds for habitat types depending on available sample sizes. We used points with at least 50% of the cover type and no riparian covers for the few cases where this still gave us over 50 survey points. If this sample size was not met, we used the 25% threshold with no riparian, and if the sample size was still low, then we used the 25% threshold with riparian habitat nearby.

A working estimate of statewide population size can then be estimated by multiplying the densities by the number of hectares currently in each habitat type, and summing over all habitat types in each of the 13 regions from the climate model, which can then be summed for the state.

These population estimates were only generated for the purpose of estimating effect size of climate change and should thus not be used for other purposes, such as absolute population size estimation for the state. From these population estimates, we deleted estimates obtained for habitat types where a species cannot occur based on its known natural history, as we assume that detections at such survey points were due to the presence of preferred habitats. For some statewide habitat types, data for the Mojave region (which for the purpose of this report, included the Clover-Delamar region identified in TNC 2011) were separated from data for the Great Basin region, but most habitat types were largely restricted to one or the other. Species density estimates only included the regions in which the species is known to nest (Floyd et al. 2007).

Climate Change Modeling of Bird Responses

The complex state-and-transition models included changes in disturbance regimes as well as simple effects of changes in temperature and precipitation. The following are components of the models that are likely to be particularly important to birds (from TNC 2011):

1. Increased dispersal of non-native species (annual grasses, forbs, and trees) caused by CO_2 fertilization of plant growth during wetter than average years

2. Higher tree mortality during longer growing season droughts

3. Longer period of low flows caused by earlier snowmelt

4. Greater flood variability due to greater frequency of rain-on-snow events, which may favor cottonwood and willow recruitment on currently regulated rivers and creeks

5. More frequent, larger fires in forested systems

6. Longer fire return intervals in shrubland systems due to increased drought frequency preventing fine fuel build up

7. Increased dispersal of pinyon and juniper into shrublands caused by CO_2 fertilization during wetter than average years

8. Greater conifer and deciduous tree species recruitment and growth in wetlands/riparian due to drought and CO_2 fertilization

9. Impaired recruitment of willow and cottonwood due to descending peak flows occurring one month earlier, and limited ability of these species to flower one month earlier in cold drainages

Some of these climate change hypotheses carry contradictory predictions, e.g., increased recruitment of trees vs. more frequent forest fires, which we assume that the overall climate model takes into account. For this report, we used the (unedited) model output from TNC (2011) to predict bird population change based only on habitat shifts and changes in habitat condition predicted by the TNC model.

We used current acreages and model projections for future acreages after 50 years of climate change with minimal management for each condition class within biophysical settings (TNC 2011) to project expected changes in landbird populations. These predictions carry the same limitations and assumptions as do the predictions for vegetation change, and also assume that habitat change will dictate most changes in bird populations (but see above for cautionary comments).

Projections for bird population change were calculated separately for the 13 regions in Nevada used in this analysis (for details on these regions, see TNC 2011). For birds with statewide breeding distributions, we summed habitat acreages across regions for one statewide total. Southern Nevada species were analyzed using only those appropriate regions (usually Mojave and Clover-Delamar). We used the estimated species density using the minimum cover criteria for each habitat type that is known as breeding habitat for that species (see below, Table 3). We excluded habitat types that are unsuitable as breeding habitat, because bird records from these habitat types generally represented sightings from adjacent, suitable habitat near the survey point. Using the density estimates, we calculated a working estimate of population size for the state, including only those regions in which the species is known to breed (Floyd et al. 2007). This estimate of population size was *only* calculated for the purpose of estimating population change under the climate model, and it should not be used to draw inferences about absolute statewide population size of a species, as several assumptions for such estimate would be violated. Some condition classes were projected to change greatly due to climate change, but some of these changes were not available in the current map, either because these classes are currently rare or because the available GIS layers cannot delineate them. In these cases, we made qualitative judgments about expected effects on the birds that occupy the changing habitats that were not mapped.

To calculate bird responses, we used estimated density (birds per 40 ha) for each habitat type's current area (in hectares) to estimate population size supported by that habitat type, then calculated estimated future population size supported by that habitat type using the projections from TNC's (2011) model, and combined the estimated population sizes for all habitat types to represent overall population change under the model. For each habitat type, we report the steps in this calculation by listing the working population size estimates (current and future), the projected change over 50 years under the model, and the contribution of each habitat type to population change in the form of estimated number of birds lost or gained.

Results and Discussion

Bird-Habitat Types Resulting From Merging Vegetation Covers

Table 2 lists the biophysical settings and condition classes for which at least some bird data from the NBC program and similar projects exist. It also illustrates how many points met the 25% minimum cover threshold before merging them into 55 habitat types that are based on commonalities in bird communities and in structural and floristic attributes of vegetation covers. Table 3 lists the available sample sizes of bird survey points under different threshold criteria

(25% and 50% minimum cover, and with and without riparian vegetation present in the survey area buffer for upland habitat types).

Table 2. Merged cover types and their new habitat type names used in this report for habitat modeling. Listed are biophysical setting (BPS) and condition class (SCLASS) numbers and names from TNC (2011), the number of bird survey points available for each cover type (cover types with no bird data are not included), the habitat types resulting from merging cover types.

BPS	BPS Name	SCLASS	SCLASS Name	# Points Before Merge	Habitat Type Name
1087	Creosotebush	1	A:early	137	Creosote, Early
1087	Creosotebush	2	B:late-closed	188	Creosote, Late
10821	Blackbrush mesic	1	A:early	28	Blackbrush, Early
10820	Blackbrush thermic	1	A:early	100	
10820	Blackbrush thermic	2	B:late-closed	363	Blackbrush-thermic, Late
10821	Blackbrush mesic	2	B:mid-closed	72	Blackbrush-mesic, Late
10821	Blackbrush mesic	3	C:late-closed	42	
10821	Blackbrush mesic	14	shrub-annual-per	7	Blackbrush, shrub/annual
10820	Blackbrush thermic	14	shrub-annual-per	1	
1081	Mixed Salt Desert	1	A:early	9	Salt Desert, Early
1081	Mixed Salt Desert	2	B:late-open	231	Salt Desert, Mid/Late
1081	Mixed Salt Desert	3	C:late-open	22	SD-Greasewood, Late
1153	Greasewood	2	B:late-closed	100	
1081	Mixed Salt Desert	10	annual grassland	14	Salt Desert, shrub/annual
1081	Mixed Salt Desert	14	shrub-annual-per	68	
1153	Greasewood	10	annual grassland	2	Greasewood, shrub/annual
1153	Greasewood	14	shrub-annual-per	89	
1125	Big SAGE Steppe	1	A:early	2	Sagebrush, Early
10801	Big SAGE upland	1	A:early	4	
1126	Montane SAGE	1	A:early	4	
10800	Wyoming Big SAGE	1	A:early	6	
1124	Low SAGE Steppe	1	A:early	0	
1079	Low-Black SAGE	1	A:early	6	
1079	Low-Black SAGE	2	B:mid-open	82	Low/Black Sage, Mid/Late
1079	Low-Black SAGE	3	C:late-open	26	
1124	Low SAGE Steppe	3	C:late-closed	124	Low Sage, Mid/Late
1124	Low SAGE Steppe	2	B:mid-open	50	
10800	Wyoming Big SAGE	3	C:late-closed	130	WY Big Sage, Late
10801	Big SAGE upland	2	B:mid-open	15	Big Sage upland, Mid/Late
10801	Big SAGE upland	3	C:mid-closed	25	
10801	Big SAGE upland	4	D:late-open	22	

BPS	BPS Name	SCLASS	SCLASS Name	# Points Before Merge	Habitat Type Name
10800	Wyoming Big SAGE	2	B:mid-open	120	Big Sage, Mid-open
1125	Big SAGE Steppe	2	B:mid-open	14	
1125	Big SAGE Steppe	3	C:mid-closed	78	Big Sage, Mid-closed
1126	Montane SAGE	2	B:mid-open	62	Mtn Sage, Mid-open
1126	Montane SAGE	3	C:mid-closed	320	Mtn Sage, Mid-closed
1126	Montane SAGE	4	D:late-open	27	Mtn Sage, Late-open
1126	Montane SAGE	5	E:late-closed	82	Mtn Sage, Late-closed
1079	Low-Black SAGE	4	D:late-closed	47	Low/Big Sage, Late-closed
10801	Big SAGE upland	5	E:late-closed	22	
10800	Wyoming Big SAGE	14	shrub-annual-per	273	Big Sage, shrub/annual
10801	Big SAGE upland	14	shrub-annual-per	25	
10800	Wyoming Big SAGE	10	annual grassland	4	Sage, annual grass
1125	Big SAGE Steppe	10	annual grassland	0	
10801	Big SAGE upland	10	annual grassland	2	
1079	Low-Black SAGE	10	annual grassland	0	
10801	Big SAGE upland	8	depleted	35	Big Sage, depleted
1124	Low SAGE Steppe	8	depleted	4	Low Sage, depleted
1079	Low-Black SAGE	8	depleted	99	
1125	Big SAGE Steppe	14	shrub-annual-per	6	Sage, shrub/annual
1079	Low-Black SAGE	14	shrub-annual-per	45	
1126	Montane SAGE	14	shrub-annual-per	137	Mtn Sage, shrub/annual
1126	Montane SAGE	8	depleted	156	Mtn Sage, depleted
1126	Montane SAGE	10	annual grassland	46	Mtn Sage, annual grass
10800	Wyoming Big SAGE	9	tree-annual-grass	265	Big Sage, tree-encroach
10801	Big SAGE upland	13	tree-encroached	2	
10801	Big SAGE upland	9	tree-annual-grass	0	Mixed-Sage, tree-encroach
1126	Montane SAGE	13	tree-encroached	1	
1079	Low-Black SAGE	9	tree-annual-grass	3	
1124	Low SAGE Steppe	13	tree-encroached	2	Low Sage, tree-encroach
1079	Low-Black SAGE	13	tree-encroached	38	
1086	Mountain Shrub	1	A:early	1	Mountain Shrub/Chaparral
1086	Mountain Shrub	2	B:mid-open	0	
1086	Mountain Shrub	3	C:mid-closed	4	
1086	Mountain Shrub	8	depleted	0	
1086	Mountain Shrub	13	tree-encroached	18	
1086	Mountain Shrub	14	shrub-annual-per	4	
1103	Chaparral	1	A:early	0	
1103	Chaparral	2	B:late-closed	8	
1103	Chaparral	14	shrub-annual-per	0	

BPS	BPS Name	SCLASS	SCLASS Name	# Points Before Merge	Habitat Type Name
1062	Mountain Mahogany	1	A:early	29	Mountain Mahogany
1062	Mountain Mahogany	2	B:mid-closed	10	
1062	Mountain Mahogany	3	C:mid-open	2	
1062	Mountain Mahogany	4	D:late-open	10	
1062	Mountain Mahogany	5	E:late-closed	20	
1019	Pinyon-Juniper	1	A:early	12	Pinyon/Juniper, Early
1019	Pinyon-Juniper	2	B:mid-open	6	
1019	Pinyon-Juniper	3	C:mid-open	51	
1019	Pinyon-Juniper	4	D:late-open	166	Pinyon/Juniper, Late
1052	Mixed Conifer	1	A:early	0	Mixed Conifer/ Dry Pine
1052	Mixed Conifer	2	B:mid-closed	16	
1052	Mixed Conifer	3	C:mid-open	4	
1052	Mixed Conifer	4	D:late-open	0	
1052	Mixed Conifer	5	E:late-closed	20	
1054	Ponderosa Pine	1	A:early	0	
1054	Ponderosa Pine	2	B:mid-closed	1	
1054	Ponderosa Pine	3	C:mid-open	1	
1054	Ponderosa Pine	4	D:late-open	0	
1054	Ponderosa Pine	5	E:late-closed	28	
1031	Jeffery Pine	1	A:early	3	
1031	Jeffery Pine	2	B:mid-closed	60	
1031	Jeffery Pine	3	C:mid-open	19	
1031	Jeffery Pine	4	D:late-open	0	
1031	Jeffery Pine	5	E:late-closed	0	
1031	Jeffery Pine	10	annual grassland	0	
1032	Red Fir	1	A	7	Red Fir (not modeled by TNC 2011)
1032	Red Fir	2	B	54	
1032	Red Fir	3	C	1	
1032	Red Fir	4	D	0	
1032	Red Fir	5	E	2	
1055	Spruce Fir	1	A:early	1	Spruce/ Fir
1055	Spruce Fir	2	B:mid-closed	9	
1055	Spruce Fir	3	C:mid-open	12	
1055	Spruce Fir	4	D:late-closed	29	
1020	Limber-Bristlecone	1	A:early	4	Subalpine Pine
1020	Limber-Bristlecone	2	B:mid-open	14	
1020	Limber-Bristlecone	3	C:late-open	26	
11551	Washes	1	A:early	28	Washes
11551	Washes	2	B:mid-closed	28	

BPS	BPS Name	SCLASS	SCLASS Name	# Points Before Merge	Habitat Type Name
11551	Washes	3	C:late-closed	33	Washes, Late
11550	Warm Desert Riparian	1	A:early	32	Warm Desert Riparian, CHAR
11550	Warm Desert Riparian	2	B:mid-closed	7	
11550	Warm Desert Riparian	3	C:mid-open	16	
11550	Warm Desert Riparian	4	D:late-closed	3	
11550	Warm Desert Riparian	5	E:late-closed	0	
11550	Warm Desert Riparian	16	exotic forb	93	Warm Desert Riparian,
1154	Montane Riparian	1	A:early	113	Montane Riparian, Early
1154	Montane Riparian	2	B:mid-open	70	Montane Riparian, Late
1154	Montane Riparian	3	C:late-closed	87	
1154	Montane Riparian	16	exotic forb	136	Montane Riparian, Exotic
1154	Montane Riparian	18	desertified	138	Montane Riparian,
1160	Subalpine Riparian	1	A:early	0	Subalpine Riparian
1160	Subalpine Riparian	2	B:mid-open	18	
1160	Subalpine Riparian	3	C:late-closed	1	
1160	Subalpine Riparian	16	exotic forb	1	
1011	Aspen Woodland	1	A:early	36	Aspen Woodland
1011	Aspen Woodland	2	B:mid-closed	23	
1011	Aspen Woodland	3	C:late-closed	6	
1011	Aspen Woodland	8	depleted	34	
1011	Aspen Woodland	4	D:late-open	42	Aspen Wood, Late
1061	Aspen-Mixed Conifer	1	A:early	1	Aspen Mixed-Conifer
1061	Aspen-Mixed Conifer	2	B:mid-closed	0	
1061	Aspen-Mixed Conifer	3	C:mid-closed	10	
1061	Aspen-Mixed Conifer	4	D:late-open	0	
1061	Aspen-Mixed Conifer	5	E:late-closed	67	Aspen Mixed-Conifer, Late

Table 3. Sample sizes for bird survey points in habitat cover types after merging vegetation covers from TNC (2011). Sample sizes in habitat types may be higher than the sum of sample sizes in the original cover types before merging because, in some cases, the merging resulted in additional survey points meeting the minimum cover threshold. In bold, we list the group of points used for analysis of bird population responses for the climate change model.

Habitat Type	Points with ≥ 25% cover	Points with ≥ 25% cover, no riparian/aspen cover in upland habitats	Points with ≥ 50% cover, no riparian/aspen cover in upland habitats
Creosote, Early	137	121	**74**
Creosote, Late	188	165	**85**

Habitat Type	**Points with ≥ 25% cover**	**Points with ≥ 25% cover, no riparian/aspen cover in upland habitats**	**Points with ≥ 50% cover, no riparian/aspen cover in upland habitats**
Blackbrush, Early	146	138	**54**
Blackbrush-thermic, Late	363	337	**180**
Blackbrush-mesic, Late	133	**96**	31
Blackbrush, shrub/annual	9	**8**	3
Salt Desert, Early	9	8	**8**
Salt Desert, Mid/Late	231	126	**75**
Salt Desert-Greasewood, Late	119	**82**	47
Salt Desert, shrub/annual	86	**66**	31
Greasewood, shrub/annual	92	**79**	38
Sagebrush, Early	**26**	16	0
Low/Black Sage, Mid/Late	112	**86**	23
Low Sage, Mid/Late	173	99	**64**
WY Big Sage, Late	129	**65**	31
Big Sage upland, Mid/Late	70	**55**	11
Big Sage, Mid-open	136	**48**	26
Big Sage, Mid-closed	78	**51**	24
Mtn Sage, Mid-open	62	**52**	16
Mtn Sage, Mid-closed	318	289	**178**
Mtn Sage, Late-open	**27**	16	3
Mtn Sage, Late-closed	82	**51**	16
Low/Big Sage, Late-closed	70	**52**	12
Big Sage, shrub/annual	360	230	**101**
Sage, annual grass	**9**	7	1
Big Sage, depleted	**35**	18	5
Low Sage, depleted	105	**84**	38
Sage, shrub/annual	**52**	39	15
Mtn Sage, depleted	156	**96**	33
Mtn Sage, shrub/annual	137	84	**53**
Mtn Sage, annual grass	**46**	31	6
Big Sage, tree-encroach	272	166	**58**
Mixed-Sage, tree-encroach	3	2	0
Low Sage, tree-encroach	**41**	35	13
Mountain Shrub/Chaparral	**45**	24	12
Mountain Mahogany	**110**	26	14
Pinyon/Juniper, Early	83	**57**	16
Pinyon/Juniper, Late	200	108	**67**
Mixed Conifer/ Dry Pine	146	**53**	43
Red Fir (not modeled)	**57**	35	34
Spruce/ Fir	**53**	32	16
Subalpine Pine	**52**	31	21
Washes	**84**	83	13
Washes, Late	**33**	33	3
Warm Desert Riparian, CHAR	**76**	n/a	n/a
Warm Desert Riparian, exotic	**93**	n/a	n/a

Habitat Type	**Points with ≥ 25% cover**	**Points with ≥ 25% cover, no riparian/aspen cover in upland habitats**	**Points with ≥ 50% cover, no riparian/aspen cover in upland habitats**
Montane Riparian, Early	**112**	n/a	n/a
Montane Riparian, Late	**223**	n/a	n/a
Montane Riparian, Exotic	**136**	n/a	n/a
Montane Riparian, Desertified	**136**	n/a	n/a
Subalpine Riparian	**31**	n/a	n/a
Aspen Woodland	**151**	n/a	n/a
Aspen Wood, Late	**42**	n/a	n/a
Aspen Mixed-Conifer	**20**	n/a	n/a
Aspen Mixed-Conifer, Late	**67**	n/a	n/a

Current and Projected Habitat Areas

After merging vegetation cover types into bird-habitat types, we applied TNC's (2011) climate change projections for change in vegetation cover to the bird-habitat types. The current and future projected area cover (in hectares), as well as percent future from current cover (as estimated by the climate model), are listed for each of 54 habitat types in Table 4. The cover change over 50 years was used for projections of change in bird populations. In Table 5, we list those vegetation cover classes for which we could not model bird population change, either because we had insufficient sampling points in the current cover, or because they were not modeled in the TNC (2011) effort.

Table 4. Merged vegetation categories used in this report (see also Table 3), with total hectares statewide under current conditions and projected number of hectares remaining after 50 years with the TNC (2011) model using reported averages under climate change and minimum management. The percent change after 50 years is calculated by the ratio of projected/current area.

Habitat Type	Current Area in Nevada (ha)	Projected Area in Nevada after 50 years under TNC (2011) climate model (ha)	Percent of Current Area after 50 years
Creosote, Early	310,088	52,677	17%
Creosote, Late	592,274	699,389	118%
Blackbrush, Early	753,132	618,218	82%
Blackbrush-thermic, Late	99,566	128,585	129%
Blackbrush-mesic, Late	975,869	804,681	82%
Blackbrush, shrub/annual	61,612	280,329	455%
Salt Desert, Early	152,214	478,492	314%
Salt Desert, Mid/Late	2,555,571	1,690,351	66%
SD-Greasewood, Late	1,763,477	1,730,951	98%
Salt Desert, shrub/annual	1,358,474	1,758,856	129%
Greasewood, shrub/annual	228,856	399,088	174%
Sagebrush, Early	385,198	936,273	243%
Low/Black Sage, Mid/Late	982,465	786,973	80%
Low Sage, Mid/Late	527,249	438,122	83%
WY Big Sage, Late	397,562	523,017	132%
Big Sage upland, Mid/Late	776,199	660,058	85%
Big Sage, Mid-open	851,357	457,022	54%
Big Sage, Mid-closed	235,536	174,208	74%
Mtn Sage, Mid-open	693,382	690,185	100%
Mtn Sage, Mid-closed	2,093,449	1,106,313	53%
Mtn Sage, Late-open	216,566	303,032	140%
Mtn Sage, Late-closed	350,873	279,411	80%
Low/Big Sage, Late-closed	276,391	286,545	104%
Big Sage, shrub/annual	857,049	453,712	53%
Sage, annual grass	330,785	1,071,553	324%
Big Sage, depleted	154,232	148,548	96%
Low Sage, depleted	679,390	595,727	88%
Sage, shrub/annual	212,868	374,491	176%

Habitat Type	Current Area in Nevada (ha)	Projected Area in Nevada after 50 years under TNC (2011) climate model (ha)	Percent of Current Area after 50 years
Mtn Sage, depleted	680,489	493,324	72%
Mtn Sage, shrub/annual	597,771	484,980	81%
Mtn Sage, annual grass	245,797	391,558	159%
Big Sage, tree-encroach	1,968,035	1,788,612	91%
Mixed-Sage, tree-encroach			862%
Low Sage, tree-encroach	387,293	354,119	91%
Mountain Shrub/Chaparral	112,698	98,563	87%
Mountain Mahogany	248,170	239,471	96%
Pinyon/Juniper, Early	741,774	556,470	75%
Pinyon/Juniper, Late	1,180,690	1,294,859	110%
Mixed Conifer/ Dry Pine	76,482	80,036	105%
Spruce/ Fir	27,024	28,956	107%
Subalpine Pine	53,902	55,814	104%
Washes	122,763	20,609	17%
Washes, Late	16,226	137,753	849%
Warm Desert Riparian, CHAR	66,215	370	1%
Warm Desert Riparian, exotic	286	3,202	1119%
Montane Riparian, Early	72,173	22,679	31%
Montane Riparian, Late	129,886	107,614	83%
Montane Riparian, Exotic	115,384	152,829	132%
Montane Riparian, Desertified	110,638	112,875	102%
Subalpine Riparian	31,963	28,346	89%
Aspen Woodland	96,138	142,896	149%
Aspen Wood, Late	121,537	63,659	52%
Aspen Mixed-Conifer	8,924	24,509	275%
Aspen Mixed-Conifer, Late	64,317	40,615	63%

Table 5. Vegetation classes that could not be included in bird population projections, either because current cover did not include and bird survey points, or because they were not mapped in the climate model.

BPS	SCLASS	Current Area (ha)	Projected Area (ha)	Percent of Current Area after 50 Years
Blackbrush mesic	annual grassland	4	5812	143620%
Blackbrush mesic	bare ground	unmapped	7803	n/a
Blackbrush mesic	tree-annual-grass	2314	32318	1396%
Big Sagebrush Steppe	annual grassland	3127	29936	957%
Big Sagebrush upland	early shrub	unmapped	83100	n/a

BPS	SCLASS	Current Area (ha)	Projected Area (ha)	Percent of Current Area after 50 Years
Blackbrush thermic	annual grassland	225	2731	1211%
Blackbrush thermic	bare ground	unmapped	11309	n/a
Creosotebush-Bursage	annual grassland	622	128487	20643%
Creosotebush-Bursage	bare ground	unmapped	21496	n/a
Chaparral	shrub-annual-perennial	745	9111	1222%
Low-Black Sagebrush	early shrub	unmapped	221999	n/a
Mixed Conifer	annual grassland	4	1160	28670%
Mountain Shrub	early shrub	55	5193	9435%
Subalpine Riparian	C:late-closed	214	4268	1990%
Warm Desert Riparian	desertified	645	54175	8393%
Warm Desert Riparian	exotic forb	286	3202	1119%
Warm Desert Riparian	exotic tree	2577	5951	231%
Wyoming Big Sagebrush	early shrub	unmapped	497511	n/a

Projected Bird Responses to Climate Change

Sagebrush Species

Brewer's Sparrow, Sage Sparrow, and Sage Thrasher

The combined effects of altered fire regimes, grazing, and invasive weeds, particularly cheatgrass (*Bromus tectorum*), have already degraded large sagebrush areas to the point that many sagebrush bird species are declining (Rich et al. 2005, Knick et al. 2003). These changes are projected to continue over the next 50 years due to an increase in fire frequency and subsequent increase in cheatgrass, which drives much of the change in sagebrush habitat condition. "Sagebrush" is a complex habitat type with complex issues, which is why the WAP and TNC (2011) discuss six different biophysical settings, each with a number of characteristic and uncharacteristic condition classes. Here, we present and discuss the model results for the three sagebrush-obligate WAP priority species, Brewer's Sparrow, Sage Sparrow, and Sage Thrasher, and then summarize their overall climate change response patterns.

All three species reach their highest estimated densities in mid-successional stages of most sagebrush types, because they select for nesting habitat relatively tall and moderately dense sagebrush cover, but generally avoid trees (GBBO 2010). The Brewer's Sparrow has especially high estimated breeding densities in montane sagebrush (Table 6), and all three species use higher-elevation sagebrush zone which is important to climate modeling (Tables 6 - 8). Brewer's Sparrow population change is most affected by projected losses of big sagebrush/mid-open, mountain sagebrush/mid-closed, and mountain sagebrush/depleted covers, and shows the largest projected gains in sagebrush/annual grass and salt desert/shrub/annual covers, for a projected total of a 14% reduction in statewide population size over 50 years (Table 6). Sage Sparrow populations are projected to be most affected by reductions in mountain sagebrush/mid-closed and salt desert/mid-late covers, but are expected to see population gains in salt desert/shrub/annual cover, for a projected statewide population reduction of 20% (Table 7). Sage Thrasher is expected to be most affected by projected losses in mountain sagebrush/mid-closed, big sagebrush/mid-open, and salt desert shrub/late covers, and is expected to gain some birds in salt desert shrub/annual, Wyoming big sagebrush/late, and greasewood/shrub/annual covers, for a total projected statewide population loss of 21% (Table 8).

In a follow-up analysis, we asked the question of how much the presence of big sagebrush influences the estimated abundance of sagebrush birds, and based on estimated densities in low sagebrush plots where big sagebrush was also present (vs. absent), Sage Sparrow responded strongly to the presence of big sagebrush, indicating that this cover type plays a significant role in its breeding habitat selection (Table 9).

Table 6. Quantitative species model for the Brewer's Sparrow by habitat type. *Current population estimate* = current area cover multiplied by estimated birds per hectare (not shown); *N* = number of survey points used for calculation; *Projected population estimate* = projected area cover multiplied by estimated birds per hectare; *Proportional change* = percent of population remaining after 50 years (projected/current population estimate); *Estimated population change* = number of individuals estimated to be lost or gained. Habitat types listed only include those in which the species was recorded and which it is known to use during breeding, and are listed in descending order of current population estimate. Habitat types that represent a departure into uncharacteristic conditions are shaded in gray.

Habitat Type	N	Birds per 40 ha	Current Population Estimate	Projected Population Estimate	Proportional Change	Estimated Population Change
Big Sage, Mid-open	48	24.74	526,560	282,665	54%	-243,894
Low, Sage Mid/Late	64	24.53	323,333	268,676	83%	-54,657
Big Sage, Mid-closed	51	20.55	121,036	89,521	74%	-31,515
Big Sage, depleted	35	16.73	64,523	62,145	96%	-2,378
Mtn Sage, Mid-closed	178	15.29	800,305	422,932	53%	-377,372
Low Sage, depleted	84	15.01	254,935	223,541	88%	-31,394
Mtn Sage, Late-open	27	14.85	80,424	112,535	140%	32,110
WY Big Sage, Late	65	14.51	144,200	189,704	132%	45,504
Mtn Sage, Mid-open	52	11.46	198,604	197,688	100%	-916
Big Sage, shrub/annual	101	10.51	225,099	119,165	53%	-105,934
Mtn Sage, depleted	96	9.12	155,122	112,456	72%	-42,665
Mtn Sage, annual grass	46	8.03	49,325	78,575	159%	29,250
Big Sage upland, Mid/Late	55	7.91	153,484	130,519	85%	-22,966
SD-Greasewood, Late	82	7.82	344,748	338,389	98%	-6,359
Sage, annual grass	9	7.78	64,345	208,442	324%	144,096
Mtn Sage, shrub/annual	53	7.73	115,582	93,773	81%	-21,809
Sagebrush, Early	26	7.14	68,773	167,162	243%	98,389
Greasewood, shrub/annual	79	6.53	37,375	65,176	174%	27,801
Sage, shrub/annual	52	5.79	30,839	54,253	176%	23,415
Low/Black Sage, Mid/Late	86	5.78	141,970	113,721	80%	-28,249

Big Sage, tree-encroach	58	5.14	253,098	230,024	91%	-23,075
Salt Desert, shrub/annual	66	4.76	161,724	209,389	129%	47,665
Salt Desert, Mid/Late	75	3.61	230,542	152,489	66%	-78,053
Low/Big Sage, Late-closed	52	1.68	11,618	12,044	104%	427
Mtn Sage, Late-closed	51	0.37	3,285	2,616	80%	-669
Low Sage, tree-encroach	41	0.31	3,007	2,749	91%	-258
TOTAL	**1632**		**4,563,856**	**3,940,351**	**86%**	**-623,505**

Table 7. Quantitative species model for the Sage Sparrow. *Current population estimate* = current area cover multiplied by estimated birds per hectare (not shown); *N* = number of survey points used for calculation; *Projected population estimate* = projected area cover multiplied by estimated birds per hectare; *Proportional change* = percent of population remaining after 50 years (projected/current population estimate); *Estimated population change* = number of individuals estimated to be lost or gained. Habitat types listed only include those in which the species was recorded and which it is known to use during breeding, and are listed in descending order of current population estimate. Habitat types that represent a departure into uncharacteristic conditions are shaded in gray.

Habitat Type	N	Birds per 40 ha	Current Population Estimate	Projected Population Estimate	Proportional Change	Estimated Population Change
Mtn Sage, Mid-closed	178	13	680,155	359,438	53%	-320,717
Mtn Sage, Mid-open	52	9.24	160,227	159,489	100%	-739
Salt Desert, shrub/annual	66	8.25	280,251	362,850	129%	82,598
Mtn Sage, shrub/annual	53	7.51	112,191	91,022	81%	-21,169
Big Sage upland, Mid/Late	55	6.28	121,789	103,566	85%	-18,223
SD-Greasewd, Late	82	5.97	262,982	258,131	98%	-4,851
Big Sage, Mid-open	48	5.37	114,232	61,322	54%	-52,911
Salt Desert, Mid/Late	75	5.31	339,425	224,509	66%	-114,917
Low/Black Sage, Mid/Late	86	5.31	130,304	104,376	80%	-25,928
Mtn Sage, depleted	96	4.26	72,484	52,548	72%	-19,936
Big Sage, shrub/annual	101	3.97	85,094	45,048	53%	-40,046
Sage, shrub/annual	52	3.24	17,265	30,374	176%	13,109
Greasewood, shrub/annual	79	3.15	18,043	31,465	174%	13,422
Low Sage, depleted	84	2.75	46,770	41,010	88%	-5,759
Mtn Sage, annual grass	46	1.52	9,355	14,902	159%	5,547
Sagebrush, Early	26	0.98	9,432	22,925	243%	13,493
Big Sage, Mid-closed	51	0.87	5,145	3,806	74%	-1,340
WY Big Sage, Late	65	0.78	7,788	10,245	132%	2,457
Big Sage, depleted	35	0.61	2,338	2,252	96%	-86
Low Sage, Mid/Late	64	0.58	7,605	6,319	83%	-1,286
Low/Big Sage, Late-closed	52	0.34	2,369	2,456	104%	87
Big Sage, tree-encroach	58	0.26	12,961	11,779	91%	-1,182
Mountain Mahogany	110	0.17	1,077	1,039	96%	-38
Low Sage, tree-encroach	41	0.16	1,503	1,375	91%	-129

Habitat Type	N	Birds per 40 ha	Current Population Estimate	Projected Population Estimate	Proportional Change	Estimated Population Change
Mtn Sage, Late-open	27	0.12	638	893	140%	255
Mtn Sage, Late-closed	51	0.12	1,095	872	80%	-223
TOTAL	**1733**		**2,502,520**	**2,004,010**	**80%**	**-498,510**

Table 8. Quantitative species model for the Sage Thrasher. *Current population estimate* = current area cover multiplied by estimated birds per hectare (not shown); *N* = number of survey points used for calculation; *Projected population estimate* = projected area cover multiplied by estimated birds per hectare; *Proportional change* = percent of population remaining after 50 years (projected/current population estimate); *Estimated population change* = number of individuals estimated to be lost or gained. Habitat types listed only include those in which the species was recorded and which it is known to use during breeding, and are listed in descending order of current population estimate. Habitat types that represent a departure into uncharacteristic conditions are shaded in gray.

Habitat Type	N	Birds per 40 ha	Current Population Estimate	Projected Population Estimate	Proportional Change	Estimated Population Change
Big Sage, Mid-closed	51	6.66	39,202	28,995	74%	-10,207
Big Sage, Mid-open	48	6.06	128,911	69,201	54%	-59,710
Low Sage, Mid/Late	64	4.48	59,090	49,101	83%	-9,989
Mtn Sage, Mid-closed	178	3.8	198,745	105,030	53%	-93,715
Mtn Sage, depleted	96	3.65	62,049	44,983	72%	-17,066
WY Big Sage, Late	65	3.53	35,044	46,103	132%	11,059
Mtn Sage, Late-open	27	3.3	17,872	25,008	140%	7,136
Big Sage, depleted	35	3.21	12,390	11,934	96%	-457
Mtn Sage, shrub/annual	53	2.99	44,677	36,247	81%	-8,430
Big Sage, shrub/annual	101	2.64	56,465	29,892	53%	-26,573
Greasewood, shrub/annual	79	2.6	14,874	25,937	174%	11,064
Low Sage, depleted	84	2.17	36,901	32,357	88%	-4,544
Mtn Sage, Mid-open	52	2.11	36,608	36,439	100%	-169
Salt Desert, Mid/Late	75	2.01	128,497	84,993	66%	-43,504
Mtn Sage, annual grass	46	1.66	10,205	16,257	159%	6,052
Big Sage, tree-encroach	58	1.46	72,005	65,441	91%	-6,565
SD-Greasewood, Late	82	1.45	64,082	62,900	98%	-1,182
Big Sage upland, Mid/Late	55	1.38	26,853	22,835	85%	-4,018
Salt Desert, shrub/annual	66	1.34	45,441	58,834	129%	13,393
Low/Black Sage, Mid/Late	86	1.05	25,909	20,754	80%	-5,155
Sage, shrub/annual	52	0.88	4,669	8,214	176%	3,545
Sagebrush, Early	26	0.12	1,179	2,866	243%	1,687
Low/Big Sage, Late-closed	52	0.12	846	877	104%	31
Mtn Sage, Late-closed	51	0.08	730	581	80%	-149
TOTAL	**1639**		**1,126,007**	**887,850**	**79%**	**-238,157**

Table 9. Comparison of estimated densities of three sagebrush birds in low-sagebrush survey points when big sagebrush is absent or present within 100 m of the survey point.

Habitat	Big Sagebrush within 100 m?	N	Brewer's Sparrow (birds per 40 ha)	Sage Thrasher (birds per 40 ha)	Sage Sparrow (birds per 40 ha)
Low-Black Sage, Mid/Late	No	27	4.52	0.12	0.94
Low-Black Sage, Mid/Late	Yes	59	6.36	1.48	7.30
Low Sage Steppe, Mid/Late	No	28	22.51	6.59	0.91
Low Sage Steppe, Mid/Late	Yes	71	23.99	3.11	0.61

Effects of Annual Grass Invasion on Sagebrush Birds

One of the most dramatic projections for future shrub vegetation covers in Nevada is the widespread conversion of sagebrush and other upland habitats to covers dominated by annual grasses (primarily cheatgrass). All three sagebrush species are potentially sensitive to cheatgrass invasion because it results in less sagebrush cover for nesting and less preferred ground covers suitable for foraging. The effect is currently difficult to quantify, however, because we have few survey points in the small areas mapped as being currently in this condition. We have more bird data for the intermediate shrub/annual/perennial condition classes that retain shrubs and have not yet been converted to a pure annual grass condition. It is possible that the shrub-dependent species remain relatively common when some shrubs are still present during annual grass invasion, and may disappear entirely when only annual grasses remain.

To approximate the effects of sagebrush loss to cheatgrass on birds, we focused on montane sagebrush steppe and big sagebrush (combined from various BPS classes to improve sample size), for which sufficient survey points exist for both the shrub/annual/perennial and pure annual grasses conditions, as well as the "depleted" condition, which has neither annual nor native grasses. In Table 10, we show the estimated densities in these condition classes for the three sagebrush species, indicating that the uncharacteristic conditions produce lower estimated densities in Brewer's and Sage sparrows, but have little effect on Sage Thrasher density estimates. These effects should, however, again be viewed as conservative estimates of the consequences of annual grass invasion, as the reference condition of pure annual grasslands is poorly represented in our distribution of sampling points.

Table 10. Comparison of estimated densities of three sagebrush birds in montane sagebrush and big sagebrush covers in different vegetation condition classes.

Habitat Type	N	Brewer's Sparrow (birds per 40 ha)	Sage Thrasher (birds per 40 ha)	Sage Sparrow (birds per 40 ha)
Montane Sage, Mid-closed	178	15.29	3.80	13.00
Montane Sage, Mid-open	52	11.46	2.11	9.24
Montane Sage, depleted	96	9.12	3.65	4.26

Habitat Type	N	Brewer’s Sparrow (birds per 40 ha)	Sage Thrasher (birds per 40 ha)	Sage Sparrow (birds per 40 ha)
Montane Sage, shrub/annual/perennial	53	7.73	2.99	7.51
Montane Sage, annual grass	46	8.03	1.66	1.52
Big Sage (WY and upland), Mid-open	48	24.74	6.06	5.37
Big Sage (WY), Late	65	14.51	3.53	0.78
Big Sage (WY and upland), shrub/annual	101	10.51	2.64	3.97
Big Sage(WY and upland), annual grass	9	7.78	5.65	0

Effects of Early Shrub Cover Classes

Another potentially important effect on bird habitats is the post-disturbance conversion to rabbitbrush stands that indicates degraded sagebrush condition, which is designated as an early shrub condition class in the TNC vegetation models. This type of conversion is expected to greatly increase in the next 50 years. However, it is impossible for us to project effects on bird populations because this condition is not mapped in the GIS layers depicting current conditions. While this change in habitat condition might be expected to reduce densities of sagebrush specialist species, the magnitude of the impact will depend on whether the birds can make use of early shrubs for nesting and foraging during the breeding season. We have currently no clear evidence that they avoid early shrubs, but the issue needs further study. A preliminary examination of field data showed no apparent decrease in estimated bird density in sites with rabbitbrush present compared with undisturbed sites, but low sample sizes and the presence of sagebrush prevent us from estimating the effects of a full conversion to rabbitbrush.

Tree Encroachment into Sagebrush

The encroachment of trees into sagebrush stands is expected to increase in some (but not all) sagebrush types, especially in montane sagebrush. Sagebrush associated birds are generally expected to respond negatively to tree encroachment, although Brewer’s Sparrow makes use of sagebrush patches within lightly forested mosaics (Wilson et al. 2009). Proximity to forest edge, however, appears to increase the potential for nest predation, and Brewer’s Sparrow densities and nest success rates are consequently highest in treeless areas; Sage Thrashers are known to avoid areas with junipers, even if these are present in low densities (Noson et al. 2006).

We examined these effects in three ways in our analyses. Tables 6 - 8 show that tree-encroached cover classes and late-successional classes (which often support low tree densities) are among the cover types with the lowest densities for all three species, especially in “Low/Big Sage, Late-closed” and “Mtn Sage, Late-closed.” When comparing these late-successional classes with trees to those without trees, we found that particularly Sage Sparrow was more abundant when trees were absent (Table 11).
A similar reaction can be seen by comparing points with and without these late-successional stages with trees, among only those points with 100% sage BPS types within 100 m:

Table 11. Comparison of estimated densities of three sagebrush birds in sagebrush covers with conifers present or absent within 100 m.

	N	Brewer's Sparrow (birds per 40 ha)	Sage Thrasher (birds per 40 ha)	Sage Sparrow (birds per 40 ha)
Without conifer trees	459	14.61	3.87	7.54
With conifer trees	280	11.36	1.97	0.85

Finally, we examined sagebrush habitat points with and without the presence of pinyon-juniper or mixed conifer habitat types within the 100 m area of the sampling point (Table 12), which represents a coarser scale of conifer presence than in Table 11, but still showed a large effect on Sage Sparrow.

Table 12. Comparison of estimated densities of three sagebrush birds in sagebrush covers with conifer cover types (pinyon-juniper or mixed conifer) present or absent within 100 m.

	N	Brewer's Sparrow (birds per 40 ha)	Sage Thrasher (birds per 40 ha)	Sage Sparrow (birds per 40 ha)
Without nearby conifer	528	13.50	3.74	8.63
With nearby conifer	215	15.71	2.19	1.13

Other Shrubland Associated Species

Another upland-shrub associated species that is abundant in Nevada is the Loggerhead Shrike, which is also a priority species of the WAP. It was not included in the sagebrush section because, while it occurs in sagebrush, it is more of an upland shrub generalist species based on our statewide data.

Loggerhead Shrike

Loggerhead Shrike populations in Nevada are projected to be most negatively impacted by losses of salt desert/mid-late and mountain sagebrush/mid-closed, but are expected to see gains in the habitat types salt desert/shrub/annual, creosote/late, washes/late, and greasewood/shrub/annual, with an overall stable population size (Table 12). From our experience, Loggerhead Shrike habitat selection is extraordinarily difficult to model beyond its clear preference for open upland shrub habitats, partly because it is probably tolerant of a variety of disturbance conditions. It does require shrubs for off-ground nest placement, but its foraging habits likely allow it to exploit a variety of vegetation conditions.

Table 12. Quantitative species model for the Loggerhead Shrike by habitat type. *Current population estimate* = current area cover multiplied by estimated birds per hectare (not shown); *N* = number of survey points used for calculation; *Projected population estimate* = projected area cover multiplied by estimated birds per hectare; *Proportional change* = percent of population remaining after 50 years (projected/current population estimate); *Estimated population change* = number of individuals estimated to be lost or gained. Habitat types listed only include those in which the species was recorded and which it is known to use during breeding, and are listed in descending order of current population estimate. The

habitat type "Sage, annual grass" was deleted because the density was considered an outlier (2.83 per 40 ha based on only 9 points).

Habitat Type	N	Birds per 40 ha	Current Population Estimate	Projected Population Estimate	Proportional Change	Estimated Population Change
Creosote, Early	74	0.35	2,728	463	17%	-2,265
Creosote, Late	85	1.5	22,222	26,241	118%	4,019
Blackbrush, Early	54	1.33	25,033	20,549	82%	-4,484
Blackbrush-thermic, Late	180	1.1	2,750	3,552	129%	802
Blackbrush-mesic, Late	96	0.87	21,219	17,497	82%	-3,722
Blackbrush, shrub/annual	8	0.27	409	1,859	455%	1,450
Salt Desert, Mid/Late	75	0.91	58,363	38,603	66%	-19,759
SD-Greasewd, Late	82	0.86	38,031	37,329	98%	-701
Salt Desert, shrub/annual	66	0.56	18,927	24,506	129%	5,578
Greasewood, shrub/annual	79	0.47	2,711	4,728	174%	2,017
Low/Black Sage, Mid/Late	86	1.07	26,364	21,118	80%	-5,246
Low Sage, Mid/Late	64	0.17	2,185	1,816	83%	-369
WY Big Sage, Late	65	0.29	2,920	3,842	132%	922
Big Sage upland, Mid/Late	55	0.35	6,738	5,730	85%	-1,008
Big Sage, Mid-open	48	0.57	12,044	6,466	54%	-5,579
Mtn Sage, Mid-open	52	0.29	4,952	4,929	100%	-23
Mtn Sage, Mid-closed	178	0.54	28,389	15,003	53%	-13,387
Mtn Sage, Late-open	27	0.47	2,553	3,573	140%	1,019
Big Sage, shrub/annual	101	0.09	1,865	987	53%	-878
Low Sage, depleted	84	0.45	7,723	6,772	88%	-951
Sage, shrub/annual	52	0.2	1,086	1,910	176%	824
Mtn Sage, depleted	96	1.44	24,443	17,720	72%	-6,723
Mtn Sage, shrub/annual	53	1.2	17,951	14,564	81%	-3,387
Mtn Sage, annual grass	46	0.14	850	1,355	159%	504
Low Sage, tree-encroach	41	0.08	752	687	91%	-64
Mountain Shrub/Chapparal	45	0.28	797	697	87%	-100
Pinyon/Juniper, Early	57	0.15	2,762	2,072	75%	-690
Washes	83	1.24	3,820	641	17%	-3,178
Washes, Late	33	0.77	313	2,657	849%	2,344
Warm Desert Ripar, CHAR	76	0.6	993	6	1%	-987
Montane Riparian, Early	112	0.76	1,379	433	31%	-946
Montane Riparian, Exotic	136	0.69	1,985	2,629	132%	644
TOTAL	**3777**		**368,723**	**366,807**	**99%**	**-1916**

Coniferous Woodland Species

The coniferous woodland species that are priorities in the WAP include species primarily associated with pinyon-juniper, Black-chinned Sparrow, Virginia's Warbler, and Pinyon Jay, and species primarily associated with tall conifers, Cassin's Finch, Olive-sided Flycatcher, and White-headed Woodpecker. We have point count data for all of these, but Olive-sided Flycatcher is relatively rare as a breeder in Nevada, and White-headed Woodpecker only occurs in the Sierra Nevada portion of Nevada, which was not included in the TNC (2011) model.

Black-chinned Sparrow

Based on the TNC (2011) model, Black-chinned Sparrows in Nevada may be affected by the decline in late-successional, higher-elevation (mesic) blackbrush, which is partially offset by minor gains in other cover types, resulting in a projected population decrease of 19% in 50 years (Table 13). Insofar as the loss of blackbrush represents a conversion to shrubless "annual grass" condition classes, this could be a concern for this species, especially if the problem is considered largely irreversible.

Table 13. Quantitative species model for the Black-chinned Sparrow by habitat type. *Current population estimate* = current area cover multiplied by estimated birds per hectare (not shown); *N* = number of survey points used for calculation; *Projected population estimate* = projected area cover multiplied by estimated birds per hectare; *Proportional change* = percent of population remaining after 50 years (projected/current population estimate); *Estimated population change* = number of individuals estimated to be lost or gained. Habitat types listed only include those in which the species was recorded and which it is known to use during breeding, and are listed in descending order of current population estimate.

Habitat Type	N	Birds per 40 ha	Current Population Estimate	Projected Population Estimate	Proportional Change	Estimated Population Change
Pinyon/Juniper, Early	28	1.63	3,552	2,719	77%	-833
Montane Riparian, Late	23	1.16	99	67	67%	-32
Mountain Shrub	31	1.1	2,255	1,964	87%	-291
Blackbrush-mesic, Late	93	0.99	6,632	5,152	78%	-1,480
Montane Riparian, Desertif	35	0.92	354	446	126%	92
Blackbrush-thermic, Late	180	0.46	1,140	1,208	106%	68
Blackbrush, Early	138	0.23	2,786	2,231	80%	-555
Washes	84	0.1	257	9	3%	-248
Wash, Late	33	0.03	10	78	771%	68
TOTAL	**645**		**17,086**	**13,873**	**81%**	**-3,213**

Virginia's Warbler

Overall, this species is projected to decrease by 9% over the next 50 years (Table 14) based on the climate change model (TNC 2011). Estimated densities are relatively low in this species in all habitat types it is known to use during nesting, and the main losses projected under the climate model occur in aspen mixed-conifer/late and blackbrush-mesic/late, while birds are expected to be gained in aspen mixed-conifer (Table 14). Perhaps because this species is uncommon, the pattern of projected population responses is difficult to interpret, but our density estimates indicate that mountain mahogany, aspen mixed-conifer, and mountain shrub/chaparral appear to be important landcovers for this species. The possible association of this species with aspen was not previously documented in Nevada and deserves further study, as this may imply that the species is vulnerable to aspen loss. It is very surprising that pinyon-juniper, which is its primary habitat type in Nevada, shows low density estimates for this species, a result that we are unable to explain.

Table 14. Quantitative species model for the Virginia's Warbler by habitat type. *Current population estimate* = current area cover multiplied by estimated birds per hectare (not shown); *N* = number of survey points used for calculation; *Projected population estimate* = projected area cover multiplied by estimated birds per hectare; *Proportional change* = percent of population remaining after 50 years (projected/current population estimate); *Estimated population change* = number of individuals estimated to be lost or gained. Habitat types listed only include those in which the species was recorded and which it is known to use during breeding, and are listed in descending order of current population estimate.

Habitat Type	N	Birds per 40 ha	Current Population Estimate	Projected Population Estimate	Proportional Change	Estimated Population Change
Blackbrush-mesic, Late	96	0.07	1,714	1,413	82%	-301
Mtn Sage, Late-closed	51	0.08	730	581	80%	-149
Low Sage, tree-encroach	41	0.1	1,002	916	91%	-86
Mountain Shrub/Chaparral	45	0.46	1,303	1,139	87%	-163
Mountain Mahogany	110	0.55	3,435	3,315	96%	-120
Pinyon/Juniper, Early	57	0	0	0		0
Pinyon/Juniper, Late	67	0.01	234	256	110%	23
Mixed Conifer/ Dry Pine	53	0.36	698	730	105%	32
Aspen Mixed-Conifer	20	0.8	178	488	275%	310
Aspen Mixed-Conifer, Late	67	0.86	1,375	868	63%	-507
TOTAL	**607**		**10,668**	**9,707**	**91%**	**-961**

Pinyon Jay

Pinyon Jay populations are projected, based on this climate model, to experience losses from habitat change in mountain sagebrush/mid-closed, big sagebrush/shrub/annual, and pinyon-juniper, and they are expected to gain birds in Wyoming big sagebrush/late, pinyon-juniper/late, and mountain sagebrush/late-open (Table 15), for an overall projected population decline of 19%. Recent research suggests that this species has a complex response to pinyon-juniper succession, indicating that it very much requires open early-mid successional woodlands (GBBO 2010), which is also reflected here by their relatively high estimated densities in sagebrush and blackbrush cover types.

Table 15. Quantitative species model for the Pinyon Jay by habitat type. *Current population estimate* = current area cover multiplied by estimated birds per hectare (not shown); *N* = number of survey points used for calculation; *Projected population estimate* = projected area cover multiplied by estimated birds per hectare; *Proportional change* = percent of population remaining after 50 years (projected/current population estimate); *Estimated population change* = number of individuals estimated to be lost or gained. Habitat types listed only include those in which the species was recorded and which it is known to use during breeding, and are listed in descending order of current population estimate. The habitat type "Sage, early" was deleted because its estimated density was considered an outlier (5.39 per 40 ha, based on only 26 points).

Habitat Type	N	Birds per 40 ha	Current Population Estimate	Projected Population Estimate	Proportional Change	Estimated Population Change
Blackbrush, Early	54	0.28	5,272	4,327	82%	-944
Blackbrush-thermic, Late	180	1.56	3,895	5,030	129%	1,135
Blackbrush-mesic, Late	96	2.38	58,176	47,970	82%	-10,205
Blackbrush, shrub/annual	8	1.06	1,634	7,436	455%	5,802
Salt Desert, Mid/Late	75	0.14	9,038	5,978	66%	-3,060
Salt Desert, shrub/annual	66	0.21	7,280	9,425	129%	2,146
Greasewood, shrub/annual	79	0.02	88	153	174%	65
Low/Black Sage, Mid/Late	86	0.07	1,818	1,456	80%	-362
WY Big Sage, Late	65	2.64	26,283	34,577	132%	8,294
Big Sage upland, Mid/Late	55	0.23	4,492	3,820	85%	-672
Mtn Sage, Mid-open	52	1.96	33,955	33,799	100%	-157
Mtn Sage, Mid-closed	178	3.17	165,968	87,708	53%	-78,260
Mtn Sage, Late-open	27	1.3	7,021	9,824	140%	2,803
Mtn Sage, Late-closed	51	2.02	17,702	14,097	80%	-3,605
Low/Big Sage, Late-closed	52	3.53	24,363	25,258	104%	895
Big Sage, shrub/annual	101	2.51	53,721	28,439	53%	-25,282
Low Sage, depleted	84	0.4	6,804	5,966	88%	-838
Sage, shrub/annual	52	0.24	1,303	2,292	176%	989
Mtn Sage, depleted	96	2.49	42,306	30,670	72%	-11,636
Big Sage, tree-encroach	58	0.88	43,203	39,264	91%	-3,939
Low Sage, tree-encroach	41	3.83	37,084	33,908	91%	-3,176
Mountain Shrub/Chaparral	45	0.28	788	689	87%	-99
Pinyon/Juniper, Early	57	3.31	61,312	45,995	75%	-15,316
Pinyon/Juniper, Late	67	2.1	61,890	67,874	110%	5,984
TOTAL	**1725**		**675,395**	**545,957**	**81%**	**-129,438**

Cassin's Finch

Based on the climate model, overall populations of Cassin's Finch are projected to remain stable over the next 50 years (Table 16). Decreases based on habitat cover change are expected in some habitat types, such as pinyon-juniper/early, but these are projected to be offset by increases from other habitat types, such as pinyon-juniper/late. The highest estimated densities currently occur in mixed conifer/dry pine, subalpine pine, and mountain mahogany (Table 15).

Table 16. Quantitative species model for the Cassin's Finch by habitat type. *Current population estimate* = current area cover multiplied by estimated birds per hectare (not shown); *N* = number of survey points used for calculation; *Projected population estimate* = projected area cover multiplied by estimated birds per hectare; *Proportional change* = percent of population remaining after 50 years (projected/current population estimate); *Estimated population change* = number of individuals estimated to be lost or gained. Habitat types listed only include those in which the species was recorded and which it is known to use during breeding, and are listed in descending order of current population estimate.

Habitat Type	N	Birds per 40 ha	Current Population Estimate	Projected Population Estimate	Proportional Change	Estimated Population Change
Blackbrush-thermic, Late	180	0.12	306	395	129%	89
Mtn Sage, Late-closed	51	0.83	7,300	5,813	80%	-1,487
Low/Big Sage, Late-closed	52	0.67	4,624	4,794	104%	170
Low Sage, tree-encroach	41	0.12	1,128	1,031	91%	-97
Mountain Mahogany	110	4.14	25,715	24,814	96%	-901
Pinyon/Juniper, Early	57	1.4	26,023	19,522	75%	-6,501
Pinyon/Juniper, Late	67	3.32	97,876	107,341	110%	9,464
Mixed Conifer/ Dry Pine	53	7.15	13,674	14,309	105%	635
Spruce/ Fir	53	3.84	2,597	2,782	107%	186
Subalpine Pine	52	5.14	6,929	7,175	104%	246
Aspen Woodland	151	1.13	2,709	4,026	149%	1,318
Aspen Wood, Late	42	1.19	3,616	1,894	52%	-1,722
Aspen Mixed-Conifer	20	2.33	521	1,430	275%	909
Aspen Mixed-Conifer, Late	67	2.7	4,349	2,746	63%	-1,603
TOTAL	**996**		**197,367**	**198,073**	**100%**	**706**

Olive-sided Flycatcher

Projecting population responses of Olive-sided Flycatcher was hampered by the fact that over half on the known breeding grounds of this species in Nevada are in the Sierra Nevada portion of the state, which was not included in the TNC (2011) climate model. Lowland sightings of this species were excluded, as these almost certainly represented migrant individuals. With the remaining sample size, the population is projected to be stable over the next 50 years based on the climate model (Table 17). Projected losses from cover change in mountain sagebrush/late-closed are offset by projected increases of mixed conifer/dry pine. However, much of the change in statewide Olive-sided Flycatcher populations will depend on the breeding habitats of the Sierra Nevada's Carson Range.

Table 17. Quantitative species model for the Olive-sided Flycatcher by habitat type. *Current population estimate* = current area cover multiplied by estimated birds per hectare (not shown); *N* = number of survey points used for calculation; *Projected population estimate* = projected area cover multiplied by estimated birds per hectare; *Proportional change* = percent of population remaining after 50 years (projected/current population estimate); *Estimated population change* = number of individuals estimated to be lost or gained. Habitat types listed only include those in which the species was recorded and which it is known to use during breeding, and are listed in descending order of current population estimate.

Habitat Type	N	Birds per 40 ha	Current Population Estimate	Projected Population Estimate	Proportional Change	Estimated Population Change
Mtn Sage, Late-closed	51	0.12	1,095	872	80%	-223
Pinyon/Juniper, Late	67	0.02	701	769	110%	68
Mixed Conifer/ Dry Pine	53	1.17	2,243	2,347	105%	104

Habitat Type	N	Birds per 40 ha	Current Population Estimate	Projected Population Estimate	Proportional Change	Estimated Population Change
Aspen Woodland	151	0.04	101	151	149%	49
TOTAL	**322**		**4,140**	**4,139**	**100%**	**-1**

White-headed Woodpecker

In Nevada, White-headed Woodpeckers are limited to the Sierra Nevada region, where it was recorded on seven NBC transects. Because this region was excluded from the TNC (2011) future projection model, we could not make quantitative projection under this model. The locations where the species was recorded were dominated by Jeffrey pine, red fir, or both, based on the current vegetation map, which covered the Sierra Nevada portion of Nevada. The predominant condition class (SCLASS) for these transects was Class 2, corresponding to the "mid-closed" successional stage. For Jeffrey Pine, this class is projected to increase by 14% elsewhere in the state due to young forests cycling through succession. However, Jeffrey pines are usually associated with later-successional pine forests that have open to moderate canopy closure. Because woodpeckers have large home ranges encompassing a variety of mixed-conifer forests, it would be difficult to estimate densities in the different condition classes even if more data were available. Visual inspection shows the detection on two of the three red-fir dominated transects to be associated with recent fires or other forest openings.

White-headed Woodpeckers will probably decline at lower elevations where Jeffrey pine stands may convert to chaparral or pinyon-juniper. Three of the transects with detections are on the eastern (lower-elevation) edge of the Jeffrey pine forest in the Carson Valley, where such changes are likely to occur. Management scenarios involving prescribed burning in mid-successional closed canopy classes would probably not be detrimental, unless large trees or snags are removed (for more detail, see GBBO 2010).

Mojave Upland Species

Two WAP priority species, the Scott's Oriole and Le Conte's Thrasher, are primarily associated with Mojave upland shrubs, particularly Joshua tree and other *Yucca* species (Scott's Oriole and some Le Conte's Thrasher populations), and Mojave Salt Desert scrub (Le Conte's Thrasher). The Scott's Oriole also occurs in lower numbers in the Great Basin, particularly in pinyon-juniper woodlands, while the Le Conte's Thrasher is restricted to the shrublands of the Mojave region.

Scott's Oriole

Based on the climate model projections, Scott's Orioles are projected to decrease primarily in areas where blackbrush/early, washes, and blackbrush-mesic/late decline, and increase with increases in blackbrush/shrub/annual and blackbrush-thermic/late, with an overall projected reduction in the statewide population of 11% (Table 17). It is important to note that the *Yucca*-dominated vegetation covers cannot directly be mapped and modeled for this project, as these vegetation covers are not distinguishable with current remote sensing methods. The highest estimated densities of this species occurs in blackbrush-thermic/late and pinyon-juniper/early, two vegetation covers that are likely interspersed with, or include, *Yucca*-dominated areas. While the TNC models did not explicitly address Joshua trees, climate concerns for this species are reflected by the decline in healthy blackbrush habitats and in our additional knowledge of the susceptibility of Joshua trees to increased fire and drought (DeFalco et al. 2010, Vamstad and Rotenberry 2010).

Table 17. Quantitative species model for the Scott's Oriole by habitat type. *Current population estimate* = current area cover multiplied by estimated birds per hectare (not shown); *N* = number of survey points used for calculation; *Projected population estimate* = projected area cover multiplied by estimated birds per hectare; *Proportional change* = percent of population remaining after 50 years (projected/current population estimate); *Estimated population change* = number of individuals estimated to be lost or gained. Habitat types listed only include those in which the species was recorded and which it is known to use during breeding, and are listed in descending order of current population estimate.

Habitat Type	N	Birds per 40 ha	Current Population Estimate	Projected Population Estimate	Proportional Change	Estimated Population Change
Creosote, Early	74	0	0	0		0
Creosote, Late	85	0	0	0		0
Blackbrush, Early	138	1.59	19,037	15,243	80%	-3,795
Blackbrush-thermic, Late	180	5.97	14,870	15,757	106%	888
Blackbrush-mesic, Late	93	1.35	9,051	7,030	78%	-2,020
Blackbrush, shrub/annual	8	0.53	699	2,109	302%	1,411
Mountain Shrub/Chaparral	31	0.58	1,194	1,040	87%	-154
Pinyon/Juniper, Early	28	2.18	4,753	3,638	77%	-1,115
Pinyon/Juniper, Late	16	1.96	5,025	5,653	113%	629
Washes	84	1.03	2,621	91	3%	-2,531
Washes, Late	33	0.25	91	703	771%	612
Warm Desert Riparian, CHAR	76	0	0	0		0
Warm Desert Riparian, exotic	93	0	0	0		0
TOTAL	**939**		**57,340**	**51,264**	**89%**	**-6,076**

Le Conte's Thrasher

Le Conte's Thrashers are projected to lose populations to loss of the habitat types washes and creosote/early, which are partially offset by projected gains in the habitat types creosote/late and washes/late, resulting in an overall projected population reduction of 10% over 50 years (Table 18). Our estimated densities for Le Conte's Thrasher are probably inflated by random chance (due to an unusually high number of records on our transects), but these high numbers could also suggest that the species may be more prevalent than previously assumed (but still likely nowhere near the working population estimate used for our projections).

This species is thought to avoid large expanses of monotypic creosote (Sheppard 1996) and is often absent from seemingly suitable habitat, so the extrapolation of densities across all creosote covers is likely an overestimate. Loss of nesting substrate, such as cholla cactus or Yucca, would lead to additional losses, and the species' specialized foraging habits make it vulnerable to the loss native understories and litter-associated invertebrates.

Table 18. Quantitative species model for the Le Conte's Thrasher by habitat type. *Current population estimate* = current area cover multiplied by estimated birds per hectare (not shown); *N* = number of survey points used for calculation; *Projected population estimate* = projected area cover multiplied by estimated birds per hectare; *Proportional change* = percent of population remaining after 50 years (projected/current population estimate); *Estimated population change* = number of individuals estimated to be lost or gained. Habitat types listed only include those in which the species was recorded and which it is known to use during breeding, and are listed in descending order of current population estimate.

Habitat Type	N	Birds per 40 ha	Current Population Estimate	Projected Population Estimate	Proportional Change	Estimated Population Change
Washes	84	0.73	1,845	64	3%	-1,782
Creosote, Late	165	0.68	10,052	11,856	118%	1,804
Blackbrush, Early	138	0.4	4,746	3,800	80%	-946
Wash, Late	33	0.36	132	1,016	771%	884
Blackbrush-thermic, Late	180	0.24	608	644	106%	36
Creosote, Early	121	0.24	1,865	287	15%	-1,577
Blackbrush-mesic, Late	93	0.08	524	407	78%	-117
TOTALS	**890**		**20,097**	**18,076**	**90%**	**-2,021**

Riparian Species

Three WAP priority species, for which we have data, are riparian, including the Lewis's Woodpecker that occurs primarily in montane riparian and aspen of the Great Basin, the Bank Swallow, which occurs primarily in river channels and nearby earthen cliffs in the Great Basin, and the Bell's Vireo, which occurs in lowland riparian woodlands in the Mojave and Clover regions of the TNC (2011) mapping effort.

Lewis's Woodpecker

In Nevada, the Lewis's Woodpecker is most strongly associated with montane riparian woodlands that are dominated by aspen or cottonwood and occur in very narrow gallery woodlands. Therefore, our model is, unlike for the other species, based on points with a minimum cover threshold of only 5% for riparian in order to allow us to examine all condition classes with sufficient sample sizes. Lewis's Woodpeckers were found in aspen woodland and montane riparian, but not in the aspen-mixed conifer BPS. Within aspen woodland, they were less common in the mid to late successional closed-canopy classes (which were the only ones projected to increase). Under the climate model, Lewis's Woodpecker populations are projected to decrease based primarily on losses in aspen/late-open, and aspen woodland/early, but they will gain birds from increases in aspen/mid-closed, with an overall projected loss of 12% of the statewide population (Table 19).

Table 19. Quantitative species model for the Lewis's Woodpecker by habitat type. *Current population estimate* = current area cover multiplied by estimated birds per hectare (not shown); *N* = number of survey points used for calculation; *Projected population estimate* = projected area cover multiplied by estimated birds per hectare; *Proportional change* = percent of population remaining after 50 years (projected/current population estimate); *Estimated population change* = number of individuals estimated to be lost or gained. Habitat types listed only include those in which the species was recorded and which it is known to use during breeding, and are listed in descending order of current population estimate.

Habitat Type	N	Birds per 40 ha	Current Population Estimate	Projected Population Estimate	Proportional Change	Estimated Population Change
Aspen Woodland, early	173	0.68	801	405	51%	-396
Aspen, mid-closed	164	0.58	210	1,147	547%	937
Aspen, late-closed	69	0.18	62	89	142%	26
Aspen, late-open	195	0.68	2,080	1,090	52%	-991
Aspen, depleted	168	0.5	267	265	99%	-2
Aspen, fenced	Not mapped					
Aspen-Mixed Conifer	217	0	0	0		0
Montane Riparian, early	222	0.01	10	3	31%	-7
Montane Rip., mid-open	433	0.53	704	534	76%	-170
Montane Rip., late-close	459	0.3	571	501	88%	-70
Montane Rip., exotic forb	405	0	0	0		0
Montane Rip., desertified	608	0.27	753	768	102%	15
Subalpine Riparian	112	0.04	5	4	82%	-1
TOTAL			**5,464**	**4,805**	**88%**	**-659**

In Table 20, we examined the effects of other habitats present in the survey area. We found that Lewis's Woodpeckers are twice as abundant when aspen woodland is mixed with montane riparian than in isolated aspen stands, and they are much less common in montane riparian if aspen is absent. This is likely a result of aspen being the dominant canopy tree in most montane riparian areas in Nevada, and if it is absent little opportunity for cavity nesting exists. The presence of nearby riparian shrubs, which are likely a primary foraging substrate, may explain how the species is able to maintain population levels even in "depleted" aspen woodland. Further research is warranted to clarify these habitat requirements.

Table 20. Comparison of estimated densities of Lewis's Woodpecker in different aspen and montane riparian settings based on cover types present within 100 m.

Habitat Type	N	Birds per 40 ha
Aspen Woodland only	202	0.84
Aspen-Mixed Conifer only	72	0.00
Aspen Woodland and Riparian	520	1.68
Montane Riparian only	1411	0.08

Bank Swallow

Although we detected Bank Swallows at 80 survey points, little could be discerned about specific habitat relationships other than an obvious association with the montane riparian cover type (as defined by TNC 2011). The species is not known to breed in Mojave riparian areas of southern Nevada.

The Bank Swallow is not tied to any particular habitat except for nesting, which requires slow, meandering waterways with eroding banks or nearby earthen terraces. Healthy riparian vegetation is probably important for insect productivity, but foraging habitats can also be wetlands, open water, grasslands, agricultural areas, shrublands, and occasionally upland woodlands. A study in California suggested that restoration of grasslands may be more important to this species than restoration of cottonwood forests (Moffat et al. 2005).

In California, much of Bank Swallow's nesting habitat has been eliminated by flood- and erosion control. These projects can destroy or alter nesting habitat by sloping banks and placing large rocks (rip-rap) to stabilize the channel. Restoring flows and subsequent erosion processes are considered beneficial to Bank Swallows because they provides habitat in the form of freshly eroded banks. But as is the case in all early-successional habitats, such disturbances may both destroy and create potential nest sites (Moffat et al. 2005).

Bell's Vireo

Bell's Vireo data were analyzed using all survey points with riparian or wash habitat within 100 m in TNC's Mojave region (because all riparian in the Clover-Delamar region, where the species also occurs, was classified as montane riparian and was thus mapped separately). Bell's Vireo occurs primarily in what is classified as Warm Desert Riparian in TNC (2011), but Warm Desert Riparian vegetation covers classified as "uncharacteristic" were largely not available on the current conditions map. This made it difficult to project population changes, as Warm Desert Riparian is projected to largely convert to "uncharacteristic" classes in the Mojave region, which would undoubtedly have significant effects on Bell's Vireo populations. For the habitat types, for which spatial data were available, we project an overall slight population increase as a result of one cover type, washes/late-closed, projected to offset near-complete losses in most other cover types that were available for this analysis (Table 21). Given that washes are really secondary breeding habitat for this species in Nevada (with riparian areas being the primary habitat, GBBO 2010), we expect that these projected effects will be washed out by any landscape-wide changes that will occur in riparian woodlands.

Qualitatively, we can predict that desertification would be detrimental to the Bell's Vireo, even if it is unclear how degraded current conditions already are. Although desertifying areas may retain riparian vegetation in the short-term, the preference of this species for riparian shrub thickets would eventually drive the species out of previously-occupied sites. Besides desertification, the invasion of exotic forbs and trees, especially saltcedar, is already underway. From this and our previous analyses (GBBO 2010), we found that Bell's Vireos appear generally neutral to the amount of saltcedar present, but they tend to disappear from sites where saltcedar cover exceeds 90%, suggesting that extensive, monotypic saltcedar stands will reduce the population of this species.

Table 21. Quantitative species model for the Bell's Vireo by habitat type. *Current population estimate* = current area cover multiplied by estimated birds per hectare (not shown); *N* = number of survey points used for calculation; *Projected population estimate* = projected area cover multiplied by estimated birds per hectare; *Proportional change* = percent of population remaining after 50 years (projected/current population estimate); *Estimated population change* = number of individuals estimated to be lost or gained. Habitat types listed only include those in which the species was recorded and which it is known to use during breeding, and are listed in descending order of current population estimate.

Habitat Type	N	Birds per 40 ha	Current Population Estimate	Projected Population Estimate	Propor-tional Change	Estimated Population Change
Warm Desert Riparian, early	141	1.52	1,352	1	0.07%	-1,351
Warm Desert Riparian, mid-closed	93	1.38	527	1	0.19%	-526
Warm Desert Riparian, mid-open	102	1.93	99	0	0.00%	-99
Warm Desert Riparian, late-closed	99	1.45	57	0	0.00%	-57
Warm Desert Riparian, desertified		Not mapped				
Warm Desert Riparian, desertified-exotic forb		Not mapped				
Warm Desert Riparian, desertified-exotic tree		Not mapped				
Warm Desert Riparian, exotic forb	138	3.32	24	203	846%	179
Warm Desert Riparian, exotic tree		Not mapped				
Washes, early	209	0.94	1,474	7	0.47%	-1,467
Washes, mid-closed	208	1.36	1,286	94	7.31%	-1,192
Washes, late-closed	187	2.14	780	6,002	769%	5,222
Washes, exotic tree-forb	72	3.64	1	26	2600%	25
TOTAL	**1249**		**5,600**	**6,335**	**113%**	**735**

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