2024 Biennial Adaptive Management Report - FINAL

Prepared for:
Desert Conservation Program, Clark County, Nevada

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Acronyms and Abbreviations

AMMP	Adaptive Management and Monitoring Plan
AMP	Adaptive Management Program
AMR	Adaptive Management Report
Alta	Alta Science & Engineering, Inc.
BCCE	Boulder City Conservation Easement
BGO	Biological Goal and Objective
DCP	Desert Conservation Program
ECO	Enduring Conservation Outcomes
ESA	Endangered Species Act
IPB	Implementation Plan and Budget
MOA	Memorandum of Agreement
MSHCP	Multiple Species Habitat Conservation Plan
Permit	Incidental Take Permit #TE34927-0
Permittees	Clark County; cities of Boulder City, Henderson, Las Vegas, Mesquite, and North Las Vegas; and Nevada Department of Transportation
PIE	Public information, education, and outreach
SMART	Specific, Measurable, Achievable, Result-oriented, and Time-fixed
USFWS	U.S. Fish and Wildlife Service
USNVC	U.S. National Vegetation Classification

Section 1 Introduction and Background

This Biennial Adaptive Management Report (AMR) describes the analysis and subsequent recommendations from the Science Advisor Panel's independent review of the implementation of the Clark County Multiple Species Habitat Conservation Plan (MSHCP) and associated Biological Opinion (USFWS 2000).

Clark County coordinates compliance with the Incidental Take Permit #TE34927-0 (Permit) issued by the U.S. Fish and Wildlife Service (USFWS) in 2001, in accordance with Section 10(a)(1)(B) of the Endangered Species Act (ESA). Permittees include Clark County; the cities of Boulder City, Henderson, Las Vegas, Mesquite, and North Las Vegas; and the Nevada Department of Transportation (Permittees). Clark County serves as the Plan Administrator for the MSHCP on behalf of the other Permittees, with the Desert Conservation Program (DCP) representing Clark County in this role. Compliance with the Permit requires implementation of the MSHCP and Implementing Agreement (Clark County 2000, USFWS et al. 2000). The current Permit expires in February 2031.

The MSHCP and Permit consists of 78 species categorized as "covered" species, which includes 15 reptiles and amphibians, 8 birds, 4 mammals, 10 invertebrates, and 41 plants (USFWS 2001). Covered species include both listed and non-listed species under the ESA and are those species for which sufficient information was known so management prescriptions could be implemented and supported by the Permit. At the time the MSHCP was finalized in 2000, the desert tortoise (*Gopherus agassizii*) and the southwestern willow flycatcher (*Empidonax traillii extimus*) were the only species listed under the ESA as threatened and endangered, respectively. Since 2000, after the MSHCP was finalized, the Mount Charleston blue butterfly (*Icaricia shasta charlestonensis*) and the western population of the yellow-billed cuckoo (*Coccyzus americanus*) have been listed as endangered and threatened, respectively. The DCP is preparing for an amendment to the MSHCP which will propose a modified species list to better reflect current conservation status of species within Clark County that are likely to be impacted by private land development. Proposed species not currently covered include two species of bats, seven species of birds, one mammal species, one reptile, two invertebrates, and four plant species.

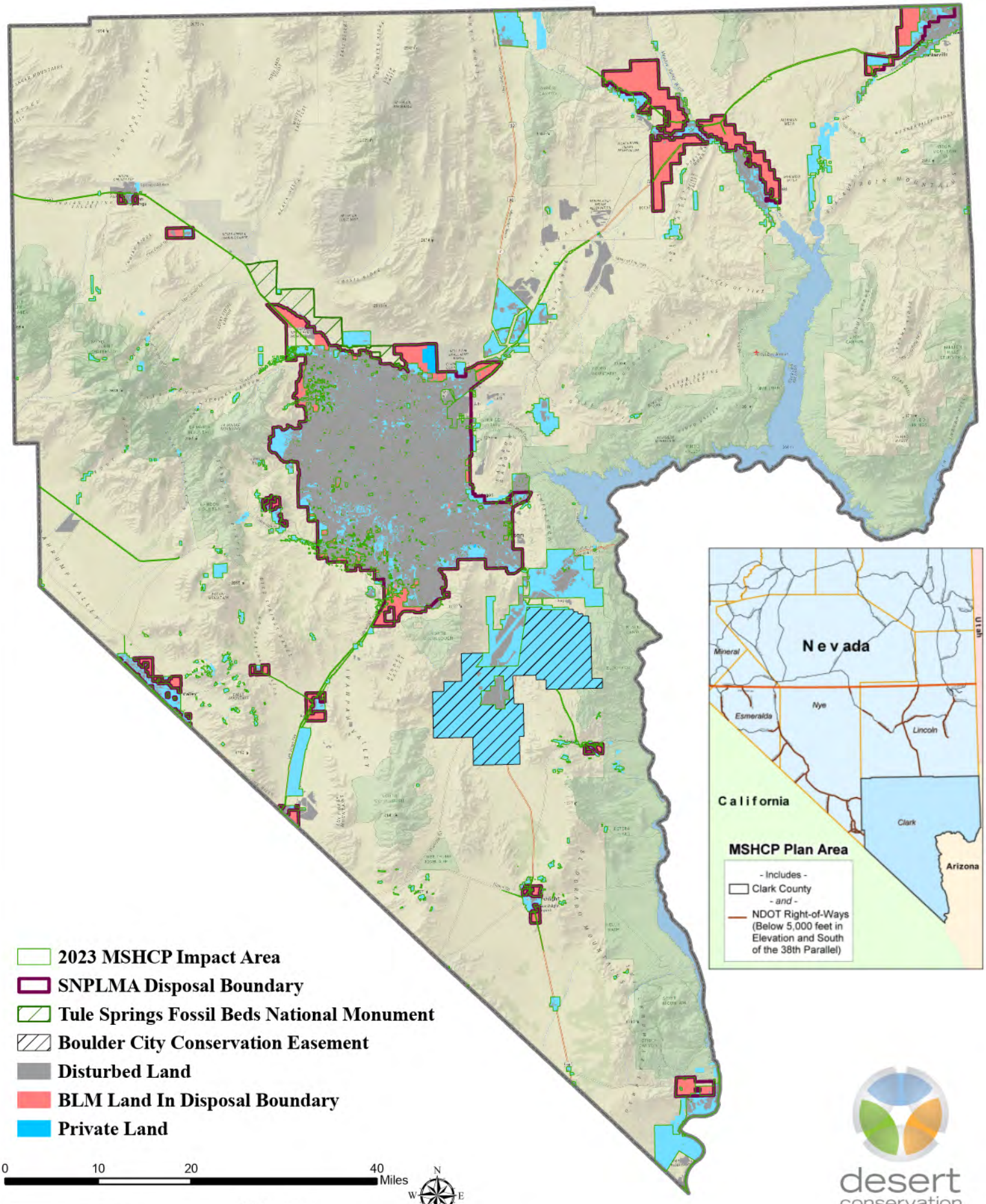
The MSHCP plan area includes Clark County, as well as lands in Nye, Lincoln, Mineral, and Esmeralda counties that lie below the 38th parallel, are less than 5,000 feet in elevation, and are in association with Nevada Department of Transportation activities (Figure 1). The Permit originally allowed for the incidental take of MSHCP-covered species from 145,000 acres within the plan area, which has since increased by 22,650 acres (due to the credit provided by the creation of the Tule Springs Fossil Beds National Monument) for a total of 167,650 acres. The MSHCP covers all of Clark County; however, impacts are confined to the following area (referred to as the 'available development area' [synonymous with 'impact area'], Figure 1)

- Non-federal lands in Clark County; and
- Any federal lands within Clark County that may be designated by a federal agency for disposal and eventual transfer to non-federal ownership (i.e., Federal Disposal Boundaries).

Additional introductory information, such as the history (including the background of the Adaptive Management Program [AMP]), function, and the proposed future amendment of the MSHCP and Permit is detailed in the 2016 Biennial AMR (Enduring Conservation Outcomes [ECO] 2016).

MSHCP Permit Area

Figure 1



desert conservation PROGRAM

National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

1.1 Purpose

The MSHCP and Permit required the development of a science-based adaptive management process, the AMP. Consequently, a Memorandum of Agreement (MOA) was prepared to describe the AMP, including specific goals and guiding principles (Clark County 2000, USFWS 2001 and 2002). The AMP is designed to provide an objective, quantitative evaluation of the effectiveness of management actions in attaining program goals through the interpretation of inventory, monitoring, and research (USFWS 2000). The AMP thus provides data, analysis, and a framework on which to base and evaluate management decisions (USFWS 2000). The AMP is required to have an objective, science-based adaptive management contractor (i.e., Science Advisor Panel) to provide an independent assessment of MSHCP implementation. The independent review is accomplished by obtaining information on recent projects, reports, and datasets, and by performing the following four assessments (USFWS 2000):

1. Analyze all land-use trends in Clark County to ensure that take and habitat disturbance are balanced with conservation (Section 2).
2. Track habitat loss by ecosystem (Section 3).
3. Evaluate the effectiveness of management actions at meeting MSHCP goals of conservation and recovery (Section 4).
4. Monitor population trends and ecosystem health (Section 5).

The purpose of the Biennial AMR is to document the Science Advisor Panel's analyses, findings, and subsequent recommendations of the above four items to improve the DCP's AMP and the MSHCP implementation.

1.2 Previous Biennial AMR

Prior to this Biennial AMR, the most recent report was completed in 2022 and included data from 2001 through 2021 (Alta 2021). This Biennial AMR summarizes recommendations from the 2022 report and narrative from the DCP to evaluate how recommendations have been implemented (Appendix A). This Biennial AMR also summarizes new recommendations to assist the DCP in the upcoming biennium (Section 6).

1.2.1 Summary of 2022 Biennial AMR Recommendations

The 2022 Biennial AMR included 5 recommendations that were intended for implementation by the DCP, and DCP staff comments for each are in Appendix A. The Science Advisor Panel agrees that (based on the responses from the DCP) all recommendations have been or are being implemented successfully.

1.3 Significant Updates since the 2022 Biennial AMR

Since the Biennial AMR in 2022, there have been two significant updates: 1) The Adaptive Management and Monitoring Plan (AMMP) was substantially revised (Version 2.0, Alta 2023); and 2) The vegetation layer used to categorize and track habitat loss was updated from a 2011 data source to a 2019 data source.

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1.3.1 Adaptive Management and Monitoring Plan – 2023 Revision

The Adaptive Management and Monitoring Plan (AMMP) was substantially revised (Version 2.0, Alta 2023) with the following updates:

- Revised Biological Goals and Objectives (BGOs) to align with USFWS Specific, Measurable, Achievable, Result-oriented, and Time-fixed ('SMART') principles,
- Added monitoring methods for desert upland and riparian habitat,
- Added monitoring methods for covered plant species,
- Revised monitoring methods for species based on current scientific knowledge and existing site-specific data,
- Added species proposed to be covered under permit amendment so that baseline monitoring can be started now, for species detectable using existing methods and surveys,
- Revised the adaptive management process to remove targets and apply triggers more broadly to BGOs, species, and habitats.

The initial AMMP was developed based on BGOs written in 2016 and was recently revised in February, 2023 (Version 2.0, Alta 2023). The AMMP applies to an entire suite of conservation actions conducted under the MSHCP to formalize adaptive management of the conservation program. The AMMP provides the technical direction for collecting and assessing monitoring data, determining the success of conservation actions in achieving the BGOs, and maintaining or enhancing populations of MSHCP-covered species and their habitats through an adaptive management process. The incorporation of relevant information and quantitative data obtained through systematic and consistent monitoring is a fundamental component of the AMMP. This information is used to periodically evaluate conservation success. Adaptive management of individual projects can also be important but is not directly described in the main body of the AMMP; guidance is provided in Appendix B of the AMMP for these individual projects. Understanding the process and timing of adaptive management tasks will serve to streamline DCP workflow and maximize effectiveness toward permit requirements and biological goals.

A portion of the AMMP describes the evaluation timeline for both analyzing monitoring data and the adaptive management process (Alta 2023):

- The adaptive management evaluation process is a regular, systematic, recurring process performed every four years. This 2024 AMR includes an adaptive management evaluation (Appendix B).
- The adaptive management action process occurs when necessary, beginning at the four-year evaluation interval and continuing until the stated goals have been met.
- Analysis of monitoring data for reporting purposes can occur at any time as individual projects dictate, but at a minimum, analyses should be conducted every two years as part of the Biennial AMR to serve as a benchmark for conservation progress (See Section 4.3 of AMMP).
- Quantification and reporting of project-level progress that leads to the achievement of BGOs should be part of the adaptive management evaluation (see first bullet).

Integration of concepts and analyses from the AMMP into DCP workflow should occur at an intentional pace. The 2020 Biennial AMR included the first iteration of the adaptive management

evaluation process and partially based on that analysis, the revised AMMP is implemented in the 2024 Adaptive Management Evaluation.

1.3.2 Vegetation Layer Update

The vegetation layer that has historically been used for categorizing and tracking habitat loss was updated in the current AMR. Previous AMRs (Alta 2017, Alta 2020, Alta 2022) used a vegetation layer created in 2011 to calculate habitat loss by ecosystem (i.e., the "2011 ecosystems layer"). The 2011 ecosystems layer consisted of 12 ecosystem types. DCP recently updated both the underlying data and subsequent vegetation classification in a new vegetation layer (i.e., the "2019 USNVC division layer"). The new vegetation layer is based on 2019 NAIP imagery and uses the U.S. National Vegetation Classification (USNVC) system for classification. Methods used for disturbance mapping for both the 2011 and 2019 data are included as Appendix C. Reasons for updating the vegetation layer include:

- The 2011 ecosystems layer was an update to the 2001 SW ReGAP dataset. The 2001 data was nearing 20 years old when the 2019 NAIP imagery was obtained, which is sufficient time for substantial vegetation changes to occur. A new dataset is more representative of current habitats.
- The resolution of the 2011 data is 30 x 30-meters. The 2019 NAIP imagery and subsequent 2019 USNVC division layer is a vector file of habitat polygons and allows for more detailed habitat calculations.

This AMR provides a transition between the 2011 and 2019 vegetation layers (Section 3, Figure 2 and Figure 3). The 2019 USNVC division layer will henceforth be used to calculate habitat loss by ecosystem. The proportion of each of the 12 ecosystem types from the 2011 ecosystems layer that correspond to each of the 2019 USNVC divisions are provided in Appendix D. Descriptions for each of the 2019 divisions follow USNVC requirements and can be found in Appendix E and online at https://www1.usgs.gov/csas/nvcs/. Information describing the 2011 ecosystem types was detailed in the 2016 Biennial AMR (ECO 2016).

The spatial footprint that each vegetation dataset covers is substantially different. The 2011 ecosystem layer covers Clark County in its entirety, whereas the 2019 USNVC division layer does not cover specific areas, such as Department of Defense (DOD) lands and the Lake Mead National Recreation Area, neither of which can currently be developed under the MSHCP. The footprint for the 2019 USNVC division layer is hereafter referred to as the 'mapped area'.

Section 2 Land Use Trends in Clark County – Analysis and Discussion

The first assessment tool of the AMR states "*Analyze all land-use trends in Clark County to ensure that take and habitat disturbance are balanced with conservation"* (USFWS 2000). The Science Advisor Panel is particularly interested in change from native or undisturbed ecosystem types to disturbed ecosystem types, which may represent loss of habitat for covered species. In the MSHCP, permitted acres (i.e., the number of acres which are permitted to undergo land use change) and habitat loss are the primary measures of "take" for the 78 covered species (Clark County 2000).

The original MSHCP allowed for 145,000 acres to be developed between 2001 and 2031. The establishment of the Tule Springs Fossil Beds National Monument provided the opportunity for an amendment to the MSHCP, which allowed for an additional 22,650 acres of development within the original MSHCP timeframe. As acres are permitted for development, each of the

Permittees provides monthly updates on expended permitted acres which are summarized in Quarterly Administrator Update reports. The Science Advisor Panel's assessment used data through July 2023, provided by DCP staff (DCP 2023). The Science Advisor Panel assumes the data from the Permittees are accurate, complete, and current. Because mitigation fees are required to be paid prior to disturbing habitat, the acres of actual habitat loss are expected to be less than expended permitted acres. Expended permitted acres are used to track the remaining permitted acres available for development under the MSHCP.

Habitat loss is determined from the total number of acres developed and acts as a surrogate for assessing impacts on covered species, with the assumption that any disturbed habitat results in habitat loss for covered species. Habitat loss is measured on non-federal lands and federal disposal areas within the county. Non-federal lands include lands in private, municipal (city and county), and state ownership.

This section summarizes the number of acres permitted and habitat loss that has occurred since the last assessment in 2022 (Alta 2021) and cumulatively since the initiation of the MSHCP in 2001. Overall, the assessment is structured by two questions regarding habitat loss (ECO 2010). These assessment questions are discussed in the sub-section below:

- How many acres have been permitted for habitat loss?
- How many total acres of habitat loss have occurred?

2.1 Assessment of General Habitat Loss

The reported number of expended permitted acres was compared to county-wide aerial imagery collected in early July, 2023, to determine actual habitat loss to date versus permitted disturbance acres to date (see ECO 2016 and Appendix C for detailed descriptions of the aerial imagery and spatial analysis). The results presented in this sub-section pertain to actual habitat loss, assuming that all development equates to habitat loss. Habitat loss discussed in this sub-section is irrespective of ecosystem. Habitat loss from currently undeveloped permitted acreage, if developed in the future, will be captured in the 2026 Biennial AMR.

As of June, 2023, a total of 123,786.02 acres have been recorded as disturbed under the MSHCP, including 15,000 municipal acres that were exempted from paying the per-acre fee in the original MSHCP. This is 73.8% of the total permitted acres under the amended MSHCP (including the Tule Springs Fossil Beds National Monument; 167,650 acres total). Also, as of July, 2023, a total of 121,934 – 121,998 acres of habitat have been developed (i.e., actual habitat loss; Table 1 - Table 4; Figure 2 and Figure 3). Based on the higher number of 121,998, this is 72.8% of the amended allowed acreage. From March, 2021 to July, 2023, 7,527 acres of development occurred, which is a habitat loss of 0.1% of all land in Clark County (Table 1, Figure 4a). This is in contrast to the 11,154 acres of habitat lost to development in the previous biennium (Alta 2021). Habitat loss from 2021 to 2023 was 34.2% less than the average habitat loss across all previous bienniums (7,527 acres versus 11,447 acres, on average; based on the overall total acreage developed between 2001 and 2021). Habitat loss from 2021 to 2023 was 2.4% of the total amount of developed land in Clark County (Figure 4b). Habitat loss was 4.4% of the total amended permitted acres (Figure 4c).

Current and historic rates of habitat loss can be used to project potential future rates of loss. From 2001 to 2023 the average amount of development per biennium was 11,091 acres (average of 5,545.3 acres per year). At this rate, the remaining 45,653 acres permitted for development under the current MSHCP would be developed in 8.2 years from July 2023, or approximately in 2031. However, several recent bienniums have not experienced such high

rates of development. With the average 6,596.7 acres of development per biennium (average 3,298.3 acres per year) from 2015 to 2023 (excluding the 2019 – 2021 development because of its relatively high rate of development), the remaining acres permitted for development would be developed in 14 years from July 2023, or approximately in 2037. For reference, the current Permit is valid until February 2031. These calculations are for informational purposes only and do not represent projections of actual future rates of development. Actual development has been highly variable over time and is expected to continue as such in the future.

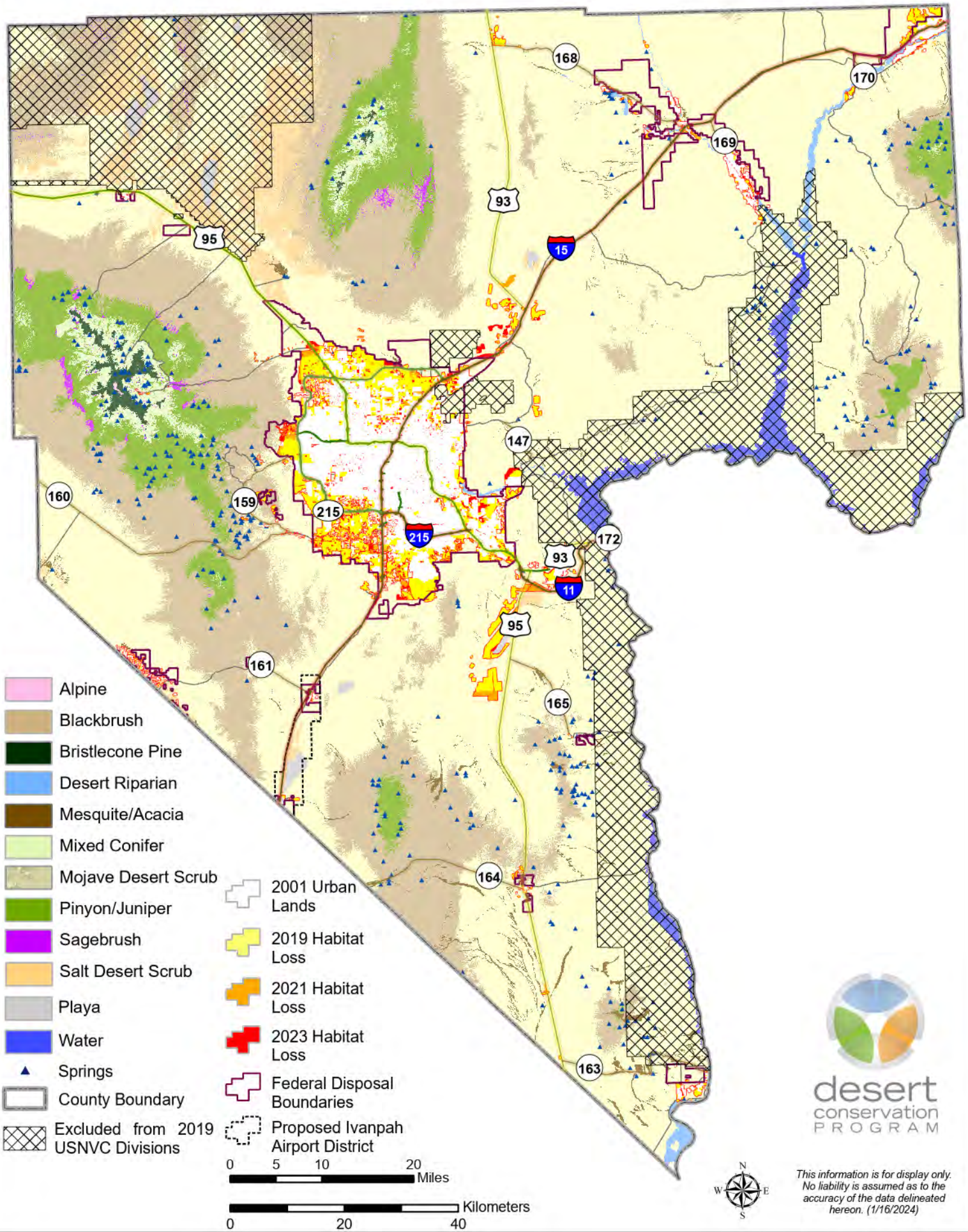
Table 1. Total area, development area (habitat loss), and percent habitat loss prior to 2001, 2001 – 2021, and 2021 – 2023 in Clark County, Nevada

Total acres in Clark County	Acres developed (habitat loss) within each time period[1] (% total acres[2] / % permitted acres[3])			Cumulative developed acres (% total acres / % permitted acres)
	Prior 2001	2001-2021	2021-2023[4]	
5,159,738	180,754 (3.5% / NA[5])	114,471 (2.2% / 68.3%)	7,527 (0.1% / 4.5%)	302,752 (5.9% / 72.8%[6])

[1]Based on aerial imagery. The total developed acres are fewer than the number of acres permitted for development.
[2]Percentage of total acres in Clark County developed within time period.
[3]Percentage of MSHCP-permitted acres developed within time period.
[4]Through July 2023.
[5]Not Applicable, as MSHCP began in 2001.
[6]Cumulative percentage of expended permitted acres developed is based on acres developed since the permit began in 2001 (121,998 acres).

The change in vegetation layer from 2011 to 2019 data does not impact the data or assessment presented in this section because its focus is on total habitat loss, not habitat loss by ecosystem type. To facilitate the transition between vegetation layer data sources, however, Figure 2 (which has historically been presented in this section on total habitat loss) illustrates the 2011 ecosystem layer with an overlay of the areas excluded from the 2019 mapped areas. Figure 3 illustrates the 2019 USNVC division layer and is overlain with the historic habitat loss layer back to the initial habitat loss layer from 2001.

Figure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215
172
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11
95
161
165
164
163
Alpine
Blackbrush
Bristlecone Pine
Desert Riparian
Mesquite/Acacia
Mixed Conifer
Mojave Desert Scrub
Pinyon/Juniper
Sagebrush
Salt Desert Scrub
Playa
Water
Springs
County Boundary
Excluded from 2019 USNVC Divisions
2001 Urban Lands
2019 Habitat Loss
2021 Habitat Loss
2023 Habitat Loss
Federal Disposal Boundaries
Proposed Ivanpah Airport District
0 5 10 20
Miles
0 20 40
Kilometers
N
W
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2019 USNVC Divisions

Figure 3

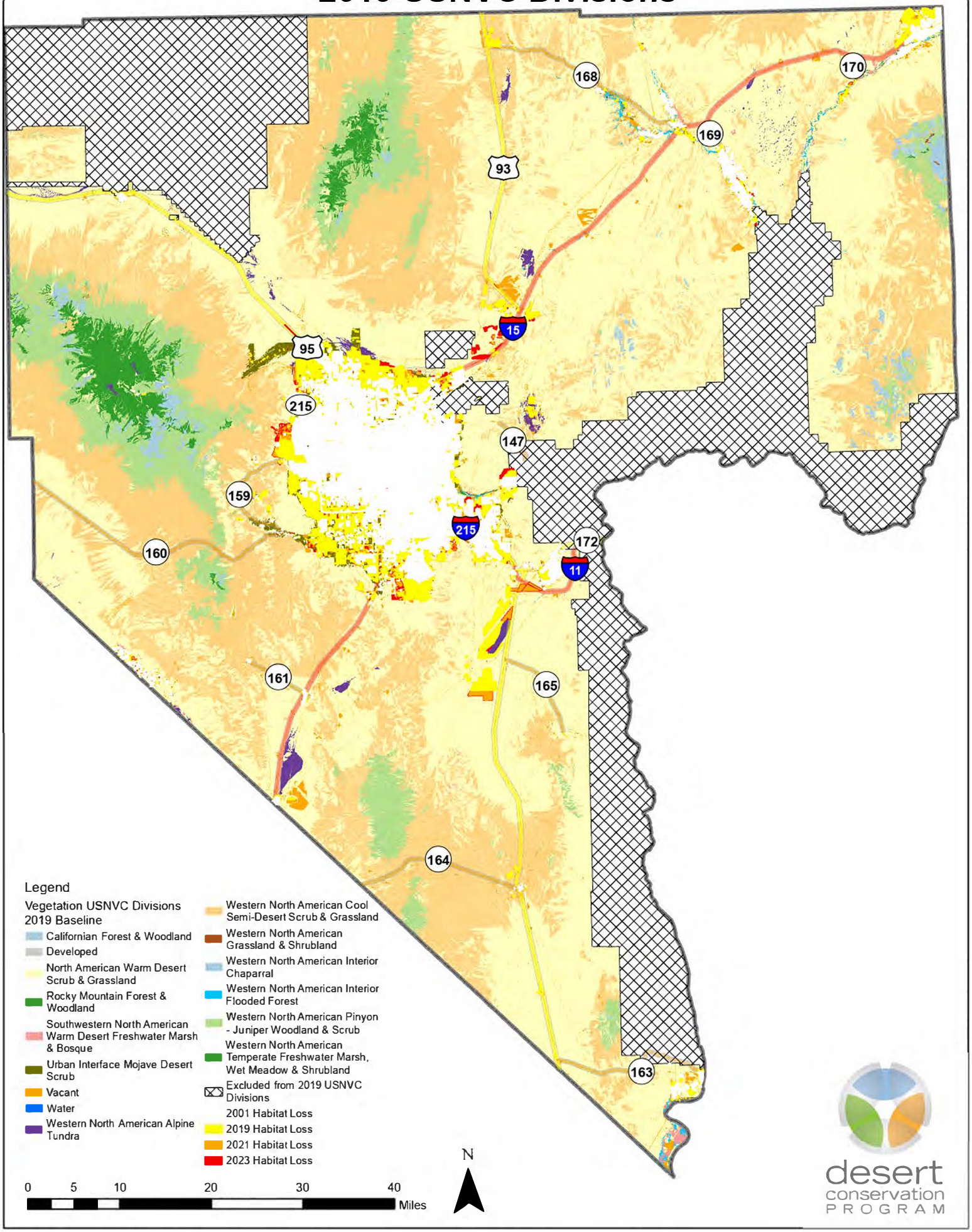
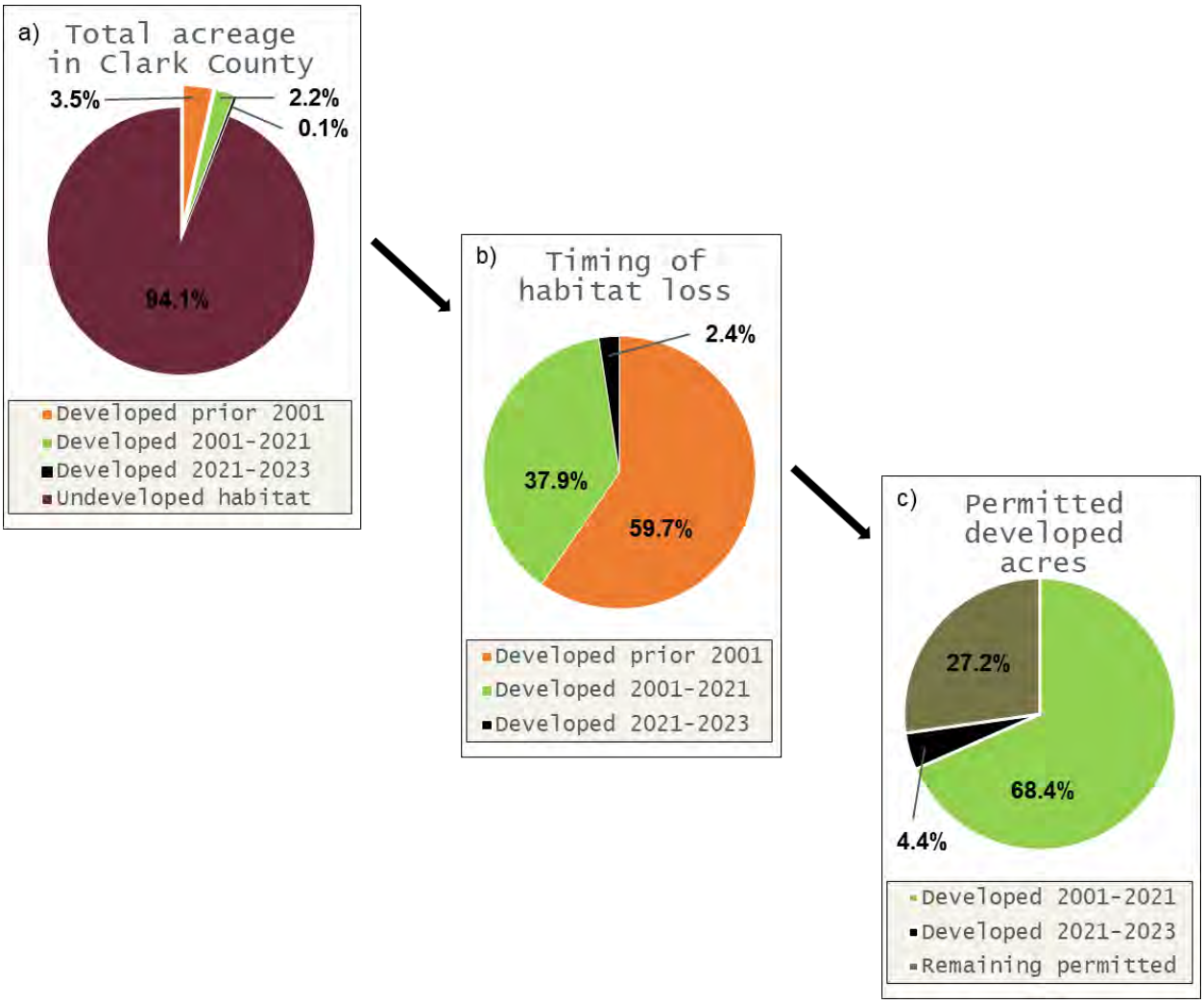


Figure 4. Percent habitat loss as a function of total habitat, time period, and development pace of permitting acreage



(a) Habitat loss, by time period, compared to total habitat (i.e., total acreage) within Clark County.
(b) Distribution of habitat loss by time period.
(c) Proportion of total amended permitted acres developed per time period.
Note: Each color among pie charts represents the same calculated acreage and time period (e.g., orange slices are the amount of habitat developed prior to 2001 [180,754 ac] in both [a] and [b]).

2.2 Conclusions and Recommendations for Land Use Trend Analysis

Based on the Science Advisor Panel's assessment of land use trends (i.e., general habitat loss), conclusions are:

- General habitat loss is commensurate with what is expected given the percentage of habitat loss at this point in the timeline of the MSHCP. However, annual rates of habitat take have varied tremendously over the duration of the MSHCP and may increase or decrease with changing economic conditions in the region.
- In a general sense, current conservation actions are balancing habitat take (USFWS 2000) because the Permit conditions are being met.

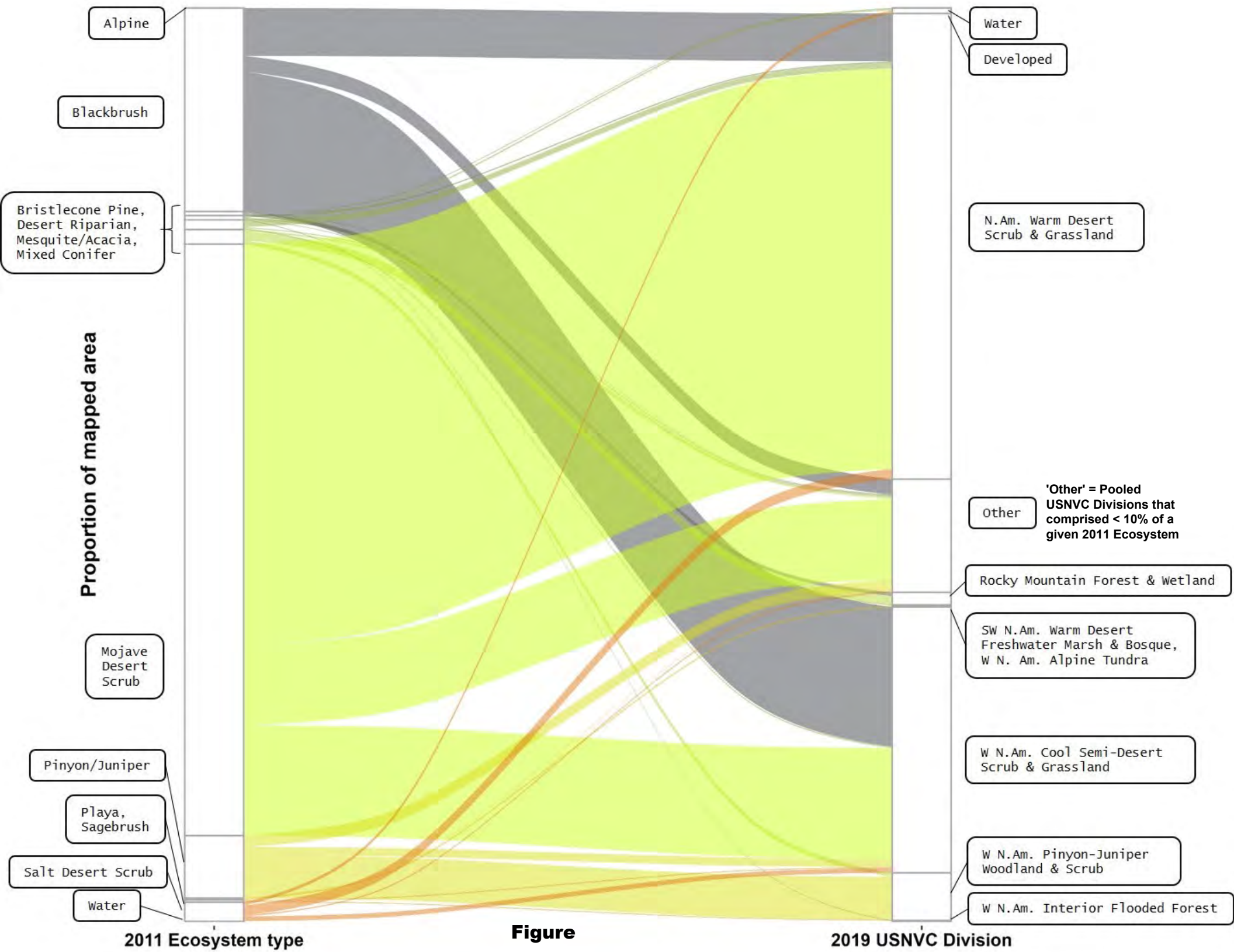
These conclusions are consistent with the 2022 AMR conclusions.

The Science Advisor Panel does not have any specific recommendations for the DCP to implement in this section.

Section 3 Habitat Loss by Ecosystem – Analysis and Discussion

The second assessment tool of the AMR states "*Track habitat loss by ecosystem*" (USFWS 2000). In addition to tracking total habitat loss, the DCP tracks habitat loss by ecosystem (i.e., habitat type) as an assessment of development impacts (i.e., "take") on 78 covered species.

This assessment provides a transition between the 2011 ecosystems layer and the 2019 USNVC division layer. The proportion of each of the 2011 ecosystem types are crosswalked to the 2019 USNVC divisions in Appendix D and are shown in a simplified alluvial flowchart in Figure 5. The dominant 2011 ecosystem types within the mapped area were Mojave Desert Scrub, Blackbrush, and Salt Desert Scrub. These primary 2011 ecosystem types reclassified to the 2019 USNVC Division are dominated by North American Warm Desert Scrub and Grassland, Western North American Cool Semi-Desert Scrub and Grassland, and Western North American Pinyon-Juniper Woodland and Scrub.


Alpine
Blackbrush
Bristlecone Pine, Desert Riparian, Mesquite/Acacia, Mixed Conifer
Mojave Desert Scrub
Pinyon/Juniper
Playa, Sagebrush
Salt Desert Scrub
Water
Proportion of mapped area
2011 Ecosystem type
Water
Developed
N.Am. Warm Desert Scrub & Grassland
Other
'Other' = Pooled USNVC Divisions that comprised < 10% of a given 2011 Ecosystem
Rocky Mountain Forest & Wetland
SW N.Am. Warm Desert Freshwater Marsh & Bosque, W N. Am. Alpine Tundra
W N.Am. Cool Semi-Desert Scrub & Grassland
W N.Am. Pinyon-Juniper Woodland & Scrub
W N.Am. Interior Flooded Forest
2019 USNVC Division

Figure

Table 2 –Table 4 summarize acres of habitat that have been developed (i.e., habitat loss) using the 2011 data and 2019 data. The tables also categorize acres by ecosystem relative to that ecosystem's prevalence throughout Clark County.

Table 2 provides habitat loss using the 2011 ecosystem layer, matching the assessment in previous AMRs.

Table 3 connects the 2011 ecosystem layer habitat loss data to the 2019 USNVC division 'mapped area'.

Table 4 presents the habitat loss using the new 2019 USNVC division layer.

Noticeable differences between Table 2 and Table 4 include:

- The 2019 USNVC division data show lower numbers of developed acres than the 2011 ecosystems data. This is likely because the 2011 data added only whole acres to the habitat loss and only on a year-by-year basis.
- The 2019 USNVC division data show a total of 4.19 million acres in Clark County, versus 5.1 million acres in the 2011 ecosystems data. The difference in acreage is due to the 2019 map excluding lands managed by the Department of Defense and the Lake Mead National Recreation Area.

Sources and methods used to calculate habitat loss for both the 2011 and 2019 data sources are included in Appendix C.

A summary of information provided in Tables 2-4 includes:

- In the most recent biennium (2021 – 2023), a total of 7,357 - 7,527 acres of classified ecosystem types were developed, depending on the vegetation layer used (Table 2 versus Table 4).
- Based on the 2011 ecosystem layer (Table 2), the majority of development was in Mojave Desert Scrub (7,088 acres; 94.2% of development this biennium). Considerably more Mesquite/Acacia was developed in this biennium than in the previous biennium (253 versus 22 acres [Alta 2021]), while Salt Desert Scrub was developed much less than in the previous biennium (47 versus 505 acres [Alta 2021]).
- Data from the 2019 USNVC division layer (Table 4) show the majority of development was seen in the North American Warm Desert Scrub & Grassland (3,228 acres; 43.9% of development this biennium), and the Urban Interface Mojave Desert Scrub (2,878 acres; 39.1% of development this biennium).

Table 2. Habitat loss by ecosystem during 2021 – 2023 and cumulative loss since Permit began in 2001, based on the 2011 ecosystems layer.

Ecosystem[1]	Total acres (% of Clark County[2])	Developed acres (i.e., habitat loss)			
		Prior 2001[3]	*2001 - 2021*	*2021 - 2023[4]*	*Cumulative 2001 - 2023 (% of ecosystem type[5])*
Blackbrush	1,027,144 (19.91%)	1	696	34	730 (0.17%)
Desert Riparian	27,717 (0.54%)	3,005	568	11	579 (2.09%)
Mesquite/Acacia	50,008 (0.97%)	5,546	2,199	253	2,452 (4.90%)
Mixed Conifer	67,556 (1.31%)	31	8	0	8 (0.01%)
Mojave Desert Scrub	3,377,939 (65.47%)	165,412	102,383	7,088	109,471 (3.24%)
Pinyon/Juniper	286,400 (5.55%)	36	6	0	6 (<0.01%)
Sagebrush	11,632 (0.23%)	0	3	0	3 (0.03%)
Salt Desert Scrub	204,329 (3.96%)	6,723	8,471	47	8,518 (4.17%)
Playa	19,180 (0.37%)	0	137	92	229 (1.19%)
Total	5,159,738	180,754	114,471	7,527	121,998 (2.36%)

[1]Excludes 'Alpine', 'Bristlecone Pine', and 'Water', as these ecosystems total 1.7% of Clark County. 'Alpine' and 'Bristlecone Pine' have had 0 acres developed, and, based on the more accurate re-calculation of developed areas, 110 acres of 'Water' were developed prior to 2015. 'Water' can be developed due to the resolution and classification errors in the Heaton et al. (2011) ecosystem model, and in specific instances such as a man-made reservoir.
[2]Percent of Clark County comprised of each ecosystem. Calculation is for the entirety of Clark County, including federal land, and therefore reflects ecosystem acreages for the larger county-encompassed landscape.
[3]Existing development before Permit began.
[4]Spring 2021 – Summer 2023
[5]Cumulative percent development rounded to nearest 0.01%. Percentages are based on the total area of each ecosystem in Clark County, Nevada.

Table 3. Habitat loss by ecosystem during 2021 – 2023 and cumulative loss since Permit began in 2001, based on the 2011 ecosystems layer and within the footprint of the 2019 USNVC layer.

2011 Ecosystem type[1]	*Developed Acres Within 2019 USNVC Footprint*		
	2001 - 2021	*2021 - 2023*	*Cumulative 2001 - 2023 (% of ecosystem type[4])*
Blackbrush	697	34	731 (0.07%)
Desert Riparian	568	0	568 (2.05%)
Mesquite/Acacia	2,199	245	2,444 (4.89%)
Mixed Conifer	8	0	8 (0.01%)
Mojave Desert Scrub	102,384	7,045[5]	109,427 (3.24%)
Pinyon/Juniper	6	0	6 (<0.01%)
Sagebrush	3	0	3 (0.03%)
Salt Desert Scrub	8,471	47	8,518 (4.17%)
Playa	137	92	229 (1.19%)
Total	114,471	7,463	121,934 (2.36%)

[1]Excludes 'Alpine', 'Bristlecone Pine', and 'Water', as these ecosystems total 1.7% of Clark County. 'Alpine' and 'Bristlecone Pine' have had 0 acres developed, and, based on the more accurate re-calculation of developed areas, 110 acres of 'Water' were developed prior to 2015. 'Water' can be developed due to the resolution and classification errors in the Heaton et al. (2011) ecosystem model, and in specific instances such as a man-made reservoir.
[3]Existing development before Permit began.
[4]Cumulative percent development rounded to nearest 0.01%. Percentages are based on the total area of each ecosystem in Clark County, Nevada.
[5]There were changes from federal ownership to private during 2021 that had caused an error in not capturing the disturbance correctly, because this disturbance is only with the MSHCP impact area which does not include federal land. There was also a change in how ArcGIS Pro calculates acres vs ArcGIS Desktop. All of these figures are based on the most stable method between the two of calculating square meters and dividing that by 4046.86. This gave reliable results across the platforms.

Table 4. Habitat loss by 2019 USNVC division.

USNVC division	Total baseline acres in 2019 (% of mapped area)[1]	Developed acres (i.e., habitat loss)			
		Prior 2019[2]	2019 – 2021[3]	2021 - 2023	Cumulative 2019 - 2023 (% of USNVC division in county)
Californian Forest & Woodland	601 (0.0%)	0	0	0	0 (0.0%)
Developed	299,872 (7.2%)	284,376	2	0	0 (0.0%)
North American Warm Desert Scrub & Grassland	2,139,051 (51.1%)	0	4,455	3,228	7,683 (0.4%)
Rocky Mountain Forest & Woodland	73,844 (1.8%)	0	0	0	0 (0.0%)
Southwestern North American Warm Desert Freshwater Marsh & Bosque	6,078 (0.1%)	0	6	1	7 (0.1%)
Urban Interface Mojave Desert Scrub	38,127 (0.9%)	0	4,514	2,878	7,392 (19.4%)
Vacant or Cleared	61,243 (1.5%)	0	1,821	1,075	2,896 (4.7%)
Water	1,199 (0.0%)	0	2	8	10 (0.8%)
North American Western Interior Brackish Marsh, Playa & Shrubland	18,385 (0.4%)	0	90	78	168 (0.9%)
Western North American Cool Semi-Desert Scrub & Grassland	1,217,744 (29.1%)	0	68	70	138 (0.0%)
Western North American Grassland & Shrubland	216 (0.0%)	0	0	0	0 (0.0%)
Western North American Interior Chaparral	39,910 (1.0%)	0	0	0	0 (0.0%)
Western North American Interior Flooded Forest	5,688 (0.1%)	0	0	16	16 (0.3%)
Western North American Pinyon - Juniper Woodland & Scrub	280,425 (6.7%)	0	0	0	0 (0.0%)
Western North American Temperate Freshwater Marsh, Wet Meadow & Shrubland	2,728 (0.1%)	0	4	3	7 (0.3%)
Total	4,185,112	284,376	10,963	7,357	18,317 (0.4%)

[1]Acreage within 'mapped area' after adjusting the 2019 USNVC division layer with the 2019 DCP disturbance layer. These data have not undergone accuracy assessment after which the total acres of each category may change.
[2]Existing land in DCP's 2019 Disturbance layer was reclassified as Developed when the layer was created.
[3]Developed acres were previously disturbed (prior to 2019) acres of federal land that were transferred to non-federal ownership.

3.2 Conclusions and Recommendations for Habitat Loss by Ecosystem Analysis

Based on the Science Advisor Panel's assessment of habitat loss categorized by ecosystem, **conclusions** are:

- Based on the 2011 ecosystem layer, Mesquite/Acacia, Salt Desert Scrub, Playa, and Desert Riparian ecosystem types are rare both within the entire county and within the MSHCP available development area, yet these ecosystem types were disproportionately highly developed both since 2001 and from 2021 to 2023. These are the same ecosystem types identified in the 2022 AMR and recommended for targeted conservation projects. Appendix A includes information on how DCP is addressing the 2022 recommendation. Specifically of note in Appendix A is that significant work is underway to address Desert Riparian, Mesquite/Acacia, and Mojave Desert Scrub conservation. Equally significant is the acknowledgement that no covered species occur in the Playa habitat, highlighting that DCP's conservation efforts should focus on conserving the MSHCP-listed species and conservation of the habitat types are a surrogate for the species.
- Based on the 2019 USNVC division layer, North American Warm Desert Scrub & Grassland and Urban Interface Mojave Desert Scrub experienced the highest rate of development, both since 2019 and in the most recent biennium.
- There are substantial differences between 2011 ecosystem layer and the 2019 USNVC division that impact the assessment and interpretation of habitat loss. This AMR serves as the transition point between the two data sources and future AMRs will report habitat loss in the context of the 2019 USNVC division layer only. Habitat loss that occurred prior to 2019 cannot be categorized using the 2019 data. Habitat loss by division will be the metric used moving forward.
- DCP does not have control over which ecosystems are developed, or at what rate they are developed; therefore, a reasonable assessment of their attention to development trends lies in combining the assessments in Section 3 with the evaluation of ongoing project effectiveness in Section 4. Often, project descriptions and information available to the Science Advisor Panel for use in evaluating project effectiveness (Section 4) do not explicitly connect ecosystem type to each project implemented. However, Appendix A includes DCP responses to how they have addressed previous recommendations to place conservation attention on ecosystem types that are being developed at both high overall rates, as well as those being disproportionately developed.

The following are **recommendations** from the Science Advisor Panel that are intended for DCP implementation:

- Continue to develop conservation actions for those ecosystems undergoing the highest total loss and the highest proportional loss since both metrics could be important to the conservation and management of covered species. These include **Mesquite/Acacia, Salt Desert Scrub, and Desert Riparian** ecosystems for the 2011 ecosystem layer (Playa is excluded from this recommendation based on conclusions above paired with information in Appendix A [none of the MSHCP-listed species occur in Playa]), and the **North American Warm Desert Scrub & Grassland** for the 2019 USNVC division layer.
- Determine which of the 2019 USNVC divisions warrant DCP conservation focus. For example, the Urban Interface Mojave Desert Scrub division experienced the second highest habitat loss in the recent biennium, but the SAP does not think it warrants

specific conservation effort because it is presumably already degraded; therefore we recommend general habitat conservation to mitigate these lost acres, but without a specific focus on the urban interface areas.

Section 4 Effectiveness of Management Actions – Analysis and Discussion

The third assessment tool in the AMR states "*Evaluate the effectiveness of management actions at meeting MSHCP goals of conservation and recovery*" (USFWS 2000). Management actions are the various projects that the DCP implements and manages (see Biennium Progress Reports for project descriptions, budgets, and timelines; Clark County 2023). To evaluate the effectiveness of project-based management actions, the Science Advisor Panel reviewed the project list and noted which BGOs were being addressed by each project. Tabulating the BGOs across multiple projects provided a simple metric to quantify outcomes to assess the entire program and identify where gaps may exist. This analysis is anticipated to differ for each Biennial AMR, as it is dependent on the administered projects at that time and the adaptive management tools utilized by the DCP. The BGOs were updated in the 2023 AMMP and the assessment here uses these updated BGOs. The updated BGOs include three goals (relating to habitat, species, and community) and 14 objectives; the BGOs now more closely adhere to USFWS SMART principals, ensuring the objectives are Specific, Measurable, Achievable, Result-oriented, and Time-fixed (USFWS and NOAA 2016). While the Science Advisor Panel sees the update of the BGOs as an overall positive, the update makes like-for-like comparisons with previous years limited. Furthermore, this analysis will become increasingly quantitative with each AMR as concepts from the BGOs and 2023 AMMP report are further integrated into the DCP workflow.

The 2018 AMR indicated the AMMP B1 worksheets were to be implemented at the start of each project to document project expectations and outcomes with respect to the BGOs, and act as an evaluation tool at the conclusion of the project. The DCP continues to transition to this new process, and furthermore, the B1 worksheets were reformatted in 2020 and 2021 to better guide the tracking of BGOs at the project-level. The B1 worksheets will also be updated to reflect the new BGOs. The updated worksheet is anticipated to more directly link and quantify the project objectives with the BGOs. Information learned during the current Biennial AMR (2024) analyses will further inform revisions to the B1 worksheets.

The biological goals are included below (see Alta 2023 for complete description and corresponding biological objectives).

> **Goal 1.** Maintain or improve habitat quality and quantity within DCP reserve system lands to promote resiliency, redundancy, and representation for covered species.
>
> **Goal 2.** Maintain stable or increasing populations of covered species occurring within DCP reserve system lands.
>
> **Goal 3.** Foster community and stakeholder engagement to maintain or improve covered species populations and their habitats.

To facilitate this assessment, the DCP provided the Science Advisor Panel with a list of 120 projects which included project number, program area, budget, timelines, narratives describing each project, and a summary of accomplishments (Clark County 2023). After accounting for the overlap within the list of projects (related to how project budgets were split), the Science Advisor Panel assigned the 85 projects according to which Biological Goal they contributed to (Table 6 and Appendix F). All projects were assigned by the DCP to one of seven program areas,

summarized below and in Table 6**.** The projects include both desert and riparian contracts, as well as acquisition, restoration, education, land management, research, and survey efforts.

1. **AMP**. Components include contracting an independent Science Advisor Panel and design and implementation of research projects. Specific projects in this category are those for desert upland areas (range-wide desert tortoise monitoring and occupancy projects, predator-prey dynamics studies, desert tortoise connectivity projects, the Eastern Mojave Conservation Collaborative, and species and habitat monitoring for birds, bats, reptiles, and small mammals) and riparian reserve units (projects include surveys for birds, bats, small mammals, and surveys for federally listed birds). There were 21 projects in this category that were assessed for addressing the biological goals, with the great majority of projects addressing goals 1 and 2.
2. **Boulder City Conservation Easement (BCCE) projects** include property management, maintenance, and restoration. Specific projects in this category are law enforcement and restoration of desert tortoise and gypsum habitat. A total of nine projects were assessed in meeting the biological goals; all projects addressed biological goals 1, 2, or 3.
3. **Conservation projects** include general funding of conservation actions to provide for conservation and recovery of covered species which encompass research, habitat protection, or species inventory. Specific projects for this biennium include gila monster threat assessment and modeling efforts, rare plant surveys and propagation studies, and pollinator surveys. Eleven projects in this category addressed goals 1 and 2. No conservation projects addressed biological goal 3.
4. **Public information, education, and outreach (PIE) projects** aim to inform the public about the MSHCP and include programs to encourage people to respect and protect the desert. Specific projects are the Mojave Max education program and general MSHCP outreach and education. There were five projects assessed in this category which all addressed goal 3.
5. **Program administration and permit compliance** encompasses all aspects of implementing the MSHCP and complying with the incidental take permit. Specific projects include surveys, modeling, and genomic analysis for the desert pocket mouse, avian surveys and species modeling in support of the MSHCP permit amendment, vegetation modeling, bat surveys, data analysis, and contracting consultants. The eleven assessed projects in this category addressed all three biological goals.
6. **Riparian reserves projects** focus on acquiring private lands in desert riparian habitats to conserve habitat for riparian birds covered by the MSHCP. Projects include avian nest monitoring, the Muddy River habitat restoration and tree removal, water rights consulting, and property acquisition. There were 18 assessed riparian projects that addressed biological goals 1 and 2.
7. **Wild desert tortoise assistance projects** include maintenance of tortoise exclusion fencing, tortoise telemetry and health assessments, a restoration workshop, the Road Warrior mortality and fence survey, and desert tortoise translocation. There were 10 assessed projects that addressed goals 1 and 2.

Table 5. Categories of projects tallied by which biological goals they support

Project Category	Number of projects and sub-projects assessed	Goal 1	Goal 2	Goal 3
AMP	21	15	18	2
BCCE	9	7	2	3
Conservation	11	9	9	0
PIE	5	0	0	5
Administration	11	7	10	4
Riparian	18	16	5	0
Wild desert tortoise	10	5	7	1

4.1 Conclusions and Recommendations for Management Action Effectiveness

Based on the Science Advisor Panel's assessment of management action effectiveness, conclusions are:

- Overall, the assessment of the effectiveness of the DCP's management actions is positive because all biological goals have projects that are either recently completed or are in progress.
- Classification of projects was conducted post-hoc and was based on information provided by the DCP (as it was for the 2018 – 2022 AMRs). For future implementation of concepts from the AMMP, each project should be cross-referenced with its applicable BGOs during project inception and should be validated during project close-out (Alta 2023). This will provide more consistent and quantitative data on which BGOs are applicable to each project and will be based on DCP staff's knowledge of each project.

The following are recommendations from the Science Advisor Panel that are intended for DCP implementation:

- Implement all effectiveness worksheets described in the AMMP. The Science Advisor Panel is aware that implementation of these worksheets is in progress and it is estimated that they will be ready for use by the next AMR in 2026. Collating projects in a spreadsheet will lead to the availability of direct, quantitative assessments within the next Biennial AMR.

Section 5 Species Status and Population Trends

The final assessment tool in the AMR states "*Monitor population trends and ecosystem health"* (USFWS 2000). The MSHCP directs the DCP to monitor the status and trends of covered species and their habitats to prevent loss or fragmentation of habitat for the benefit of stabilizing or increasing population numbers within Clark County (Clark County 2000, USFWS 2002). No quantitative goals were established at the initiation of the MSHCP; however, quantitative goals were to be developed over time through surveys, monitoring, and adaptive management.

Monitoring the status of populations and the habitats of MSHCP-covered species provides information on the benefits of conservation actions conducted by the DCP as part the

MSHCP implementation. Additionally, monitoring can serve as a safeguard against failing to detect MSHCP-covered species population declines in spite of successful implementation of the MSHCP.

The recently revised AMMP outlines the rationale and general methodology for monitoring species' status and population trends for all MSHCP-covered species (Alta 2023). Monitoring will be used to record and evaluate species' population and habitat trends, and potentially to demonstrate the impact of conservation actions on the populations of MSHCP- covered species. Furthermore, the AMMP outlines how monitoring data will be used to conduct the program-level adaptive management process. The adaptive management evaluation for populations and habitats of MSHCP-covered species is to be completed every 4 years and is separate from the Biennial AMR (see Section 1.3.1), but the AMMP requires monitoring data to be synthesized and disseminated in the Biennial AMR.

5.1 Adaptive Management Evaluation for Species and Habitat

The evaluation of species and habitat trends is detailed in the AMMP with final output being tables that state whether each population and habitat trend is exceeding a threshold (i.e., the threshold is exceeded if a population/habitat shows a statistically significant decline). A detailed write-up on input data, statistical methods, and full results are provided in Appendix B, and the output tables are below (Table 7 and Table 8).

There are nine species that are meeting expectations (i.e., had sufficient data for a statistical test and are not declining), including all three MSHCP-listed species that are federally listed (desert tortoise, yellow-billed cuckoo, and Southwestern willow flycatcher). The remaining MSHCP-listed species do not have sufficient data to conduct the appropriate statistical test and therefore have an output of 'Unknown'.

Table 7 also includes species that are not currently covered under the MSHCP, but are anticipated to be included under the upcoming HCP amendment. The DCP is currently collecting data on these species to establish baseline data. No threshold is assigned to these species because they are not MSHCP-listed, and as such are coded as 'NA' in Table 7.

There are not enough upland or riparian habitat data for statistical testing (Table 8). The DCP is beginning to implement the ecosystem health monitoring as described in the recently revised AMMP.

Table 6. Threshold Results for Species Monitoring

Species[a]	Monitoring Survey	Covered Species Group	Threshold[b] Exceeded?
Desert tortoise	Occupancy sampling	Desert upland reptiles[a]	No
Great Basin collared lizard			Unknown
Desert iguana			No
Large-spotted leopard lizard			No
Yellow-billed cuckoo	Federal protocol	-	No
Southwestern willow flycatcher	Federal protocol	-	No
Blue grosbeak	Point count / passive acoustic occupancy	Riparian birds	No
Summer tanager			Unknown
Vermillion flycatcher			Unknown
Arizona Bell's vireo			No
Ridgway's rail			*NA*
American peregrine falcon		Desert upland birds	Unknown
Phainopepla			No
Western burrowing owl			*NA*
Gilded flicker			*NA*
Loggerhead shrike			*NA*
Bendire's thrasher			*NA*
Le Conte's thrasher			*NA*
Golden eagle			*NA*
Silver-haired bat	Passive acoustic occupancy	Bats	Unknown
Long-eared myotis			Unknown
Long-legged myotis			Unknown
Townsend's big-eared bat			*NA*
Spotted bat			*NA*
Sticky ringstem	Three-tiered sampling	Desert upland plants[c]	Unknown
Las Vegas bearpoppy			Unknown
White bearpoppy			Unknown
Threecorner milkvetch			Unknown

[a]Species in **bold** are federally listed under the Endangered Species Act. Species in *italics* are proposed to be covered under a future amended MSHCP. Currently covered and proposed species not included here are sufficiently rare, cryptic, or unknown as to whether they are specifically surveyed for; these species are assumed to be covered using desert upland or riparian habitat quality as a surrogate.

[b]The threshold is a statistically significant downward trend in populations on reserve lands during the assessment period. Proposed covered species under the upcoming MSHCP amendment have data and trends presented in reports for informational purposes, but do not have associated thresholds. 'Unknown' exceedance findings indicate insufficient data for trend assessment at this time.

[c]Additional MSHCP-covered and proposed plant species should be included in monitoring as populations are located through targeted surveys. Currently covered species should have associated thresholds; proposed species should not.

Table 7. Threshold Results for Habitat Monitoring

Habitat	Monitoring Survey	Monitored Habitat Characteristics	Threshold	Threshold[a] Exceeded?
Desert upland	AIM protocol augmented with remote sensing	Foliar cover	Statistically significant decline	Unknown
		Species richness	Statistically significant decline	Unknown
		Vegetation height	Statistically significant decline	Unknown
		Percent bare ground	Statistically significant increase	Unknown
		Proportion of soils surface in gaps	Statistically significant increase	Unknown
		Soil aggregate stability	Statistically significant decline	Unknown
Riparian	Remote sensing with ground truthing	Cover: • Vegetation composition • Total cover • Cover by functional group or species • Cover by canopy (understory vs overstory)	Thresholds are not defined for each riparian habitat characteristics because the MSHCP-covered avian species have widely diverging habitat requirements. A mosaic of habitat for all species should be maintained across all properties. The collective threshold for riparian habitat is a significant increase in acreage across all DCP riparian lands that does not meet requirements for any MSCHP-covered avian species; increase must not be due to natural event [e.g., severe flooding] nor the result of active restoration [e.g., tamarisk mastication]).	Unknown
		Vegetation Height: • Overall / average height • Height by canopy level		
		Vegetation Density		
		Vigor / greenness		

[a]Threshold exceedance of 'Unknown' indicates insufficient data for trend analysis at this time.

5.2 Conclusions and Recommendations for Species Status and Trends

Based on the Science Advisor Panel's assessment of species status and trends, **conclusions** are:

- No species are exceeding the threshold (i.e., showing a statistically significant decline), however, data for some species are not robust enough to model temporal trends in the population (see next bullets).
- Exploratory surveys for MHSCP-covered plants have been conducted off of reserve unit lands; the AMMP specifies monitoring for MSCHP-covered plants if they are detected on reserve unit lands. Until such time as MSHCP-covered plant species is detected on reserve unit lands, monitoring data is not expected to be collected, nor be sufficient for a statistical test.
- Data for bats have been collected and processed for a single year at upland and a single year at riparian survey sites, so temporal trends in occupancy cannot yet be modeled.

The following are **recommendations** from the Science Advisor Panel that are intended for DCP implementation:

- Continue processing the bat acoustic detection data in order to model temporal trends in the populations. Appropriate general(ized) linear models should be used to monitor trends in area occupied and population size to meet the monitoring requirements outlined in the AMMP.
- Monitoring ecosystem health is included in the language for this assessment (USFWS 2000), and DCP is working with the Science Advisor Panel to implement the habitat monitoring plans included in the AMMP revision (Alta 2023). With the understanding that DCP is beginning to implement the ecosystem health monitoring described in the revised AMMP, we have the following recommendations:
    - Preliminary data were collected from the first-year effort of upland habitat monitoring. We recommend DCP continues to monitor upland habitat as described in the revised AMMP, and to consider conducting statistical analysis prior to the next AM Evaluation (scheduled for the 2028 AMR) to help evaluate whether methods are appropriate/achieving the goal of monitoring ecosystem health.
    - DCP has also developed a project to initiate baseline data collection for riparian habitat to be included in the 2023 - 2025 Implementation Plan and Budget (IPB). We recommend assessing this project and its outcomes to help evaluate whether methods are appropriate/achieving the goal of monitoring ecosystem health.

Section 6 Summary of Conclusions and Recommendations

This Biennial AMR describes the independent analysis and subsequent conclusions and recommendations from the Science Advisor Panel's assessment of land use trends, habitat loss by ecosystem, the effectiveness of management actions at meeting MSHCP goals, population trends and ecosystem health, and the Adaptive Management Evaluation detail in Appendix B. Conclusions are presented in Table 8 and recommendations are presented in Table 9.

Table 8. Summary of conclusions for all assessments performed by the Science Advisor Panel for the 2024 Biennial AMR

Assessment section	Summary of conclusions
Section 2—Analyze all land-use trends in Clark County to ensure that take and habitat disturbance are balanced with conservation.	Habitat loss is commensurate with what is expected given the percentage of habitat loss at this point in the timeline of the MSHCP.
Section 3—Track habitat loss by ecosystem.	There are substantial differences between the 2011 ecosystem layer and the 2019 USNVC division layer. This AMR is the transition point between the two data sources and future AMRs will report habitat loss in the context of the 2019 USNVC division layer only. 2011 ecosystem types undergoing the highest habitat loss are Mesquite/Acacia, Salt Desert Scrub, Playa, and Desert Riparian. These are the same ecosystem types identified in the previous AMR (and see Appendix A). 2019 USNVC divisions undergoing the highest habitat loss are North American Warm Desert Scrub & Grassland, and Urban Interface Mojave Desert Scrub.
Section 4—Evaluate the effectiveness of management actions at meeting MSHCP goals of conservation and recovery	All biological goals have projects that are either recently completed or are in progress.
Section 5—Monitor population trends and ecosystem health.	No species with sufficient data are exceeding the threshold (i.e., a statistically significant decline). Monitoring for MSCHP-covered plants is not expected to occur regularly until such time these species are detected on reserve unit lands. Processing bat acoustic data is required before analysis or assessment of population status can occur. Monitoring of upland and riparian habitats has begun, but more results are needed for analysis.
Adaptive Management Evaluation (Appendix B)	All BGOs are being addressed by DCP conservation efforts. Riparian and habitat monitoring analyses are introductory at this time, as there has not been sufficient opportunity for data collection.

Recommendations for each assessment are described in their corresponding sections and are summarized in Table 9, below.

Table 9. Summary of recommendations for all assessments performed by the Science Advisor Panel for the 2024 Biennial AMR

Assessment section	Summary of recommendations
Section 2—Analyze all land-use trends in Clark County to ensure that take and habitat disturbance are balanced with conservation.	The Science Advisor Panel did not have any specific recommendations for the DCP to implement in this section.
Section 3—Track habitat loss by ecosystem.	Continue to develop conservation actions for ecosystems undergoing the highest total loss and the highest proportional loss. These include Mesquite/Acacia, Salt Desert Scrub, and Desert Riparian ecosystems. Playa is excluded from this recommendation (See conclusions and Appendix A). Determine which of the 2019 USNVC divisions warrant DCP conservation focus (e.g., Urban Interface Mojave Desert Scrub division had the second highest habitat loss in the recent biennium, but does an urban interface area warrant specific DCP conservation effort?)
Section 4—Evaluate the effectiveness of management actions at meeting MSHCP goals of conservation and recovery	Effectiveness worksheets should be implemented (implementation is ongoing but not complete at the time of preparing this AMR). By doing so, and collating in a spreadsheet, direct quantitative assessment within the next Biennial AMR should be possible.
Section 5—Monitor population trends and ecosystem health.	Processing of bat acoustic detection data should be continued to yield several more years of species presence and abundance records. Continue monitoring upland and riparian habitats to evaluate trends.
Adaptive Management Evaluation Appendix	Specific recommendations are included with each BGO and habitat sub-sections of Appendix B.

The Science Advisor Panel's overall appraisal, based on the above four primary assessments (Sections 2 - 5 and summarized in Table 8 and Table 9), is that the DCP is successfully implementing the current MSHCP. General recommendations include improving project- and program-level tracking and reporting to allow for more quantitative rigor in future assessments, and the continuation/completion of several monitoring and planning efforts.

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Appendix A

Summary of Recommendations from Previous Biennial AMR

Assessment section	Summary of recommendations from 2022 AMR	DCP comment on progress since 2022 AMR
Section 2—Analyze all land-use trends in Clark County to ensure that take and habitat disturbance are balanced with conservation.	The Science Advisor Panel does not have any specific recommendations for the DCP to implement in this section.	NA
Section 3—Track habitat loss by ecosystem.	Develop conservation actions for ecosystems undergoing the highest total habitat loss and the highest proportional habitat loss. These include: o Desert Riparian, Mesquite/Acacia, Salt Desert Scrub, and Playa, due to their low prevalence and high historic and recent relative rate of development. o Mojave Desert Scrub ecosystem due to the total high rate of habitat loss.	o Significant work has been targeted for Desert Riparian, Mesquite/Acacia and Mojave Desert Scrub. o One project will put up exclusionary fencing to help protect Salt Desert Scrub north of Las Vegas. o No work has been done on Playas as none of our covered species occur in that habitat.
Section 4—Evaluate the effectiveness of management actions at meeting MSHCP goals of conservation and recovery.	Implement all effectiveness worksheets after the updates they are currently undergoing are finalized (planned for 2022). By doing so, and collating in a spreadsheet, direct quantitative assessment within the next Biennial AMR will be possible.	These are still undergoing revisions and being transformed into a database format from excel. They should be available by the next AMR.
Section 5—Monitor population trends and ecosystem health.	Processing bat acoustic data is required before analysis or assessment of population status can occur. Monitoring plans for ecosystem health should be finalized and implemented. Avian survey methods should be revisited in conjunction with the Science Advisor Panel to ensure cost and effort efficiency.	o We are currently in the process of analyzing the acoustic data for the last few years which should be completed before the end of the year. o We have finalized the monitoring plan for ecosystem health and have begun collecting data. o We continue to do avian surveys under the old protocols but intend to begin a pilot study using passive acoustic monitors in the near future.

Appendix B
Adaptive Management Evaluation

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M E M O R A N D U M

To: Scott Cambrin, Clark County Desert Conservation Program, Las Vegas, Nevada

From: Tarita Harju, Alta Science & Engineering, Inc., Kellogg, Idaho
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Seth Harju, Heron Ecological, Kingston, Idaho

Date: February 4, 2024

Contract No./Title: 2019-ALTA-2020C D27

Alta Project No.: 22040-41

Subject: **2024 Adaptive Management Evaluation - FINAL**

1 Introduction

The Adaptive Management and Monitoring Plan (AMMP; Alta 2023a) provides technical direction for collecting and assessing monitoring data, determining the success of conservation actions in achieving Biological Goals and Objectives (BGOs), and maintaining or enhancing species' populations and habitats that are covered under the Multiple Species Habitat Conservation Plan (MSHCP). Achievement of these aims is periodically evaluated through an adaptive management process with relevant, quantitative data obtained through systematic, consistent monitoring, as described in the AMMP:

- The adaptive management evaluation process is a regular, systematic, recurring process to be performed every four years.
- The adaptive management action process occurs when necessary, beginning at the four-year evaluation interval and continuing until the actions have met their stated goals.
- Analysis of monitoring data for reporting purposes can occur at any time as individual projects dictate, but at a minimum, should be conducted every two years as part of the Biennial Adaptive Management Report (BAMR) to serve as a benchmark for conservation progress. Additionally, a more in-depth analysis should take place as part of the adaptive management evaluation.
- Quantification and reporting of project-level progress that leads to achievement of BGOs should be part of the adaptive management evaluation.

There are two sets of criteria included in the AMMP and both are evaluated in this memorandum:

- Project-level progress leading to achievement of BGOs (Section 2)
- Species and habitat monitoring (Section 3)

2 Evaluation of Actions Taken by DCP to Achieve BGOs

Biological goals provide rationale for conservation actions and biological objectives aid achievement of those goals through implementation, evaluation, and adaptive refinement of the actions. BGOs were initially drafted in 2016 and the first version finalized in 2017. The BGOs and AMMP (Alta 2023a) were recently reviewed and revised in 2022, with a second version finalized in early 2023 (Table 1). The intent in the revision was to more closely align the BGOs with guidance from U.S. Fish and Wildlife Service (USFWS) on implementation of habitat conservation plans. More specifically, the BGOs were revised to meet Specific, Measurable, Achievable, Result-oriented, and Time-fixed (SMART) principles (USFWS and NOAA 2016).

Table 1. 2023 Biological Goals and Objectives

Biological Goal 1: Maintain or improve habitat quality and quantity within DCP reserve system lands to promote resiliency, redundancy, and representation for covered species.	
Obj 1.1	Utilize invasive species treatment methods to maintain or decrease the 8-year average area requiring weed management.
Obj 1.2	Acquire riparian acreage at an equivalent rate as take over the life of the permit. An 8-year lag after riparian acreage is developed is allowed to account for the willing-seller, willing-buyer basis of property exchange, within the life of the permit.
Obj 1.3	Protect, restore, or otherwise increase the quality and quantity of habitat for MSHCP-covered species, as determined by the monitoring methods, definition of quality, and timeframes specified in the AMMP.
Obj 1.4	Incorporate natural ecological, hydrological, and geomorphological processes into restoration design and implementation to maintain ecological integrity, ecosystem function, and biological diversity. Include consideration that climate change may result in significant changes in these processes over historical frequencies and magnitudes. Review quadrennially as part of every other Adaptive Management Report (AMR) using project level worksheets (B1 Worksheets).
Obj 1.5	Identify critical uncertainties (e.g., climate change, human population growth) of MSHCP-funded projects on DCP reserve system lands and report on them in biennial updates to the DCP Reserve System Management Plans.
Obj 1.6	Incorporate concepts of ecosystem redundancy and representation to promote ecological resiliency in the biennial updates to the DCP Reserve System land Management Plans.
Obj 1.7	Protect and enhance connectivity (i.e., road restoration, culvert placement) within DCP reserve system lands for Desert Tortoise and other high priority covered species. Review and report on the status of these projects quadrennially in every other AMR.

Biological Goal 2: Maintain stable or increasing populations of covered species occurring within DCP reserve system lands.	
Obj 2.1	Monitor covered wildlife species as described in the AMMP. Report quantitative population data, as described in the AMMP, for covered species biennially in the AMR and report statistical analyses of population trends quadrennially in every other AMR.
Obj 2.2	Conduct surveys for covered plant species as described in the AMMP. Protect, conserve, and monitor known occurrences of these species annually. Report quantitative population data as described in the AMMP biennially in the AMR, and report statistical analyses of population trends quadrennially in every other AMR.
Obj 2.3	Translocate and augment desert tortoise populations in accordance with USFWS guidance through translocation programs that achieve survivorship rates within 10 percentage points of resident tortoise survival rates in the same areas (or with survivorship as prescribed by USFWS guidance). Report survivorship data biennially in the AMR and report analysis on aggregated translocated tortoise survivorship compared to aggregated resident tortoise survivorship quadrennially in every other AMR.
Obj 2.4	Ensure the best available scientific information is being evaluated and incorporated into population management efforts for covered species, including monitoring methods and identification of critical uncertainties (e.g., climate change, human population growth), by completing a focused literature review (or Systematic Review) and updating it quadrennially in the AMMP.
Biological Goal 3: Foster community and stakeholder engagement to maintain or improve covered species populations and their habitats.	
Obj 3.1	Develop and disseminate educational materials that cover the following topics: 1) the value of the desert ecosystem in Clark County; 2) promoting responsible recreation; 3) promoting following development procedures; and 4) avoiding and minimizing impacts to the environment. Re-evaluate material's relevance quadrennially (branding, technology, social and recreation trends, etc.).
Obj 3.2	Protect habitats within the Boulder City Conservation Easement (BCCE) from unauthorized land use through vigilance (by patrolling an average of at least 100 hours each month) and education (by providing information during encounters). Compile data annually and report quadrennially in every other AMR.
Obj 3.3	Provide information to permitted users (project proponents, construction personnel, researchers, biological consultants) about best management practices (BMPs) for the desert tortoise and associated reporting procedures. If BMPs are developed for other covered species, this objective would expand to apply to them also. Compile data annually and report quadrennially in every other AMR.

The following sections present project-level information provided to the SAP by DCP to evaluate progress leading to the achievement of the BGOs. Progress towards achieving BGOs is evaluated based on whether actions are inherently addressing the BGO, and whether projects' data fit within the context of the SMART principles for each BGO.

Objective 1.1. Utilize invasive species treatment methods

Utilize invasive species treatment methods to maintain or decrease the 8-year average area requiring weed management.

The DCP contracts with the National Park Service (NPS) to control invasive plant species on riparian reserve units and the BCCE. The NPS treats invasive plants on DCP land similarly to how the NPS does on its own land. The following is a summary of information gleaned from available GIS data and NPS reports (Clark County DCP and NPS 2016, 2017, 2018, 2019, 2020, 2021, 2022, NPS 2013, 2014, 2016, 2021, 2022, 2023):

- Invasive plant surveys, mapping, and treatment occur on several Virgin River (Bunkerville, Lower Mormon Mesa, Riverside Bridge) and nine Muddy River parcels (Muddy River Reserve Units A, B, C, D, E, F, G, H, and I that total 118 acres). Surveys are conducted on foot using a systematic grid pattern twice a year during the winter and spring/summer periods; according to tables in the reports from 2013 – 2023 (excluding 2017 for which there were no data reported), total area surveyed varies year to year (Table 2). Inventories and treatments are recorded with GPS according to the North American Invasive Species Management Association's standards (NAISMA.org). Treatment consists of both mechanical and chemical methods.
- According to reports from 2014 – 2022 (excluding 2015 for which there was no report), foot and vehicle surveys (at least twice per year) on the BCCE include 92 (in 2014) - 95 (2016 onward) miles of open public roads and 43 miles of private right of way maintenance roads. Total area surveyed varies year to year because once invasive plants are detected on either side of the road, surveys are continued on foot beyond the roadside to determine the extent of the population (Table 3). Infestations are recorded with GPS and chemical and manual treatment occurs on a prioritized basis.
- Multiple surveys per year are meant to detect a variety of species that can emerge throughout the course of the year due to weather patterns/seasons.

Data from the surveys are reported in Table 2.

Table 2. Reported gross infested acres treated and total acres surveyed on riparian parcels.

Scientific Name	Gross Infested Acres Treated | Total Acres Surveyed															
	2013 – 2015		2015*		2016*		2017*		2018*		2018-2021		2021-2022		2022-2023	
Acroptilon repens	36.19	117.25	0.00	--	--	--	--	--	--	--	6.40	26.40	--	5.30	0.01	27.50
Alhagi maurorum	--	--	--	--	--	--	--	--	--	--	4.76	14.96	--	70.43	--	--
Arundo donax	--	--	--	--	--	--	--	--	--	--	--	--	--	70.43	--	--
Atriplex semibaccata	65.77	117.25	0.27	--	7.07	--	--	--	0.02	--	5.50	26.40	--	--	14.24	40.19
Bassia hyssopifolia	16.79	117.25	--	--	3.04	--	--	--	--	--	5.49	26.40	--	--	10.21	67.69
Bassia scoparia	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.10	67.70
Brassica tournefortti	0.60	117.25	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bromus rubens	69.43	117.25	--	--	--	--	--	--	--	--	--	--	--	--	0.01	27.50
Bromus tectorum	11.19	117.25	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Centaurea melitensis	37.19	117.25	13.74	--	12.50	--	--	--	--	--	3.40	26.60	--	--	--	--
Chrorispora tenella	5.10	117.25	--	--	8.85	--	--	--	--	--	--	--	--	--	--	--
Convolvulus arvensis	35.21	117.25	0.05	--	15.56	--	--	--	1.05	--	5.50	--	--	--	0.02	27.50
Cynodon dactylon	51.47	117.25	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Elaeagnus angustifolia	--	--	--	--	--	--	--	--	--	--	0.01	32.88	--	70.43	--	--
Erodium cicutarium	19.02	117.25	--	--	7.70	--	--	--	--	--	--	--	--	--	--	--
Kochia prostrata	9.90	117.25	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lactuca serriola	9.35	117.25	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lepidium latifolium	--	--	--	--	--	--	--	--	--	--	1.26	8.06	4.79	70.43	--	--
Malcolmia africana	88.57	117.25	0.58	--	4.14	--	--	--	--	--	--	--	--	--	4.21	67.70
Malva neglecta	--	--	--	--	5.64	--	--	--	--	--	--	--	--	--	--	--
Salsola spp	--	--	--	--	--	--	--	--	0.92	--	26.77	26.77	--	--	0.11	27.50
Salsola kali	79.57	117.25	2.06	--	25.77	--	--	--	23.57	--	--	--	--	--	--	--
Salsola tragus	--	--	--	--	3.75	--	--	--	--	--	--	--	--	19.40	--	--
Sisymbrium irio	58.82	117.25	--	--	15.08	--	--	--	1.27	--	7.96	26.40	--	--	--	--
Sonchus arvensis	7.90	117.25	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sonchus asper	4.37	117.25	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sorghum halepense	1.11	117.25	0.02	--	0.03	--	--	--	--	--	0.40	26.40	--	--	0.02	40.20
Tamarix aphylla	--	--	--	--	--	--	--	--	--	--	0.14	2.60	0.03	5.30	--	--
Tamarix ramosissima	43.15	117.25	--	--	0.02	--	--	--	0.18	--	41.08	89.02	10.79	77.53	--	--
Tribulus terrestris	0.11	117.25	--	--	6.79	--	--	--	--	--	--	--	--	--	0.19	67.70
Vitex agnus-castus	0.96	117.25	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Washingtonia filifera	--	--	--	--	--	--	--	--	--	--	0.02	4.80	--	--	0.02	27.50
Total	**651.77**	**2579.50**	**16.72**	**0.00**	**115.95**	**0.00**	**0.00**	**0.00**	**27.02**	**0.00**	**108.68**	**337.69**	**15.61**	**389.26**	**29.11**	**488.67**

*Data were presented in one report but separated out by year when possible. Note that numbers are the SAP's interpretation from reports and may not be 100% accurate, particularly in overlapping years (e.g., 2015, 2018, 2021, 2022).

Table 3. Reported gross infested acres treated and total acres surveyed on the BCCE

Scientific Name	Gross Infested Acres Treated | Total Acres Surveyed																	
	2014		2015		2016		2017		2018		2019		2020		2021		2022	
Arundo donax	0.02	1903.00	--	--	0.02	6468.00	--	--	--	--	--	--	--	--	--	--	--	--
Bassia scoparia	--	--	--	--	--	--	--	--	--	--	--	--	--	64.50	--	--	--	--
Brassica juncia	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Brassica nigra	0.05	1903.00	--	--	0.37	6468.00	--	--	--	--	--	--	--	--	--	--	--	--
Brassica tournefortii	2.11	1903.00	--	--	134.48	6468.00	12.46	891.67	14.32	47.85	3.67	--	174.50	1505.00	--	838.00	--	463.80
Bromus berteroanus/B. trinii	0.00	1903.00	--	--	0.0001	6468.00	--	--	--	--	--	--	--	--	--	--	--	--
Bromus diandrus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	838.00	--	--
Bromus madritensis/B. rubens	--	--	--	--	0.74	6468.00	--	--	--	--	--	--	--	--	--	--	--	463.80
Chondrilla juncea	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Descurainia sophia	--	--	--	--	--	--	--	--	0.0001	0.0001	--	--	--	--	--	--	--	--
Erodium cicutarium	0.02	1903.00	--	--	58.70	6468.00	--	--	0.001	0.001	3.40	--	--	--	--	593.00	--	--
Malva spp	0.001	1903.00	--	--	6468.00	6468.00	--	--	--	--	--	--	--	--	--	--	--	--
Pennisetum ciliare	--	--	--	--	--	--	--	--	0.01	0.01	--	--	--	160.90	--	--	--	463.80
Salsola kali	351.84	1903.00	--	--	393.80	6468.00	60.95	891.67	--	--	3.40	--	2.67	237.75	--	838.00	--	463.80
Salsola tragus	--	--	--	--	--	--	0.05	891.67	--	--	--	--	--	--	--	--	--	--
Schismus arabicus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	593.00	--	--
Sisymbrium altissiumum	--	--	--	--	--	--	--	--	0.001	0.001	--	--	1.17	160.90	--	838.00	--	--
Sisymbrium irio	0.38	1903.00	--	--	51.76	6468.00	--	--	--	--	3.40	--	--	--	--	--	--	--
Sorghum bicolor	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.50	4.50	--	--
Tamarix ramosissima	9.14	1903.00	--	--	8.25	6468.00	0.17	891.67	0.12	0.12	--	--	--	--	--	--	--	--
Tribulus terrestris	--	--	--	--	1.25	6468.00	--	--	0.01	0.01	3.40	--	--	--	7.60	196.00	292.30	610.20
Tripleurospermum perforatum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	630.60	--	--
Total	**363.56**	**17127.00**	**0.00**	**0.00**	**7117.37**	**71148.00**	**73.63**	**3566.68**	**14.45**	**47.98**	**6.10**	**0.00**	**178.34**	**2129.05**	**12.10**	**5369.10**	**292.30**	**2465.40**

*Note that numbers are the SAP's interpretation from reports and may not be 100% accurate.

Because the total acreage surveyed varies year to year, and because the GIS data and reports provide only data for species that were detected and treated, as opposed to also including acreages that were surveyed where no species were detected, it is unclear if each species was surveyed year after year. In general, data are not presented in a consistent manner, as some reports include tables while others include only maps, some years lack reports, and the GIS data do not link clearly to the reports.

Though cooperating with the NPS to manage invasive plants is beneficial and is meeting the nature of the BGO, the data and reporting do not allow direct evaluation of the BGO and its SMART principles. To evaluate the objective as written, the following information is required for each survey event:

- BCCE—
  - the total length of road driven/surveyed, and
  - the length of infestation along the surveyed road.
- Riparian properties—
  - the total area surveyed on each parcel, and
  - the total infested area on each parcel.

The reporting could be done by grouping all species together, or if certain species are of particular interest, the information listed above could be reported separately for each species. Additional data that may be informative and provide context to the information listed above include:

- Tracking of patch size (area of infestation that needs to be revisited) by target species until patch size reaches 0. For example, list the patches by location (or unique ID or label) that are surveyed year after year and report the patch size year after year.
- A list of target species as determined by NPS – is each species surveyed each time? If not, report which species are surveyed for and which are not.

While NPS efforts to annually treat weeds on DCP Reserve lands are aimed at the intent behind this objective, we recommend reporting the data as bulleted above to allow for trend analysis and full evaluation of DCP's activities in achieving this objective.

Summary of whether actions are achieving BGO and SMART principles				
Specific	**Measurable**	**Achievable**	**Result-oriented**	**Time-fixed**
Treated acreage	Acres treated for invasives each year	Yes	Yes, maintain or decrease invasives	8 years
✓ Data are specific in that the numbers of treated acres per species can be reported	? See bulleted recommendations for future data reporting consistency	? See bulleted recommendations for future data reporting consistency	? Not enough consistent data to detect a stable or decreasing result	✓

Objective 1.2. Acquire riparian acreage

Acquire riparian acreage at an equivalent rate as take over the life of the permit. An 8-year lag after riparian acreage is developed is allowed to account for the willing-seller, willing-buyer basis of property exchange, within the life of the permit.

Since 2020, a total of 174.98 acres of riparian parcels have been acquired, bringing the total riparian reserve unit acreage across the Muddy and Virgin Rivers to 782.95 acres (DCP 2023a). A total of 579 acres of riparian habitat have been developed since the permit began in 2001 (Alta 2023b), indicating 202.95 more acres have been acquired than have been developed. Objective 1.2 is being met.

Summary of whether actions are achieving BGO and SMART principles				
Specific	**Measurable**	**Achievable**	**Result-oriented**	**Time-fixed**
Acquire riparian at rate of take	Acres acquired vs acres developed	Yes; 8-yr lag to accommodate willing seller / willing buyer	1:1 acreage	8-yr lag and life of permit
✓	✓	✓	✓	✓

Objective 1.3. Protect, restore, or otherwise increase the quality and quantity of habitat for MSHCP-covered species

Protect, restore, or otherwise increase the quality and quantity of habitat for MSHCP-covered species, as determined by the monitoring methods, definition of quality, and timeframes specified in the AMMP.

Section 3 below describes monitoring activities for habitats of MHSCP-covered species. The AMMP (2023a) established 'threshold' as the key metric for assessing quality and quantity of habitats. Essentially, thresholds are defined in the AMMP as statistically significant measurements of declining habitat characteristics, such as significant declines in cover, richness, composition, etc. (Table 8, Section 3.3).

Study design, methods, and data requirements for both riparian and desert upland habitat monitoring were finalized in early 2023, less than one year prior to this Adaptive Management Evaluation. Therefore, the analysis and discussion for this BGO is limited to describing the efforts DCP has taken to implement the methods in the AMMP. These efforts include:

- Data collection for desert upland habitat monitoring which began in 2023 and appear to follow the methods in the AMMP.
- A project to initiate baseline data collection for riparian habitat which is included in the 2023-2025 Implementation Plan and Budget (IPB).

Actions to achieve Objective 1.3 are beginning and are in-line with expectations, given that the AMMP was finalized less than a year ago.

Summary of whether actions are achieving BGO and SMART principles				
Specific	**Measurable**	**Achievable**	**Result-oriented**	**Time-fixed**
Increase habitat quality/quantity for 1 or more covered species through protection, restoration, and monitoring	Quantitative methods in AMMP	Yes	Projects are aimed at monitoring, protecting, and restoring habitat for 1 or more covered species	Assess biennially; continue by following AMMP habitat monitoring timeframe
✓	? Quantitative methods are in AMMP; data not yet available to test outcomes	? Data not yet available to test outcomes	✓	? Understanding of whether riparian habitat monitoring can be assessed biennially is in progress

Objective 1.4. Incorporate natural ecological, hydrological, and geomorphological processes into restoration design and implementation

Incorporate natural ecological, hydrological, and geomorphological processes into restoration design and implementation to maintain ecological integrity, ecosystem function, and biological diversity. Include consideration that climate change may result in significant changes in these processes over historical frequencies and magnitudes. Review quadrennially as part of every other AMR using project level worksheets (B1 Worksheets).

This objective relies on review of project-level worksheets (i.e., B1 worksheets) to assess whether processes are being incorporated into restoration design and implementation. Because B1 worksheets were not complete for this analysis, we used the 2022 – 2023 Biennium Progress Report (DCP 2023b) as the primary resource to evaluate whether three processes were incorporated. The following projects appear to include elements of natural processes:

- Permit Amendment – Application (Contract 2) – DCP initiated development of methodology to credit riparian restoration work at the site-specific scale to provide documentation of habitat improvements for mitigation purposes.
- BCCE Project 2: Restoration (Contract 1) – DCP planted approximately 530 salvaged native perennial plants across five different sites to camouflage access points to decommissioned roads, deter future vehicle entry, and restore habitat functionality to the areas. DCP also repaired and expanded a high-priority restoration site by re-contouring the ground to reduce line of site and minimize erosion before planting approximately 900 salvaged native perennial plants.
- Riparian Project 3: Muddy River Reserve Unit Restoration – DCP undertook habitat restoration efforts, including fuels reduction and removal of non-native plant species, to enhance and expand habitat for covered species.
- Riparian Project 4: Riparian Studies (Contract 5) – DCP completed three vegetation surveys and analyzed data from restoration activities conducted in 2014 and 2021 by Clark County within the Mormon Mesa Subunit. DCP also determined that restoration treatments reduced the invasive tamarisk, although further control treatments will likely be necessary.

B1 worksheets and any restoration planning documents, if available, should be used in the future to provide more details and examples of how DCP activities are achieving this BGO and meeting SMART principles.

The intent of Objective 1.4 appears to be met, but detailed project-level documentation was not available to complete the evaluation.

Summary of whether actions are achieving BGO and SMART principles				
Specific	**Measurable**	**Achievable**	**Result-oriented**	**Time-fixed**
Incorporate three processes into restoration design and implementation	Count tally of projects	Yes; relies on self-reporting in B1 worksheets	Result is' Yes' or 'No': the processes were incorporated into restoration design and implementation or they were not	Quadrennially
✓	✓	? Appears achievable, but B1 worksheets are not yet complete	✓	? B1 worksheets are not yet complete to evaluate

Objective 1.5. Identify critical uncertainties

Identify critical uncertainties (e.g., climate change, human population growth) of MSHCP-funded projects on DCP reserve system lands and report on them in biennial updates to the DCP Reserve System Management Plans.

This objective requires that critical uncertainties of MSHCP-funded projects on Reserve System lands are identified and reported on in biennial updates to the Plans. The Riparian Reserve Units Management Plan (DCP 2023a) and the BCCE Management Plan (DCP 2023c) list and describe the following stressors:

- Non-native and invasive species
- Altered local and regional aquifers and altered surface flow
- Fire
- Livestock trespass
- Development
- Infrastructure
- Agriculture
- Climate change
- Recreation

The 2023 Plans were reviewed for updates in spring 2023 and the Science Advisor Panel concluded that the critical uncertainties identified in the 2019 and 2021 Plans were still accurate and relevant. However, this review and conclusion were not explicitly stated in the 2023 Plans. We recommend explicit statements be included in future plans if the critical uncertainties are reviewed and the conclusion is that they do not require updates.

The critical uncertainty sections also did not link to projects (specific projects nor categories/generalizations of projects) or reports, though this objective was finalized in

February, 2023, and the 2023 Plans were finalized in March, 2023 (BCCE), and April, 2023 (Riparian). We relied on the 2022 – 2023 Biennium Progress Report (DCP 2023b) to summarize projects that address the stressors listed above. There are several individual projects and/or elements of specific projects that address these stressors, including:

- Permit Amendment – Application (Contract 1) – DCP completed Climate Change Summary Worksheets for Covered Species and habitats, and also completed significant revisions to Chapter 7, Changed and Unforeseen Circumstances.
- Permit Amendment – Application (Contract 2) – DCP completed draft appendices for covered species accounts, desert tortoise and burrowing owl clearance protocols, seed collection protocols, and climate change worksheets.
- BCCE Project 1: Management (Contracts 7 and 8) – DCP completed winter and spring weed surveys using ocular surveys by vehicle and on foot by field crews, treated weeds using low impact methods such as selective herbicide application and hand pulling/hoeing, and documented location of noxious weeds and treatments with mapping-grade GPS equipment.
- Riparian Project 1: Riparian Management (Contract 3) – DCP completed weed surveys using ocular surveys by field crews, treated weeds using low impact methods such as selective herbicide application and hand pulling/hoeing, and documented location of noxious weeds and treatments with mapping-grade GPS equipment.
- Conservation Project 1: Gila Monster – DCP worked to understand habitat requirements to assess how the species will be affected by changes in habitat (i.e., development, degradation, fragmentation) and climate.

The intent of Objective 1.5 is being met by the presence of the Critical Uncertainties section in the management plans, however we recommend two adjustments in the future:

- Include an explicit statement to the section in the management plan if it is reviewed and considered sufficient with no updates, and
- Link projects and reports as applicable to the management plan sections on critical uncertainties.

Summary of whether actions are achieving BGO and SMART principles				
Specific	**Measurable**	**Achievable**	**Result-oriented**	**Time-fixed**
Identify (specific) uncertainties in Reserve System projects	Presence of section updates (i.e., can the updates be counted?)	Yes	Result is 'Yes' or 'No': the uncertainties were identified or they were not	Biennially
Uncertainties were previously identified and are still relevant	Recommend including a statement on review and any updates	Unclear if biennial section updates connecting to project reports is achievable	Uncertainties were previously identified and are still relevant	Unclear if biennial section updates connecting to project reports is achievable

Objective 1.6. Incorporate concepts of ecosystem redundancy and representation

Incorporate concepts of ecosystem redundancy and representation to promote ecological resiliency in the biennial updates to the DCP Reserve System land Management Plans.

Concepts of ecosystem redundancy and representation to promote ecological resiliency are to be incorporated into biennial updates to the Reserve System Management Plans. The Riparian Reserve Units Management Plan from 2021 was updated to include a section on ecological resiliency, and this section was reviewed during 2023 Riparian and BCCE Plan updates. The Science Advisor Panel determined the section was still relevant and accurate, so no changes were made. Similar to Objective 1.5, we recommend explicit statements be included in future plans if the ecosystem resiliency sections are reviewed and the conclusion is that updates are not required.

According to the 2022 – 2023 Biennium Progress Report (DCP 2023b), the following projects appear to include elements of ecological resiliency:

- Permit Amendment – Application (Contract 1) – DCP developed a Habitat Quality Assessment Methodology to assess MSHCP impacts and determine the appropriate mitigation based on an ecosystem approach that accounts for both habitat quality and quantity.
- Conservation Project 3: Rare Plant Propagation Studies – DCP increased knowledge of reproductive mechanisms and propagation techniques while generating conservation seed collections to mitigate for anthropogenic disturbances and in event of unforeseen population declines.

Summary of whether actions are achieving BGO and SMART principles				
Specific	**Measurable**	**Achievable**	**Result-oriented**	**Time-fixed**
Incorporate two concepts into plan updates	Presence of section updates	Yes	Result is 'Yes' or 'No': the concepts were incorporated or they were not (ideally, this is the number of projects that made incorporations)	Biennially
Concepts were previously incorporated and are still relevant	Recommend including a statement on review and any updates	Biennial section review/updates to the Reserve System Mgmt. Plan should be achievable	Concepts were previously incorporated and are still relevant	Section review/updates to the Reserve System Mgmt. Plan can be made biennially

Objective 1.7. Protect and enhance connectivity for high priority species

Protect and enhance connectivity (i.e., road restoration, culvert placement) within DCP reserve system lands for desert tortoise and other high priority covered species. Review and report on the status of these projects quadrennially in every other AMR.

Projects from 2019 – 2022 that dealt with desert tortoise connectivity and movement contributed to a connectivity management plan that details ways in which to increase connectivity for the desert tortoise (S. Cambrin, pers. comm.).

According to the 2022 – 2023 Biennium Progress Report (DCP 2023b), the following projects appear to protect or enhance connectivity for high priority species:

- BCCE Project 2: Restoration (Contract 1) – DCP planted approximately 530 salvaged native perennial plants across five different sites to camouflage access points to decommissioned roads, deter future vehicle entry, and restore habitat functionality to the areas.
- Riparian Project 3: Muddy River Reserve Unit Restoration – DCP undertook habitat restoration efforts to enhance and expand habitat for covered species.
- Wild DT Project 3: Road Warriors – DCP conducted a pilot project to evaluate the potential use of citizen scientist volunteers to conduct systematic surveys under the guidance of qualified biologists.
- Wild DT Project 4: Evaluating Desert Tortoise Habitat Restoration Methods – DCP investigated the existing science behind habitat restoration for desert tortoise recovery to identify areas where more research is needed.
- Wild DT Project 5: Tule Springs Fence – DCP provided financial and project management assistance to Tule Springs Fossil Beds National Monument to construct combination post-and-cable fencing with desert tortoise exclusion fencing along the western boundary of the monument. The project provided for protection of sensitive environmental resources within the Monument and will also protected desert tortoises from crossing U.S. Highway 95.
- AMP Project 3: Desert Tortoise Connectivity Studies – DCP initiated this project with the larger goal of developing a management plan that addresses desert tortoise habitat connectivity within Clark County, Nevada. Smaller projects focused on data collection related to on-the-ground aspects of connectivity, including determining proper corridor designs and examining how tortoises overcome anthropomorphic impediments (e.g., roads) to habitat connectivity.

In addition to the acquirement of riparian acreage discussed above, over 10 acres and more than 8 miles of roads were reclaimed (Table 4).

Table 4. Roads restored

Year	Active Restored (ac)	Active Restored (linear ft)	Reclaimed (mi)
2020	9.5	15791.5	3.4
2021	0.4	1731.7	2.8
2022	0.4	1562.5	2.5
2023	0.0	0.0	0.0

Objective 1.7 is being met.

Summary of whether actions are achieving BGO and SMART principles				
Specific	**Measurable**	**Achievable**	**Result-oriented**	**Time-fixed**
Initiate projects	Countable within Implementation Plan and Budget plans	Yes, especially if Reserve System grows	Result is 'Yes' or 'No': whether projects were initiated and aimed at improving connectivity	Quadrennially
✓	✓	✓	✓	✓

Objective 2.1. Monitor covered wildlife species

Monitor covered wildlife species as described in the AMMP. Report quantitative population data, as described in the AMMP, for covered species biennially in the AMR and report statistical analyses of population trends quadrennially in every other AMR.

Section 3 below describes monitoring activities for covered wildlife species and includes analysis of population trends. The AMMP (Alta 2023a) established 'threshold' as the key metric for assessing species' populations. Essentially, thresholds are defined in the AMMP as statistically significant measurements of failing populations, such as significant declines in abundance, density, occupancy, etc (Section 3.1).

Surveys for avian species were conducted at riparian reserve units in 2017 – 2022 and at BCCE in 2018 – 2022. Data were collected for desert tortoises from 2013 – 2023, with the exception of 2019, while data collection for Great Basin collared lizards, desert iguanas, and leopard lizards began in 2015. Data for bats have been collected and processed for a single year at upland and a single year at riparian survey sites, so temporal trends in occupancy cannot yet be modeled. The first-year results should be appended with future survey results and appropriate general(ized) linear models should be used to monitor trends in area occupied and population size to meet the monitoring requirements outlined in the AMMP.

Objective 1.2 is being met.

Summary of whether actions are achieving BGO and SMART principles				
Specific	**Measurable**	**Achievable**	**Result-oriented**	**Time-fixed**
Survey and report	Methods in AMMP	Yes	Result is 'Yes' or 'No': whether actionable data were collected	Biennially and quadrennially
✓ Surveys were conducted	✓ Methods are appropriate and as described	✓	✓	✓

Objective 2.2. Conduct surveys for covered plant species

Conduct surveys for covered plant species as described in the AMMP. Protect, conserve, and monitor known occurrences of these species annually. Report quantitative population data as

described in the AMMP biennially in the AMR, and report statistical analyses of population trends quadrennially in every other AMR.

Section 3 below describes monitoring activities for covered plant species. The AMMP (Alta 2023a) established 'threshold' as the key metric for assessing species' populations. Essentially, thresholds are defined in the AMMP (Alta 2023a) as statistically significant measurements of failing populations, such as significant declines in abundance, density, occupancy, etc. (Table 6 below).

An exploratory survey for MSHCP-covered plant species occurred in 2021 and four MSHCP-covered plant species (sticky ringstem, Las Vegas bearpoppy, white bearpoppy, and Blue Diamond cholla) were located off reserve unit lands. The AMMP specifies monitoring for MSCHP-covered plants if they are detected on reserve unit lands. Until such time as MSHCP-covered plant species are detected on reserve unit lands, monitoring data is not expected to be collected, nor to be sufficient for a statistical test.

Objective 2.2 is being met.

Summary of whether actions are achieving BGO and SMART principles				
Specific	**Measurable**	**Achievable**	**Result-oriented**	**Time-fixed**
Survey and report	Methods in AMMP	Yes	Result is 'Yes' or 'No': whether actionable data were collected if species were found	Biennially and quadrennially
✓ An exploratory survey was conducted and reported on in 2021	✓	✓ Appears achievable given exploratory effort	✓	✓

Objective 2.3. Translocate and augment desert tortoise populations

Translocate and augment desert tortoise populations in accordance with USFWS guidance through translocation programs that achieve survivorship rates within 10 percentage points of resident tortoise survival rates in the same areas (or with survivorship as prescribed by USFWS guidance). Report survivorship data biennially in the AMR and report analysis on aggregated translocated tortoise survivorship compared to aggregated resident tortoise survivorship quadrennially in every other AMR.

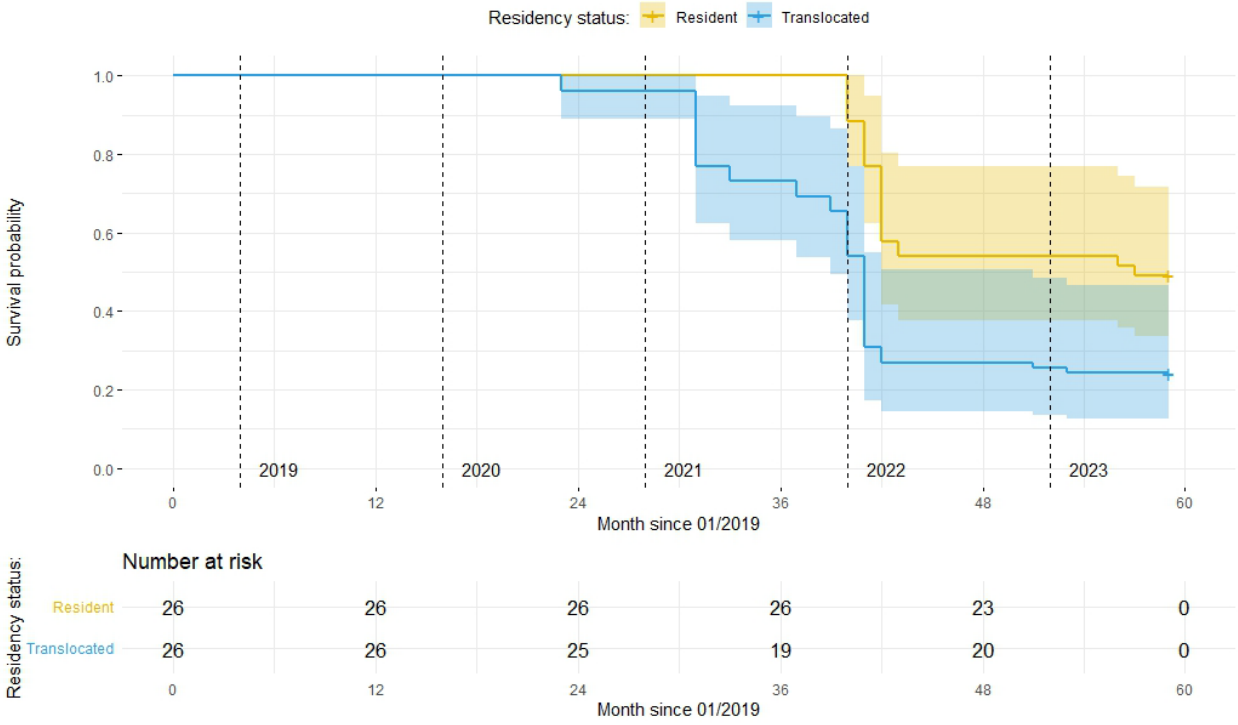
The desert tortoise has been monitored annually since 2013 on the BCCE. The goal of this evaluation was to quantify survival rates over the last 4 years for resident versus translocated tortoises to determine if translocated tortoises are surviving post-translocation and whether resident tortoises show decline in survival after translocated animals are released into the population.

We used staggered-entry Kaplan-Meier methods and the 'survival' package (Program R v4.2.2) to analyze survival of tortoises from January, 2019, through November, 2023, following previous methods and assumptions (Alta 2020, Appendix B Attachment C). The dataset consisted of 74 individual tortoises (35 residents, 39 translocated). The statuses of two tortoises were unknown

but because the transmitters were found ripped off, we presumed them dead for a total of 35 mortality events (14 resident, 21 translocated).

Analysis showed that translocated and resident tortoises survive at relatively equivalent rates (Figure 1). Resident tortoises appear unaffected by translocation efforts, indicating that translocated tortoises do not negatively impact residents. Survival rates at the end of the period were 0.492 (95% CI 0.337 – 0.717) for residents and 0.242 (95% CI 0.127 – 0.464) for translocated tortoises. However, because the survival rate for translocated tortoises is not within 10 percentage points of the survival rate of resident tortoises, or with survivorship as prescribed by USFWS guidance (USFWS 2020), the 'equivalent survivorship' portion of this BGO is not being achieved.

Figure 1. Kaplan-Meier survival curves and 95% confidence intervals for Mojave desert tortoises on the Boulder City Conservation Easement, NV, 2019 - 2023.



Objective 2.3 is being not met. We recommend continued evaluation to determine likely causes of the difference in survival between resident and translocated tortoises. Additional project concepts that may provide valuable information could include newly started projects investigating predator-prey dynamics, removal of predator subsidies near Boulder City, pausing translocations during times of drought, or investigating other release sites (e.g., Stump Springs). Expanded analysis of mortality rates on nearby monitored populations (e.g., solar projects, connectivity research study animals) may be warranted to investigate regional survivorship.

Summary of whether actions are achieving BGO and SMART principles				
Specific	**Measurable**	**Achievable**	**Result-oriented**	**Time-fixed**
Translocate and monitor survival	Translocation events; quantify survival rates	Yes, assuming availability/permission for translocations	Equivalent survivorship	Quadrennially
✓	✓	✓	☒	✓

Objective 2.4. Ensure the best available scientific information is evaluated and incorporated into population management efforts

Ensure the best available scientific information is being evaluated and incorporated into population management efforts for covered species, including monitoring methods and identification of critical uncertainties (e.g., climate change, human population growth), by completing a focused literature review (or Systematic Review) and updating it quadrennially in the AMMP.

AMMP revisions were finalized in February, 2023. In doing so, the best available scientific information (e.g., current, up-to-date monitoring methods) was incorporated. The Science Advisor Panel stays abreast of the latest methods and regularly updates the DCP via lightning talks at quarterly meetings. The DCP has integrated the latest science by adopting passive acoustic monitoring for birds and bats and passive aeolian catchment structures for creation of plant microhabitats. Examples of recent scientific information used include:

- Darras, K., P. Batary, B.J. Furnas, I. Grass, Y.A. Mulyani, and T. Tscharntke. 2019. Autonomous sound recording outperforms human observation for sampling birds: A systematic map and user guide. Ecological Applications 29:e01954.

Objective 2.4 is currently being met.

Summary of whether actions are achieving BGO and SMART principles				
Specific	**Measurable**	**Achievable**	**Result-oriented**	**Time-fixed**
Review and incorporate	Updated AMMP sections	Yes	Using best available scientific information	Quadrennially / when AMMP is updated
✓	✓	✓	✓	✓

Objective 3.1. Develop and disseminate educational materials

Develop and disseminate educational materials that cover the following topics: 1) the value of the desert ecosystem in Clark County; 2) promoting responsible recreation; 3) promoting following development procedures; and 4) avoiding and minimizing impacts to the environment. Re-evaluate material's relevance quadrennially (branding, technology, social and recreation trends, etc.).

This objective is meant to educate the public on the following four topics:

1) the value of the desert ecosystem,
2) responsible recreation,
3) development procedures, and
4) avoiding and minimizing impacts to the environment.

Recent (2022 – 2023) DCP Public Information and Education accomplishments to develop and disseminate educational materials include the following:

- The 2022 – 2023 school year ended with 20 school assemblies and over 60 Tortoise Talks (reaching over 4,500 students directly)
- Revised education materials into two age-appropriate categories (K-2 and 3-5)
- Hosted Mojave Max assemblies for homeschool students for the first time in the history of the program
- Facilitated the Mojave Max Emergence Contest (a total of 4,584 students entered a guess)
- Facilitated Mojave Max Emergence Contest winner announcement and field trip
- Facilitated multiple media interviews with both local and national news outlets
- Hosted education tables at multiple outreach events, including the Clark County Fair and Rodeo, several County Commissioners' community events, multiple events at the Clark County Wetlands Park, OHV 3-day event in Logandale, and the Mint 400 off-road race
- Expanded direct outreach to new groups, including Senior Citizens, OHV event participants, Future Farmers of America students, and SafeKey after school programs
- Adapted the Mojave Max presentation to accommodate learning by visually impaired/blind students using tactile interaction
- Increased social media followers by 17%
- Increased social media postings by 12%
- Expanded social media platforms by adding TikTok and LinkedIn accounts
- Held dust classes for developers and distributed flyers promoting responsible development and recreation

Objective 3.1 is currently being met.

Summary of whether actions are achieving BGO and SMART principles				
Specific	**Measurable**	**Achievable**	**Result-oriented**	**Time-fixed**
Education materials on four topics developed or disseminated	List of products developed/disseminated annually	Yes	Number of educational materials developed and/or members of the public or development educated	Annually with re-evaluation quadrennially
✓	✓	✓	✓	✓

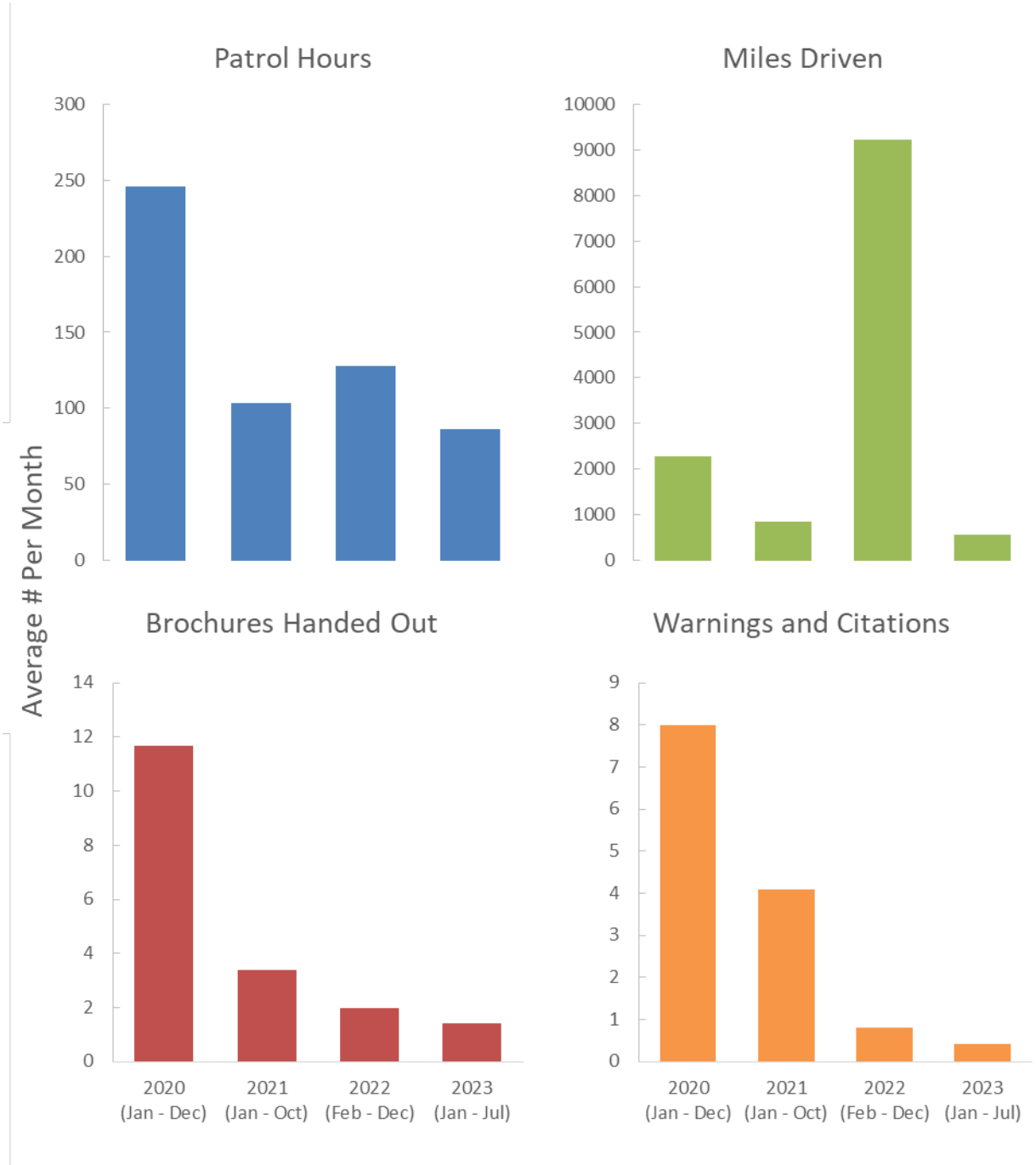
Objective 3.2. Protect habitats within the BCCE from unauthorized land use

Protect habitats within the BCCE from unauthorized land use through vigilance (by patrolling an average of at least 100 hours each month) and education (by providing information during encounters). Compile data annually and report quadrennially in every other AMR.

Data used to evaluate whether habitats are being protected from unauthorized land use include the average number of patrol hours spent per month, average number of miles driven per month, average number of brochures handed out per month, and the average number of warnings and citations issued per month (Figure 2).

This objective is being met through an average of at least 100 hours per month of patrol by law enforcement and the distribution of brochures.

Figure 2. Action taken (average number per month) to protect habitats from unauthorized land use, 2020 – 2023.



Objective 3.2 is currently being met.

Summary of whether actions are achieving BGO and SMART principles				
Specific	**Measurable**	**Achievable**	**Result-oriented**	**Time-fixed**
Law enforcement presence	Hours / month; numbers and descriptions of encounters	Yes	Result is 'Yes' or 'No': whether the 100/hrs/mo are being met and information is being distributed during encounters	Annually and Quadrennially
✓	✓	✓	✓	✓

Objective 3.3. Provide information to permitted users about BMPs

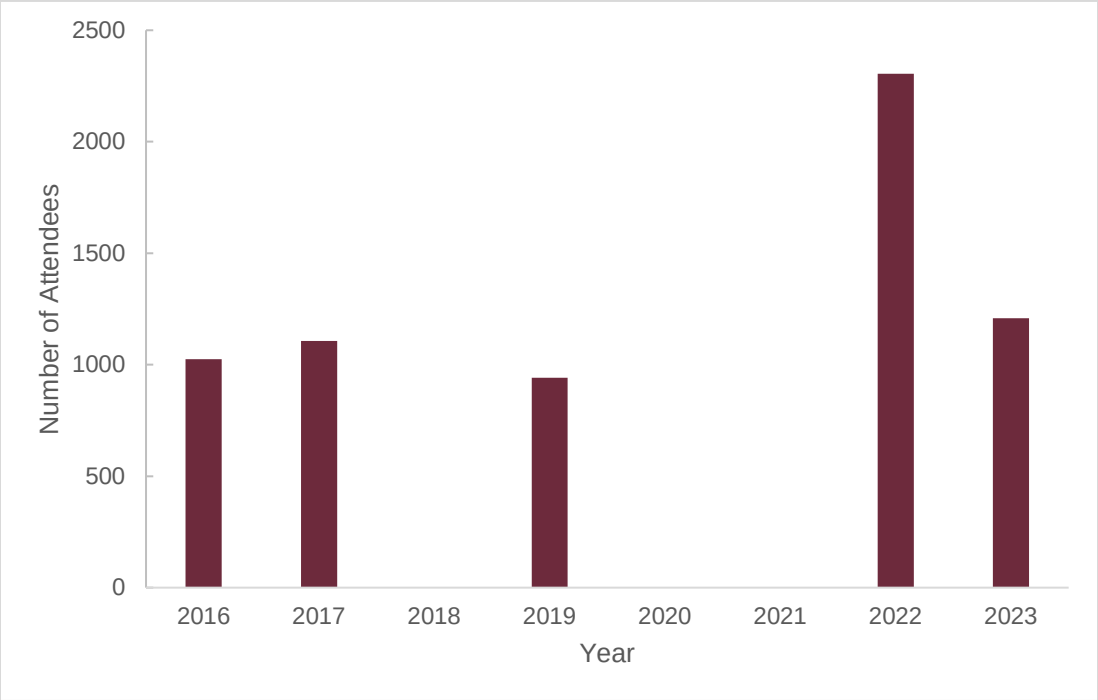
Provide information to permitted users (project proponents, construction personnel, researchers, biological consultants) about best management practices (BMPs) for the desert tortoise and associated reporting procedures. If BMPs are developed for other covered species, this objective would expand to apply to them also. Compile data annually and report quadrennially in every other AMR.

This objective is met largely through participation in air quality dust classes (Table 5, Figure 3) that are held at the Clark County building, typically twice per month. The dust class is required for construction personnel to obtain a dust permit. The DCP gives a 15-minute presentation at the beginning of all on-site dust classes. The presentation consists of a 10-minute video covering procedures for tortoise encounters and is followed up by a question-and-answer period.

Table 5. Dust class attendance

	2022	2023
January	96	167
February	111	195
March	230	165
April	202	146
May	187	141
June	330	287
July	284	108
August	251	NA
September	314	NA
October	100	NA
November	76	NA
December	124	NA
Total	**2305**	**1209**

Figure 3. Dust class attendance 2016 – 2023.



NOTE: In 2018, no attendee count data were retained, but classes were held consistently twice per month from January – September. No classes were held in 2020 – 2021, due to the COVID-19 pandemic.

In addition to the dust classes, DCP provides desert tortoise training to contractors each year. They provide a two-day training to 8 – 10 biologists for occupancy sampling, which includes a background on the project, what and how the data are to be collected, a short tutorial on reptile identification, and a field visit to practice collecting data and performing surveys. The DCP also teams with the USFWS to provide training for range-wide monitoring which includes walking transects and correcting search patterns, training from a licensed veterinarian on proper biosecurity and disease symptoms, handling training, and telemetry training. This training is for biologists with little to no tortoise experience and lasts two weeks. Additional training occurs during translocation events, when biologists can sign up to participate and gain handling experience that counts towards their Authorized Biologist permits.

Objective 3.3 is currently being met.

Summary of whether actions are achieving BGO and SMART principles				
Specific	**Measurable**	**Achievable**	**Result-oriented**	**Time-fixed**
Education	Counts / events	Yes	Developer and biologist education (# of users to which information was disseminated)	Annually and Quadrennially
✓	✓	✓	✓	✓

2.1 Summary of Actions Taken to Achieve SMART BGOs

The nature and intent of all 14 BGOs are being addressed by DCP, but not all objectives are completely met. The assessment of whether/how data and projects inform on the SMART principles is tallied by the each of the 14 BGOs including 5 smart principles (14*5=70 individual components of the SMART principles). Of the 70 SMART principle components:

- 58 of them appear to be accomplishable and on-track, receiving a
- 12 of them received a because it is unclear whether the desired outcome can or will be achieved, generally due to lack of data, or a specific aspect that is problematic and noted in each section.
- One objective is not achieving all components and received a

3 Evaluation of species and habitat monitoring

MSHCP-covered species and habitat monitoring are described in the AMMP (Alta 2023a), including the process for evaluating status and trends. A threshold is used to determine if there is statistical evidence that a monitored population or habitat is faring poorly—the threshold being a statistically significant declining trend. If the threshold is reached, the adaptive management process is enacted to identify causes and possible remedies to the declines.

3.1 Methods for species monitoring

Twenty-eight individual species are included for monitoring and subsequent analysis as part of this four-year adaptive management evaluation (Table 2 of the AMMP, Alta 2023a; Table 6 here). This includes 4 reptile species, 15 avian species (8 covered under the current MSHCP and 7 that are proposed for coverage under permit amendment), 5 bat species (3 that are covered by the current MSHCP, and 2 that are proposed for coverage under the amendment), and 4 plant species. MSHCP-covered species not specifically named in this list are assumed to be covered by the general riparian and desert upland habitats as a proxy for monitoring their populations. Species listed in Table 6, below, that are not currently MSHCP-covered species, are included because their monitoring data will be used as baseline data for informational purposes only.

The following sub-sections describe data and analysis methods for each of the species, followed by sub-sections that describe analysis results. For clarity, Table 6, below, includes information on both the methods and the overall results regarding whether the threshold was exceeded.

Table 6. Methods and threshold results for species monitoring.

Species[a]	Monitoring Survey	Covered Species Group[a]	Threshold[b] Exceeded?
Desert tortoise	Occupancy sampling	Desert upland reptiles	No
Great Basin collared lizard			Unknown
Desert iguana			No
Large-spotted leopard lizard			No
Yellow-billed cuckoo	Federal protocol	-	No
Southwestern willow flycatcher	Federal protocol	-	No
Blue grosbeak	Point count / passive acoustic occupancy	Riparian birds	No
Summer tanager			Unknown
Vermillion flycatcher			Unknown
Arizona Bell's vireo			No
Ridgway's rail			NA
American peregrine falcon		Desert upland birds	Unknown
Phainopepla			No
Western burrowing owl			*NA*
Gilded flicker			*NA*
Loggerhead shrike			*NA*
Bendire's thrasher			*NA*
Le Conte's thrasher			*NA*
Golden eagle			*NA*
Silver-haired bat	Passive acoustic occupancy	Bats	Unknown
Long-eared myotis			Unknown
Long-legged myotis			Unknown
Townsend's big-eared bat			*NA*
Spotted bat			*NA*
Sticky ringstem	Three-tiered sampling	Desert upland plants	Unknown
Las Vegas bearpoppy			Unknown
White bearpoppy			Unknown
Threecorner milkvetch			Unknown

[a]Species in **bold** are federally listed under the Endangered Species Act. Species in *italics* are proposed to be covered under a future amended MSHCP. Currently covered and proposed species not included here are sufficiently rare, cryptic, or unknown as to whether they are specifically surveyed for; these species are assumed to be covered using desert upland or riparian habitat quality as a surrogate.

[b]The threshold is a statistically significant downward trend in populations on reserve lands during the assessment period. Proposed covered species under the upcoming MSHCP amendment should have data and trends presented in reports, but do not have associated thresholds because they are not currently covered by the MSHCP (i.e., Threshold Exceeded = NA).

3.1.1 Reptiles

Surveys to determine occupancy of desert tortoises were conducted from 2013 through 2023, except for 2019. Additional reptile species were incidentally observed and recorded during the desert tortoise surveys starting in 2015. We used dynamic occupancy models (MacKenzie et al. 2003) and the 'unmarked' package (Program R v4.2.2) to analyze the data of desert tortoises, desert iguanas, and leopard lizards. We fit fully-parameterized models to each species' data, which allowed colonization, extinction, and the probability of detection to vary independently from year to year. We then used these estimated rates to derive the estimated annual occupancy rates. We tested for a statistical trend over time with constant intercept (i.e., no trend), simple linear trend, and quadratic trend regressions on the estimated annual occupancy rates. We compared models using Akaike's Information Criterion adjusted for small sample size (i.e., AICc).

3.1.2 Birds

Surveys for the ESA-listed yellow-billed cuckoo and southwestern willow flycatcher followed established federal survey protocols specific to each species and took place at multiple riparian reserve units each year from 2017 - 2022. Surveys included 4 – 5 visits within a breeding season to conduct callback surveys and visual point counts. To account for unequal sizes of survey areas and unequal time spent (effort) in each unit, we standardized the detections of individuals by the number of hours spent surveying each unit.

Point count surveys for all other avian species were conducted at riparian reserve units in 2017 – 2022 and at BCCE in 2018 – 2022. Surveys were 10 minutes in duration and survey stations were visited three times each year. Each avian species observed was recorded along with the estimated distance from the survey point. For the avian species for which there were sufficient data (three currently listed: Bell's vireo, blue grosbeak, and phainopepla; one proposed for future listing: LeConte's thrasher), we analyzed the trends in occupancy rates using each species' detection/non-detection data and dynamic occupancy models using the 'unmarked' package (Program R v4.2.2). We fit fully parameterized models to each species' data, which allowed colonization, extinction, and the probability of detection to vary independently from year to year. We then used these estimated rates to derive the estimated annual occupancy rates. We tested for a statistical trend over time with constant intercept (i.e., no trend), simple linear, and quadratic regressions on the estimated annual occupancy rates. We compared models using Akaike's Information Criterion (AIC) adjusted for small sample size.

We also used distance sampling models with the 'unmarked' package (Program R v4.2.2) to assess trends in the detection-corrected densities of the same three species. For each species, we used AIC to select the distance decay function that best approximated imperfect detection of that species based on half-normal, hazard, exponential, and uniform decay functions. We allowed detection probabilities to vary independently from year to year to more accurately specify the decay function.

3.1.3 Bats

Passive acoustic monitors were deployed for six to nine nights at each of 16 sites on the BCCE in May – July, 2018, and at 13 sites on riparian reserve properties in May – August, 2019. Of the five covered or proposed covered species, only silver-haired bats and Townsend's big-eared bats were detected using passive acoustic monitoring. We modeled occupancy of these two bat species using multi-species occupancy analysis (Rota et al. 2016). We considered individual survey nights as independent survey occasions. We modeled occupancy of the two species by upland or riparian habitat type. We also estimated detection probability (i.e., the probability of

detecting a species on a given survey night given that they truly occurred at the survey site). We used the spreadsheet column 'FinalSpeciesID' as the definitive record on acoustic analysis and collapsed the occurrence records to 1/0 (i.e., detected/not detected) for each survey station-night combination. We assumed no misidentification of bat species. At the time of writing this report, data have been processed for a single year at both upland and riparian survey sites. Therefore we did not model temporal trends in occupancy of survey sites but encourage this type of analysis in the next AMMP analysis (Balantic and Donovan 2019). We used the 'unmarked' package in Program R (v4.2.2) for occupancy estimation.

3.1.4 Plants

Contractor biologists conducted an exploratory survey at 16 locations, covering 10,168 acres to locate populations, calculate area occupied, and count the number of individuals of five MSHCP-covered plants (four in AMMP Table 2 [Table 6 in this document]: sticky ringstem, Las Vegas bearpoppy, white bearpoppy, and threecorner milkvetch; one not in AMMP Table 2: Blue Diamond cholla). Survey methods and results were presented in Ironwood (2021) and summary results are presented in section 3.2.4. As described in the AMMP – Appendix C, if MSHCP-covered plants are located on DCP reserve lands in the future, monitoring as outlined in the AMMP will begin.

3.2 Results for species monitoring

3.2.1 Reptiles

A total of 2,970 reptile occupancy surveys were conducted between 2013 and 2023. During these surveys, a desert tortoise was observed within the survey plot 184 times. Other reptile species were less common, with 60 desert iguanas, 58 leopard lizards, and 3 Great Basin collared lizard observed between 2015 and 2023.

Detection probability of live desert tortoises varied among years, with the lowest detection probability of 0.097 in 2015 and the highest probability of 0.338 in 2013 (Figure 4). Apparent occupancy rate of desert tortoises also varied, ranging from a low of 0.131 in 2013 to a high of 0.531 in 2015 (Figure 5). Of the three models tested for trend analysis, the no-trend model was best-supported compared to either the linear (ΔAICc = 4.1) or quadratic (ΔAICc = 4.8) trend models.

Figure 4. Estimated detection probabilities and error bars (+/- 1 SE) for Mojave Desert tortoises on the Boulder City Conservation Easement, NV, 2013 - 2023.

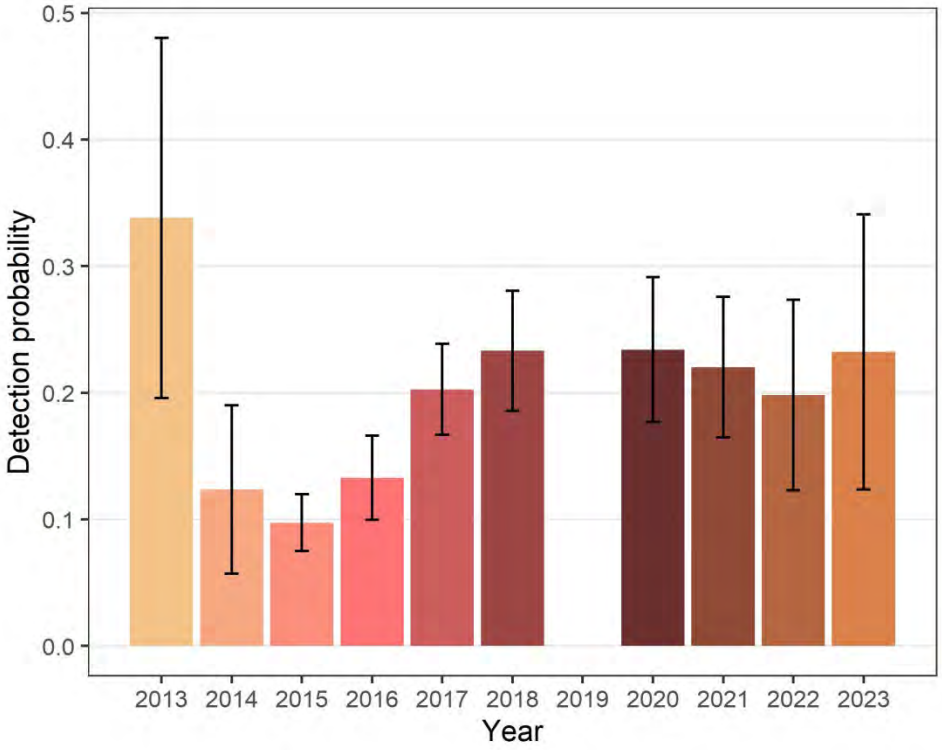
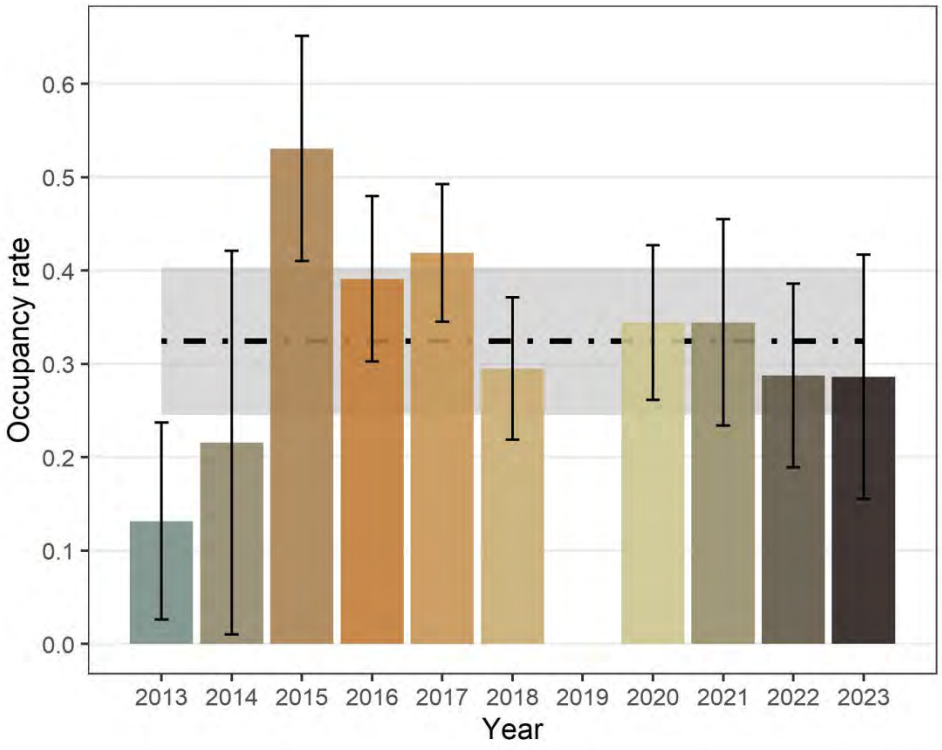
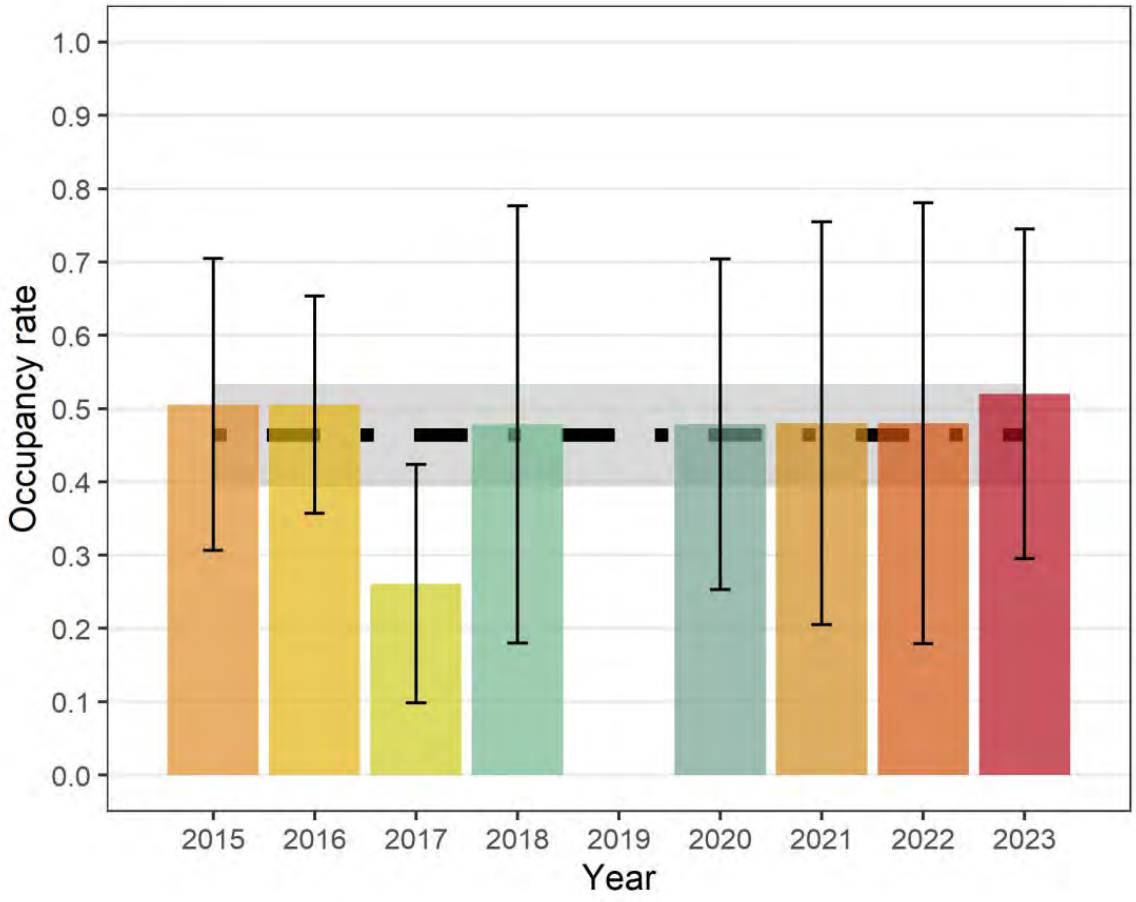


Figure 5. Estimated occupancy rates and error bars (+/- 1 SE) for Mojave Desert tortoises on the Boulder City Conservation Easement, NV, 2013 - 2023.



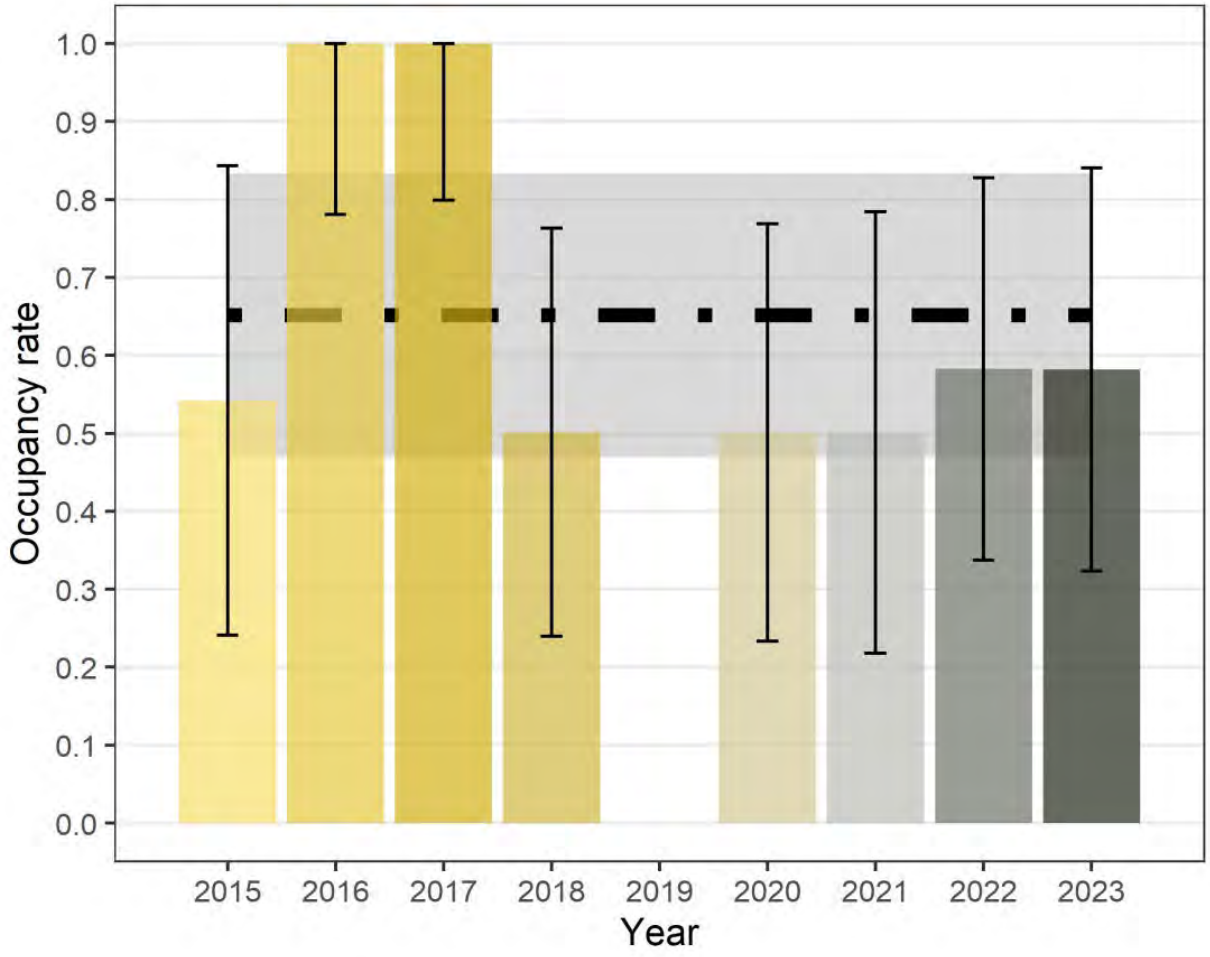
Detection probabilities for desert iguanas were low, ranging from 0.005 in 2018 to 0.111 in 2017 while occupancy rates ranged from 0.261 in 2017 to 0.520 in 2023 (Figure 6). The no-trend model performed best, fitting the trend in occupancy considerably better than the linear (ΔAICc = 5.2) or quadratic (ΔAICc = 13.0) trend models.

Figure 6. Estimated occupancy rates and error bars (+/- 1 SE) for desert iguanas on the Boulder City Conservation Easement, NV, 2015 - 2023.



Detection probabilities for leopard lizards were also low, ranging from 0.009 in 2021 to 0.057 in 2020. Estimated occupancy rates of leopard lizards varied, ranging from 0.501 in 2018 and 2020 to almost 1.000 in 2016 and 2017 (Figure 7). The no-trend model performed best and fit the occupancy trend considerably better than either the linear (ΔAICc = 3.9) or quadratic (ΔAICc = 13.2) trend models.

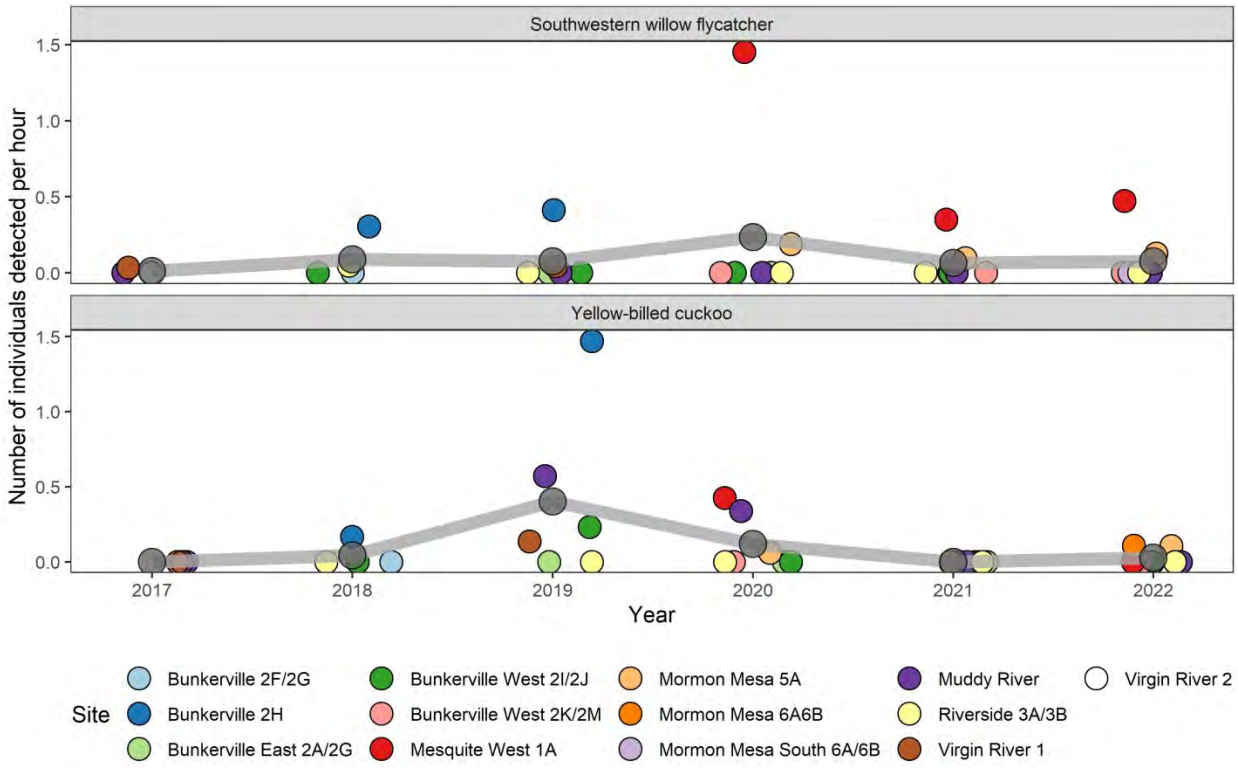
Figure 7. Estimated occupancy rates and error bars (+/- 1 SE) for leopard lizards on the Boulder City Conservation Easement, NV, 2013 - 2023.



3.2.2 Birds

Individual birds detected per hour of survey effort has remained relatively steady across time from 2017 through 2022 for both yellow-billed cuckoos and southwestern willow flycatchers, except for an increase in flycatchers detected on the Mesquite West 1A unit from 2020 to 2022 and cuckoos on Bunkerville 2H unit in 2019 (Figure 8).

Figure 8. Number of southwestern willow flycatchers and yellow-billed cuckoos detected per hour of survey effort, Clark County, NV, 2017 - 2022.



Note: Color circles are individual reserve units and gray circles are within-year averages across units.

Throughout 2017 – 2022, the number of detections of non-ESA listed birds on riparian reserve units and the BCCE varied greatly. On riparian reserve units, surveyors detected phainopeplas a total of 40 occasions on 21 sites ($\bar{x}$ = 0.7 detections/site, max = 5 detections/site). Blue grosbeaks were observed on 72 occasions on 32 sites ($\bar{x}$ = 1.2, max = 5), and Arizona Bell's vireos were observed 172 occasions on 44 sites ($\bar{x}$ = 2.9, max = 9). Surveyors also detected vermilion flycatchers on 6 occasions, summer tanagers on 6 occasions, peregrine falcons on 9 occasions, and loggerhead shrikes on 10 occasions.

Throughout 2018 – 2022 on the BCCE, golden eagles were observed once, phainopeplas twice, and loggerhead shrikes on 12 occasions, while LeConte's thrashers were observed on 32 occasions on 24 sites ($\bar{x}$ = 0.8, max = 3).

Estimated occupancy rates of phainopeplas in the riparian reserve units ranged from 0.287 in 2019 to 0.576 in 2017. The no-trend model performed best and fit the occupancy trend considerably better than either the linear (ΔAICc = 8.4) or quadratic (ΔAICc = 23.1) trend models, suggesting occupancy appears to be stable.

Estimated occupancy rates of blue grosbeaks in the riparian reserve units ranged from 0.507 in 2017 to 0.637 in 2021. The no-trend model performed best and fit the occupancy trend better than either the linear (ΔAICc = 9.9) or quadratic (ΔAICc = 37.5) trend models, suggesting occupancy appears to be stable.

Estimated occupancy rates of Arizona Bell's vireos in the riparian reserve units ranged widely, from 0.233 in 2017 to 0.810 in 2018. The no-trend model still performed best and fit the occupancy trend better than either the linear (ΔAICc = 9.8) or quadratic (ΔAICc = 33.9) trend models, suggesting occupancy appears to be stable.

Estimated occupancy rates of LeConte's thrashers on the BCCE ranged from 0.471 in 2018 to 0.999 in 2022. The no-trend model performed best and fit the occupancy trend better than the linear (ΔAICc = 16.1) model, suggesting occupancy appears to be stable. The high occupancy estimates are due to very, very low detection probabilities, making the occupancy estimates somewhat unreliable.

3.2.3 Bats

Silver-haired bats were detected at six of 16 BCCE sites in 2018 and at all 13 riparian sites in 2019. Townsend's big-eared bats were detected at zero BCCE sites in 2018 and at four of the riparian sites in 2019. The multi-species occupancy model found that habitat type (upland versus riparian) did better at predicting occupancy rates than a model where habitat type was ignored (ΔAIC = 13.0). Detection probability of silver-haired bats was moderate (p = 0.55, 95% CI 0.47 – 0.63) but was low for Townsend's big-eared bats (p = 0.04, 95% CI 0.02 – 0.11). Silver-haired bats were more likely to occupy riparian sites than BCCE sites (riparian ψ = 1.00, 95% CI 0.00 – 1.00; BCCE ψ = 0.38, 95% CI 0.00 – 1.00) whereas Townsend's big-eared bats were much more likely to occupy riparian sites than BCCE sites (riparian ψ = 1.00, 95% CI 0.00 – 1.00; BCCE ψ = 0.00, 95% CI 0.00 – 1.00).

3.2.4 Plants

Exploratory plant surveys were conducted off of the reserve units to better understand where MSHCP-listed plant species are likely to occur in Clark County, including potentially on resrve units. Three of the four plant species listed in AMMP Table 2 (sticky ringstem, Las Vegas bearpoppy, and white bearpoppy) and an additional MSHCP-covered species (Blue Diamond cholla) were located (Table 7). Threecorner milkvetch and all other MSHCP-covered vascular plants were not located during the surveys. Although these located populations will not be monitored as part of the AMMP, their contributions to improved species distribution models may facilitate locating and monitoring within the reserve units.

Table 7. Summary results of rare plant surveys in Clark County, NV, 2021.

Common name	Species	No. locs.	Area Occupied (ac)	No. individs.
Sticky ringstem	*Anulocaulis leiosolenus*	5	19.2	90
Las Vegas bearpoppy	*Arctomecon californica*	6	22.9	579
White bearpoppy	*Arctomecon merriamii*	3	37.5	135
Blue Diamond cholla	*Cylindropuntia multigeniculata*	6	1427.6	> 16,772
Threecorner milkvetch	*Astragalus geyeri* var. *triquetrus*	not found		

3.3 Methods for habitat monitoring

Two vegetation communities (riparian and desert upland) are included for monitoring and evaluation (Table 8) to comply with MSHCP requirements. To aid in defining quality habitat on DCP's riparian properties, monitoring focuses on MSHCP-covered avian species and their habitat requirements for breeding. DCP's upland property consists of the BCCE, which is the focus for long-term monitoring of important ecosystem attributes and processes that contribute to biotic integrity, soil and site stability, and hydrologic function (Belnap et al. 2008, Herrick et al. 2009, Herrick et al. 2017).

Table 8. Methods and results for habitat monitoring.

Habitat	Monitoring Survey	Monitored Habitat Characteristics	Threshold	Threshold Exceeded?[a]
Desert upland	AIM protocol augmented with remote sensing	Foliar cover	Statistically significant decline	Unknown
		Species richness	Statistically significant decline	Unknown
		Vegetation height	Statistically significant decline	Unknown
		Percent bare ground	Statistically significant increase	Unknown
		Proportion of soils surface in gaps	Statistically significant increase	Unknown
		Soil aggregate stability	Statistically significant decline	Unknown
Riparian	Remote sensing with ground truthing	Cover: • Vegetation composition • Total cover • Cover by functional group or species • Cover by canopy (understory vs overstory)	Thresholds are not defined for each riparian habitat characteristics because the MSHCP-covered avian species have widely diverging habitat requirements. A mosaic of habitat for all species should be maintained across all properties. The collective threshold for riparian habitat is a significant increase in acreage across all DCP riparian lands that does not meet requirements for any MSCHP-covered avian species (AMMP Appendix C; increase must not be due to natural event [e.g., severe flooding] nor the result of active restoration [e.g., tamarisk mastication]).	Unknown
		Vegetation Height: • Overall / average height • Height by canopy level		
		Vegetation Density		
		Vigor / greenness		

[a]Threshold exceedance of 'Unknown' indicates insufficient data for trend analysis at this time.

3.3.2 Riparian

Several datasets are potentially available for use in riparian habitat monitoring depending on scale or extent of analysis and desired level of quality, minimum thresholds, resolutions, and specifications for remote-sensing sensors (Table 9). Data and analysis described in this section are introductory and opportunistic. Requirements for riparian habitat monitoring and associated analyses were not described in the AMMP until 2023; therefore there is no expectation that DCP has obtained sufficient data for full analysis. Future AMRs will address this need.

The California Wildlife Habitat Relationships (CWHR; described further in the AMMP, Alta 2023) method is the focus on riparian habitat monitoring because it focuses on habitat needs of the MSHCP-listed avian species, includes habitats similar to riparian areas in the Mojave desert, and has an established and efficient assessment method used by land managers.

Table 9. AMMP-Recommended analyses and sensors for riparian habitat attributes

Habitat Attribute	Minimum Change-detection	Specific Attribute / Analysis	Recommended Sensor for Quantitative Results
Cover[a]	10% cover change	Vegetation and ground composition	4+ Band MS
			LiDAR
		Total cover	4+ Band MS; and/or LiDAR (CRR analysis)
		Cover by group and/or species	4+ Band MS
		Understory vs overstory	LiDAR
Height[a]	2.0-ft height change	Overall/average height	LiDAR
		Height by canopy level	LiDAR
Vegetation Density[b]	Not required for CWHR	LAI/LAD	4+ Band MS (LAI); and/or LiDAR (LAD)
		NDVI / MSAVI	4+ Band MS
Vigor/ Greenness[b]	Not required for CWHR	NDVI/MSAVI/TGI (visible bands)	4+ Band MS
		Live vs stressed vs dead	RGB and/or 4+ Band MS (neither sensor will result in a reliably quantitative analysis)
Geomorphology[b]	Not required for CWHR	Slopes/bank height	LiDAR

CWHR = California Wildlife Habitat Relationships
LAD = Leaf Area Density; LAI = Leaf Area Index; LiDAR = Light Detection and Ranging; MS = multispectral
MSAVI = Modified Soil-Adjusted Vegetation Index; NVDI = Normalized Difference Vegetation Index
RGB = Red-Green-Blue; TGI = Triangular Greenness Index
[a] Required attribute for CWHR.
[b] Not required, but highly recommended for characterizing general riparian habitat health and to document change over time. These habitat attributes are calculated from the same dataset as those required for CWHR.

For this assessment, publicly available National Agriculture Inventory Program (NAIP) aerial imagery was used from 2019 and 2022 to calculate three riparian attributes included in Table 9:

- Cover > > Total cover,
- Vegetation Density > > NDVI/MSAVI
- Vigor/Greenness >> NDVI/MSAVI/TGI

The NAIP imagery consisted of 4 bands: red, green, blue, and near-infrared (NIR). The Normalized Difference Vegetation Index (NDVI) was calculated, a common measure of vegetation 'vigor' or 'greenness', using the standard equation (NIR – Red)/(NIR + Red). Possible NDVI values ranged from -1.0 (water) to 0.0 (zero live vegetation), to 1.0 (healthy, dense live vegetation). Supervised random forest classification ('randomForest' package, Program R, v4.2.2) was then used to separate bare ground from vegetation in the NAIP images, using all four reflectance bands plus NDVI as predictors. Supervised classification was based on 41 heads-up digitized random bare ground and 51 heads-up digitized random vegetated locations across all riparian properties. Performance of the landcover classification was assessed, based on the out-of-box estimated error rate, evaluating the accuracy of the resultant landcover predictions at predicting the landcover of the training locations. Using the predicted landcover layers, the mean vegetative cover in each riparian property for 2019 and 2022 was calculated.

NAIP imagery was also used to calculate the Modified Soil-Adjusted Vegetation Index (MSAVI), an imagery index that corrects NDVI for soil brightness in dryland or desert landscapes with a high degree of exposed soil surface. We calculated MSAVI as (NIR-Red)/(NIR+Red+L)*(1+L), where L is the soil brightness correction factor ('LSRS' package v0.2.0, Program R, v4.2.2). L was defined as 2*s*(NIR-Red)*(NIR-s*Red)/(NIR+Red), where s was the slope of the soil line from a plot of Red versus NIR brightness values. MSAVI values from -1.0 to 0.2 indicate water or bare soil and values from 0.2 to 0.6 indicate increasing vegetation greenness. Values from 0.6 to 1.0 indicate full vegetation cover and better performance of NDVI over MSAVI. Mean NDVI and MSAVI values are presented per riparian property in 2019 and 2022 to establish a baseline for future trend analyses.

3.3.3 Desert upland

Seven plots (of the 35 plots recommended based on power analyses) on the BCCE were sampled in 2023 (Great Basin Institute 2023). Plots consisted of a spoke design and measurements included the five key attributes recommended in the AMMP (Alta 2023a) plus a qualitative record:

- Vegetation composition [foliar cover (%) and species richness]
- Vertical structure (vegetation height)
- Bare ground (%)
- Proportion of soils surface in gaps
- Soils aggregate stability

3.4 Results for habitat monitoring

3.4.1 Riparian

The 2019 landcover classification found that across all riparian properties, on average, vegetation cover was consistent in both 2019 (51.7%) and 2022 (51.2%). There were, however, stark differences in vegetation cover both across riparian properties (e.g., vegetative cover of

8.2% at Muddy River I and 98.9% at Mesquite, both in 2019) and within riparian properties over time (e.g., a 21.9% estimated decline in vegetative cover at Muddy River G from 2019 to 2022). Of the 15 riparian properties, five had a >10% increase in vegetative cover from 2019 to 2022 (Figure 9), four had a >10% decrease in vegetative cover (Figure 9), and six had <10% change in vegetative cover (Table 10). The landcover models validated well when applied to the training data, with low out-of-box error rates of 4.4% in 2019 and 1.0% in 2022.

Table 10. Estimated vegetative cover (%) at Desert Conservation Program riparian properties in 2019 and 2022 in Clark County, Nevada.

Watershed	Riparian Property	Vegetative Cover (%)		Percent Change	10% Increase/ Decrease?[a]
		2019	2022		
Muddy River	A	57.4%	60.7%	5.8%	-
Muddy River	B	82.6%	90.5%	9.5%	-
Muddy River	C	34.1%	37.9%	11.2%	Increase
Muddy River	D	27.4%	51.5%	88.0%	Increase
Muddy River	E	20.6%	28.3%	37.2%	Increase
Muddy River	F	17.8%	25.3%	42.0%	Increase
Muddy River	**G**	80.6%	63.0%	**-21.9%**	**Decrease**
Muddy River	**H**	48.4%	38.2%	**-20.9%**	**Decrease**
Muddy River	**I**	8.2%	0.7%	**-92.1%**	**Decrease**
Virgin River	Bunkerville East	37.8%	38.2%	1.2%	-
Virgin River	Bunkerville West	57.6%	61.4%	6.6%	-
Virgin River	Mesquite	98.9%	99.1%	0.3%	-
Virgin River	**Mormon Mesa**	81.1%	39.2%	**-51.7%**	**Decrease**
Virgin River	Mormon Mesa South	90.1%	91.9%	1.9%	-
Virgin River	Riverside	33.2%	42.7%	28.6%	Increase

Note: Properties in **bold** showed a >10% decline in vegetative cover, a key monitoring metric for habitat attribute 'Cover > > Total cover' from Table C4 in the Adaptive Management and Monitoring Plan.

[a]Adaptive Management and Monitoring Plan, Table C4, indicates that riparian vegetation monitoring should seek to detect a 10% change in vegetative cover.

Figure 9. Examples of estimated increases (subpanel a) and decreases (subpanel b) in vegetative cover at Desert Conservation Program riparian properties in Clark County, Nevada.

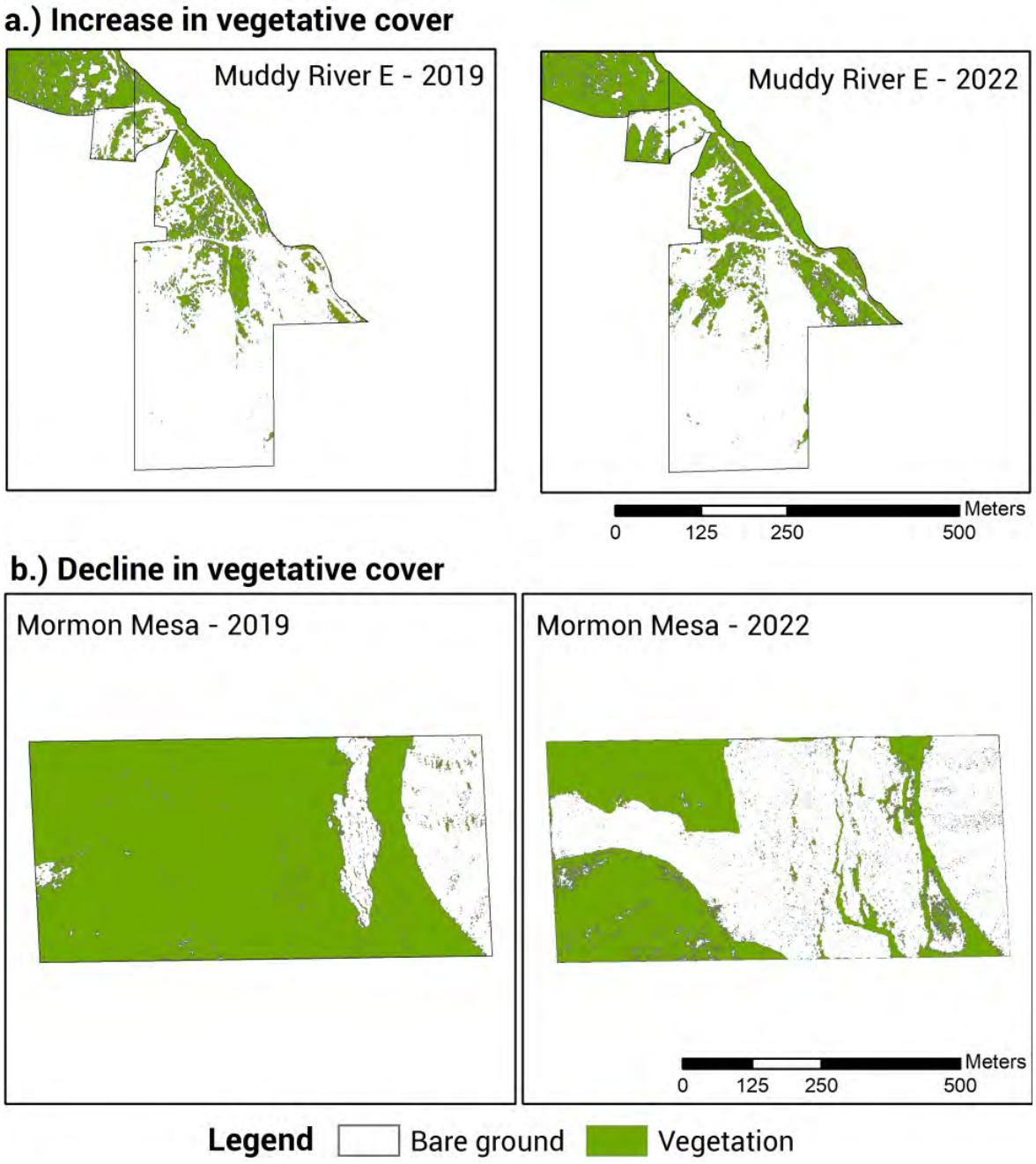


Figure 9 uses Mormon Mesa to illustrate areas with >10% decrease in cover between 2019 and 2022. Here, DCP has completed large tamarisk mastication efforts at the Mormon Mesa property, thereby reducing vegetative cover.

The vegetation vigor/greenness metric NDVI increased slightly from 2019 to 2022, from an across-property average of 0.09 to 0.11, reflecting largely dry vegetative conditions in both years. NDVI ranged widely among properties, ranging from -0.11 at Muddy River I to 0.50 at Mesquite in 2019 and 0.04 at Bunkerville West to 0.28 at Mesquite in 2022 (Table 11). Table C4 in the AMMP does not establish a metric for undesired change in NDVI over time, but we found that from 2019, NDVI decreased at six riparian properties and increased at nine properties (Figure 10, panel a).

Table 11. Estimated Normalized Difference Vegetation Index (NDVI) at Desert Conservation Program riparian properties in 2019 and 2022 in Clark County, Nevada.

Watershed	Riparian Property	NDVI[a]		Change
		2019	2022	
Muddy River	A	0.23	0.15	Decrease
Muddy River	B	0.21	0.17	Decrease
Muddy River	C	0.11	0.08	Decrease
Muddy River	D	0.07	0.13	Increase
Muddy River	E	0.04	0.09	Increase
Muddy River	F	0.00	0.10	Increase
Muddy River	G	0.12	0.07	Decrease
Muddy River	H	0.06	0.07	Increase
Muddy River	I	-0.11	0.10	Increase
Virgin River	Bunkerville East	0.08	0.09	Increase
Virgin River	Bunkerville West	0.09	0.04	Decrease
Virgin River	Mesquite	0.50	0.28	Decrease
Virgin River	Mormon Mesa	0.00	0.10	Increase
Virgin River	Mormon Mesa South	-0.03	0.14	Increase
Virgin River	Riverside	0.02	0.11	Increase

Note: NDVI values range from -1.0 (water), to 0.0 (no live vegetation), to 1.0 (healthy, dense live vegetation).

[a]Normalized Difference Vegetation Index - higher values reflect higher vegetation vigor/greenness.

The modified vegetation vigor/greenness metric (MSAVI) increased slightly from 2019 to 2022, from an across-property mean value of 0.39 to 0.43. Within riparian properties, eight properties showed increasing mean MSAVI vegetation vigor/greenness between 2019 and 2022, and seven properties showed declines in vigor/greenness (Table 12). MSAVI is illustrated for example properties in Figure 10, panel b.

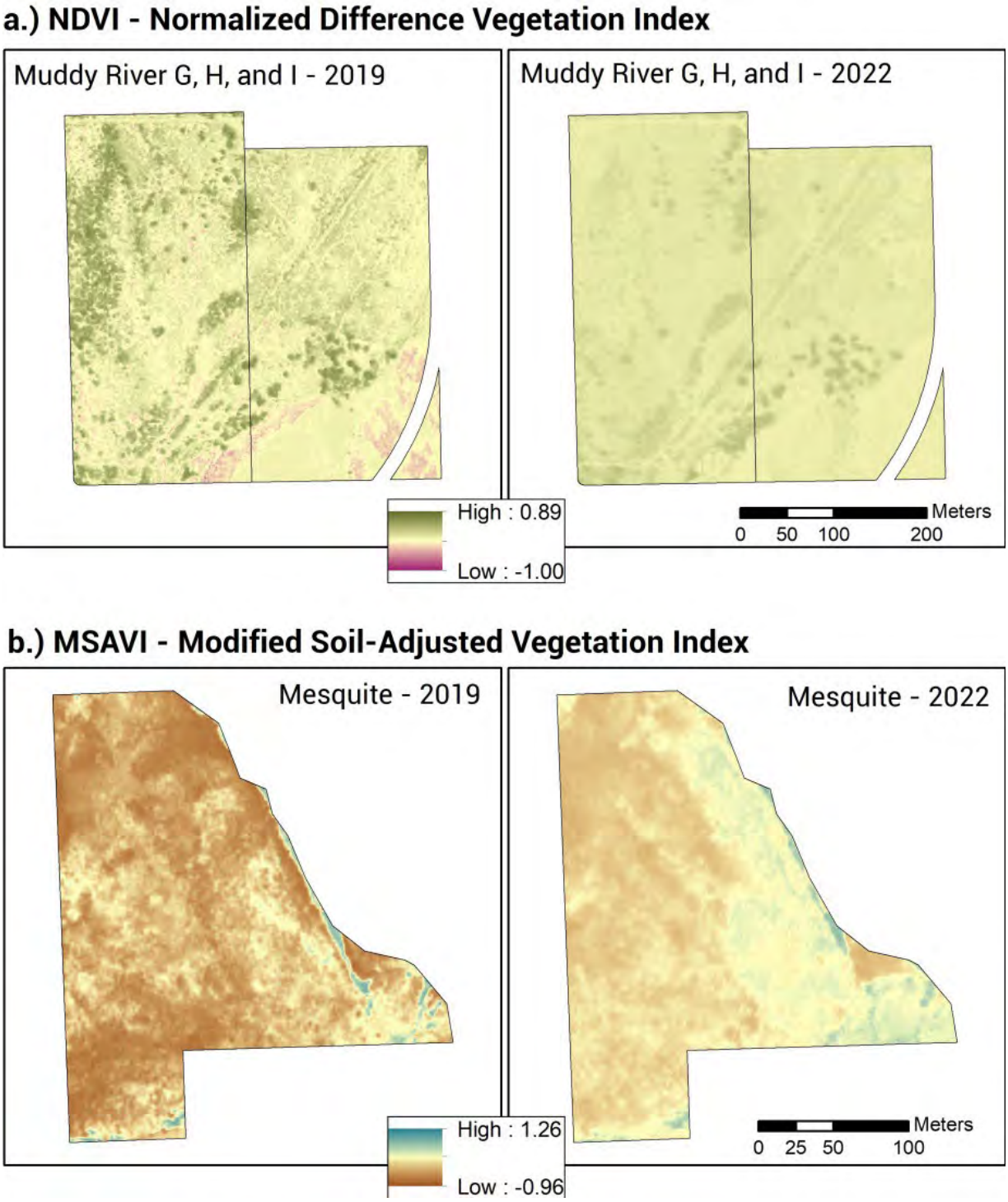
Table 12. Estimated Modified Soil-Adjusted Vegetation Index (MSAVI) at Desert Conservation Program riparian properties in 2019 and 2022 in Clark County, Nevada.

Watershed	Riparian Property	MSAVI[a]		Change
		2019	2022	
Muddy River	A	0.17	0.34	Increase
Muddy River	B	0.10	0.27	Increase
Muddy River	C	0.49	0.50	Increase
Muddy River	D	0.38	0.38	Decrease
Muddy River	E	0.46	0.52	Increase
Muddy River	F	0.52	0.45	Decrease
Muddy River	G	0.63	0.59	Decrease
Muddy River	H	0.67	0.55	Decrease
Muddy River	I	0.24	0.41	Increase
Virgin River	Bunkerville East	0.47	0.50	Increase
Virgin River	Bunkerville West	0.78	0.71	Decrease
Virgin River	Mesquite	-0.30	0.01	Increase
Virgin River	Mormon Mesa	0.31	0.44	Increase
Virgin River	Mormon Mesa South	0.29	0.27	Decrease
Virgin River	Riverside	0.57	0.45	Decrease

Note: MSAVI values range from -1.0 to 0.2 (water or bare soil), from 0.2 to 0.6 (increasing vegetative greenness), and from 0.6 to 1.0 (healthy, dense live vegetation).

[a]Modified Soil-Adjusted Vegetation Index - higher values reflect higher vegetation vigor/greenness. Similar to NDVI but more robust to landscapes with exposed soil surface.

Figure 10. Example decline in a measure of vegetative vigor/greenness (NDVI, subpanel a) and an increase in bare soil-adjusted vegetative vigor/greenness (MSAVI, subpanel b) at two Desert Conservation Program riparian properties in Clark County, Nevada, from 2019 – 2022.



3.4.2 Desert upland

No trend analyses were conducted here because of the single year of survey data currently available; we present simple summary results instead. Average foliar cover on the seven plots was 18.3% (range = 6 – 38%) while average percentage of bare ground was 35.4% (range = 2 – 82%). The average species count was 13.3 (range = 7 – 23). The average height of woody vertical structure was 52.1 cm (range = 22.6 – 87.0) while the average height of herbaceous vertical structure was 12.8 cm (range = 1 – 37.9). Average soil stability for all surface samples was 2.26, which average for protected samples as 3.48 and for unprotected samples was 1.49.

3.5 Species and Habitat Monitoring Summary

The AMMP is used to guide and ensure regular monitoring of MSHCP-covered species and their habitats and to provide a mechanism for identification of corrective conservation actions if species and/or habitats are faring poorly (Tables 6 and 8).

3.5.1 Species Monitoring

Trends appear to be stable for the species for which there were sufficient data to conduct analyses: desert tortoises, desert iguanas, leopard lizards, yellow-billed cuckoos, southwestern willow flycatchers, blue grosbeaks, Arizona Bell's vireos, and phainopeplas. For the remainder of the species in Table 6, detailed analyses were not possible due to lack of data; however, additional data should be available for the next Adaptive Management Evaluation.

3.5.2 Habitat Monitoring

Analysis and assessment of riparian and upland habitat data is considered introductory and opportunistic at this time. Additional data is anticipated for the next Adaptive Management Evaluation. Opportunistic analyses that were conducted include total cover, vigor/greenness, and density for riparian habitats. Vigor/greenness and density are represented by the same set of data calculating NDVI and MSAVI.

The estimated changes in vegetative cover in aggregate were small, but there were large changes for some properties. This may reflect variability in herbaceous cover, which is likely to vary widely within properties between years for the specific dates that aerial imagery was taken. Perennial shrub cover is more consistent among years, and the properties with minor changes in vegetative cover (e.g., Mesquite or Mormon Mesa South) were also dominated by perennial shrubs.

The NDVI results are presented for informational purposes, but because of the large amount of bare ground at many of the riparian properties, we focus assessment on the MSAVI results. Patterns of increasing or decreasing MSAVI-based vegetative vigor/greenness were not consistent among watersheds, with five of nine Muddy River properties and three of six Virgin River properties showing increasing greenness from 2019 to 2022 (with the remainder showing decreased greenness). This highlights the spatiotemporal variability in property-level vegetation communities (e.g., mixtures of perennial and herbaceous plant species) and likely spatiotemporal variation in precipitation over the short time period. Conducting these assessments of vegetative vigor/greenness over longer time periods should better capture long-term trends in the vigor of vegetative communities on Desert Conservation Program riparian properties.

We note that using the multispectral aerial imagery alone, we were not able to assess all of the habitat metrics detailed in the AMMP (including Table C4). Several of those metrics, such as vegetation community types, cover by community types or species, canopy heights, and

slopes/bank height metrics require z-axis data (i.e., height above ground), such as that obtained via LiDAR. We anticipate that LiDAR flights will be flown at least every 10 years, as suggested in the AMMP, and that analyses of multispectral data combined with LiDAR data will sufficiently yield the monitoring metrics for riparian habitat quality as outlined in the AMMP.

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Appendix C
Ecosystem Disturbance Mapping Procedure

2011 Ecosystem Disturbance Mapping Procedure

Disturbance Mapping occurs every year based on updated aerial imagery obtained by Clark County or cooperating agency. This should follow a very specific procedure using specific layers.

Prior to starting:

Create a Local copy of Z:\CrGeoDb\Source\Parcel.gdb

For Performance concerns this database should not be run over a network drive.

Load the Following Layers:

Y:\Permit_Amend_2015\D21_Final_Model_target_2_playa.lyr

Y:\Permit_Amend_2015\Permit_Amend.gdb\Layers\Disturbed{Current year}spr_priv_fed

(i.e. For 2019 – 2021 biennium the file is Y:\Permit_Amend_2015\Permit_Amend.gdb\Layers\Disturbed2021spr_priv_fed)

Parcel.gdb\Parcel\AOParcels

Parcel.gdb\AOExtract

Procedure:

Step 1: Create a Join AOParcels

Inputs:

1: APN
2: AOExtract
3: PARCEL

Join Options:

Keep All Records

Step 2: Set the Layer Definition Query of the layer “AOParcels” as Follows

AOExtract.OWNER IN('USA' , 'USA BUREAU LAND MANAGEMENT' , 'USA BUREAU OF MINES' , 'USA BUREAU RECLAMATION' , 'USA CORPS OF ENGINEERS' , 'USA CORPS OF ENGINEERS ARMY' , 'USA DEPT OF AGRICULTURE' , 'USA DEPT OF TRANSPORTATION FAA' , 'USA FISH & WILDLIFE SERVICE' , 'USA FOREST SERVICE' , 'USA FOREST SERVICE ETAL' , 'USA FT MOHAVE INDIAN RESERVATION' , 'USA INDIAN SPRINGS AIR BASE' , 'USA LV INDIAN RESERVATION' , 'USA MOAPA INDIAN RESERVATION' , 'USA MOAPA PAIUTE INDIANS' , 'USA PARK SERVICE' , 'USA PARK SERVICE ETAL' , 'USA POSTAL SERVICE' , 'USA TRUST LAS VEGAS PAIUTE TRIBE' , 'USA TRUST LV PAIUTE INDIANS' , 'USA TRUST MOAPA PAIUTE INDIANS' , 'USA TRUST MOAPA PAIUTES INDIANS')

*This layer is now the Federal Land in Clark County Layer.

Step 3: Union

Input Features:
Disturbed{Current year}spr_priv_fed
AOParcels(With Definition Query)
Output Feature Class:
Disturbed{Current year}_Union

Step 4: Set the Layer Definition Query of the layer “Disturbed{Current year}_Union” as Follows
FID_Disturbed2021spr_priv_fed <> -1
This removes the features that are not disturbed.

Step 5: Select the layer “Disturbed{Current year}_Union” by Attributes with the following criteria
FID_AOParcels_AOExtract =-1 AND Private NOT IN (1,2,3)

Step 6: Calculate Field in layer “Disturbed{Current year}_Union” ‘Private’ = 1

Step 7: Select the layer “Disturbed{Current year}_Union” by Attributes with the following criteria
FID_AOParcels_AOExtract <> -1 AND Private NOT IN(1,2,3)

Step 8: Calculate Field “Disturbed{Current year}_Union” ‘Private’ = 3

Step 9: Run Geoprocessing “Raster to Polygon” with the following inputs (This can be skipped if a Vector version of the Ecosystems map is available.)
Input Raster: D21_Final_Model_target_2_playa
Field: Value
Output Polygon: D21_Final_Model_target_2_playa_Vector
Uncheck “Simplify Polygons”

Step 10: Select the layer “Disturbed{Current year}_Union” by Attributes with the following criteria
‘Private’ = 1

Step 11: Clip D21_Final_Model_target_2_playa_Vector with Selected features from Step 10.
Input Features: D21_Final_Model_target_2_playa_Vector
Clip Features: “Disturbed{Current year}_Union” with applied selection “Private” = 1
Output Feature Class: Disturbed{Current year}_priv_ecosystems

Step 12: Run Geoprocessing “Dissolve”
Input Features: “Disturbed2021_priv_ecosystems”
Output Feature Class: Disturbed2021_priv_ecos_Dis
Dissolve Fields: gridcode
Check Create Multipart Features

Step 13: Add Field to Disturbed2021_priv_ecos_Dis
Name: Acres
Type: Double

Step 14: Add Field to Disturbed2021_priv_ecos_Dis

Name: Ecosystem
Type: Text

Step 15: Calculate Geometry for “Acres” Field
Property: Area
Use Coordinate system of the data source: PCS: NAD 1983 UTM Zone 11N
Units: Acres

Step 16: Calculate Field for “Ecosystem” Field
Parser: Python
Check: Show Code Block
Pre-Logic Script Code:

```
def eco(gc):
  options = {0 : "0",
        1 : "Alpine",
        2 : "Blackbrush",
        3 : "Bristlecone Pine",
        4 : "Desert Riparian",
        5 : "Mesquite/Acacia",
        6 : "Mixed Conifer",
        7 : "Mojave Desert Scrub",
        8 : "Pinyon/Juniper",
        9 : "Sagebrush",
        10 : "Salt Desert Scrub",
        12 : "Water",
        13 : "Playa"
  }
  return options[gc]
```

Ecosystem =

```
        eco( !gridcode!)
```

2019 USNVC Disturbance Mapping Procedure

The USNVC Divisions layer is derived from the Coarse level vegetation Map dissolving the features by the USNVC Division level of the taxonomy with the following modifications.

- Areas that were classified in the coarse level vegetation map as disturbed though did not appear to be developed and were not part of the 2019 DCP Disturbance layer were classified as "Urban Interface Mojave Desert Scrub". Or land that still contains characteristics similar to the USNVC Classification "North American Warm Desert Scrub & Grassland" though had been significantly disturbed due to the proximity to existing development.
- Multiple classes of vacant or cleared lands were combined as a single Vacant classification. Including dirt roads and tracks, cleared areas for transmission lines, denuded but undeveloped lots, etc.
- All land classified in the DCP 2019 Disturbance layer were reclassified as Developed to avoid conflicts.

Disturbance Mapping occurs every year based on updated aerial imagery obtained by Clark County or cooperating agency. This should follow a very specific procedure using specific layers.

Prior to starting:

Create a Local copy of the current Parcel.gdb

For Performance concerns this database should not be run over a network drive.

Load the Following Layers:

Vegetation_USNVC_Divisions_2019_Baseline 20230104

Disturbed{Current year}spr_priv_fed

(i.e. For 2019 – 2021 biennium the file is Disturbed2023spr_priv_fed)

Parcel.gdb\Parcel\AOParcels

Parcel.gdb\AOExtract

Procedure:

Step 1: Create a Join AOParcels

Inputs:

1: APN

2: AOExtract

3: PARCEL

Join Options:

Keep All Records

Step 2: Set the Layer Definition Query of the layer "AOParcels" as Follows

AOExtract.OWNER IN('USA' , 'USA BUREAU LAND MANAGEMENT' , 'USA BUREAU OF MINES' , 'USA BUREAU RECLAMATION' , 'USA CORPS OF ENGINEERS' , 'USA CORPS OF ENGINEERS ARMY' , 'USA DEPT OF AGRICULTURE' , 'USA DEPT OF TRANSPORTATION FAA' , 'USA FISH & WILDLIFE SERVICE' , 'USA FOREST SERVICE' , 'USA FOREST SERVICE ETAL' , 'USA FT MOHAVE INDIAN RESERVATION' , 'USA INDIAN SPRINGS AIR BASE' , 'USA LV INDIAN RESERVATION' , 'USA MOAPA INDIAN RESERVATION' , 'USA MOAPA PAIUTE INDIANS' , 'USA PARK SERVICE' , 'USA PARK SERVICE ETAL' , 'USA POSTAL SERVICE' , 'USA TRUST LAS VEGAS PAIUTE TRIBE' , 'USA TRUST LV PAIUTE INDIANS' , 'USA TRUST MOAPA PAIUTE INDIANS' , 'USA TRUST MOAPA PAIUTES INDIANS')

*This layer is now the Federal Land in Clark County Layer.

Step 3: Union

Input Features:
Disturbed{Current year}spr_priv_fed
AOParcels(With Definition Query)
Output Feature Class:
Disturbed{Current year}_Union

Step 4: Set the Layer Definition Query of the layer "Disturbed{Current year}_Union" as Follows
FID_Disturbed2021spr_priv_fed <> -1
This removes the features that are not disturbed.

Step 5: Select the layer "Disturbed{Current year}_Union" by Attributes with the following criteria
FID_AOParcels_AOExtract =-1 AND Private NOT IN (1,2,3)

Step 6: Calculate Field in layer "Disturbed{Current year}_Union" 'Private' = 1

Step 7: Select the layer "Disturbed{Current year}_Union" by Attributes with the following criteria
FID_AOParcels_AOExtract <> -1 AND Private NOT IN(1,2,3)

Step 8: Calculate Field "Disturbed{Current year}_Union" 'Private' = 3

Step 9: Select the layer "Disturbed{Current year}_Union" by Attributes with the following criteria
'Private' = 1

Step 10: Clip D21_Final_Model_target_2_playa_Vector with Selected features from Step 10.
Input Features: Vegetation_USNVC_Divisions_2019_Baseline 20230104
Clip Features: "Disturbed{Current year}_Union" with applied selection "Private" = 1
Output Feature Class: Disturbed{Current year}_priv_USNVC

Step 11: Run Geoprocessing "Dissolve"
Input Features: "Disturbed{Current year}_priv_USNVC"
Output Feature Class: Disturbed{Current year}_priv_ecos_Dis
Dissolve Fields: Group
Check Create Multipart Features

Step 12: Add Field to Disturbed2021_priv_ecos_Dis
Name: Acres
Type: Double

Step 14: Calculate Geometry for "Acres" Field
Property: Area
Use Coordinate system of the data source: PCS: NAD 1983 UTM Zone 11N
Units: Acres

Appendix D
2011 Ecosystems to 2019 USNVC Divisions Crosswalk

Ecosystem[a]	USNVC Division[b]	Acres	Percent of acres
Alpine	Western North American Alpine Tundra	232.4	76.1%
	Rocky Mountain Forest & Woodland	71.7	23.5%
	Western North American Pinyon - Juniper Woodland & Scrub	1.5	0.5%
Blackbrush	Western North American Cool Semi-Desert Scrub & Grassland	639,886.5	68.7%
	North American Warm Desert Scrub & Grassland	219,314.3	23.5%
	Western North American Pinyon - Juniper Woodland & Scrub	59,209.2	6.4%
	Western North American Interior Chaparral	6,837.5	0.7%
	Vacant	4,605.8	0.5%
	Urban Interface Mojave Desert Scrub	1,182.5	0.1%
	Californian Forest & Woodland	211.6	0.0%
	Southwestern North American Warm Desert Freshwater Marsh & Bosque	186.1	0.0%
	Western North American Alpine Tundra	116.2	0.0%
	Developed	70.7	0.0%
	Western North American Interior Flooded Forest	67.2	0.0%
	Rocky Mountain Forest & Woodland	39.6	0.0%
	Vacant or Cleared	15.4	0.0%
	Western North American Temperate Freshwater Marsh, Wet Meadow & Shrubland	5.1	0.0%
	Water	0.1	0.0%
Bristlecone Pine	Rocky Mountain Forest & Woodland	17,042.5	91.2%
	North American Warm Desert Scrub & Grassland	642.1	3.4%
	Western North American Pinyon - Juniper Woodland & Scrub	524.6	2.8%
	Western North American Alpine Tundra	290.2	1.6%
	Western North American Cool Semi-Desert Scrub & Grassland	94.8	0.5%
	Western North American Temperate Freshwater Marsh, Wet Meadow & Shrubland	77.7	0.4%
	Western North American Interior Chaparral	20.6	0.1%
Desert Riparian	North American Warm Desert Scrub & Grassland	5,842.7	29.4%
	Western North American Interior Flooded Forest	3,554.1	17.9%
	Developed	3,302.4	16.6%
	Southwestern North American Warm Desert Freshwater Marsh & Bosque	2,772.3	14.0%
	Western North American Temperate Freshwater Marsh, Wet Meadow & Shrubland	1,081.9	5.4%
	Vacant	1,011.8	5.1%
	Vacant or Cleared	802.2	4.0%
	Western North American Cool Semi-Desert Scrub & Grassland	697.0	3.5%
	Water	533.6	2.7%
	Urban Interface Mojave Desert Scrub	257.7	1.3%

Ecosystem[a]	USNVC Division[b]	Acres	Percent of acres
Mesquite/Acacia	North American Warm Desert Scrub & Grassland	25,967.6	59.2%
	Developed	6,738.1	15.4%
	Western North American Cool Semi-Desert Scrub & Grassland	6,494.3	14.8%
	Southwestern North American Warm Desert Freshwater Marsh & Bosque	1,271.4	2.9%
	Vacant	1,129.6	2.6%
	Western North American Pinyon - Juniper Woodland & Scrub	689.6	1.6%
	Western North American Interior Flooded Forest	615.3	1.4%
	Vacant or Cleared	414.7	0.9%
	Urban Interface Mojave Desert Scrub	315.4	0.7%
	Western North American Interior Chaparral	147.0	0.3%
	Western North American Temperate Freshwater Marsh, Wet Meadow & Shrubland	32.0	0.1%
	Water	30.0	0.1%
	Californian Forest & Woodland	23.2	0.1%
	Western North American Alpine Tundra	14.4	0.0%
Mixed Conifer	Rocky Mountain Forest & Woodland	40,861.5	60.5%
	Western North American Pinyon - Juniper Woodland & Scrub	18,651.8	27.6%
	Western North American Interior Chaparral	3,871.9	5.7%
	North American Warm Desert Scrub & Grassland	1,879.5	2.8%
	Western North American Cool Semi-Desert Scrub & Grassland	1,416.5	2.1%
	Western North American Temperate Freshwater Marsh, Wet Meadow & Shrubland	766.8	1.1%
	Vacant	93.9	0.1%
	Developed	10.1	0.0%
	Californian Forest & Woodland	3.6	0.0%
Mojave Desert Scrub	North American Warm Desert Scrub & Grassland	1,836,036.9	67.8%
	Western North American Cool Semi-Desert Scrub & Grassland	506,313.8	18.7%
	Developed	250,108.6	9.2%
	Vacant	53,119.0	2.0%
	Urban Interface Mojave Desert Scrub	36,030.0	1.3%
	Vacant or Cleared	10,824.3	0.4%
	Western North American Alpine Tundra	7,895.2	0.3%
	Western North American Interior Chaparral	3,492.9	0.1%
	Southwestern North American Warm Desert Freshwater Marsh & Bosque	1,900.2	0.1%
	Western North American Interior Flooded Forest	1,713.8	0.1%
	Western North American Pinyon - Juniper Woodland & Scrub	1,240.3	0.0%
	Water	947.3	0.0%
	Western North American Temperate Freshwater Marsh, Wet Meadow & Shrubland	222.3	0.0%
	Californian Forest & Woodland	18.7	0.0%

Ecosystem[a]	USNVC Division[b]	Acres	Percent of acres
Pinyon/Juniper	Western North American Pinyon - Juniper Woodland & Scrub	195,587.6	68.3%
	Western North American Cool Semi-Desert Scrub & Grassland	38,172.8	13.3%
	Western North American Interior Chaparral	25,311.6	8.8%
	Rocky Mountain Forest & Woodland	15,320.3	5.4%
	North American Warm Desert Scrub & Grassland	10,185.0	3.6%
	Western North American Temperate Freshwater Marsh, Wet Meadow & Shrubland	559.8	0.2%
	Vacant	455.3	0.2%
	Californian Forest & Woodland	343.9	0.1%
	Western North American Grassland & Shrubland	216.0	0.1%
	Urban Interface Mojave Desert Scrub	54.3	0.0%
	Developed	12.4	0.0%
	Western North American Interior Flooded Forest	0.2	0.0%
Sagebrush	Western North American Cool Semi-Desert Scrub & Grassland	4,645.2	44.6%
	Western North American Pinyon - Juniper Woodland & Scrub	4,549.8	43.7%
	Rocky Mountain Forest & Woodland	515.5	4.9%
	North American Warm Desert Scrub & Grassland	385.2	3.7%
	Western North American Interior Chaparral	251.2	2.4%
	Vacant	58.6	0.6%
	Western North American Temperate Freshwater Marsh, Wet Meadow & Shrubland	11.4	0.1%
	Western North American Interior Flooded Forest	3.8	0.0%
	Developed	1.1	0.0%
	Vacant or Cleared	0.9	0.0%
Salt Desert Scrub	North American Warm Desert Scrub & Grassland	46,066.7	52.6%
	Western North American Cool Semi-Desert Scrub & Grassland	21,676.0	24.8%
	Developed	14,570.8	16.7%
	Western North American Alpine Tundra	3,218.8	3.7%
	Vacant	1,156.2	1.3%
	Urban Interface Mojave Desert Scrub	287.1	0.3%
	Vacant or Cleared	210.2	0.2%
	Southwestern North American Warm Desert Freshwater Marsh & Bosque	189.4	0.2%
	Western North American Interior Flooded Forest	52.9	0.1%
	Western North American Temperate Freshwater Marsh, Wet Meadow & Shrubland	32.5	0.0%
	Water	21.8	0.0%
	Western North American Pinyon - Juniper Woodland & Scrub	20.7	0.0%

Ecosystem[a]	USNVC Division[b]	Acres	Percent of acres
Water	Water	95.3	69.1%
	North American Warm Desert Scrub & Grassland	40.5	29.4%
	Western North American Interior Flooded Forest	1.2	0.9%
	Vacant	0.5	0.3%
	Western North American Temperate Freshwater Marsh, Wet Meadow & Shrubland	0.3	0.2%
	Developed	0.1	0.0%
	Western North American Cool Semi-Desert Scrub & Grassland	0.0	0.0%
Playa	Western North American Alpine Tundra	7,001.3	88.9%
	North American Warm Desert Scrub & Grassland	688.6	8.7%
	Vacant	127.4	1.6%
	Developed	47.9	0.6%
	Southwestern North American Warm Desert Freshwater Marsh & Bosque	12.6	0.2%
	Western North American Interior Flooded Forest	0.9	0.0%
	Urban Interface Mojave Desert Scrub	0.2	0.0%

[a]Ecosystem category from 2011

[b]U.S. National Vegetation Classification from 2019

Appendix E
USNVC Division Descriptions

Name **Californian Forest & Woodland**

Database Code	Classification Code	Hierarchy Level	Status
D007	1.B.1.Nc	Division	Accepted

Translated Name California Live Oak - California Laurel - Western Cypress species Forest & Woodland Division

Scientific Name Quercus agrifolia - Umbellularia californica - Hesperocyparis spp. Forest & Woodland Division

Summary This division is comprised of mesic to dry upland forests, woodlands, and savannas that are dominated by warm-temperate endemic and/or naturalized broad-leaved and conifer tree species in lowland to low montane settings throughout cismontane California, on the mainland of and on islands of Baja California, and in the foothills of the Cascade Range in southwestern Oregon.

Description The division is comprised of mesic to dry upland forests, woodlands, and savannas that are dominated by warm-temperate endemic and/or naturalized broad-leaved and conifer tree species in lowland to low montane settings throughout cismontane California, on the mainland of and on islands of Baja California, and in the foothills of the Cascade Range in southwestern Oregon. The division includes closed-canopy forests, usually in mesic settings and open woodlands or savannas in drier habitats. They are dominated by native evergreen or deciduous broad-leaved trees and/or conifers, including evergreen and deciduous *Quercus* spp., *Pinus* spp., *Hesperocyparis* spp., *Pseudotsuga* spp., *Notholithocarpus densiflorus, Arbutus menziesii, Umbellularia californica, Juniperus californica*,and other species and, less commonly, by planted or naturalized non-native tree species, including *Eucalyptus* spp., *Acacia* spp., *Schinus* spp., and others. The frequent importance of evergreen broad-leaved (hardwood) tree species and/or of closed-cone conifers in stands is characteristic. The climate is Mediterranean, with strongly seasonal (dry summers, wetter winter) precipitation patterns, little to no snowfall, and long (up to year-round) growing seasons. Within its preferred climate and elevation range, stands tend to occupy sites that are moderately dry. Topographic and edaphic settings within this division are diverse. Elevations of stands range from sea level to about 700 m in the north and to about 1500 m in the south.

Diagnostic Characteristics This division is comprised of upland forests, woodlands, and savannas in lowland to low montane settings in the Californian Floristic Province. The strongly Mediterranean climate with little to no snowfall, and long (up to year-round) growing seasons, is unique among other North American forests and woodlands. Strongly diagnostic tree taxa that are relatively widespread throughout the range of the division include *Quercus agrifolia, Quercus chrysolepis, Quercus douglasii, Quercus engelmannii, Quercus lobata, Quercus wislizeni, Pinus attenuata, Pinus coulteri, Pinus radiata, Pinus muricata, Pinus sabiniana, Hesperocyparis macnabiana, Hesperocyparis macrocarpa, Hesperocyparis sargentii, Juniperus californica, Umbellularia californica*, and *Eucalyptus* spp.

Rationale The nominal species are the same as those of the primary macrogroup of this division, which includes all of the non-ruderal vegetation of the division.

Physiognomy

Stands are dominated by short to tall (5-35 m) trees that are evergreen needle-leaved, evergreen sclerophyllous broad-leaved and deciduous broad-leaved. Shrub, herbaceous, and nonvascular strata usually are present and are variable in cover and height.

Floristics

This macrogroup consists of stands with a tree stratum that is comprised of various mixtures of oak, oak with pine or other conifers, conifers with broad-leaved evergreen trees, and closed-cone cypress and pines. Native tree taxa that are relatively widespread throughout the range of the division, and that also are strongly to moderately diagnostic, include *Arbutus menziesii, Chrysolepis chrysophylla var. chrysophylla, Hesperocyparis macnabiana*, the partially native *Hesperocyparis macrocarpa, Hesperocyparis sargentii, Juniperus californica, Notholithocarpus densiflorus (= Lithocarpus densiflorus), Pinus attenuata, Pinus coulteri, Pinus muricata, Pinus radiata, Pinus sabiniana, Quercus agrifolia, Quercus chrysolepis, Quercus douglasii, Quercus engelmannii, Quercus lobata, Quercus wislizeni*, and *Umbellularia californica*. Non-native tree taxa include *Acacia dealbata, Acacia melanoxylon, Ailanthus altissima, Eucalyptus camaldulensis, Eucalyptus globulus, Ficus carica, Robinia pseudoacacia*, and *Schinus molle*. Native trees with constancy, but common in other divisions include *Calocedrus decurrens, Pinus ponderosa, Pseudotsuga menziesii, Quercus garryana*, and *Quercus kelloggii*. More localized endemic tree taxa of this division include *Hesperocyparis abramsiana, Hesperocyparis arizonica, Hesperocyparis bakeri, Hesperocyparis goveniana, Lyonothamnus floribundus, Pinus contorta var. bolanderi, Pinus torreyana*, and *Quercus tomentella*. Localized non-native species include *Acacia cyclops, Acacia redolens, Corymbia citriodora (= Eucalyptus citriodora), Eucalyptus cladocalyx, Eucalyptus polyanthemos, Eucalyptus pulverulenta, Eucalyptus sideroxylon, Eucalyptus tereticornis, Eucalyptus viminalis, Myoporum laetum, Pinus halepensis*, and *Schinus terebinthifolius*.

Shrub, herbaceous, and nonvascular stratum species are exceedingly diverse; a summary of the most widespread, frequent, and/or dominant taxa awaits further investigation.

Environment

The warm-temperate Mediterranean climate is the primary factor for the development of this division. Elevations of stands range from sea level to about 700 m in the north and to about 1500 m in the south (Minnich 2007b); montane cool-temperate forests (primarily of 1.B.2.Nd ~Vancouverian Forest & Woodland Division (D192)$$ predominate at higher elevations that abut the range of this division. Topographic and edaphic settings within this division are diverse. Within its preferred climate and elevation range, stands tend to occupy sites that are lower in moisture availability than those dominated by lowland types of (more mesic) cool-temperate forests or by (more hydric) riparian. In turn, this division tends to yield dominance to shrublands and grasslands on more xeric sites or those that are more prone to stress from wind (coastal areas) or fire (interior areas). Ruderal stands of this division probably require proximity to a planted source of the dominant non-native species.

Climate: Most areas that support stands of this division experience an average of 250 to 365 frost-free days per year. Mean January temperatures are from about 7°C (44°F) (Orland, CA) to 13°C (56°F) (San Diego, CA) (Minnich 2007a). Mean January temperatures are from about 16°C (60°F) (Monterey, CA) to 29°C (84°F) (Bakersfield, CA). In general, coastal areas experience less summer to winter temperature variation than do inland areas (Minnich 2007a). Annual precipitation generally ranges from 15 cm (6 inches) (Bakersfield, CA) to 62 cm (24 inches) (Three Rivers, CA), with up to 160 cm (63 inches) in the northern extremes of the range (northern Klamath Mountain region of northern California and

southern Oregon) (Minnich 2007a). The precipitation distribution is strongly seasonal; at locations that support vegetation of this division, 85-92% of the annual precipitation falls during the wetter months of November through April. Mean annual snowfall is usually less than 1 cm (1 inch). In contrast, locations within or adjacent to the California Mediterranean climate region that support primarily cool-temperate forests and woodlands (e.g., in the Sierra Nevada, Cascades, Klamath, Great Basin, Mojave, or southern California Peninsular/Transverse ranges) show a less strongly seasonal pattern of 60-85% of annual precipitation occurring during the November to April period, and/or have much higher total annual precipitation (e.g., along the California North Coast).

Soils/substrate: Soil and substrate conditions over this large region are diverse. Entisols, Inceptisols, Alfisols, and Mollisols are the most abundant soil orders (O'Geen et al. 2007).

Biogeography: Stands of this division are found throughout the California [floristic] Province of McLaughlin (2007). This corresponds to the California Floristic Province as defined by Baldwin et al. (2012), excluding the High Sierra Nevada (SNH) and High Cascade Range (CaRH) subregions, and the higher elevations of the Klamath Ranges (KR) subregion.

Range

Stands of this division are found throughout lower elevation cismontane California. They generally occur below 700 m in elevation in the north and below 1500 m in elevation in the south. Their distribution includes coastal valleys and foothills, the Great Valley, low to moderate elevations of the Klamath Mountains, Transverse, Coast, Peninsular, Sierra Nevada, and Cascade ranges, and some mountains within the Mojave Desert. The division extends southward into the northern and central mainland and islands of Baja California, from coastal to cismontane regions and northward into the valleys and foothills of the Cascades and Klamath Mountains in southwestern Oregon.

Synonymy

> Closed-cone Pine and Cypress Forests (Barbour 2007) [combination of Oak Woodlands and Forests (Allen-Diaz et al. 2007), Closed-cone Pine and Cypress Forests (Barbour 2007), Southern California Conifer Forests (in part) (Minnich 2007b), and Forests of Northwestern California (in part) (Sawyer 2007).]
> Forests of Northwestern California (in part) (Sawyer 2007) [combination of Oak Woodlands and Forests (Allen-Diaz et al. 2007), Closed-cone Pine and Cypress Forests (Barbour 2007), Southern California Conifer Forests (in part) (Minnich 2007b), and Forests of Northwestern California (in part) (Sawyer 2007).]
> Oak Woodlands and Forests (Allen-Diaz et al. 2007) [combination of Oak Woodlands and Forests (Allen-Diaz et al. 2007), Closed-cone Pine and Cypress Forests (Barbour 2007), Southern California Conifer Forests (in part) (Minnich 2007b), and Forests of Northwestern California (in part) (Sawyer 2007).]
> Southern California Conifer Forests (in part) (Minnich 2007b) [combination of Oak Woodlands and Forests (Allen-Diaz et al. 2007), Closed-cone Pine and Cypress Forests (Barbour 2007), Southern California Conifer Forests (in part) (Minnich 2007b), and Forests of Northwestern California (in part) (Sawyer 2007).]
> combination of Blue Oak woodland, Southern Oak Woodland, and Mixed Evergreen Forest (Barbour 1988)
> combination of Californian Evergreen Forest and Woodland (123.2), and Relict Conifer Forest (123.4) (in part) (Brown et al. 1998)
> combination of Californian Mixed Evergreen Forest (123.2) and Californian Evergreen Forest and Woodland (123.4), and Relict Conifer Forests and Woodlands (123.5) (in part) (Brown et al. 1979)

Dynamics Fire is an important factor for much of this division. The closed-cone pines and cypress species are serotinous and, therefore, rely on fires, including those of stand-replacing intensity, for regeneration (Barbour 2007). In general, low-intensity fires are important for maintaining the composition and structure of open oak woodlands, but fires in general are rare in more mesic and more closed-canopy forest types. Herbivory by ungulates, particularly in oak woodlands by livestock during the 19th, 20th, and 21st centuries (Allen-Diaz et al. 2007), has had a profound influence on vegetation structure. Other processes that influence stand structure and composition include insect and disease outbreaks and severe weather events (landslides following rainfall events, wind). Stands dominated by non-native, naturalized tree species are established from dispersal of propagules from plantings established for windbreaks and horticultural purposes; woodland stands dominated by native tree species are often dominated by non-native annual grasses that have become well-established since the increase in agricultural use of land in about 1860 (Bossard and Randall 2007).

Taxonomic Parent Warm Temperate Forest & Woodland

Parent Key F018

Name North American Warm Desert Scrub & Grassland

Database Code	Classification Code	Hierarchy Level	Status
D039	3.A.2.Na	Division	Accepted

Translated Name Catclaw Acacia - Christmas Cholla - Bush Muhly North American Warm Desert Scrub & Grassland Division

Scientific Name Acacia greggii - Cylindropuntia leptocaulis - Muhlenbergia porteri North American Warm Desert Scrub & Grassland Division

Summary This division contains aridland shrublands and grasslands dominated by xerophytic woody shrubs, succulents and grasses that occur among the lowland intermountain basins and foothills of desert mountain ranges across the southwestern U.S. and northern Mexico.

Description

This division is characterized by the dominance of xerophytic shrubs and grasses (and occasionally trees) that tolerate warm-temperate to subtropical arid conditions of the deserts of the southwestern U.S. and northern Mexico (Viscaino-Baja California and Mojave eastward to the Sonoran, Chihuahuan, and the Tamaulipan mattoral/mezquital of northeastern Mexico). Shrublands have sparse to moderate canopies dominated by drought-tolerant micro-microphyllous or broad-leaved species. Strong diagnostic shrubs include *Fouquieria splendens, Larrea tridentata, Acacia greggii, Prosopis glandulosa*, and *Prosopis velutina*. Moderately-diagnostic regional dominants include *Flourensia cernua, Jatropha cuneata, Leucophyllum frutescens*, and *Viguiera stenoloba* along with dwarf-shrubs such as *Ambrosia dumosa, Eriogonum fasciculatum*, and *Parthenium incanum*. Cacti and rosette stem succulents, and sarcocaulescent trees are also common. *Cylindropuntia leptocaulis* is a strong diagnostic species; others are characteristic of specific desert regions, e.g., *Agave lechuguilla, Bergerocactus emoryi, Bursera microphylla, Carnegiea gigantea, Cylindropuntia bigelovii, Cylindropuntia prolifera*, and *Yucca treculeana*. Desert grasslands are dominated by drought-tolerant, warm-season (C4) bunchgrasses. Moderately strong diagnostic grasses include *Bouteloua breviseta, Bouteloua eriopoda, Muhlenbergia porteri, Muhlenbergia setifolia, Pleuraphis mutica, Pleuraphis rigida, Sporobolus flexuosus*, and *Tridens muticus*. Other, often abundant grasses include *Bouteloua curtipendula, Bouteloua gracilis, Bouteloua hirsuta, Sporobolus airoides, Sporobolus wrightii*, and *Panicum obtusum*. While xerophytic shrubs can be conspicuous elements of desert grasslands, they typically are not dominants, e.g., *Dasylirion leiophyllum, Ephedra torreyana, Nolina microcarpa, Nolina texana*, and *Yucca elata*. Perennial forbs are diverse, but typically low in cover; annual forbs can be locally to regionally abundant in any given year depending on rainfall amounts and timing, or essentially absent (e.g., *Eschscholzia californica*). There are also grasslands that have been invaded by non-native, often aggressive species such as *Eragrostis curvula, Eragrostis lehmanniana, Pennisetum ciliare*, and *Pennisetum setaceum*. Intermixed among the grasslands and shrublands are ephemeral dry washes dominated by shrubs tolerant of high episodic stream flows; characteristic species include *Chilopsis linearis, Fallugia paradoxa, Hymenoclea monogyra*, and *Hymenoclea salsola*.

This is a division of warm-temperate to subtropical arid conditions with peak summer temperatures that can exceed 50°C and mean annual precipitation ranges from 30 to 250 (300) mm. In the higher elevation or more continental regions (Mojave and Chihuahuan), temperatures can drop below freezing for extended periods in winter. Desert grasslands

are more prevalent in the eastern, summer rainfall-dominated regions (Chihuahuan and Tamaulipan) that favor the more shallow-rooted grasses during the growing season. In contrast, shrublands tend to dominate the Sonoran, Mojave, and Viscaino-Baja California deserts where the predominantly winter-rainfall regime favors shrubs that are able to access deeper stored soil moisture during the growing season. Sites extend from sea level (or below) to about 1600 m for shrublands and 2000 m for desert grasslands. The vegetation types are sorted from low-lying, broad basin bottoms with fine clay alluvial soils (including alkaline ephemeral playa lakes) up adjacent coalesced alluvial fan piedmonts (bajadas) with shallow gravelly soils and desert pavements to the colluvial foothill slopes of bordering desert mountain ranges with their cobbly and rocky soils (including sparsely vegetated cliff faces and boulder slopes). The desert basin can also have extensive sandy plains (sand sheets) and dunelands (including unique gypsum dune communities). Fire plays a role in desert grasslands (return intervals between 10 and 30 years) but has minimal impact on desert scrubs. Excessive burning of desert grasslands can also favor shrubs.

Diagnostic Characteristics

Aridland shrublands and grasslands are dominated by a combination of xerophytic woody shrubs and grasses, while succulents and grasses occur from basin bottoms to desert mountain foothills. Shrubs include tall and dwarf multi-stemmed woody shrubs that are microphyllous or broad-leaved, evergreen or drought-deciduous species. *Acacia greggii, Fouquieria splendens, Larrea tridentata, Prosopis glandulosa*, and *Prosopis velutina* are strong diagnostic species with *Ambrosia dumosa, Eriogonum fasciculatum, Flourensia cernua*, and *Leucophyllum frutescens* as regionally important dominants. In addition, there are cacti and rosette stem succulents, and, on occasion, sarcocaulescent trees and shrubs. *Cylindropuntia leptocaulis* and *Cylindropuntia bigelovii* are strong and moderately diagnostic species, respectively; others are regionally diagnostic: *Encelia farinosa* (Mojave), *Bursera microphylla* (Baja California), *Carnegiea gigantea* (Sonoran), *Agave lechuguilla* (Chihuahuan), and *Yucca treculeana* (Tamaulipan). The division also includes communities of ephemeral desert washes with *Chilopsis linearis, Fallugia paradoxa*, and *Hymenoclea monogyra* as the strong diagnostic dominants, along with ruderal communities dominated by invasive grasses such as *Eragrostis curvula, Eragrostis lehmanniana, Pennisetum ciliare*, and *Pennisetum setaceum*.

Rationale

Acacia greggii and *Cylindropuntia leptocaulis* range across the entire division distribution and are near-endemics that are representative of the woody and succulent shrub components, respectively (although *Cylindropuntia leptocaulis* is never a dominant). *Muhlenbergia porteri* is also a near-endemic that ranges across the division except in the Tamaulipan zone. It represents the grass component, but it too is seldom a dominant. *Larrea tridentata* may also be a good candidate species to include in the name.

Physiognomy

This division is characterized by the dominance of xerophytic shrubs and grasses (and occasionally trees). Shrub growth forms are diverse and include tall and dwarf multi-stemmed, woody shrubs that are microphyllous or broad-leaved which can be evergreen or drought-deciduous (and some cases, cold-deciduous), and cacti and rosette stem succulents (and on occasion, sarcocaulescent trees). Thorns and spines are common, lending the term thorn scrub. Shrub-dominated desert communities are typically low in production and may form very open (10% cover) to moderately (50-66%) closed canopies, and may or may not have a significant herbaceous layer of grasses and forbs. Desert grasslands, in contrast, are dominated by drought-tolerant, often robust warm-season (C4) bunchgrasses that can range from 10% to nearly 100% in cover.

Floristics

Shrub growth forms are diverse. There are tall and dwarf multi-stemmed woody shrubs that are microphyllous or broad-leaved and they can be evergreen or drought-deciduous (and some cases, cold-deciduous). Among these, *Acacia greggii (= Senegalia greggii), Fouquieria splendens, Larrea tridentata, Prosopis glandulosa*, and *Prosopis velutina* are strong diagnostic species with *Ambrosia dumosa, Eriogonum fasciculatum, Flourensia cernua, Jatropha cuneata, Leucophyllum frutescens*, and *Viguiera stenoloba* as regionally important dominants. In addition, there are cacti and rosette stem succulents, and on occasion, sarcocaulescent trees. Among these, *Cylindropuntia leptocaulis* and *Cylindropuntia bigelovii* are strong and moderately diagnostic species, respectively. Others, while restricted to the division, are common and often conspicuous elements of specific desert regions, e.g., *Bursera microphylla* (Baja California), *Carnegiea gigantea* (Sonoran), *Agave lechuguilla* (Chihuahuan), and *Yucca treculeana* (Tamaulipan). Shrub-dominated desert communities are typically low in production and may form very open canopies (10% cover) to moderately closed (50-66%) ones at best, and with or without a significant herbaceous layer of grasses and forbs.

Desert grasslands, in contrast, are dominated by drought-tolerant, warm-season (C4) bunchgrasses and can be more productive with grass cover that can range from 10% to nearly 100%. Among desert grasslands of the division, moderately strong diagnostics include*Bouteloua eriopoda, Muhlenbergia porteri, Pleuraphis mutica, Pleuraphis rigida*, and *Sporobolus flexuosus*. Xerophytic shrubs can be conspicuous and moderately diagnostic elements of the grasslands, but not the dominants, e.g., *Dasylirion leiophylla, Ephedra torreyana, Nolina texana*, and *Yucca elata*. Perennial forbs are diverse, but typically low in cover; annual forbs can be locally to regionally abundant in any given year depending on rainfall amounts and timing, or essentially absent. Desert grasslands are more prevalent in the eastern, summer rainfall-dominated regions (Chihuahuan and Tamaulipan) that favor the more shallow-rooted grasses during the growing season. In contrast, shrublands tend to dominate the Sonoran, Mojave, and Viscaino-Baja California deserts where the predominantly winter-rainfall regime favors shrubs that can access deeper stored soil moisture from the winter during the growing season.

In desert washes, strong diagnostic species include*Chilopsis linearis, Fallugia paradoxa*, and *Hymenoclea monogyra*. In addition, *Baccharis sarothroides, Brickellia laciniata, Juglans microcarpa, Prosopis velutina, Prosopis glandulosa, Rhus microphylla, Olneya tesota*, and *Parkinsonia florida* are moderately diagnostic regional species (the latter two are small trees). Lastly, where sites have been heavily disturbed or near the epicenter of the introduction of aggressive non-native noxious weeds, de-novo ruderal (weedy) communities dominated by drought-tolerant species can form. Of particular concern is the invasion of desert grasslands by perennial graminoids such as *Eragrostis curvula, Eragrostis lehmanniana, Pennisetum ciliare*, and *Pennisetum setaceum*. Annuals such as *Brassica tournefortii, Bromus rubens, Schismus arabicus*, and *Schismus barbatus* can also be problematic, particularly in winter-rainfall regions where they germinate early and can alter fire regimes later in the summer dry season.

Environment

Climate: This is a division of warm-temperate to subtropical arid conditions with peak summer temperatures that can exceed 50°C and mean annual precipitation ranges from 30 to 250 (300) mm. In the higher elevation or more continental regions (Mojave and Chihuahuan), temperatures can drop below freezing for extended periods in winter. Desert grasslands are more prevalent in the eastern, summer rainfall-dominated regions

(Chihuahuan and Tamaulipan) that favor the more shallow-rooted grasses during the growing season. In contrast, shrublands tend to dominate the Sonoran, Mojave, and Viscaino-Baja California deserts where the predominantly winter-rainfall regime favors shrubs that are able access deeper stored soil moisture during the growing season. Sites extend from sea level (or below) to about 1600 m for shrublands and 2000 m for desert grasslands.

Soils/substrate: From a landscape perspective, a basin-and-range physiography forms the primary physical template for the expression of communities of the division. That is, vegetation communities are assorted from low-lying, broad basin bottoms with fine clay alluvial soils (including alkaline ephemeral playa lakes) up adjacent coalesced alluvial fan piedmonts (bajadas) with shallow gravelly soils and desert pavements to the colluvial foothill slopes of bordering desert mountain ranges with their cobbly and rocky soils (including sparsely vegetated cliff faces and boulder slopes). The desert basin can also have extensive sandy plains (sand sheets) and dunelands (including unique gypsum dune communities). The mountain ranges are composed of either fault-block uplifted sedimentary rocks (limestone and sandstone) with underlying basement granitic rocks that are sometimes exposed, or extrusive volcanics such as rhyolite. Associated with the volcanic regions are extrusive, sometimes large basaltic lava flows in the basins that also support vegetation different from those in the surrounding landscapes. Flowing through these landscape elements are ephemeral dry washes (arroyos) that support unique desert vegetation that is able to tolerate high episodic stream flows driven primarily by summer thunderstorms.

Range

This division extends from warmer deserts of the southwestern U.S. and northern Mexico from the Pacific to Atlantic oceans (Viscaino-Baja California up to the Mojave and eastward through the Sonoran and Chihuahuan deserts to the Tamaulipan mattoral/mezquital).

Synonymy

< Matorral Xerofilo (Rzedowski 1978)
> Tropical-Subtropical Desertlands (Brown 1982a)
> Tropical-Subtropical Desertlands (Brown et al. 1998)
> Warm Deserts (MacMahon 1988)
> Warm Temperate Desertlands (Brown 1982a)
> Warm Temperate Desertlands (Brown et al. 1998)

Dynamics

Fire plays a role in desert grasslands (return intervals between 10 and 30 years) but has minimal impact on desert scrubs. Excessive burning of desert grasslands can also favor shrubs. However, in recent years exotic perennial and annual grasses have introduced a fire regime into the desert scrub which lacked a fire regime prior to this. These exotic grasses carry fires which burn the non-fire-adapted shrubs and small trees.

Taxonomic Parent Warm Desert & Semi-Desert Scrub & Grassland

Parent Key F015

Name **Rocky Mountain Forest & Woodland**

Database Code	Classification Code	Hierarchy Level	Status
D194	1.B.2.Nb	Division	Accepted

Translated Name Douglas-fir - Western Hemlock - Subalpine Fir Forest & Woodland Division

Scientific Name Pseudotsuga menziesii - Tsuga heterophylla - Abies lasiocarpa Forest & Woodland Division

Summary

This division is composed of forests, woodlands and savannas of the lower montane to subalpine zones of the continental temperate climates of western North America characterized by the conifers *Abies concolor, Abies grandis, Abies lasiocarpa, Abies religiosa, Juniperus* spp. (*Juniperus osteosperma, Juniperus scopulorum*), *Larix lyallii, Larix occidentalis, Picea engelmannii, Picea x albertiana, Picea pungens, Pinus albicaulis, Pinus aristata, Pinus contorta var. latifolia, Pinus flexilis, Pinus hartwegii, Pinus longaeva, Pinus ponderosa* (*var. brachyptera, var. ponderosa, var. scopulorum*), *Pseudotsuga menziesii var. glauca, Thuja plicata*, and *Tsuga heterophylla*.

Description

This division is composed of conifer forests, woodlands and savannas of the lower montane to subalpine zones of the continental temperate climates of western North America. These communities occur in the interior Pacific Northwest, the southern Rocky Mountains, and extend east of the Continental Divide into the northwestern Great Plains region, and south at high elevations of the Sierra Madre Mountains. Strong diagnostic conifers (needle-leaved trees) are *Abies concolor, Abies lasiocarpa, Abies religiosa, Juniperus* spp. (*Juniperus osteosperma, Juniperus scopulorum*), *Larix lyallii, Larix occidentalis, Picea engelmannii, Picea x albertiana, Picea pungens, Pinus albicaulis, Pinus aristata, Pinus contorta var. latifolia, Pinus flexilis, Pinus hartwegii, Pinus longaeva, Pinus ponderosa* (*var. brachyptera, var. ponderosa, var. scopulorum*), and *Pseudotsuga menziesii var. glauca*. Other conifers that are common in these forests and woodlands are *Abies grandis, Thuja plicata, Tsuga heterophylla*, and *Tsuga mertensiana*. Deciduous hardwoods (broad-leaved deciduous trees) are infrequent and include *Acer grandidentatum, Betula papyrifera*, and *Populus tremuloides*. Savannas and woodlands occur commonly in dry climates and on dry sites, and in some cases may be dominated by short trees in a "scrub woodland" form. Woodlands also predominate at high elevations, and at the highest elevations stands are composed of tree clumps or ribbons, with intervening grasslands or shrublands. Evergreen conifers dominate stands overall. Deciduous hardwoods can occur, intermingling with conifers, and deciduous conifers can dominate some areas. Stands can be composed of just one tree species, but more often are of mixed composition, sometimes of a diverse mix. Shrub and herb layers vary widely. Sometimes the shrub layer is dominant, with tall or short broad-leaved deciduous or needle-leaved evergreen shrubs; in other cases, perennial forbs and graminoids (grasses or sedges) are the predominant growth forms. Nonvascular species (mosses, liverworts, lichens, fungi, or soil cryptogams) also vary considerably in abundance, but many forests have a high cover of mosses.

The climate is cool temperate and continental, although many areas are influenced somewhat by Pacific maritime air masses. Temperature regimes vary considerably across the range, and between seasons. Precipitation ranges from 25-240 cm annually. All areas

receive winter snow, but winter rain is also possible in most areas. In many areas, a seasonal drought period occurs. In most of the range, more arid grassland climates occur at elevations below this type and alpine tundra occurs at elevations above. Elevations range considerably. Landforms are variable and can include canyons, plateaus, draws, benches, hills, mesas, rolling plains, cinder cones, ravines, ridgetops, shoulders, sideslopes and toeslopes. Slopes can be gentle to extremely steep. Bedrock geology includes volcanic, intrusive, metamorphic, sedimentary and ultramafic rocks. Fractured rock, colluvium, and eolian materials are common substrates. Glacially-derived substrates are typical in mountainous and northern areas, and volcanically-derived substrates are common in central and southern areas. Fire is the predominant natural disturbance factor of this type. There is a strong correlation between climate and the fire regime: drier climates are dominated by fire-dependent vegetation with stand-maintaining fires common and/or short interval stand-replacing fires (as short as 30-50 years), whereas wetter climates are characterized by long fire-return intervals for stand-replacing fire events (up to 500 years or more). In recent times, fire suppression has changed the fire dynamics of natural forests. Other natural disturbance agents are insect outbreaks, disease, occasional windthrow, and avalanches. Forest harvesting is also a major factor over most of the type.

Diagnostic Characteristics

Forests, woodlands and savannas found in the lower montane to subalpine zones of the interior Pacific Northwest, southern Rocky Mountains, and extending east into the northwestern Great Plains regions. Strong diagnostic conifers are *Abies concolor, Abies lasiocarpa, Juniperus* spp. (*Juniperus osteosperma, Juniperus scopulorum*), *Larix lyallii, Larix occidentalis, Picea engelmannii, Picea x albertiana* hybrids, *Picea pungens, Pinus albicaulis, Pinus aristata, Pinus contorta var. latifolia, Pinus flexilis, Pinus longaeva, Pinus ponderosa* (*var. brachyptera, var. ponderosa, var. scopulorum*), and *Pseudotsuga menziesii var. glauca*. Associated conifers common in this division are *Abies grandis, Thuja plicata, Tsuga heterophylla*, and *Tsuga mertensiana*. Deciduous hardwoods include *Acer grandidentatum, Betula papyrifera*, and *Populus tremuloides*. Some strong diagnostic understory species are *Calamagrostis rubescens, Vaccinium myrtillus, Vaccinium membranaceum, Vaccinium scoparium*, and *Xerophyllum tenax*.

Rationale

Physiognomy

The communities of this type are mostly forests and woodlands but include savannas and tree islands. Savannas and woodlands occur commonly in dry climates and on dry sites, and in some cases may be dominated by short trees in a "scrub woodland" form. Woodlands also predominate at high elevations, and at the highest elevations stands are comprised of tree clumps or ribbons, with intervening grasslands or shrublands. Evergreen conifers dominate stands overall. Deciduous hardwoods can occur, intermingling with conifers stands, and deciduous conifers can dominate some areas. Stands can be composed of just one tree species, but more often are of mixed composition, sometimes of a diverse mix. Shrub and herb layers vary widely, with tall or short deciduous or evergreen shrubs dominating the undergrowth, or in some cases with few or no shrubs, and perennial forbs, grasses or sedges are the predominant growth forms. Nonvascular species (mosses, liverworts, lichens, fungi, or soil cryptogams) also vary considerably in abundance, but many forests have a high cover of mosses.

Floristics

The forests and woodlands of this type include characteristic western North American conifers (needle-leaved trees) such as *Abies grandis, Abies lasiocarpa, Larix occidentalis, Picea engelmannii, Pinus contorta var. latifolia, Pinus flexilis, Pinus ponderosa, Pseudotsuga*

menziesii, Thuja plicata, and *Tsuga heterophylla*. Many of these species are wide-ranging but occur in specific environments influenced by climate, site, and historical conditions.

Pinus ponderosa forests and woodlands occur in dry climatic areas and on dry rocky sites or warm aspects over much of the central and southern range. *Pinus ponderosa* often occurs in pure stands, but can also occur as mixed stands with other conifer or hardwood species, e.g., *Pseudotsuga menziesii* in slightly moister climates, or *Quercus macrocarpa* in the northwestern Great Plains. The understory of *Pinus ponderosa* woodlands is varied and can be dominated by broad-leaved shrubs, e.g., *Amelanchier alnifolia, Physocarpus malvaceus, Purshia tridentata, Symphoricarpos albus*, or grasses, e.g., *Festuca idahoensis* and *Pseudoroegneria spicata*. *Pinus ponderosa* can also occur in savannas mixed with grasslands or big sagebrush steppe.

The limber pine - juniper woodlands dominated by*Pinus flexilis, Juniperus osteosperma*, or *Juniperus scopulorum* are included in this type, as are woodlands or "savannas" of the deciduous conifer *Larix occidentalis*.

Pseudotsuga menziesii is common in forests of this division. It can dominate many dry climate areas and sites, either in pure stands or mixed with *Pinus ponderosa, Pinus contorta*, or *Larix occidentalis*. The understory can be shrubby or grassy, and sometimes dominated by mosses or lichens. A variety of shrubs occur in these stands, such as *Acer glabrum, Juniperus communis, Physocarpus malvaceus, Symphoricarpos albus*, and *Spiraea betulifolia*. Graminoids are common, e.g., *Calamagrostis rubescens, Carex geyeri*, and forbs are variable, but typical taxa include *Arnica cordifolia, Osmorhiza berteroi, Thalictrum occidentale*, and species of many other genera, including *Erigeron, Fragaria, Lathyrus, Lupinus, Penstemon*, and *Vicia*. *Pseudotsuga menziesii* can persist in more mesic stands as a long-lived seral species.

Mesic conifer forests of the lower montane regions are characteristically mixed stands dominated by two or more of*Abies grandis, Pseudotsuga menziesii, Thuja plicata, Tsuga heterophylla, Larix occidentalis*, and *Pinus contorta*. Other conifers that often comprise part of the stand are *Abies lasiocarpa, Picea engelmannii, Picea glauca x engelmannii*, and *Pinus monticola*. Deciduous hardwood species such as *Populus tremuloides* or *Betula papyrifera* also occur, but typically are not dominant. These stands typically have a well-developed shrub and/or forb understory, as a result of the more mesic conditions, but can be sparse due to a dense canopy. Common shrubs are *Acer glabrum, Amelanchier alnifolia, Paxistima myrsinites, Rubus parviflorus, Spiraea betulifolia, Symphoricarpos albus, Taxus brevifolia*, and *Vaccinium membranaceum*. *Oplopanax horridus* occurs in depressional areas with high water tables. Composition of the herbaceous layer reflects local climate, site, and degree of canopy closure and can include *Adenocaulon bicolor, Aralia nudicaulis, Clintonia uniflora, Cornus canadensis, Goodyera oblongifolia, Linnaea borealis, Tiarella trifoliata, Viola orbiculata*, and *Xerophyllum tenax*. Graminoids are generally only a very minor component. Ferns and fern allies form an important component of the understory on moist sites and commonly include *Athyrium filix-femina, Dryopteris filix-mas, Equisetum* spp., and *Gymnocarpium dryopteris*. A dense moss layer often forms on the forest floor, particularly in northern forests.

Northern forests of this macrogroup are dominated by*Picea x albertiana (= Picea engelmannii x glauca), Abies lasiocarpa*, and/or *Pinus contorta*, with *Pseudotsuga menziesii*

occurring in warmer areas and on warm sites. The deciduous hardwood species *Populus tremuloides* and *Betula papyrifera* commonly occur, dominating forests near settlements and around agriculture areas. *Picea mariana* sometimes occurs in these forests. These forests are transitional between temperate and boreal forests. The understory is similar to that of other mesic conifer forests of this division but includes some northern species such as *Rosa acicularis, Lonicera involucrata, Viburnum edule, Rubus pubescens*, and *Galium boreale*.

Abies lasiocarpa - Picea engelmannii forests and woodlands characterize upper montane to subalpine zones over much of the range of this division. *Pinus contorta* is often present and can dominate dry climate areas; other associated tree species are *Larix lyallii, Pinus albicaulis, Pinus aristata, Pinus flexilis, Pinus longaeva, Populus tremuloides*, and *Tsuga mertensiana*. Canopies can be mixed or dominated by a single species. Shrub species are highly variable, and typically are cold-deciduous (sometimes evergreen), including *Lonicera utahensis, Ribes inerme*, several *Vaccinium* spp. (*Vaccinium membranaceum (= Vaccinium globulare), Vaccinium myrtillus, Vaccinium scoparium*), *Ledum glandulosum, Menziesia ferruginea, Rhododendron albiflorum*, and *Phyllodoce empetriformis*. Associated herbaceous species are especially diverse given the wide elevational and latitudinal range of these forests, with alpine species occurring near the upper treeline and montane and subalpine species below. Mesic stands include herbaceous species such as *Clintonia uniflora, Eucephalus engelmannii (= Aster engelmannii), Gymnocarpium dryopteris, Heracleum maximum, Luzula glabrata var. hitchcockii, Pedicularis racemosa, Rubus pedatus, Senecio triangularis, Tiarella* spp., *Valeriana occidentalis, Valeriana sitchensis*, and *Xerophyllum tenax*. Drier sites close to the alpine might include xeric graminoids, such as *Calamagrostis purpurascens, Festuca arizonica, Festuca idahoensis*, and *Trisetum spicatum*.

Mid-elevation forests and woodlands of the southern Rocky Mountains are characterized by*Abies concolor, Juniperus scopulorum, Pinus ponderosa, Pseudotsuga menziesii*, and *Picea pungens*. The deciduous *Populus tremuloides* or *Acer grandidentatum* are early-seral species that may be codominant in some stands. Other conifers that may be present include *Abies lasiocarpa, Picea engelmannii, Pinus contorta, Pinus edulis*, and *Pinus flexilis*. In the southernmost range, associated trees may include *Pinus strobiformis* and *Juniperus deppeana*.

High montane (subalpine) forests of the Sierra Madre Mountains, characterized by the conifers*Pinus hartwegii* or *Abies religiosa*, are included in this division. Associated trees include *Abies concolor, Abies guatemalensis, Alnus firmifolia, Cupressus* spp., *Pinus montezumae, Pseudotsuga menziesii*, and *Quercus laurina*.

Environment

These forests and woodlands occur on upland sites of temperate continental regions of western North America. In most of the range, more arid grassland climates occur at elevations below this type and alpine tundra occurs at elevations above. In moist climate areas and in the far northern range, this type occupies all elevations below the alpine. As such, elevations range considerably. Valley forests in northwestern British Columbia as low as 100 m (330 feet) in elevation are included in this type; upper elevation transitions to alpine tundra or dwarf-shrublands occur at 1675 m (5500 feet) in the northern range, and up to 3670 m (12,000 feet) in the south.

Climate: The climate of this type is cool temperate and continental, although many areas

are influenced somewhat by Pacific maritime air masses. Temperature regimes vary considerably across the range and between seasons. Precipitation ranges from 25-240 cm annually. All areas receive winter snow (50 - 900 cm), but winter rain is also possible in most areas. In many areas, a seasonal drought period occurs. In areas east of the Continental Divide and in the Southwest, summer precipitation predominates, whereas further west and north, winter storms from the west are important sources of precipitation. High snowpack can contribute significantly to early growing season soil moisture in the moister mountains. High winds are a common feature found to the east of the Continental Divide and out in the Great Plains.

Soils/substrate: Landforms are variable and can include canyons, plateaus, draws, benches, hills, mesas, rolling plains, cinder cones, ravines, ridgetops, shoulders, sideslopes and toeslopes. Slopes can be gentle to extremely steep. In much of the range of this division, closed to open forests occupy most of the landscape. Some areas and sites are too droughty to support a closed tree canopy, so open woodlands and savannas occur. At the highest elevations, the interaction between snow deposition, desiccating winds, soil and substrate characteristics, and the interacting effects of precipitation, temperature and both latitude and elevation/aspect influence the type of forest, creating krummholz or tree patches in the alpine transition. Occurrences at high elevations are restricted by cold temperatures and are found on warmer aspects, whereas, at lower elevations, occurrences are restricted by lack of moisture and are found on cooler north aspects and mesic microsites.

Bedrock geology includes volcanic, intrusive, metamorphic, sedimentary and ultramafic rocks. Fractured rock, colluvium, and eolian materials are common substrates. Glacial till is typical in mountainous and northern areas, which can also have other glacial parent materials, e.g., glaciolacustrine, glaciofluvial. Volcanic activity is common in central and southern areas with pumice or ash deposits occurring. Many soils have good aeration and drainage, with an abundance of mineral material of medium to coarse textures, and variable rockiness. Soils range from deep and well-developed to shallow and rocky.

Biogeography: The expression of the types of forests and woodlands of this division are in response to climatic gradients of temperature and moisture. As most of the mountain ranges are perpendicular to the prevailing winds, moisture gradients are strongly influenced by windward or leeward (rainshadow) positions on the mountain ranges, in conjunction with elevation in the mountains. As such, the forest types occur in elevational bands, e.g., in dry climatic areas of eastern Washington and southern British Columbia, *Pinus ponderosa* forests and woodlands occur at the lowest elevations, with the sequence with increasing elevation (cooler temperatures and more precipitation) from *Pseudotsuga menziesii*, to *Pinus contorta*, to *Abies lasiocarpa - Picea engelmannii* forests. In moister climate regions, e.g., Idaho, the elevation sequence is *Pseudotsuga menziesii* forests, to *Tsuga heterophylla - Thuja plicata* forests, to *Abies lasiocarpa - Picea engelmannii* forests.

The division occurs over a wide latitudinal range so that a particular forest type can occur at very different elevations throughout its range, e.g.,*Pinus ponderosa* woodlands occur at 400-800 m in southern British Columbia but at 1800-2700 m in southern Utah. The division is only found at the highest forested elevations in its southern range in Mexico and Guatemala, whereas it occurs from valley bottom to mountaintop (excluding alpine tundra) over most of the southern and central interior of British Columbia.

Range

This division occurs throughout the southern and central Rocky Mountains, from western Texas and southern New Mexico north into southern Alberta and central British Columbia, west into mountain ranges of central British Columbia, Idaho, and Washington, through the Colorado Plateau, Great Basin and Mojave Desert to the eastern slopes of the Sierra Nevada, Cascades, and Coast Mountains, and then east of the Rocky Mountains to the mountains and highlands of South Dakota, the Greater Yellowstone region, and the Wind River, Gros Ventre and Bighorn ranges of Wyoming. This division also occurs at the high elevations of the Sierra Madre Mountains of Mexico and Guatemala.

Synonymy

< Forests and Meadows of the Rocky Mountains (Peet 2000) [Peet primarily discusses Rocky Mountain forests and woodlands, but does include one section on "Meadows and Parks." We exclude boreal Rocky Mountain forests and low-elevation warm-temperate pine-juniper-evergreen oak woodlands in Arizona, New Mexico and Mexico.]

Dynamics

Fire is the predominant natural disturbance factor of forests and woodlands of this division. There is a strong correlation between climate and the fire regime: drier climates are dominated by fire-dependent vegetation with stand-maintaining fires common and/or short interval stand-replacing fires (as short as 30-50 years), whereas wetter climates are characterized by long fire-return intervals for stand-replacing fire events (up to 500 years or more). In recent times, fire suppression has changed the fire dynamics of natural forests. Other natural disturbance agents are insect outbreaks, disease, occasional windthrow, and avalanches. Forest harvesting is also a major factor over most of the type.

Forests and woodlands of very dry climates and sites had historic fire regimes characterized by frequent, low-intensity surface fires that maintained relatively open stands of a mix of fire-resistant species, mostly*Pinus ponderosa* but including *Pseudotsuga menziesii* in some circumstances. Fire maintained the open canopies characteristic of savannas and open woodlands of these species. Mature trees can survive low-intensity surface fires. With human settlement and subsequent fire suppression, stands have become denser. Presently, many occurrences contain understories of more shade-tolerant species, as well as a greater density of younger cohorts. These altered structures have affected fuel loads and altered fire regimes. Presettlement fire regimes were primarily frequent (5- to 15-year return intervals), low-intensity surface fires triggered by lightning strikes or deliberately set by Native Americans. With fire suppression and increased fuel loads, fires are now less frequent and often become intense crown fires, which can kill mature trees. The result is a mixed-severity fire regime for many *Pinus ponderosa* and *Pseudotsuga menziesii* stands as stand-replacing fires are becoming more common.

Forests in dry to moist climates are characterized by stand-replacing fires with a variable return interval, ranging from about 50-150 years. Many of the important tree species in these forests are fire-adapted (e.g.,*Populus tremuloides, Pinus ponderosa, Pinus contorta*) or fire-tolerant (e.g., *Pseudotsuga menziesii*) or given the right conditions, regenerate well after fire (e.g., *Picea glauca x engelmannii*). Other species, e.g., *Abies* spp. (*Abies concolor, Abies grandis, Abies lasiocarpa*), *Thuja plicata*, or *Tsuga heterophylla*, are not fire-adapted, but are shade-tolerant and become more prevalent in stands over time, if undisturbed, as the early-seral species die off. Establishment after fire is influenced by availability of seed source or other propagules, e.g., live aspen roots, of the various species in the area. Landscape and site position influence fire behavior as well as regeneration. The pattern of forest types and stand ages on a landscape is the result of the combined influence of seed

source, fire behavior, and site conditions.

Forests in wetter climates tend to have long fire-return intervals, ranging from 150 to over 500 years for stand-replacing fires. Gap dynamics are important in older stands and pests and pathogens play a greater role in stand mortality.*Thuja plicata - Tsuga heterophylla* forests are an example of these forests; they can develop into very old forests with large, tall trees. *Picea engelmannii - Abies lasiocarpa* forests can also be very old. Although *Abies lasiocarpa* is not long-lived, it is very shade-tolerant and regenerates well in these upper elevation stands.

Insect pests, such as mountain pine beetle (*Dendroctonus ponderosae*), can cause significant stand and tree mortality and also influence stand development. Expansive stands of *Pinus contorta* that occur in many regions are particularly susceptible. *Pinus albicaulis* is a slow-growing, long-lived conifer that is common at higher elevations in the upper subalpine zone over much of the central and northern range of this division. The exotic pathogen white pine blister rust (*Cronartium ribicola*) is attacking and killing *Pinus albicaulis* trees. It is especially destructive in more mesic habitats that favor infection of its alternate host *Ribes* spp.

Two very slow-growing, long-lived pines in this division are*Pinus longaeva* and *Pinus flexilis*. *Pinus longaeva* may attain nearly 4900 years in age and 12 m in height, whereas *Pinus flexilis* may live 1000 years and attain 18 m in height.

Taxonomic Parent Cool Temperate Forest & Woodland

Parent Key F008

Name Southwestern North American Warm Desert Freshwater Marsh & Bosque

Database Code	Classification Code	Hierarchy Level	Status
D032	2.C.4.Nc	Division	Accepted

Translated Name Honey Mesquite / Southern Cattail - Common Threesquare Southwestern North American Warm Desert Freshwater Marsh & Bosque Division

Scientific Name Prosopis glandulosa / Typha domingensis - Schoenoplectus pungens Southwestern North American Warm Desert Freshwater Marsh & Bosque Division

Summary

Herbaceous marshes and riparian shrublands found throughout canyons and desert valleys of the warm desert regions of the southwestern U.S. and adjacent Mexico.

Description

This division covers herbaceous marshes and riparian shrublands widely distributed throughout canyons and desert valleys of the warm desert regions of the southwestern U.S. and adjacent Mexico. Riparian shrublands are found in riparian corridors of small, medium and large perennial and intermittent streams and rivers at low elevations (<1100 m). The vegetation is low scrub or shrub, not tall trees. Dominant scrub species are *Prosopis glandulosa* and *Prosopis velutina*, and dominant shrubs include *Baccharis salicifolia, Pluchea sericea, Salix geyeriana, Shepherdia argentea*, and *Salix exigua*. Woody vegetation is relatively dense, especially when compared to drier washes. Marsh vegetation is characterized by a lush, dense herbaceous layer with low diversity occurring sometimes as a monoculture. Dominant species include *Carex pellita, Carex praegracilis, Cyperus* spp., *Distichlis spicata, Eleocharis palustris, Flaveria chlorifolia, Helianthus paradoxus, Juncus arcticus ssp. littoralis, Paspalum distichum, Ranunculus aquatilis, Schoenoplectus americanus, Schoenoplectus pungens*, and *Typha domingensis*. Marsh vegetation occurs in bottomlands along drainages, in river floodplain depressions, cienegas, oxbow lakes, below seeps, on frequently flooded gravel bars, low-lying sidebars, infilled side channels, small ponds, stockponds, ditches and slow-moving streams, and perennial streams in valleys and mountain foothills, from 890 to 1560 m (2930-5120 feet) in elevation. Marsh substrates are variable but are generally fine-textured and often alkaline. Hydrologic regimes vary from seasonal inundation followed by complete soil desiccation to year-round standing water.

Diagnostic Characteristics

Desert climes of the southwestern U.S., seasonal inundation or at least near-surface or sub-surface water table saturation, characterized by emergent herbaceous vegetation, or intermittent and perennial streambanks and floodplains with native woody shrub species. Dominant scrub species are *Prosopis glandulosa* and *Prosopis velutina*, and dominant shrubs include *Baccharis salicifolia, Pluchea sericea, Salix exigua, Salix geyeriana*, and *Shepherdia argentea*. Dominant marsh species include *Carex pellita, Carex praegracilis, Cyperus* spp., *Distichlis spicata, Eleocharis palustris, Flaveria chlorifolia, Helianthus paradoxus, Juncus arcticus ssp. littoralis, Paspalum distichum, Ranunculus aquatilis, Schoenoplectus americanus, Schoenoplectus pungens*, and *Typha domingensis*.

Rationale

Physiognomy

The riparian shrublands are dominated by low scrub trees or shrubs, not tall trees. Woody vegetation is relatively dense, especially when compared to drier washes. The marsh vegetation is characterized by a lush, dense herbaceous layer with low diversity, occurring

sometimes as a monoculture.

Floristics

Dominant scrub species are *Prosopis glandulosa* and *Prosopis velutina*, and dominant shrubs include *Baccharis salicifolia, Pluchea sericea, Salix exigua, Salix geyeriana*, and *Shepherdia argentea*. Dominant marsh species include *Carex pellita (= Carex lanuginosa), Carex praegracilis, Cyperus* spp., *Distichlis spicata, Eleocharis palustris, Flaveria chlorifolia, Helianthus paradoxus, Juncus arcticus ssp. littoralis (= Juncus balticus), Paspalum distichum, Ranunculus aquatilis, Schoenoplectus americanus, Schoenoplectus pungens*, and *Typha domingensis*.

Environment

Soils/substrate: Riparian shrublands are found in riparian corridors of small, medium and large perennial and intermittent streams and rivers at low elevations (<1100 m). Marsh vegetation occurs in bottomlands along drainages, in river floodplain depressions, cienegas, oxbow lakes, below seeps, on frequently flooded gravel bars, low-lying sidebars, infilled side channels, small ponds, stockponds, ditches and slow-moving streams, and perennial streams in valleys and mountain foothills, from 890 to 1560 m (2930-5120 feet) in elevation. Marsh substrates are variable but are generally fine-textured and often alkaline. Hydrologic regimes vary from seasonal inundation followed by complete soil desiccation to year-round standing water.

Range

This division is found in desert climes of the southwestern U.S., including Trans-Pecos Texas, Colorado, Arizona, and New Mexico, and adjacent Mexico.

Synonymy

Dynamics

Taxonomic Parent Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland

Parent Key F013

Name **Western North American Alpine Tundra**

Database Code	Classification Code	Hierarchy Level	Status
D043	4.B.1.Nb	Division	Accepted

Translated Name Yellow Mountain-heath - Mountain-avens species - Altai Fescue Alpine Tundra Division

Scientific Name Phyllodoce glanduliflora - Dryas spp. - Festuca altaica Alpine Tundra Division

Summary This type consists of low to dwarf-shrublands, tundra and sparse vegetation at and above upper timberline in the western North American Cordillera from the Aleutian Islands of Alaska to northern Mexico.

Description

This division is found from the Alaskan mountain ranges down through the Cascade-Sierras of California and through the Rocky Mountains into northeastern Mexico. Vegetation physiognomy ranges from sparse cushion plants to dense turf, dwarf-shrublands and krummholz. Communities vary considerably in floristic composition over the range of this type. In the northern alpine, well-vegetated tundra is typically composed of *Artemisia arctica, Carex microchaeta, Dryas integrifolia* or *Dryas octopetala, Festuca altaica, Polygonum viviparum, Salix reticulata, Silene acaulis*, and some bryophytes, such as *Aulacomnium turgidum* and *Hylocomium splendens*, and lichens, such as *Stereocaulon* spp. or *Flavocetraria nivalis*.

The "typical" central and southern Rocky Mountain alpine tundra has a sparse to moderate cover dominated by*Carex elynoides, Carex siccata, Carex scirpoidea, Carex nardina, Carex rupestris, Festuca brachyphylla, Festuca idahoensis, Geum rossii, Juncus drummondii, Kobresia myosuroides, Phlox pulvinata*, or *Trifolium dasyphyllum*. Wind-exposed ridges and saddles have species such as *Arenaria capillaris, Dryas integrifolia, Kobresia myosuroides, Luzula spicata, Minuartia obtusiloba, Oxytropis podocarpa, Paronychia pulvinata, Phlox pulvinata, Poa alpina, Potentilla nivea, Potentilla villosa, Saxifraga bronchialis, Silene acaulis, Trifolium dasyphyllum*, and *Trifolium parryi*. Dwarf-shrubland dominates the coastal alpine and snowier sites in the other areas. Common heath species are *Cassiope lycopodioides, Cassiope mertensiana, Cassiope tetragona, Empetrum nigrum, Harrimanella stelleriana, Luetkea pectinata, Phyllodoce aleutica, Phyllodoce empetriformis*, and *Phyllodoce glanduliflora*. Scattered trees and patches of krummholz may occur at lower elevations, composed of *Abies lasiocarpa, Picea glauca*, or *Tsuga mertensiana*, depending upon the area. The drier alpine vegetation of the Great Basin ranges and Sierra Nevada may include lower elevation semi-desert species such as *Carex filifolia, Poa fendleriana, Poa secunda*, and *Artemisia frigida*. The alpine of northeastern Mexico is dominated by *Potentilla leonina, Arenaria* spp., and *Thelesperma muelleri*.

Environments are varied due to climatic and site variation. Wind and its effect on snow movement has a strong local effect, producing wind-scoured fell-fields, dry turf, snow accumulation heath communities, and short growing season snowbed sites. Fell-fields are typically free of snow during the winter as they are found on ridgetops, upper slopes and exposed saddles, whereas dry turf is found on gentle to moderate slopes, flat ridges, valleys, and basins where the soil has become relatively stabilized and the water supply is

more-or-less constant. Dwarf-shrubland sites tend to be in level or concave areas with late-lying snow and subirrigation from surrounding slopes. The dominant disturbances are snow avalanche, soil creep and freeze-thaw action.

Diagnostic Characteristics

Low to dwarf-shrublands, tundra and sparse vegetation at and above upper timberline in the western North American Cordillera from the Aleutian Islands of Alaska to northern Mexico. There are many strong diagnostic species of this type as compared to other alpine floras. These include the graminoids *Calamagrostis breweri, Carex elynoides, Carex helleri, Carex filifolia, Carex microchaeta, Carex rupestris, Festuca altaica*, and *Kobresia myosuroides*; the dwarf-shrubs *Cassiope mertensiana, Cassiope tetragona, Dryas integrifolia, Dryas octopetala, Phyllodoce empetriformis, Phyllodoce glanduliflora, Salix reticulata, Salix vestita*; and forbs such as *Artemisia arctica, Geum rossii, Phlox pulvinata, Potentilla nivea, Saxifraga bronchialis, Silene acaulis*, and *Trifolium dasyphyllum*.

Rationale

One key species from each of the three main types was selected. *Phyllodoce glanduliflora* occurs over much of the range of this type, particularly in coastal mountains. *Dryas octopetala* is wide-ranging and could be used without *Dryas integrifolia*, but the latter often dominates where the former does not. *Festuca altaica* characterizes the boreal alpine, although other species could be used, e.g., *Artemisia arctica* or *Salix reticulata*.

Physiognomy

The communities of this type are composed of sparse and open- to closed-canopy herbaceous stands, dominated by graminoids and/or perennial forbs, as well as dwarf-shrub stands, and near treeline, needle-leaved evergreen trees in krummholz form. Stands of low-statured forbs are often in cushion plant form or matted, flat to the ground in rosettes, and often densely haired and thickly cutinized. The low growth forms of alpine plants allows them to take advantage of the more favorable temperatures that occur near the ground. The height of krummholz is correlated with mean winter snow depth. Although some turf communities are extensive, the vegetation overall is a mosaic of small-patch plant communities.

Floristics

Communities vary considerably in floristic composition over the range of this type. Although species vary individually in their distribution, some floristic groups are evident. Many alpine tundra species also occur in the arctic tundra, e.g., *Carex rupestris, Cassiope tetragona, Dryas integrifolia, Dryas octopetala, Kobresia myosuroides, Salix reticulata*, the proportion becoming less southward, although about one-third of the Colorado alpine flora occurs in the arctic.

In the northern alpine, the more densely vegetated tundra is composed of dwarf willows, graminoids, and forbs with bryophytes and lichens. Common species of this tundra are*Artemisia arctica, Carex microchaeta, Dryas integrifolia* (limestone-influenced soils) or *Dryas octopetala, Festuca altaica, Polygonum viviparum, Salix reticulata, Silene acaulis*, and some bryophytes, such as *Aulacomnium turgidum, Hylocomium splendens*, and *Polytrichum* spp., and lichens, such as *Stereocaulon* spp. or *Flavocetraria nivalis (= Cetraria nivalis)*.

Alpine "heath," composed of*Cassiope tetragona* and other ericaceous species, occupies sites of deeper snow. Windblown sites are sparsely vegetated with cushion or mat-forming species such as *Dryas integrifolia, Oxytropis podocarpa, Potentilla nana, Saxifraga oppositifolia, Saxifraga tricuspidata*, or *Silene acaulis*. On high alpine ridges with some snow cover, *Silene acaulis* dominates, with *Artemisia arctica, Luzula spicata, Poa alpina*, and *Polytrichum* spp. Scattered trees and patchy krummholz may occur at lower elevations,

composed of species such as *Abies lasiocarpa, Picea glauca*, or *Pinus contorta*, depending upon the area.

The "typical" central and southern Rocky Mountain alpine tundra varies from sparse to moderate cover dominated by cushion plants to moderately dense to dense cover of low-growing, perennial graminoids and forbs that form a turf. Rhizomatous, sod-forming sedges are the dominant graminoids, and prostrate and mat-forming plants with thick rootstocks or taproots characterize the forbs. Dominant species include*Artemisia arctica, Carex elynoides, Carex siccata, Carex scirpoidea, Carex nardina, Carex rupestris, Festuca brachyphylla, Festuca idahoensis, Geum rossii, Juncus drummondii, Kobresia myosuroides, Phlox pulvinata*, and *Trifolium dasyphyllum*. The sparsely vegetated fell-field plants are cushioned or matted, frequently succulent, flat to the ground in rosettes, and often densely haired and thickly cutinized. Plant cover on fell-fields is 15-50%, while exposed rocks covered with crustose lichens make up the rest. They are usually found on wind-exposed ridges and saddles, within or adjacent to alpine dry turf. Common species include *Arenaria capillaris, Geum rossii, Minuartia obtusiloba, Paronychia pulvinata, Phlox pulvinata, Potentilla nivea, Potentilla villosa, Saxifraga bronchialis, Silene acaulis, Trifolium dasyphyllum*, and *Trifolium parryi*. The dwarf-shrubland "heath" of these southern areas is characterized by *Cassiope mertensiana* and *Phyllodoce empetriformis* or *Phyllodoce glanduliflora*. *Dryas octopetala*- and *Dryas integrifolia*-dominated communities occur on more windswept and drier sites than the heath communities. Dwarf willows, e.g., *Salix nivalis* or *Salix reticulata*, are often found with *Dryas*. Snowbed communities are often dominated by *Carex subnigricans* and *Sibbaldia procumbens*.

The drier alpine vegetation of the Great Basin ranges and Sierra Nevada may include lower elevation semi-desert species such as*Carex filifolia, Poa fendleriana, Poa secunda*, and *Artemisia frigida*. Other species specific to these mountains include *Aquilegia pubescens, Carex congdonii, Calamagrostis breweri, Castilleja nana, Eriogonum gracilipes, Eriogonum incanum, Phlox covillei, Podistera nevadensis*, and *Carlquistia muirii (= Raillardiopsis muirii, = Raillardella muirii)*. Alpine dwarf-shrublands are dominated or codominated by *Cassiope mertensiana, Ericameria discoidea, Kalmia microphylla, Polygonum shastense, Phyllodoce breweri, Ribes cereum, Salix arctica*, and *Vaccinium cespitosum*.

In northeastern Mexico, the alpine of Cerro Potosí in Nuevo Leon is dominated by*Potentilla leonina, Arenaria* sp., and *Bidens muelleri*. *Linum lewisii* and *Trisetum spicatum* also occur here and link this alpine region to this type. *Pinus hartwegii* is the treeline species in this area.

The coastal alpine is dominated by dwarf-shrub species, including *Cassiope lycopodioides* (Haida Gwaii), *Cassiope mertensiana, Cassiope tetragona, Empetrum nigrum, Harrimanella stelleriana, Luetkea pectinata, Phyllodoce aleutica, Phyllodoce empetriformis*, and *Phyllodoce glanduliflora*. Ericaceous species typically dominate, but sites dominated by *Salix arctica, Salix nivalis*, and *Salix reticulata* occur. Scattered tall shrubs and dwarf trees may also be present.

At the highest elevations of this division, conditions are too harsh for most vascular plants, often a combination of a short snow-free period and limited soil development (i.e., mostly rocky substrates), and the vegetation is dominated by lichens.

Environment

This alpine division occurs at and above the upper treeline in the mountains of the Western Cordillera. These alpine areas can be extensive where the mountain ranges have considerable, contiguous area above treeline, but many alpine areas are isolated on individual mountain peaks. The elevation of upper treeline varies considerably from north to south, as low as 100 m elevation in Alaska to over 3500 m in northern Mexico. The treeline elevation is lower in wet maritime climates as compared to more continental climates at the same latitude. The heavy, deep snow of maritime areas limits the length of the growing season. Alpine vegetation is controlled by snow retention, wind desiccation, soil depth, permafrost, cryoturbation, solifluction, and a short growing season. Wind exposure has a strong impact on the type of vegetation in alpine areas. Ridgetops, windward upper slopes and exposed saddles can have little snow during the winter, due to wind-scouring. Level or concave areas and leeward slopes will have deeper snow, and in some areas the snow will not melt in most summers. Areas with late snowmelt will be composed of species adapted to a very short growing season; some of these species can initiate growth under the snow, and some are capable of surviving even when there are years of continuous snow cover.

Climate: This division combines high-elevation, temperate and boreal climates, including maritime and continental expressions. The high elevations result in long cold snowy winters and a very short growing season. The precipitation regime varies considerably. In the south and along the coast, it is strongly seasonal with most precipitation falling in the winter months as snow, and little precipitation in the summers. In many northern interior areas, the opposite is the case; higher precipitation occurs during the summer months. A high snowpack characterizes this environment. The higher cover of vegetation of this division occurs on slopes and depressions where snow lingers, the soil has become relatively stabilized, and the water supply is more-or-less constant. In high-snow areas, it is common for patches of snow to persist all summer.

Soils/substrate: Soils are typically shallow, well-drained, and stony, and can be subject to colluviation, solifluction, and cryoturbation; permafrost can occur, especially in northern areas. Substrates are variable across fell-fields, alpine turf and dwarf-shrub vegetation. Fell-field sites are generally shallow, stony, low in organic matter, and poorly developed with wind deflation (erosion) often resulting in a gravelly pavement. Alpine turf sites have deeper, more developed soils, although they may have moderately high cover of cobbles and boulders present. The dwarf-shrubland soils have become relatively stabilized, are moist but well-drained, strongly acidic, and often have substantial peat layers. Subirrigation from snowmelt can be an important source of moisture, especially as soils are often shallow in depth and with rock fragments. Rock, ice and late-persisting snow characterize considerable portions of the landscape adjacent to this type.

Biogeography: Latitude, elevation, and degree of continentality impact the development of vegetation in this division. The species vary considerably over the range of latitude, although, e.g., *Trisetum spicatum* occurs over most of the range of alpine from Mexico to Alaska. There are groups of species that occur within certain latitudinal bands. Alpine also forms elevational zones, where the low alpine zone has higher plant cover overall, has krummholz, and has species of the subalpine, e.g., subalpine meadows. Conversely, the highest alpine zone is sparsely vegetated, with more rock, ice and snow patches, and a prevalence of lichen communities on the rock. Maritime alpine is dominated by heath vegetation; whereas alpine under more of a continental influence has a greater graminoid

and forb component, as well as dwarf-shrubs such as *Dryas* spp. or *Salix* spp. The heath communities are restricted to sites of deep snow.

Range

This type occurs above upper timberline in the mountains of the western North American Cordillera, including the Brooks and Alaska ranges in Alaska, the MacKenzie Mountains of Yukon and western Northwest Territories, from there southward in the Coast, Cascade and Rocky Mountain ranges and the Sierra Nevada, culminating in the Sierra Madres of Mexico and Guatemala.

Synonymy

? AM Alpine Meadow (Ecosystems Working Group 1998) [Mapping unit for British Columbia alpine meadow vegetation used in broad ecosystem inventory.]
< AT Alpine Tundra (Ecosystems Working Group 1998) [Mapping unit for British Columbia alpine vegetation used in broad ecosystem inventory.]
> Alpine Tundra Zone (Pojar and Stewart 1991) [Describes alpine vegetation of British Columbia; unit precedes Coastal, Boreal and Interior alpine zones of BC.]
< Alpine vegetation of North America (Billings 2000) [Describes alpine vegetation of all of North America, whereas this type is for the western cordillera.]
> Boreal Altai Fescue Alpine Zone (MacKenzie 2005) [Describes boreal alpine vegetation of British Columbia - applicable to alpine of YT and NT.]
> Coastal Mountain-heather Alpine Zone (MacKenzie 2005) [Describes coastal mountain alpine vegetation of British Columbia - somewhat applicable to alpine of adjacent states (AK, WA).]
> Interior Mountain-heather Alpine Zone (MacKenzie 2005) [Describes continental temperate alpine vegetation of British Columbia; applicable to alpine vegetation of adjacent states/provinces (AB, ID, MT)]

Dynamics

The dominant natural disturbances in this type are snow avalanche, soil creep and freeze-thaw action. Wind and insolation also impact strongly on vegetation development. Small mammals can be important in modifying the soil of meadows.

Taxonomic Parent Temperate & Boreal Alpine Tundra

Parent Key F037

Name **Western North American Cool Semi-Desert Scrub & Grassland**

Database Code	Classification Code	Hierarchy Level	Status
D040	3.B.1.Ne	Division	Accepted

Translated Name Big Sagebrush - Shadscale Saltbush /Needle-and-Thread Cool Semi-Desert Scrub & Grassland Division

Scientific Name Artemisia tridentata - Atriplex confertifolia / Hesperostipa comata Cool Semi-Desert Scrub & Grassland Division

Summary This division encompasses all upland shrub and grassland vegetation within the Western North American Cool Semi-desert region, primarily in the Great Basin, but extending to western margins of the Great Plains to New Mexico, northward to dry-interior southern British Columbia and south through eastern Oregon and interior California, into the mountains of northwestern Baja California, Mexico. It includes extensive shrublands dominated by *Artemisia tridentata*, ranging from mid to upper slopes and deep to shallow soils, and extensive *Atriplex* shrublands.

Description This division includes a variety of native and non-native shrub and herbaceous vegetation growing naturally within the cool semi-desert climate zone of western North America, centered within the many closed basins and isolated mountain ranges of the Great Basin Province. It includes extensive shrublands dominated by *Artemisia tridentata*, involving four main varieties, each with distinctive ecologies, ranging from mid to upper slopes and deep to shallow soils. It also includes extensive *Atriplex* shrublands, largely restricted to lower slopes and basins. Subshrub *Artemisia* species or similarly low-growing subshrubs dominate on shallow, rocky soil or heavy clay soils and in exposed rocky, subalpine settings. These species include 10 separate taxa of small sagebrush, which segregate geographically and edaphically and are diagnostic at various levels within the division. On the plateaus and mountains of the southern Great Basin, bordering on the southwestern warm deserts, are an array of distinctive shrublands including leaf-succulent *Yucca* and *Nolina* species, and a variety of shrub genera (*Buddleja, Coleogyne, Mortonia, Poliomintha*, etc.) not found elsewhere in this division.

Grasslands are generally patchy within this landscape, locally restricted to sandy or loamy soils and to areas with high fire frequencies. Throughout the northern and western portions of the Great Basin grasslands are predominantly cool-season species (including*Achnatherum, Hesperostipa, Poa, Festuca, Elymus, Pascopyrum*, and *Pseudoroegneria*. In the southern and eastern portions, warm-season grass genera (e.g., *Pleuraphis, Bouteloua, Muhlenbergia*) increase. Intermediate moisture and fire conditions have shrub-steppe, with a combination of *Artemisia* species and mostly perennial grasses and herbs. Early-seral shrublands dominated by *Ericameria* and other short-lived shrubs occur in recovering burns, cleared land, or in intermittently flooded washes. Ruderal grassland dominated and characterized by non-native Eurasian annuals (e.g., *Bromus tectorum, Taeniatherum caput-medusae*) and perennial grasses (e.g., *Agropyron cristatum*) has, through the effects of recent fire, converted many thousands of acres of native shrubland and shrub-steppe in the past 75-100 years.

This division extends south and west of the Great Basin on isolated higher elevation

mountains and plateaus surrounded by lower-lying and warmer bioclimates. It also extends eastward and northward to the edge of the Great Plains in eastern Montana, Wyoming, southern Alberta and southeastern British Columbia, Canada, and the western Dakotas. This suite of shrublands and grasslands occupies mountain slopes, plateaus, hills, valleys, and alluvium (including intermittently flooded washes and fans), within a broad range of soil types. The overall climate of the range of this division is in the Koppen bioclimatic zone Mid-latitude Dry Semiarid Steppe (BSk) with smaller areas of Mid-latitude Dry Arid Desert (BWk). Stands range from high plateaus and ridges with skeletal soils to deep well-drained alluvial soils on fans and near washes and heavy clay "self-churning" Vertisols. Some grasslands (now largely extinct) were limited to loess (e.g., Palouse Prairie). Soils harboring stands of certain ruderal vegetation (e.g.,*Acroptilon repens, Isatis tinctoria, Sisymbrium* sp.) tend to occur on previously cultivated sites where the soil profile has been disrupted.

Diagnostic Characteristics

In general, diagnostic taxa are divided into several main genera. Taller taxa of *Artemisia* (*Artemisia tridentata* and its subspecies *Artemisia tridentata ssp. tridentata, Artemisia tridentata ssp. vaseyana, Artemisia tridentata ssp. wyomingensis*, and *Artemisia tridentata ssp. xericensis*) along with *Purshia tridentata* characterize some parts of the division, as do shorter taxa of *Artemisia* (*Artemisia arbuscula, Artemisia bigelovii, Artemisia nova, Artemisia rothrockii, Artemisia pygmaea, Artemisia rigida*, and others) and midsize shrubby species in the Amaranth family (*Atriplex, Grayia*, etc.). Ruderal non-native grasses and forbs from Eurasia characterize human-disturbed stands.

Rationale

A single widespread diagnostic from each of three main macrogroups was selected to represent the breadth of the division: *Artemisia tridentata* in ~Great Basin-Intermountain Tall Sagebrush Shrubland & Steppe Macrogroup (M169)$$, *Atriplex confertifolia* in ~Great Basin Saltbush Scrub Macrogroup (M093)$$, and *Hesperostipa comata* in ~Great Basin-Intermountain Dry Shrubland & Grassland Macrogroup (M171)$$. In addition to these division-level diagnostics there are numerous species that tend to be limited to individual macrogroups, groups, or alliances within the division.

Physiognomy

The vegetation contains both open to dense shrublands dominated by largely pubescent gray-green evergreen shrubs that form a canopy of from 0.5 m to 4 m in height and herbaceous species, including grasses and forbs, may be sparse or dense with or without a shrub canopy. Trees are widely scattered or absent in drier stands or early- to mid-seral stands, but in the case of *Juniperus* may increase in cover in stands with long fire-return intervals and relatively high annual precipitation. In rocky areas, shrublands tend to be clumped and sparse with higher proportion of small-leaved or scale-leaved species, some with photosynthetic branches (*Ericameria, Ephedra*). Grasslands may be dominated by midsize (*Pascopyrum, Pseudoroegneria*), or small (*Poa, Festuca*) bunchgrasses, or by annuals which produce considerable residual dry material (e.g., *Bromus, Taeniatherum, Ventenata*).

Floristics

Taller taxa of *Artemisia* (*Artemisia tridentata* and its subspecies *Artemisia tridentata ssp. tridentata, Artemisia tridentata ssp. vaseyana, Artemisia tridentata ssp. wyomingensis*, and *Artemisia tridentata ssp. xericensis*) along with *Artemisia tripartita* and *Purshia tridentata* characterize some parts of the division, as do shorter taxa of *Artemisia* (*Artemisia arbuscula, Artemisia bigelovii, Artemisia nova*, and others) and midsize shrubby species in the Amaranth family (*Atriplex, Grayia*, etc.). Species of *Ephedra, Ericameria, Chrysothamnus*, and *Eriogonum* commonly occur.

The subshrub*Artemisia* species or similarly low-growing subshrubs dominate on shallow, rocky soil or heavy clay soils and in exposed rocky, subalpine settings (Tisdale 1994a, 1994b). These taxa include 10 separate taxa of low or small *Artemisia*, which segregate geographically and edaphically, including *Artemisia arbuscula, Artemisia bigelovii, Artemisia nova, Artemisia rothrockii, Artemisia pygmaea, Artemisia rigida, Artemisia pedatifida, Artemisia frigida*, and non-wetland *Artemisia cana* communities. On the plateaus and mountains of the southern Great Basin bordering on the southwestern warm deserts are an array of distinctive shrublands, including leaf-succulent *Yucca* and *Nolina* species, and a variety of shrub genera (*Buddleja, Coleogyne, Mortonia, Poliomintha*, etc.) not found elsewhere in this division (West 1983d).

Grasslands are generally patchy within this landscape, locally restricted to sandy or loamy soils and to areas with high fire frequencies. Throughout the northern and western portions of the Great Basin grasslands are predominantly cool-season species, including*Achnatherum (= Stipa), Hesperostipa, Poa, Festuca, Elymus, Pascopyrum*, and *Pseudoroegneria* (Tisdale 1994c). In the southern and eastern portions, warm-season grass genera (e.g., *Pleuraphis, Bouteloua, Muhlenbergia*) increase. Intermediate moisture and fire conditions have shrub-steppe, with a combination of *Artemisia* species and mostly perennial grasses and herbs (West 1983c, Young et al. 2007b). Early-seral shrublands dominated by *Ericameria* and other short-lived shrubs occur in recovering burns, cleared land, or in intermittently flooded washes. Ruderal grassland dominated and characterized by non-native Eurasian annuals (e.g., *Bromus tectorum, Taeniatherum caput-medusae*) and perennial grasses (e.g., *Agropyron cristatum*) has, through the effects of recent fire, converted many thousands of acres of native shrubland and shrub-steppe in the past 75-100 years (Johnson 1986d, Updike et al. 1990, Whisenant 1990, Petersen 2003).

Ruderal non-native grasses and forbs from Eurasia characterize human-disturbed stands

Environment

This division includes extensive shrublands dominated by *Artemisia tridentata*, involving four main varieties, each with distinctive ecologies, ranging from mid- to upper slopes and deep to shallow soils (Meyer and Monsen 1992, McArthur 1994). It also includes extensive *Atriplex* shrublands, largely restricted to lower slopes and basins (Billings 1949).

Climate: The overall climate of the range of this division is in the Köppen bioclimatic zone Mid-latitude Dry Semiarid Steppe (BSk) with smaller areas of Mid-latitude Dry Arid Desert (BWk)

Soil/substrate/hydrology: With few exceptions, vegetation in this division tends to avoid regularly flooded or saturated low-lying landscapes (Ganskopp 1986). Stands range from high plateaus and ridges with skeletal soils to deep well-drained alluvial soils on fans and near washes and heavy clay "self-churning" Vertisols. Certain vegetation, such as the *Artemisia arbuscula ssp. longiloba* alliance, is restricted to heavy clay soils derived from volcanic rock. The *Atriplex corrugata* alliance is limited to sites with shale-derived clay soils. Some were limited to loess (e.g., Palouse Prairie, now largely eliminated by human conversion to agriculture). Soils harboring stands of certain ruderal vegetation (e.g., *Acroptilon repens, Isatis tinctoria, Sisymbrium* sp.) tend to occur on previously cultivated sites where the soil profile has been disrupted.

Biogeography: The genus *Artemisia* is well represented with 29 species largely endemic to

the Great Basin Province and within the range of the division, about 42% of all North American *Artemisia* (fide BONAP 2010). *Atriplex* is represented by 21 species (23% of the North American total *Atriplex* species). *Ericameria* is represented by 7 or 8 species (about 20% of the genus in the continent). Several genera of rosaceous shrubs (*Coleogyne, Fallugia, Purshia*) are largely endemic to the vegetation in this division. Other widespread cool semi-desert shrub genera found in Eurasia include *Ephedra* and *Krascheninnikovia*, and grass genera such as *Elymus, Poa*, and *Festuca*.

Range

This division occurs from south-central Alberta, south through the Great Basin of western North America to the plateaus and mountains of New Mexico and westward to dry-interior southeastern British Columbia and the western Dakotas (West 1988), and south through eastern Oregon and interior California, into the mountains of northwestern Baja California, Mexico. Throughout most of the northern and central range this vegetation occurs below 1800 m, but in the southern portion it may exist in subalpine settings of over 3000 m.

Synonymy

= Great Basin desertscrub (Turner 1982c) [is equivalent except for the inclusion of *Sarcobatus vermiculatus*.]
? Intermountain Valleys and Lower Mountain Slopes (West and Young 2000)
= North American Temperate Desert and Semi-desert (West 1983f) [See also treatments within this reference.]

Dynamics

The current dynamics within this division are products of both natural and anthropogenic disturbance. Natural fire frequencies in the division are variable. Summer thunderstorms generate thousands of lightning strikes annually. Despite the sensitivity of most of the dominant shrub species to fire (Callison et al. 1985, Updike et al. 1990), historically fire did not burn extensive areas of Great Basin upland scrub due to lower fuel cover and natural rocky fuel breaks. Fire frequently burned more continuous stands of grasslands in the Palouse Prairie of eastern Washington (now largely converted to agriculture) and on the borders of the shortgrass prairie in eastern Montana, Wyoming, and north-central Colorado. Stands of *Artemisia arbuscula* (low sagebrush) in mountainous areas and scattered rocky upland shrublands were subject to small infrequent fires and local effects of drought, rockfall, and avalanches. The extensive basin margin stands of *Atriplex canescens* (saltbush) were affected by drought and disease and limited fire (due to lack of herbaceous fuels). Currently, with the advent of extensive invasive species, such as *Bromus tectorum, Ventenata dubia, Taeniatherum caput-medusae*, and a variety of taller annual forbs such as *Sisymbrium* sp., *Descurainia* sp., *Centaurea* sp., and *Salsola tragus*, fires carry more continuously through many of the shrublands of this division, causing widespread type-conversion (Johnson 1986, Updike et al. 1990, Whisenant 1990, Petersen 2003). Grazing intensity in some areas has increased flashy annual herb cover relative to shrub cover. Subtle combinations of fire suppression and climatic shifts to slightly moister conditions in part of the region are responsible for expansion of conifers such as *Juniperus occidentalis* (Miller et al. 2008) or *Abies concolor* (Vale 1975) into parts of this division.

Taxonomic Parent Cool Semi-Desert Scrub & Grassland

Parent Key F033

Name **Western North American Grassland & Shrubland**

Database Code	Classification Code	Hierarchy Level	Status
D022	2.B.2.Nf	Division	Accepted

Translated Name Rocky Mountain Maple / Timber Oatgrass - Western Meadowrue Western North American Grassland & Shrubland Division

Scientific Name Acer glabrum / Danthonia intermedia - Thalictrum occidentale Western North American Grassland & Shrubland Division

Summary This division contains cool-temperate lowland to subalpine shrubland, grassland, and meadow communities that are dominated by cold-deciduous shrubs or cool-season bunchgrasses or mesic forbs in the mountainous regions of western North America, from Alaska's Aleutian Islands south to the central coast of California, and down through the Intermountain West ranges and Rocky Mountains to Arizona and New Mexico.

Description This division is a mix of cool-temperate lowland and montane shrubland and grassland communities that are dominated by cold-deciduous shrubs and cool-season (C3) grasses, mesic forbs, and occasionally evergreen shrubs. It is widely distributed in the mountainous regions of the western US extending from Alaska's Aleutian Islands and Canada south to the lee side of the central coast of California, and down through the Intermountain West ranges and Rocky Mountain cordillera to Arizona and New Mexico. These are moist-mesic montane shrublands of interior cool slopes and canyons from 300 to 1650 m in elevation. They can form high cover and extensive stands of mostly tall deciduous shrubs. Strong diagnostic species that are often dominant or codominant include *Acer glabrum, Amelanchier utahensis, Ribes cereum*, and *Symphoricarpos oreophilus*. Moderate diagnostics include *Holodiscus discolor, Holodiscus dumosus, Menziesia ferruginea, Physocarpus malvaceus, Physocarpus monogynus, Rosa nutkana, Rosa woodsii*, and *Vaccinium ovalifolium*. These species can also be common constituents of adjacent mesic forests and woodlands, or as successional elements following fire or logging. Drier sites may be dominated by a mix of deciduous and evergreen shrubs and dwarf-shrubs. At higher elevations (600-2011 m), *Vaccinium myrtillus, Vaccinium scoparium*, and *Vaccinium membranaceum* are strong diagnostics with *Arctostaphylos uva-ursi* and *Juniperus communis* often prevalent. There are large swaths of dry-mesic shrublands at lower elevations (1500-2700 m) where the strong diagnostic dominants are *Amelanchier utahensis, Cercocarpus montanus, Quercus gambelii, Quercus x pauciloba, Purshia stansburiana, Purshia tridentata, Ribes cereum*, and *Robinia neomexicana*. In contrast, the division also includes moist-mesic lowland (<1000 m) shrublands along the northwest coast of the continent where *Alnus viridis ssp. fruticosa, Rubus spectabilis, Salix barclayi*, and *Vaccinium ovalifolium* are moderate regional diagnostic shrubs along with *Athyrium filix-femina, Heracleum maximum*, and *Veratrum viride*, or a variety of other moist-mesic herbaceous species.

Coastal and montane grasslands and mesic meadows of the division tend to lack a strong tall-shrub component under low-disturbance conditions. The mesic meadows are typified by high herbaceous cover and a rich complement of forbs and graminoids. Strong diagnostic forb species include*Erigeron speciosus, Osmorhiza occidentalis, Senecio hydrophiloides, Senecio serra, Senecio triangularis*, and *Thalictrum occidentale*. Mesic

graminoids form a lesser component; common moderate diagnostic species include *Bromus carinatus, Bromus sitchensis, Carex hoodii, Carex microptera*, and *Festuca viridula*. Mesic meadow stands occur on moderate to steep slopes, glacio-fluvial flats, and valley bottoms at high elevations where snow cover persists relatively late in the season (>600 m to the north; <3350 m to the south). The soils are typically seasonally moist to saturated in the spring but, if so, will dry out later in the growing season. Many occurrences are small-patch in spatial character, and are often found in mosaics with woodlands, more dense shrublands, or just below alpine communities.

Drier sites are dominated by cool-season bunchgrasses with a suite of dry-mesic forbs found in the inter-grass spaces.*Danthonia intermedia* is a strong diagnostic species with a suite of moderately diagnostic species that are regional dominants, e.g., *Danthonia parryi, Festuca arizonica, Festuca campestris, Festuca idahoensis, Festuca thurberi, Muhlenbergia montana*, and *Pseudoroegneria spicata* in montane and subalpine grasslands of the Rocky Mountains and Intermountain West; *Festuca idahoensis ssp. roemeri* and *Danthonia californica* in the far-west mountains. Forbs are diverse and tolerant of relatively dry conditions and include moderate diagnostics such as *Erigeron simplex, Eriogonum umbellatum, Potentilla hippiana*, and *Solidago multiradiata*. The grasslands occur on flat to rolling plains, in inter-montane parks, and on dry sideslopes, especially with south and west aspects. Soils are mostly fine-textured grasslands soils (Mollisols), but some sites are shallower, rocky and windswept. Most sites range from 2200 to 3000 m but extend to lower elevation foothills and plains (to 300 m). In contrast, along the west coast, these communities are found on low-elevation terraces and ridgeline balds on the dry (east) side of the mountain ranges.

Mesic grasslands and meadows can be prone to invasion by non-native naturalized forage species creating ruderal communities. Typical dominants include*Anthoxanthum odoratum, Bromus inermis, Cynosurus echinatus, Dactylis glomerata, Holcus lanatus, Phleum pratense, Poa pratensis*, and numerous other non-native herbaceous species such as *Acroptilon repens, Cardaria draba, Carduus nutans, Centaurea* spp., *Cirsium arvense, Lepidium latifolium, Linum bienne*, and *Linaria* spp. There are relatively few non-native temperate upland shrublands, but *Cytisus scoparius, Genista* spp., *Cytisus striatus* (or *Cytisus scoparius*), and *Ulex europaeus* can form shrublands best in less xeric regions.

Diagnostic Characteristics

This division is a mix of cool-temperate lowland and montane shrubland and grassland communities, which are dominated by cold-deciduous shrubs and cool-season (C3) grasses, and occasionally evergreen shrubs. Among mesic shrublands, *Acer glabrum, Amelanchier utahensis, Ribes cereum*, and *Symphoricarpos oreophilus* are strong diagnostics. Dwarf-shrubs such as *Vaccinium myrtillus, Vaccinium scoparium*, and *Vaccinium membranaceum* are also diagnostic, particularly at higher elevations. There are dry-mesic shrublands of lower elevations where the strong diagnostic dominants are *Amelanchier utahensis, Cercocarpus montanus, Purshia stansburiana, Purshia tridentata, Quercus gambelii, Quercus x pauciloba, Ribes cereum*, and *Robinia neomexicana*. Grasslands occur on drier sites as well and are dominated by cool-season bunchgrasses and dry-mesic forbs. *Danthonia intermedia* is a strong diagnostic species with a suite of moderately diagnostic species that are regional dominants, e.g., *Danthonia parryi, Festuca campestris, Festuca idahoensis, Festuca arizonica, Festuca thurberi, Muhlenbergia montana*, and *Pseudoroegneria spicata* in montane and subalpine grasslands of the Rocky Mountains and Intermountain West; *Festuca idahoensis ssp. roemeri, Festuca viridula* and *Danthonia*

californica in the far-west mountains. Among forbs, moderate diagnostic species include *Erigeron simplex, Eriogonum umbellatum, Potentilla hippiana*, and *Solidago multiradiata*. Mesic grasslands and meadows can be prone to invasion by non-native naturalized forage species; typical dominants include *Anthoxanthum odoratum, Bromus inermis, Cynosurus echinatus, Dactylis glomerata, Holcus lanatus, Phleum pratense*, and *Poa pratensis*.

Rationale

Acer glabrum is well-distributed across the range of the division and represents the shrub component; *Danthonia intermedia* reflects the montane grassland elements and is the most widespread; *Thalictrum occidentale* is representative of the mesic meadow component of the division.

Physiognomy

This division is a mix of cool-temperate lowland and montane shrubland and grassland communities that are dominated by cold-deciduous shrubs and cool-season (C3) grasses, mesic forbs, and occasionally evergreen shrubs. It includes evergreen and deciduous shrublands, shrub-steppes, grasslands, and non-graminoid herbaceous meadows (all growth forms except trees).

Floristics

There are moist-mesic montane shrublands that can form high-cover stands where the dominant strong diagnostic species are *Acer glabrum, Amelanchier utahensis, Ribes cereum*, and *Symphoricarpos oreophilus*. Moderate diagnostics include *Holodiscus discolor, Holodiscus dumosus, Menziesia ferruginea, Physocarpus malvaceus, Physocarpus monogynus, Rosa nutkana, Rosa woodsii*, and *Vaccinium ovalifolium*. Under the shrubs and in the inter-shrub spaces there may be a diverse assortment of mesic forbs and graminoids (e.g., *Arnica sororia, Delphinium bicolor, Heracleum maximum, Luzula glabrata, Chamerion angustifolium, Hydrophyllum fendleri*, which are moderate diagnostic species). Drier sites may be dominated by a mix of deciduous and evergreen shrubs and dwarf-shrubs. At higher elevations (600-2011 m), *Vaccinium myrtillus, Vaccinium scoparium*, and *Vaccinium membranaceum* are strong diagnostics with *Arctostaphylos uva-ursi* and *Juniperus communis* often prevalent. There are large swaths of dry-mesic shrublands at lower elevations (1500-2700 m) where the strong diagnostic dominants are *Amelanchier utahensis, Cercocarpus montanus, Purshia stansburiana, Purshia tridentata, Quercus gambelii, Quercus x pauciloba, Ribes cereum*, and *Robinia neomexicana*. In contrast, the division also includes moist-mesic lowland (<1000 m) shrublands along the northwest coast of the continent where *Alnus viridis ssp. fruticosa, Rubus spectabilis, Salix barclayi*, and *Vaccinium ovalifolium* are moderate regional diagnostic shrubs along with *Athyrium filix-femina, Heracleum maximum*, and *Veratrum viride*, or a variety of other moist-mesic herbaceous species. Mesic meadows are typified by high herbaceous cover; strong diagnostic forb species include *Erigeron speciosus, Osmorhiza occidentalis, Senecio hydrophiloides, Senecio serra, Senecio triangularis*, and *Thalictrum occidentale*. Mesic graminoids form a lesser component; common moderate diagnostic species include *Bromus carinatus, Bromus sitchensis, Carex hoodii*, and *Carex microptera*. Drier sites are dominated by cool-season bunchgrasses with a suite of dry-mesic forbs in found in the inter-grass spaces. *Danthonia intermedia* is a strong diagnostic species with a suite of moderately diagnostic species that are regional dominants, e.g., *Danthonia parryi, Festuca arizonica, Festuca campestris, Festuca idahoensis, Festuca thurberi, Muhlenbergia montana*, and *Pseudoroegneria spicata* in montane and subalpine grasslands of the Rocky Mountains and Intermountain West; *Festuca idahoensis ssp. roemeri (= Festuca roemeri), Festuca viridula*, and *Danthonia californica* in the far-west mountains. Forbs are diverse and tolerant of relatively dry conditions and include moderate diagnostics such as *Erigeron simplex, Eriogonum umbellatum, Potentilla hippiana*, and *Solidago multiradiata*; moderate

diagnostics include *Valeriana sitchensis, Erigeron formosissimus*, and *Geum macrophyllum*. Mesic grasslands and meadows can be prone to invasion by non-native naturalized forage species creating ruderal communities. Typical dominants include *Anthoxanthum odoratum, Bromus inermis, Cynosurus echinatus, Dactylis glomerata, Holcus lanatus, Phleum pratense, Poa pratensis*, and numerous other non-native herbaceous species such as *Acroptilon repens, Cardaria draba, Carduus nutans, Centaurea* spp., *Cirsium arvense, Lepidium latifolium, Linum bienne*, and *Linaria* spp. There are relatively few non-native temperate upland shrublands, but *Cytisus scoparius, Genista* spp., *Cytisus striatus* (or *Cytisus scoparius*), and *Ulex europaeus* can form shrublands best in less xeric regions.

Environment

Environments are highly variable and include coastal bluffs, rolling plains, valleys, wetlands, hillslopes and mountain peaks. Moist-mesic montane shrublands occur on interior cool slopes and canyons from 300 to 1650 m in elevation. Mesic meadow stands occur on moderate to steep slopes, glacio-fluvial flats, and valley bottoms at high elevations where snow cover persists relatively late in the season (>600 m to the north; <3350 m to the south). They can also occur on gentle slopes with ample early-season seepage. The soils are typically seasonally moist to saturated in the spring but, if so, will dry out later in the growing season. Many occurrences are small-patch in spatial character, and are often found in mosaics with woodlands, more dense shrublands, or just below alpine communities. The grasslands occur on flat to rolling plains, in inter-montane parks, and on dry sideslopes, especially with south and west aspects. Grassland soils are mostly fine-textured grasslands soils (Mollisols), but some sites are shallower, rocky and windswept. Most sites range from 2200 to 3000 m but extend to lower-elevation foothills and plains (to 300 m). In contrast, along the west coast, these communities are found on low-elevation terraces and ridgeline balds on the dry (east) side of the mountain ranges.

Precipitation ranges from 20 cm (desert) to 250 cm (rainforest) and varies from winter dominant (west) to summer dominant (south and east).

Range

This division is widely distributed in the mountainous regions of the western U.S. extending from Alaska's Aleutian Islands and Canada south to the lee side of the central coast of California, and down through the Intermountain West ranges and Rocky Mountain cordillera to Arizona and New Mexico.

Synonymy

>< Cold Temperate Grassland (Brown et al. 1998) [Their Rocky Mountain Montane Grassland and Oregon (Pacific Coastal) Grassland Biotic communities are included here.]
>< Cold Temperate Scrubland (Brown et al. 1998) [Their Great Basin Montane Scrub Biome Biotic Community are included here.]
> Mountain Mahogany - Oak Scrub (West and Young 2000)
> meadows and parks (Peet 2000)

Dynamics

The species in the shrublands and mesic meadows can also be common constituents of adjacent mesic forests and woodlands, or as successional elements following fire or logging. The grasslands tend to have a fire regime with rapid fire return that slows or sets back shrub invasion and maintains a low or patchy shrub distribution. Fire frequency is presumed to be less than 20 years. Shrublands have a fire regime with a longer fire-return interval or fire-adapted shrubs such as *Physocarpus malvaceus, Cercocarpus montanus, Quercus gambelii* (clonal), and *Robinia neomexicana*. Mesic meadow stands are typically not affected by fire due to moist conditions and surrounding rocky terrain. Natural processes affecting stands include fluctuating summer snowbanks (drought sequences),

snow avalanches, and rockfalls. Burrowing mammals in places will disrupt the soil and vegetation locally.

Taxonomic Parent Temperate Grassland & Shrubland

Parent Key F012

Name **Western North American Interior Chaparral**

Database Code	Classification Code	Hierarchy Level	Status
D061	2.B.2.Ng	Division	Accepted

Translated Name Greenleaf Manzanita - Mountain Whitethorn - Sonoran Scrub Oak Interior Chaparral Division

Scientific Name Arctostaphylos patula - Ceanothus cordulatus - Quercus turbinella Interior Chaparral Division

Summary These chaparral shrublands occur between low-elevation desert landscapes and higher subalpine woodlands of the western U.S. and northern Mexico.

Description These are chaparral shrublands found among montane forests of the Cascades south into Baja California, Mexico, and east in scattered locations throughout the Great Basin, Colorado Plateau, and Rocky Mountains, and then across central Arizona (Mogollon Rim) and southern New Mexico, east in mountains across Trans-Pecos Texas, and south into the Madrean Occidentale and Madrean Oriental in northern Mexico. This vegetation is also found in desert mountains in the Sonoran, Mojave, and Chihuahuan deserts. These hardy shrublands are dominated by evergreen or winter-deciduous shrubs. Some stands can have closed canopies of shrubs with little undergrowth; others have more open canopies with a moderately to well-developed herbaceous layer in the canopy openings. Dominant and diagnostic shrubs throughout the more northerly portions of its range include *Arctostaphylos glandulosa, Arctostaphylos nevadensis, Arctostaphylos patula, Ceanothus cordulatus, Ceanothus diversifolius, Ceanothus integerrimus, Ceanothus pinetorum, Ceanothus sanguineus, Ceanothus velutinus, Cercocarpus intricatus, Cercocarpus montanus var. glaber, Chrysolepis sempervirens, Eriogonum fasciculatum, Garrya flavescens, Holodiscus discolor, Prunus emarginata, Prunus subcordata, Purshia stansburiana, Quercus garryana var. fruticosa, Quercus sadleriana, Quercus vacciniifolia*, and *Rhus trilobata*. Further south, *Quercus turbinella, Arctostaphylos pungens*, or *Ceanothus greggii* frequently dominant large areas. Other characteristic shrubs further south include *Cercocarpus montanus var. paucidentatus, Garrya wrightii, Quercus toumeyi*, and *Rhus trilobata* with *Arctostaphylos pringlei* and *Arctostaphylos pungens* at higher elevations. In desert chaparral stands in the southwestern ranges, *Arctostaphylos glauca, Arctostaphylos patula, Cercocarpus montanus var. glaber, Eriodictyon angustifolium, Garrya flavescens, Juniperus californica, Nolina parryi, Quercus berberidifolia, Quercus cornelius-mulleri, Quercus john-tuckeri, Rhamnus ilicifolia*, and *Rhus ovata* characterize this shrubland. In the southeastern range, stands in the Chihuahuan Desert mountains and the Sierra Madre Oriental are codominated by evergreen shrub oak species, such as *Quercus mohriana, Quercus pungens*, and *Quercus vaseyana*. The herbaceous layer is variable, but is generally composed of semi-arid perennial grasses. This division occurs on sideslopes between low-elevation desert landscapes and higher pinyon-juniper woodlands of the western and central Great Basin, on steep, exposed slopes with rocky and/or shallow soils, and among montane forests of the Rocky Mountains, Cascades and Sierra Nevada, above 1500 m (4550 feet) elevation where much of the annual precipitation occurs as snow. The shrubs are adapted to freezing temperatures and cold winters. Further south, stands are found on foothills, xeric mountain slopes and canyons in hotter and drier habitats and often dominate along the mid-elevation (1000-2500 m) transition zone between desert scrub and montane woodlands. Most of

these chaparral species are fire-adapted, resprouting vigorously after burning or producing fire-resistant seeds. These variants may be short-duration chaparrals in previously forested areas that have experienced crown fires or recent logging.

Diagnostic Characteristics

This very widely distributed upland shrubland type is characterized by a very diverse set of diagnostic, mostly evergreen, sclerophyllous shrubs. In the Great Basin, Cascades, and Rocky Mountains these are open-canopy broad-leaved evergreen shrublands dominated by *Arctostaphylos patula, Arctostaphylos nevadensis, Ceanothus martinii, Ceanothus velutinus*. In California, chaparral or open shrubland is found among montane forests above 1500 m (4550 feet) elevation. Typical sclerophyllous chaparral shrubs include *Ceanothus cordulatus, Ceanothus diversifolius, Ceanothus pinetorum, Ceanothus integerrimus, Ceanothus velutinus, Chrysolepis sempervirens, Quercus sadleriana*, and *Quercus vacciniifolia*. Further east and south, *Arctostaphylos pungens, Quercus turbinella*, and *Ceanothus greggii* dominate large areas. Other diagnostic and often dominant shrubs include *Arctostaphylos pringlei, Cercocarpus montanus, Eriodictyon angustifolium, Garrya flavescens, Garrya ovata, Garrya wrightii, Juniperus californica, Quercus cornelius-mulleri, Quercus mohriana, Quercus pungens, Quercus toumeyi*, and *Quercus vaseyana*.

Rationale

Physiognomy

This upland shrubland is typically dominated by a moderate to dense evergreen sclerophyllous (sometimes including winter deciduous) shrub canopy usually less than 3 m tall. Herbaceous layers may be present and are typically dominated by perennial graminoids.

Floristics

In California and the Oregon Cascades, these shrublands are typically dominated by evergreen sclerophyllous shrubs. Characteristic shrub species include *Ceanothus cordulatus, Ceanothus diversifolius, Ceanothus integerrimus, Ceanothus velutinus, Ceanothus pinetorum, Chrysolepis sempervirens (= Castanopsis sempervirens), Notholithocarpus densiflorus var. echinoides (= Lithocarpus densiflorus var. echinoides), Quercus sadleriana*, and *Quercus vacciniifolia*. Other evergreen species, such as *Arctostaphylos nevadensis, Arctostaphylos patula, Arctostaphylos manzanita*, and *Garrya fremontii*, are common in some stands. Characteristic winter-deciduous shrubs might dominate some stands, but are commonly present even where not dominant. They include *Prunus emarginata, Prunus subcordata*, and *Ceanothus sanguineus* (in Oregon), *Prunus virginiana, Holodiscus discolor (= Holodiscus microphyllus)*, and *Quercus garryana garryana var. fruticosa (= var. breweri)*. Other shrub species include *Amelanchier alnifolia, Symphoricarpos mollis, Chamaebatia foliolosa*, and *Cercocarpus* spp. Emergent *Abies concolor, Pinus lambertiana, Pinus jeffreyi, Pinus sabiniana, Pinus ponderosa, Pseudotsuga menziesii, Quercus chrysolepis, Quercus wislizeni*, and *Quercus kelloggii* trees may be present at sparse cover. The herbaceous layer is variable depending on cover of shrubs (dense shrublands have little understory) and substrate.

Further east, in the Great Basin, Colorado Plateau and Rocky Mountains, the diversity of shrubs tends to be less, but some species are shared with California montane chaparral. Characteristic shrubs include*Arctostaphylos patula, Arctostaphylos nevadensis, Ceanothus velutinus, Ceanothus martinii, Ceanothus prostratus*, and *Purshia stansburiana*. Other winter-deciduous shrubs are often present, including *Amelanchier alnifolia, Artemisia tridentata, Eriogonum* spp., *Prunus virginiana*, and *Symphoricarpos* spp. Emergent *Abies concolor, Juniperus osteosperma, Juniperus scopulorum, Pinus edulis, Pinus flexilis, Pinus*

monophylla, Pinus ponderosa, Pseudotsuga menziesii trees may be present at sparse cover. The herbaceous layer is variable depending on cover of shrubs (dense shrublands have little understory) and substrate, but will include a variety of grass and forb taxa common to the Intermountain West and montane zones of the Rocky Mountains.

Further south, a moderate to dense evergreen shrub layer is dominated by the scrub oaks (*Quercus turbinella, Quercus intricata*, and *Quercus toumeyi*) along with wide diversity of other sclerophyllous shrubs that include *Ceanothus greggii, Cercocarpus montanus var. paucidentatus, Garrya wrightii*, and *Rhus trilobata*, with *Arctostaphylos pringlei* and *Arctostaphylos pungens* at higher elevations. In desert chaparral stands in the western extent, *Arctostaphylos glauca, Arctostaphylos patula, Cercocarpus montanus var. glaber, Garrya flavescens, Juniperus californica*, and *Nolina parryi, Quercus cornelius-mulleri, Rhamnus ilicifolia*, and *Rhus ovata*, characterize this shrubland. Scattered remnant pinyon and juniper trees may be present; however, in the western Mojave Desert, *Juniperus californica* sometimes forms an open, shrubby tree layer over the evergreen oaks and other shrubs. In the eastern extent, stands in the Chihuahuan Desert mountains and the Sierra Madre Oriental are dominated by evergreen shrub oak species, such as *Quercus mohriana, Quercus pungens*, and *Quercus vaseyana*, and several widespread chaparral species, such as *Arctostaphylos pungens, Ceanothus greggii, Cercocarpus montanus, Eriodictyon angustifolium, Fallugia paradoxa, Garrya wrightii*, and *Quercus grisea*. Other Madrean Orientale species include *Arbutus xalapensis (= Arbutus texana), Fraxinus greggii, Fendlera rigida (= Fendlera linearis), Garrya ovata, Juniperus pinchotii, Purshia mexicana, Rhus virens var. choriophylla (= Rhus choriophylla), Salvia lycioides (= Salvia ramosissima), Salvia roemeriana, Salvia regla* (Brown 1982a), and *Viguiera stenoloba*. The herbaceous layer is variable, but is generally composed of perennial grasses, such as *Achnatherum speciosum, Bouteloua curtipendula, Bouteloua hirsuta, Bothriochloa barbinodis, Eragrostis intermedia, Lycurus phleoides, Muhlenbergia emersleyi*, and several species of *Aristida*, which are largely restricted to rocky, protected areas because of past heavy livestock grazing. In rocky settings, pteridophytes (e.g., *Astrolepis* spp., *Cheilanthes* spp., *Notholaena standleyi, Selaginella* spp.) are often a component of this layer, and their abundance may exceed that of forbs.

Environment

This division occurs at montane elevations and in cold and warm semi-desert regions in the western U.S. and northern Mexico. The climate is seasonally warm to hot and may have a somewhat bi-modal precipitation regime with spring rains and warm-season monsoonal rains as well. Frosts tend to occur in winter, and snowpacks vary depending on latitude and orographic effects. This vegetation most typically occurs from 800 to 3000 m elevation, although it can occur as low as 50 m elevation in California. In warm desert mountains in the Sonoran, Mojave, and Chihuahuan deserts, stands are found on foothills, xeric mountain slopes and canyons in hotter and drier habitats. Further north, these shrublands are mostly found on steep, usually south-facing or exposed slopes, where soils are rocky, shallow and well-drained, often glaciated. This vegetation is found on widely varying substrates, with parent materials including igneous intrusives and extrusives, sedimentary, and metamorphics.

Range

These chaparral shrublands are found in often patchily distributed occurrences at montane elevations throughout much of the western U.S., from the Cascades east into the western Great Basin, Colorado Plateau, and Rocky Mountains, across central Arizona (Mogollon Rim) and southern New Mexico, east in mountains across Trans-Pecos Texas, and south into the Madrean Occidentale and Madrean Oriental in northern Mexico.

Synonymy

Dynamics Most of these chaparral species are fire-adapted, resprouting vigorously after burning or producing fire-resistant seeds. Some types within this division, especially those found among cold-temperate montane forests, may be short-duration chaparrals in previously forested areas that have experienced crown fires or recent logging. These chaparral patches likely shift across montane forested landscapes with catastrophic fire events. Chaparral found within the context of cold and warm deserts are likely to be far more persistent.

Taxonomic Parent Temperate Grassland & Shrubland

Parent Key F012

Name **Western North American Interior Flooded Forest**

Database Code	Classification Code	Hierarchy Level	Status
D013	1.B.3.Nd	Division	Accepted

Translated Name Fremont Cottonwood - Arizona Sycamore - Sugarberry Southwest North American Flooded Forest Division

Scientific Name Populus fremontii - Platanus wrightii - Celtis laevigata Southwest North American Flooded Forest Division

Summary This lowland riparian forest and woodland type is dominated by broad-leaved deciduous trees (cottonwoods, sycamores, and hackberries) and palms that occur along perennial and intermittent rivers, springs and oases of the California Central Valley, Southwest U.S. deserts, and the Tamaulipan region of south Texas and adjacent Mexico.

Description This division is characterized by forests and woodlands growing along lowland perennial and seasonally intermittent rivers as well as in spring areas, from the Californian Central Valley and Coast Ranges, through the warm deserts of the Southwest U.S. (Chihuahuan, Sonoran and Mojave), to the Tamaulipan region of south Texas and northeastern Mexico. Elevations range from sea level to 1800 m (6000 feet). Stands are dominated by riparian phreatophyte broad-leaved deciduous trees and occasionally fan palms (conifers are uncommon). Stands typically have multi-layered canopies with various understories of shrubs and herbs (or they can be sparse). Western stands are characterized by *Populus fremontii* and the closely related *Populus deltoides ssp. wislizeni* along with *Platanus racemosa, Platanus wrightii, Juglans major*, and *Juglans californica* as canopy dominants in monotypic to mixed stands. *Celtis laevigata var. reticulata* may also codominate in the canopies, particularly on drier sites. *Fraxinus anomala, Fraxinus velutina, Juglans microcarpa, Salix gooddingii*, and *Salix laevigata* are typical subcanopy tree species. Other riparian trees that can be common include *Acer negundo, Cephalanthus occidentalis, Salix amygdaloides, Salix lasiolepis, Salix lucida*, and *Sapindus saponaria* plus upland species that can tolerate a degree of moist conditions (e.g., *Quercus agrifolia* or *Quercus lobata*). Eastern stands are dominated by riparian trees with Tamaulipan subtropical affinities and include *Celtis laevigata var. laevigata, Salix nigra, Fraxinus berlandieriana, Taxodium mucronatum*, and *Ulmus crassifolia* with *Ebenopsis ebano, Prosopis glandulosa, Celtis ehrenbergiana*, and *Acacia farnesiana* occurring on drier sites. A shrub layer of facultative and obligate wetland species may be present, including *Baccharis salicifolia, Baccharis emoryi, Baccharis salicina, Salix exigua*, and *Salix geyeriana*, particularly in early-successional stands. On drier sites of the floodplain *Forestiera pubescens var. pubescens* and *Shepherdia argentea* may common. The herbaceous layer is variable in composition across the range and can range from very sparse to a rich and luxuriant mix of mesic forbs and graminoids. In riparian areas on serpentine, *Salix breweri, Hesperocyparis sargentii, Frangula californica ssp. tomentella*, and *Umbellularia californica* may be present. Intermixed with the native riparian forests are ruderal forests and scrubs dominated by introduced woody species with *Elaeagnus angustifolia* and *Tamarix* spp. the typical dominants, but *Ailanthus altissima, Eucalyptus* spp., and *Ulmus pumila* may also be codominants. The division also includes palm oases dominated by *Washingtonia filifera* (west) or *Sabal mexicana* (east) with or without riparian deciduous trees.

Diagnostic Characteristics This division is characterized by forests and woodlands dominated by riparian phreatophyte broad-leaved deciduous trees and occasionally palms. They grow along perennial and seasonally intermittent streams and springs in the warm desert (Sonoran and Mojave), Mediterranean and Tamaulipan regions of western North America, at low and moderate elevations. In western stands, strong diagnostic species in the overstory include *Populus fremontii* and the closely related *Populus deltoides ssp. wislizeni* along with *Platanus racemosa, Platanus wrightii, Juglans major*, and *Juglans californica*. Subcanopy strong diagnostics include *Fraxinus anomala, Fraxinus velutina, Juglans microcarpa, Salix gooddingii*, and *Salix laevigata*. Among eastern stands (Tamaulipan), moderate diagnostics include *Fraxinus berlandieriana, Ulmus crassifolia, Ebenopsis ebano*, and *Taxodium mucronatum*. Palm oases are characterized by *Washingtonia filifera* (west) or *Sabal mexicana* (east).

Rationale

Physiognomy Forests and woodlands that can have multi-layered canopies with various understories of shrubs and herbs (or they can be sparse). Tree heights among dominants can reach as much as 50 m (160 feet), but some stands are short-statured and approach shrublands in size. Young stands can be dense but often mature into open woodlands as trees senesce and die. This division also includes oases dominated by evergreen fan palms. A complex shrub and subshrub layer may or may not be present, and the herbaceous layer can vary from luxuriant to sparse in cover.

Floristics Western stands are characterized by riparian phreatophyte broad-leaved deciduous trees and occasionally palms; conifers are uncommon. *Populus fremontii* and the closely related *Populus deltoides ssp. wislizeni* along with *Platanus racemosa, Platanus wrightii, Juglans major*, and *Juglans californica* are the characteristic canopy dominants that can form monotypic to mixed stands along streams and river channels. *Celtis laevigata var. reticulata* may also codominate in the canopies, particularly on drier sites. *Fraxinus anomala, Fraxinus velutina, Juglans microcarpa, Salix gooddingii*, and *Salix laevigata* are typical subcanopy tree species. Other riparian trees that can be common include *Acer negundo, Cephalanthus occidentalis, Salix amygdaloides, Salix lasiolepis, Salix lucida*, and *Sapindus saponaria* plus upland species that can tolerate a degree of moist conditions (e.g., *Quercus agrifolia* or *Quercus lobata*). Eastern stands are dominated by riparian trees with Tamaulipan subtropical affinities and include *Celtis laevigata var. laevigata, Salix nigra, Fraxinus berlandieriana, Taxodium mucronatum*, and *Ulmus crassifolia* with *Ebenopsis ebano, Prosopis glandulosa, Celtis ehrenbergiana (= Celtis pallida)*, and *Acacia farnesiana (= Vachellia farnesiana)* occurring on drier sites. When a shrub layer is present, *Baccharis salicifolia, Baccharis emoryi*, and *Forestiera pubescens var. pubescens* are characteristic dominants, but the more widely distributed *Baccharis salicina, Shepherdia argentea, Salix exigua*, and *Salix geyeriana* can also occur either as monotypic or in mixed stands. The herbaceous layer is variable in composition across the range and can range from very sparse to a rich and luxuriant mix of mesic forbs and graminoids. In riparian areas on serpentine substrates, *Salix breweri, Hesperocyparis sargentii (= Cupressus sargentii), Frangula californica ssp. tomentella (= Rhamnus tomentella)*, and *Umbellularia californica* may be present. The division also includes palm oases dominated by *Washingtonia filifera* (west) or *Sabal mexicana* (east) with or without riparian deciduous trees.

Intermixed with the native riparian forests are ruderal forests and scrubs dominated by introduced woody species.*Elaeagnus angustifolia* and *Tamarix* spp. are the typical

dominants, but *Ailanthus altissima, Eucalyptus* spp., and *Ulmus pumila* may also be codominants.

Environment

This division occurs along riparian corridors of low-gradient rivers and streams (<1%) with primarily perennial flows, but seasonally intermittent and spring-fed sites are also possible. Stands occur on floodplain bars and terraces where trees can reach river groundwater on a consistent basis during the growing season (there are also localized areas of serpentine river deposits that provide a special environment). Climatically, the division extends from the winter-rainfall-dominated Mediterranean region of California to the summer-rainfall-dominated Chihuahuan Desert and Tamaulipan thornscrub to the east. But it is the winter snow accumulations of upstream watersheds that are critical for delivering rejuvenating spring floods and sustaining base flows through the summer growing season. In the case of *Washingtonia filifera*, a relict species of the Miocene and Pliocene (Vogl and McHargue 1966), permanent subsurface water is required to maintain them. Reproduction of *Washingtonia filifera* is limited by water supply, surface salinity, rainfall, and fire. Fan palms are fire-tolerant, while understory species are not. Other diagnostic phreatophyte trees of the division are also fire-intolerant.

Environments that favor ruderal, exotic-dominated shrublands are commonly related to altered hydrological regimes caused by dam flow regulation and reservoir sediment capture. But species such as*Elaeagnus angustifolia* and *Tamarix* spp. are aggressive invaders even under natural free-flowing conditions.

Range

This division of lowland river corridors extends from the coastal ranges of southern Oregon, southward to the Coastal Ranges and Central Valley of California, eastward through the Mojave, Sonoran and Chihuahuan Deserts and the Gulf Coastal Plain of south Texas, northward onto the Colorado Plateau into the Great Basin, and south into northern Mexico.

Synonymy

> Californian Riparian Deciduous Forest and Woodland (Brown et al. 1979) [This type is a subregional variant of a portion of this division concept.]
> Interior Southwestern Riparian Deciduous Forest and Woodland (Brown et al. 1979) [This type is a subregional variant of a portion of this division concept.]

Dynamics

These are disturbance-driven systems where flooding, scour and deposition of new sediments are recurring events at intervals of up to 100 years, and usually much less. Since most of the dominant trees are relatively short-lived (100-150 years), periodic flooding and associated sediment scour are necessary to ensure tree reproduction and stand renewal. Sufficient base flows are also required. Hence, a hydrological regime that has been significantly impacted by dams and channelization leads to deeper groundwater depths, little overbank flooding, phreatophyte stand senescence and replacement by more xerophytic woodlands, shrublands (often the ruderal exotic-dominated communities), or grasslands. Salinity is low in the root zone, but can increase near the surface where evaporation leaves salt accumulations, particularly when flooding becomes infrequent. Fires do not play a significant natural role in these ecosystems.

Taxonomic Parent Temperate Flooded & Swamp Forest

Parent Key F026

Name **Western North American Pinyon - Juniper Woodland & Scrub**

Database Code	Classification Code	Hierarchy Level	Status
D010	1.B.2.Nc	Division	Accepted

Translated Name Singleleaf Pinyon - Two-needle Pinyon - Juniper species Woodland & Scrub Division

Scientific Name Pinus monophylla - Pinus edulis - Juniperus spp. Woodland & Scrub Division

Summary These pinyon pine- and juniper-dominated woodlands, scrub, and savannas generally occur just above semi-desert shrublands and grasslands or shortgrass prairies and below montane forest vegetation throughout the semi-arid Intermountain West and western Great Plains of North America.

Description This division is composed of woodland, savanna, and scrub characterized by an open to closed tree and shrub canopy of *Pinus monophylla, Pinus edulis, Juniperus occidentalis, Juniperus osteosperma, Juniperus monosperma*, or *Juniperus scopulorum*. Typically one, or combinations of two, of these species dominate the canopy. Stands are typically open-canopied (10-30% cover), but closed-canopy conditions with a sparse understory are not uncommon. Pinyon and juniper stands may occur as persistent woodlands, open savannas, and wooded shrublands. Persistent woodlands occur where climate substrates support pinyon pines and junipers; typically with infrequent wildfire. Open savannas occur where landform and substrates support both trees and grasses, and where more frequent surface fires were likely the historical norm. Wooded shrublands occur where climate and soils support shrublands, but where trees increase in abundance under favorable climate and limited disturbance, and decrease during droughts and following disturbance. Understory layers are variable and may be dominated by shrubs, graminoids, or be absent, especially on rocky substrates. Except for in the extreme eastern and southern portion of its range, shrub layers are frequently dominated by *Artemisia tridentata*, which in places can form a moderately dense shrub canopy. Other common associated shrub species include *Arctostaphylos patula, Artemisia arbuscula, Artemisia bigelovii, Artemisia nova, Atriplex canescens, Cercocarpus intricatus, Cercocarpus ledifolius* (in tree or shrub form), *Cercocarpus montanus, Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ericameria nauseosa, Fraxinus anomala, Fraxinus cuspidata, Glossopetalon spinescens, Krascheninnikovia lanata, Purshia stansburiana, Purshia tridentata, Quercus gambelii, Quercus turbinella, Quercus x pauciloba, Ribes cereum, Rhus trilobata, Tetradymia* spp., *Yucca baccata*, and *Yucca glauca*. The most frequent succulents are *Cylindropuntia imbricata, Opuntia phaeacantha*, and *Opuntia polyacantha*. The herbaceous layer may be sparse to dense depending on overstory density, substrate, landscape position, and disturbance history, with the densest graminoid layer in open-tree or shrub savanna. Common graminoid associates include *Bouteloua curtipendula, Bouteloua gracilis, Carex filifolia, Festuca idahoensis, Hesperostipa comata, Leymus cinereus, Leymus salinus, Pleuraphis jamesii, Pseudoroegneria spicata, Poa fendleriana*, and *Poa secunda*. Forb species may be diverse but typically have low canopy cover values, and can include *Astragalus* spp., *Castilleja integra, Cryptantha cinerea var. jamesii, Erigeron divergens, Eriogonum jamesii, Hymenopappus filifolius, Ipomopsis multiflora, Mentzelia* spp., *Penstemon* spp., and *Petradoria pumila*.

Diagnostic Characteristics Structurally complex, low woodland, scrub, and savanna with pinyon pine and or juniper dominance in uppermost canopy, especially *Pinus monophylla, Pinus edulis, Juniperus occidentalis, Juniperus osteosperma, Juniperus monosperma*, or *Juniperus scopulorum*. The understory is dominated by either shrub or grass species of cool-temperate affinity.

Rationale

Physiognomy This broadly defined evergreen division is composed of a woodland, savanna (or open woodland), and scrub structure. Stands are typically short (2-10 m tall), with an open to closed (10-60% cover), evergreen needle-leaved or scale-leaved or broad-leaved, sclerophyllous tree and/or shrub canopy. The understory is variable with lush grass cover and occasionally scattered shrubs in the savanna stands to a sparse to dense short-shrub layer and/or herbaceous layer in woodland stands. This division encompasses savanna that has widely spaced, short (2-10 m tall), mature (>150-year-old) trees with a moderately dense to dense herbaceous layer dominated by perennial graminoids. On extremely xeric sites, diagnostic juniper and pinyon trees species may only attain 2 m in height and have a more shrub form. However, *Juniperus occidentalis*-dominated stands have two different tree canopy structures: (1) an old-growth woodland with large, fairly well-spaced trees with rounded crowns, and (2) relatively young, often dense junipers trees with pointed crowns. Cover of understory species sharply declines when tree canopy cover exceeds 40% (Young et al. 1982). Many of the tree savannas have a sparse shrub layer present. Herbaceous layers are variable depending on the density of woody canopy, substrate, landscape position, and disturbance history. Perennial graminoids typically dominate most herbaceous layers with most species individually contributing low cover.

Floristics This division includes woodland, savanna (or open woodland), and scrub characterized by an open to closed tree and shrub canopy of *Pinus monophylla* and/or *Pinus edulis, Juniperus occidentalis, Juniperus osteosperma, Juniperus monosperma*, or *Juniperus scopulorum*. Typically one, or combinations of two, of these species dominate the canopy. In the Mohave Desert mountains, *Yucca brevifolia* may be an associate of *Pinus monophylla*. Shrub species include *Arctostaphylos patula, Artemisia arbuscula, Artemisia bigelovii, Artemisia nova, Artemisia tridentata, Atriplex canescens, Cercocarpus intricatus, Cercocarpus ledifolius* (in tree or shrub form), *Cercocarpus montanus, Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ericameria nauseosa, Fraxinus anomala, Fraxinus cuspidata, Glossopetalon spinescens, Krascheninnikovia lanata, Purshia stansburiana, Purshia tridentata, Quercus gambelii, Quercus turbinella, Quercus x pauciloba, Ribes cereum, Rhus trilobata, Tetradymia* spp., *Yucca baccata, Yucca brevifolia*, and *Yucca glauca*. Shrub species more characteristic of 1.B.1.Nc ~Californian Forest & Woodland Division (D007)$$, such as *Juniperus californica, Quercus chrysolepis*, and/or *Quercus john-tuckeri*, may occur near the southwestern limits of the range. The most frequent succulents are *Cylindropuntia imbricata, Opuntia phaeacantha*, and *Opuntia polyacantha*. The herbaceous layer may be sparse to dense depending on overstory density, substrate, landscape position, and disturbance history, with the densest graminoid layer in open-tree or shrub savanna. Common graminoid associates include *Bouteloua curtipendula, Bouteloua eriopoda, Bouteloua gracilis, Carex filifolia, Hesperostipa comata, Hesperostipa neomexicana, Festuca idahoensis, Leymus cinereus (= Elymus cinereus), Leymus salinus, Muhlenbergia pauciflora, Pleuraphis jamesii, Poa fendleriana, Poa secunda, Pseudoroegneria spicata*, and the non-native invasive annual *Bromus tectorum*. Forb species may be diverse but typically have low canopy cover values, and can include

Astragalus spp., *Castilleja integra, Cryptantha cinerea var. jamesii (= Cryptantha jamesii), Eriogonum jamesii, Erigeron divergens, Hymenopappus filifolius, Ipomopsis multiflora, Mentzelia* spp., *Penstemon* spp., and *Petradoria pumila*.

Environment

Stands of this division in the Colorado Plateau, Great Basin, and Mohave Desert mountains occur between 1500 and 2600 m elevation on warm, dry sites of lower mountain slopes, hills, mesas, plateaus, ridges, and more recently on basins and flats where trees are expanding into semi-desert grasslands and steppe. Substrates are variable, but are generally shallow, cobbly, gravelly, or sandy loams to clay loam or clay. Parent materials are variable. Juniper stands in the Columbia Plateau range from under 200 m elevation along the Columbia River in central Washington to over 1500 m. In central Oregon, they occur on all aspects and slope positions. Stands of this division also occur in dry mountains and foothills in southern Colorado south into central New Mexico, extending east into the plains on breaks in the southwestern Great Plains. They are found in dry sites in lower slopes of mountains, plateaus and foothills and on limestone and shale breaks in the plains. In this portion of the range, stands are found at elevations from 1370 to 2900 m. Climate is cool-temperate. Severe weather events occurring during the growing season, such as frosts and drought, are thought to limit the distribution of pinyon-juniper woodlands to relatively narrow altitudinal belts on a given mountainside, and particularly influence the proportion of pinyon trees relative to juniper.

Range

This division generally occurs just above semi-desert shrublands and grasslands or shortgrass prairies and below montane forest vegetation throughout the semi-arid Intermountain West and western Great Plains of North America.

Synonymy

Dynamics

Key dynamic processes are drought, fire, herbivory, and insect/disease outbreaks. Characteristic *Pinus* spp. and *Juniperus* spp. are relatively short (generally <15 m tall), shade-intolerant, drought-tolerant, slow-growing, long-lived trees (especially *Juniperus osteosperma* can reach 650 years old). *Pinus* spp. are non-sprouting and may be killed by fire. The effect of a fire on these stands is largely dependent on the tree height and density, fine fuel load on the ground, weather conditions and season. Large trees generally survive unless the fire gets into the crown due to heavy fuel loads in the understory. Fire acts to open stands, increase diversity and productivity in understory species, and create a mosaic of stands of different sizes and ages across the landscape while maintaining the boundary between woodlands and adjacent shrublands or grasslands.

As modeled by Landfire, this division is generally characterized by a spectrum of fire regimes, including frequent non-lethal fires, mixed-severity mosaic fires (mean FRI of 50-200 years), and very infrequent replacement fires (mean FRI of 200-500 years). Surface fire was likely the most frequent in savannas. Frequently, fire spreads from adjacent vegetation. Severe climatic events occurring during the growing season, such as frosts and drought, are thought to limit the distribution and density of pinyon and/or juniper stands to relatively narrow altitudinal belts on mountainsides and foothills. Weather-related stress thins trees in more closed stands. Insects/disease has a similar effect, but with a greater frequency in closed stands (mean return interval of 100 years) than open ones (mean return interval of 1000 years). Competition from grasses and older trees in late open stands is also included as a disturbance that maintains open woody canopies.

Taxonomic Parent Cool Temperate Forest & Woodland

Parent Key F008

Name **Western North American Temperate Freshwater Marsh, Wet Meadow & Shrubland**

Database Code	Classification Code	Hierarchy Level	Status
D031	2.C.4.Nb	Division	Accepted

Translated Name Sitka Alder - Booth's Willow / Sedge species Western North American Freshwater Marsh, Wet Meadow & Shrubland Division

Scientific Name Alnus viridis ssp. sinuata - Salix boothii / Carex spp. Western North American Freshwater Marsh, Wet Meadow & Shrubland Division

Summary

This division contains marshes, wet meadows and shrublands, singly and in mosaics, along riparian corridors, around vernal pools, depressions, seeps and springs on mineral soils or shallow organic layers over mineral substrates in temperate latitudes of western North America.

Description

This is a broad division that covers freshwater marshes, wet meadows and shrub-dominated wetlands found at all elevations up to, but excluding, alpine areas throughout the Pacific coast, from the Aleutian Islands of Alaska to southern Oregon, and throughout the temperate (and possibly southern boreal) interior of western U.S. and Canada.

Species composition is highly varied across this division. In the**coastal Pacific Northwest shrublands** dominant canopy species include *Alnus viridis ssp. sinuata*, various species of *Salix* (such as *Salix commutata* and *Salix sitchensis*), *Spiraea douglasii, Malus fusca, Cornus sericea, Alnus incana ssp. tenuifolia, Alnus viridis ssp. crispa*, and *Myrica gale*. The **interior regions riparian shrublands** include *Alnus incana, Betula occidentalis, Acer glabrum, Artemisia cana, Artemisia tridentata ssp. tridentata, Cornus sericea, Crataegus douglasii, Crataegus rivularis, Dasiphora fruticosa, Forestiera pubescens, Oplopanax horridus, Philadelphus lewisii, Prunus virginiana, Rhus trilobata, Rosa nutkana, Rosa woodsii*, many *Salix* species, *Shepherdia argentea*, and *Symphoricarpos* spp.

Freshwater herbaceous marshes along the coast tend to be dominated by species that include *Deschampsia beringensis, Festuca rubra, Argentina egedii, Lathyrus japonicus var. maritimus, Heracleum maximum, Parnassia palustris, Lupinus nootkatensis, Angelica lucida, Carex mackenziei, Leymus mollis, Carex lyngbyei*, and *Carex obnupta*. **Maritime Alaska freshwater marshes** are described as having *Carex rostrata, Equisetum fluviatile, Carex aquatilis var. dives, Menyanthes trifoliata, Comarum palustre, Eleocharis palustris*, and *Schoenoplectus tabernaemontani*. **Freshwater mudflats** can be dominated by *Eleocharis obtusa, Lilaeopsis occidentalis, Crassula aquatica, Limosella aquatica, Gnaphalium palustre, Eragrostis hypnoides*, and *Ludwigia palustris*. **Non-coastal freshwater marshes** are dominated by mostly graminoids (*Carex, Scirpus* and/or *Schoenoplectus, Eleocharis, Juncus, Typha latifolia*) but also some forbs such as *Sparganium, Sagittaria, Bidens, Cicuta, Rorippa*, and *Mimulus*.

Vernal pool species composition is highly specific and often contains many endemic species. Characteristic plant species in northern California and the southern Cascades vernal pool herbaceous communities include*Blennosperma nanum, Callitriche marginata, Cicendia quadrangularis, Cressa truxillensis, Downingia bella, Downingia insignis, Epilobium densiflorum, Eryngium aristulatum, Eryngium mathiasiae, Eryngium vaseyi, Lasthenia*

ferrisiae, Lasthenia glaberrima, Plagiobothrys leptocladus, Pogogyne douglasii, Psilocarphus brevissimus, Sedella pumila, Spergularia salina, and many others. Less than a third of the California vernal pool species overlap with vernal pools found further north and are not listed here.

High-elevation wet meadows in the Rocky Mountains, Pacific Northwest and Intermountain regions are often dominated by*Carex illota, Carex lachenalii, Carex nigricans, Carex vernacula, Deschampsia cespitosa, Juncus drummondii*, and forbs *Caltha leptosepala, Trollius laxus, Phippsia algida, Rorippa alpina, Sibbaldia procumbens*, and *Trifolium parryi*. **Lower-elevation wet meadows** include *Calamagrostis canadensis, Calamagrostis stricta, Carex aquatilis, Carex bolanderi, Carex exsiccata, Carex illota, Carex microptera, Carex scopulorum, Carex utriculata, Eleocharis quinqueflora, Glyceria striata, Juncus drummondii, Juncus nevadensis*, and *Scirpus* and/or *Schoenoplectus* spp. Forb species include *Camassia quamash, Cardamine cordifolia, Dodecatheon jeffreyi, Phippsia algida, Rorippa alpina, Senecio triangularis, Trifolium parryi*, and *Veratrum californicum*. Due to intensive historical sheep and cattle grazing and other land uses, wet meadows throughout the West can become dominated by non-native species such as *Agrostis gigantea, Agrostis stolonifera, Conyza canadensis, Phalaris arundinacea, Phragmites australis, Poa palustris*, and *Poa pratensis*.

Stands occur on poorly-drained or well-drained seasonally wet to saturated soils that may dry out completely during the growing season, and are located in depressions, around lakes or ponds, or river terraces and floodplains where water tables fluctuate seasonally. Some depressions are poorly-drained with fine-textured organic, muck or mineral soils with standing water common throughout the growing season. Others are semipermanently to seasonally flooded during the growing season or have only subsurface saturation. Substrates range from sand dunes to hardpan caliche layers, bedrock or shallow organic over mineral soils, loose unconsolidated highly stratified alluvial material. Water sources may be groundwater, riverflows, direct rainwater or snowmelt runoff. The physical setting for these wetlands is highly variable and includes interdunal areas, delta deposits, uplifted marshes, beach deposits; mudflats of seasonally flooded shallow lakebeds and floodplains; streambanks of permanent, intermittent and ephemeral streams; active channel low-gradient gravel bars; steep avalanche chutes; and stagnant oxbow lakes, levees, and sloughs. The freshwater emergent marshes and wet meadows can be found on mineral soils at low and high elevations. Bogs and fens on true organic soils (>40 cm depth) are in their own division, ~North American Bog& Fen Division (D029)$$.

Diagnostic Characteristics

Shrublands and wet herbaceous communities on saturated to well-drained but seasonally wet soils, that can be fine-grained muck or mineral overlain by shallow organic soils (<40 cm) but are for the most part mineral soil wetlands. A diagnostic list of species is needed for this division.

Rationale

Physiognomy

Floristics

Species composition is highly varied across this division. In the **coastal Pacific Northwest shrublands** dominant canopy species include *Alnus viridis ssp. sinuata*, various species of *Salix* (such as *Salix commutata* and *Salix sitchensis*), *Spiraea douglasii, Malus fusca, Cornus sericea, Alnus incana ssp. tenuifolia (= Alnus tenuifolia), Alnus viridis ssp. crispa (= Alnus*

crispa), and *Myrica gale*. The **interior regions riparian shrublands** include *Alnus incana, Betula occidentalis, Acer glabrum, Artemisia cana, Artemisia tridentata ssp. tridentata, Cornus sericea, Crataegus douglasii, Crataegus rivularis, Dasiphora fruticosa, Forestiera pubescens, Oplopanax horridus, Philadelphus lewisii, Prunus virginiana, Rhus trilobata, Rosa nutkana, Rosa woodsii*, many *Salix* species, *Shepherdia argentea*, and *Symphoricarpos* spp.

Freshwater herbaceous marshes along the coast tend to be dominated by species that include *Deschampsia beringensis, Festuca rubra, Argentina egedii (= Potentilla egedii), Lathyrus japonicus var. maritimus, Heracleum maximum, Parnassia palustris, Lupinus nootkatensis, Angelica lucida, Carex mackenziei, Leymus mollis, Carex lyngbyei*, and *Carex obnupta*. **Maritime Alaska freshwater marshes** are described as having *Carex rostrata, Equisetum fluviatile, Carex aquatilis var. dives (= Carex sitchensis), Menyanthes trifoliata, Comarum palustre, Eleocharis palustris*, and *Schoenoplectus tabernaemontani*. **Freshwater mudflats** can be dominated by *Eleocharis obtusa, Lilaeopsis occidentalis, Crassula aquatica, Limosella aquatica, Gnaphalium palustre, Eragrostis hypnoides*, and *Ludwigia palustris*. **Non-coastal freshwater marshes** are dominated by mostly graminoids (*Carex, Scirpus* and/or *Schoenoplectus, Eleocharis, Juncus, Typha latifolia*) but also some forbs such as *Sparganium, Sagittaria, Bidens, Cicuta, Rorippa*, and *Mimulus*.

Vernal pool species composition is highly specific and often contains many endemic species. Characteristic plant species in northern California and the southern Cascades vernal pool herbaceous communities include*Blennosperma nanum, Callitriche marginata, Cicendia quadrangularis, Cressa truxillensis, Downingia bella, Downingia insignis, Epilobium densiflorum (= Boisduvalia densiflora), Eryngium aristulatum, Eryngium mathiasiae, Eryngium vaseyi, Lasthenia ferrisiae, Lasthenia glaberrima, Plagiobothrys leptocladus (= Allocarya leptoclada), Pogogyne douglasii, Psilocarphus brevissimus, Sedella pumila (= Parvisedum pumilum), Spergularia salina (= Spergularia marina)*, and many others. Less than a third of the California vernal pool species overlap with vernal pools found further north and are not listed here.

High-elevation wet meadows in the Rocky Mountains, Pacific Northwest and Intermountain regions are often dominated by*Carex illota, Carex lachenalii, Carex nigricans, Carex vernacula, Deschampsia cespitosa, Juncus drummondii*, and forbs *Caltha leptosepala, Trollius laxus, Phippsia algida, Rorippa alpina, Sibbaldia procumbens*, and *Trifolium parryi*. **Lower-elevation wet meadows** include *Calamagrostis canadensis, Calamagrostis stricta, Carex aquatilis, Carex bolanderi, Carex exsiccata, Carex illota, Carex microptera, Carex scopulorum, Carex utriculata, Eleocharis quinqueflora, Glyceria striata (= Glyceria elata), Juncus drummondii, Juncus nevadensis*, and *Scirpus* and/or *Schoenoplectus* spp. Forb species include *Camassia quamash, Cardamine cordifolia, Dodecatheon jeffreyi, Phippsia algida, Rorippa alpina, Senecio triangularis, Trifolium parryi*, and *Veratrum californicum*.

Due to intensive historical sheep and cattle grazing and other land uses, wet meadows throughout the West can become dominated by non-native species such as*Agrostis gigantea, Agrostis stolonifera, Conyza canadensis, Phalaris arundinacea, Phragmites australis, Poa palustris*, and *Poa pratensis*.

Environment

Soils/substrate: Stands occur on poorly-drained or well-drained seasonally wet to saturated soils that may dry out completely during the growing season, and are located in depressions, around lakes or ponds, or river terraces and floodplains where water tables

fluctuate seasonally. The vegetation can occur as relatively simple stands of wet shrublands, marshes and wet meadows, or in extensive mosaics of all three kinds. Some depressions are poorly-drained with fine-textured organic, muck or mineral soils with standing water common throughout the growing season. Others are semipermanently to seasonally flooded during the growing season, or have only subsurface saturation. Substrates range from sand dunes to hardpan caliche layers, bedrock or shallow organic over mineral soils, loose unconsolidated highly stratified alluvial material. Water sources may be groundwater, riverflows, direct rainwater or snowmelt runoff. The physical setting for these wetlands is highly variable and includes interdunal areas, delta deposits, uplifted marshes, beach deposits; mudflats of seasonally flooded shallow lakebeds and floodplains; streambanks of permanent, intermittent and ephemeral streams; active channel low-gradient gravel bars; steep avalanche chutes; and stagnant oxbow lakes, levees, and sloughs. The freshwater emergent marshes and wet meadows can be found on mineral soils at low and high elevations.

Range This type occurs throughout the temperate regions of western North America, from the Aleutian Islands to Baja California east into the Great Basin and Rocky Mountains, and possibly into the southern boreal regions of northwestern Canada and Alaska.

Synonymy

Dynamics

Taxonomic Parent Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland

Parent Key F013

Name North American Western Interior Brackish Marsh, Playa & Shrubland

Database Code	Classification Code	Hierarchy Level	Status
D036	2.C.5.Nd	Division	Accepted

Translated Name Greasewood - Iodinebush - Chairmaker's Bulrush North American Interior Brackish Marsh, Playa & Shrubland Division

Scientific Name Sarcobatus vermiculatus - Allenrolfea occidentalis - Schoenoplectus americanus North American Interior Brackish Marsh, Playa & Shrubland Division

Summary Interior saline-alkaline wetlands of North American interior west, including salt flats, marshes and seeps, whose species composition is driven by water chemistry and duration and seasonality of wetness. Stands range from sparse cover of shrubs and/or herbs to productive marshes dominated by tall emergent graminoids.

Description This division covers non-tidal interior saline-alkaline wetlands, salt flats, lower basins, marshes and seeps that occur throughout much of interior temperate to subtropical North America from Oregon, eastern Washington, and southern British Columbia across the intermountain basins, eastward through the Great Plains and from southern and central California and adjacent Baja California, Mexico, through the warm deserts of North America to Texas. Stands may occur near drainages on stream terraces and flats or may form rings around more sparsely vegetated playas. They may also occur at the interior edge of coastal salt marshes along the southwestern portion of the Pacific Coast where relatively low rainfall and high evaporation tends to concentrate salts near the surface. In general, key taxa are divided into two groups: halophytes of substrates with higher salt concentrations and salt-tolerant marsh plants. Halophytes include various woody and herbaceous members of the Chenopodiaceae which either store water in stems or leaves or exude excess salt from glands on leaves, and also include some members of the Asteraceae such as the *Isocoma acradenia-Isocoma arguta-Isocoma rusbyi* complex. The brackish marsh key species *Schoenoplectus americanus* is an excellent disperser and is regularly found in most stands throughout the range of the division. *Allenrolfea occidentalis* is a strong diagnostic species covering the southwestern portion of the extent of the division. It overlaps with *Sarcobatus vermiculatus*, which covers the northern and western portion of the division's distribution.

The climate of most stands is characterized by long periods of drought during the summer months. Maximum or minimum temperatures range widely from well over 45°C to well below 0°C. Coastal fringes of the desert or semi-desert in southern California south to central Baja California, Mexico, have mild temperatures, but may have very high evaporation. Many of the key species of shrubs or wetland herbs have broad distributions and have broad temperature tolerance. Salinity ranges from brackish to hypersaline. Texture ranges from peat and muck in perennial wetlands to heavy clay soils in and around playas or uplifted sea or lake beds in interior basins and valleys. Most soils are fine-textured and many have mineral crusts. Hydrology varies from permanent stream and spring flow to highly episodic flooding along desert streams and playa basins. Many stands of halophytic shrubs have fluctuating saline water tables.

Diagnostic Characteristics Key species are restricted to non-tidal, salt-tolerant shrublands or herbaceous wetlands of

permanent brackish marshes, seasonally or intermittently wet playas, lake margins, and closed basins. This division contains several related taxa, which taken together taxonomically are key taxa being largely restricted, widespread, and often dominant. These include the *Schoenoplectus americanus - Schoenoplectus pungens* complex, *Sarcobatus vermiculatus - Sarcobatus baileyi* complex, *Suaeda calceoliformis - Suaeda moquinii* complex, and the *Salicornia rubra-Salicornia depressa* complex. *Distichlis spicata*, although common and ubiquitous, is a moderate diagnostic because it occurs in a number of divisions.

Rationale

Physiognomy

Stands are variable depending upon degree of perennial to seasonal saturation or flooding, and degree of salinity/alkalinity of substrates. Of the true halophytes, *Allenrolfea occidentalis* alliance stands have the highest tolerance for salt, followed by *Sarcocornia utahensis, Sarcobatus vermiculatus*, and *Atriplex nuttallii* (Goodman 1973).

Floristics

Sites exhibit a range of soil moisture and salinity/alkalinity, from slightly brackish perennial springs to rarely inundated, hypersaline evaporate crusts. Areas with higher water tables and lower salinity support productive brackish marshes with tall graminoids and grasses such as *Schoenoplectus americanus*, including the ecologically similar *Schoenoplectus pungens sensu* FNA Editorial Committee (2002b), *Phragmites australis, Typha angustifolia, Eleocharis* spp., and *Bolboschoenus maritimus* along with taller forbs such as *Helianthus nuttallii, Solidago spectabilis*, and *Euthamia occidentalis*. West of the Great Plains these occur where freshwater springs emerge through salty or alkaline substrate, or creeks, streams or rivers flow through edges of salt flats or coastal salt marshes. These marshes tend to have steep moisture gradients to drier adjacent saline vegetation of the seasonal or ephemeral wetland component of this division.

Seasonal or ephemeral wetlands in the division have saline soils, a shallow to moderately deep water table and flood intermittently, but remain dry for most growing seasons. Salt crusts are common throughout. The flats are intermittently, seasonally to semipermanently flooded, usually retaining subsurface water into the growing season and drying completely only in drought years. They are often found in strongly saline-alkaline playa-like depressions, old lakebeds or in floodplains of major river systems where seasonal water inputs are limited, and often include some groundwater seepage in a matrix of mixed salt desert scrub. High rates of evaporation lead to alkaline water and soil conditions, with layers of salt-encrusted soils often accumulating near seeps. Perennial seeps often have bands of distinctive vegetation radiating outward, each with lower moisture requirements and higher salinity tolerance; for example,*Anemopsis californica, Cressa truxillensis, Juncus cooperi, Juncus arcticus ssp. littoralis (= Juncus balticus), Bassia americana (= Kochia americana), Leymus triticoides, Leymus cinereus, Muhlenbergia asperifolia, Puccinellia* spp. (including the endemic *Puccinellia howellii*), *Salicornia rubra, Sesuvium verrucosum, Spartina gracilis, Sporobolus airoides*, and *Triglochin maritima*. These herb stands also are reduced in stature as they decrease in moisture and increase in salinity, and ultimately are often surrounded by a low patchy turf of *Distichlis spicata*. These herbaceous stands grade into seasonal or ephemeral wetlands on playas or salt pannes, or irregularly flooded lowlands where halophytic shrubs, tend to be characteristic. Occasional shrubs tolerant of brackish but not highly salty water may occur in and adjacent to these herbaceous wetlands. These include *Prosopis glandulosa, Prosopis pubescens*, and *Pluchea sericea* (larger stands of these species occur in other riparian divisions).

Brackish marshes from the Great Plains eastward share many of these same species but also include related species such as*Atriplex patula, Poa arida, Iva annua, Suaeda calceoliformis*, and tend to grade into surrounding grasslands or agricultural landscapes. An increase in precipitation during exceptionally wet years can dilute the salt concentration in the soils, allowing for less salt-tolerant species such as *Pascopyrum smithii* or *Hordeum jubatum* to become dominant. In general there are no highly evaporative hypersaline playas or flats east of the 100th meridian.

Shrublands characteristic of salty warm or cool desert conditions are prevalent in this division throughout the West, but are not common from the Great Plains eastward. These periodically flooded shrublands consist of open to moderately dense stands of woody chenopods. Soils with shallow briny water tables tend to be dominated or codominated by succulent phreatophytes, including*Allenrolfea occidentalis, Arthrocnemum subterminale, Sarcobatus vermiculatus*, or *Suaeda moquinii (= Suaeda nigra)*. Less salty soils with lower or no appreciable water table tend to have non-succulent-leaved species such as *Atriplex canescens, Atriplex confertifolia, Atriplex gardneri, Atriplex parryi, Atriplex spinifera, Grayia spinosa*, or *Krascheninnikovia lanata*. Areas of overlap occur with herbs such as *Distichlis spicata, Bassia americana*, and short perennial subshrubs such as *Suaeda* spp. and *Frankenia salina* (in California) occurring with taller shrubs of *Atriplex* or *Sarcobatus*.

Environment

Climate: Most stands are characterized by long periods of drought during the summer months. Maximum or minimum temperatures range widely from well over 45°C to well below 0°C. Coastal fringes of the desert or semi-desert in southern California south to central Baja California, Mexico, have mild temperatures, but may have very high evaporation. Many of the key species of shrubs or wetland herbs have broad distributions and have broad temperature tolerance. Köppen climate system classifies the general distribution of this division within the Dry Climates (B) and include Bwh in subtropical Sonoran Desert ranging to Bsk in the northern Great Basin and the edges of the Great Plains. Large areas of the Great Basin are also Bwk.

Soil/substrate/hydrology: Salinity ranges from brackish to hypersaline. Texture ranges from peat and muck in perennial wetlands to heavy clay soils in and around playas or uplifted sea or lake beds in interior basins and valleys. Most soils are fine-textured and many have mineral crusts. Hydrology varies from permanent stream and spring flow to highly episodic flooding along desert streams and playa basins. Many stands of halophytic shrubs have fluctuating saline water tables.

Biogeography: Some of the diagnostic species for this division are members of very widely distributed genera (e.g., *Suaeda*). Species of *Salicornia* are found in both the Americas and Eurasia and Africa. *Allenrolfea* (a monotypic genus) is only in the New World. *Sarcobatus* is endemic to western North America. The marsh herbaceous genera are widespread in the Northern Hemisphere and some, such as *Schoenoplectus*, are distributed throughout the temperate and tropical zones of the world.

Range

This type occurs throughout much of the western U.S. in intermountain basins and extends onto the western Great Plains, into central Montana and into the warm deserts of North America, throughout California's Central Valley, San Joaquin Valley, and along its south coast extending into Baja California Norte, Mexico. The type is poorly developed eastward in the Great Plains primarily due to the dilution effect of higher summer rainfall and

concomitant low evaporative conditions in the eastern part of North America.

Synonymy

> Alkali Sink (Keeler-Wolf 2007) [Keeler-Wolf only discusses Mojave Desert Alkali Sink which largely excludes *Sarcobatus* of the Great Basin, but does include brackish and saline marshes with *Allenrolfea* and *Suaeda* saline shrublands.]
< Mohavean Interior Marshland (Brown et al. 1980) [Only includes the wetland herbaceous alliances, does not treat the halophytic woody vegetation.]
< Saltbush series (as part of Great Basin Desert Scrub) (Brown et al. 1980) [Divide Saltbush series elements between cold-temperate Great Basin Desert Scrub, and warm-temperate desert lands in Mojave, Chihuahuan, and Sonoran desert scrubs, replicating the same relationships within 4 different regional formations.]

Dynamics

Temporal shifts in salinity, inundation, and soil moisture strongly affect the dynamics of both herbaceous and woody components of this division. Although most western stands are subject to long periods of drought and are relatively stable in salinity, the more eastward and northward in range, the more likely are shifts in salinity based on periods of drought (higher) or wet cycles (lower). Permanent springs and seeps may also be affected by increases or decreases in salinity. In California, stands of *Atriplex spinifera, Atriplex confertifolia, Suaeda moquinii*, and other shrubs tend to be short-lived and shift depending on drought cycles (Sawyer et al. 2009). Others have found similar drought-related cycles in *Allenrolfea* or *Sarcobatus* (Trent et al. 1997, Gul et al. 2001).

Taxonomic Parent Salt Marsh

Parent Key F035

Appendix F
Current Projects Linked to BGOs

Project Number	Contract Title	Contractor	Goal 1	Goal 2	Goal 3
1920A	Science Advisor Panel	Alta Sciences & Engineering, Inc.	1	1	1
1710D	BCCE Maintenance (w/1510F & 1905C)	Gothic Landscape, Inc	1	1	0
1905G	BCCE Law Enforcement	Boulder City Conservation Easement Law Enforcement	1	1	1
1745A	Restoration at the BCCE (W/809 & 1421)	Gothic Landscape, Inc	1	0	0
1920F	DT Connectivity Across Roadways (w/1580)	Ecocentric, LLC	1	1	0
1935A	Parasitism Control and Eval (w/1750&1935)	SWCA Environmental Consultants	0	1	0
1915F	Mojave Max Education Prg Eval (w/1715)	Inform Evaluation & Research	0	0	1
1715AM	Mojave Max Education Program (w/1915)	Get Outdoors Nevada	0	0	1
1460J	Funding Analysis of the MSHCP Amend (w/2095)	Economic & Planning Systems, Inc.	1	1	1
1014K	HCP Consultant for the MSHCP Amendment	WRA Environmental Consultants	1	1	1
2092A	Vegetation Map for CC (w/1965A)	Cogan Technology Inc	1	1	0
1795A	Desert Tortoise Predator-Prey Dynamics	US Geological Survey (USGS) -Western Eco Rsrch Ctr	0	1	0
2010A	Riparian Reserves Veg Mgmt (w/1720 & 1910)	National Park Service (NPS)	1	0	0
1920E	Avian Surveys (w/1730)	SWCA Environmental Consultants	1	1	0
1920D	Avian Surveys	SWCA Environmental Consultants	1	1	0
2020D	Desert Tortoise Occupancy	Bio Logical, LLC	1	1	0
2030A	BCCE DT Telemetry & Health Assess (w/1740C & 1930B)	Great Basin Institute	0	1	0
2025A	DT Range Wide Monitoring (w/1920, 1925, 2020)	Great Basin Institute	1	1	0
804N	Tule Springs Monument Fence (w/1525, 1725, 1780, 1975)	JNJ Engineering Construction Inc	1	1	0
1720E	Water Rights Consulting (w/1440D & 1520Q)	Farr West Engineering	1	0	0
1760A	Academic Consultant for DT Rest Workshop	Natural Resource Conservation LLC	1	0	0
1997A	Assess Genetic Diversity of Gila Monster	US Geological Survey (USGS) -Western Eco Rsrch Ctr	0	1	0
1750F	Avian Nest Monitoring on Riparian Properties	SWCA Environmental Consultants	0	1	0
1910B	Avian Nest Monitoring on Riparian Properties	SWCA Environmental Consultants	1	1	0
1930A	BCCE DT Telemetry and Health Assessments	Great Basin Institute	0	1	0
2005B	BCCE Law Enforcement	City of Boulder City	0	0	1
1710B	BCCE Weed Survey	National Park Service (NPS)	1	0	0
1580J	Connectivity Data Analysis	Heron Ecological, LLC	1	1	0
1580G	Connectivity Management Plan	Recon Environmental, Inc	1	1	0
1580K	Connectivity Movement Simulation	Alta Sciences & Engineering, Inc.	1	0	0
1580H	Culvert Image Inspection	SWCA Environmental Consultants	1	1	0
1580F	Culvert Inspection for Tortoise Usage	Newfields	1	1	0
1782A	Desert Pocket Mouse Surveys	BEC Environmental, Inc.	0	1	0
1985A	Desert Tortoise Nesting Study on the BCCE	University of Nevada Reno (UNR) - BRRC	1	1	0
1541B	Desert Tortoise Range-Wide Monitoring	Great Basin Institute	0	1	0
1580C	DT Connectivity Solutions Modeling	University of Nevada Reno (UNR) - BRRC	1	1	0
1920C	DT Monitoring Data Mgmt Year 2-5	US Fish & Wildlife Service (USFWS) -Las Vegas	0	1	0

Project Number	Contract Title	Contractor	Goal 1	Goal 2	Goal 3
1580E	DT Telemetry around Culverts	Ecocentric, LLC	1	1	0
2020B	East Moj Cnsrv Collaborative Facilitation II	Southwest Decisions Resources, Inc	0	0	1
1997C	Gila Monster Habitat Modeling	University of Nevada Reno (UNR) - BRRC	1	1	0
2040C	Gila Monster Seasonal Support	Great Basin Institute	0	1	0
1997B	Gila Monsters Spatial Ecology and Habitat	Austin Peay State University	1	1	0
1905B	Law Enforcement for the BCCE	City of Boulder City	0	0	1
1915A	Mojave Max Education Program	Outside Las Vegas Foundation	0	0	1
1910D	MR Tree Removal	First Choice Tree Service Inc	1	0	0
2095A	MSHCP Amendment Reserve System Research	VENTAJAS LLC	1	1	1
1715AK	MSHCP Education Video	WE MARKET FOR HUMANS	0	0	1
1760B	Restoration Workshop Facilitation	Southwest Decisions Resources, Inc	1	0	0
1720F	Riparian Reserves Maintenance	Eagle View Contractors, Inc.	1	0	0
2095B	Workzone 6 Imagery	SkyWatch Space Applications Inc	1	0	0
2020H	Assess, Inv, and Mon of Habitat on the BCCE	Great Basin Institute	1	0	0
1750K	Avian Nest Monitoring on Riparian Properties	SWCA Environmental Consultants	1	1	0
1782B	Avian Surveys	SWCA Environmental Consultants	0	1	0
2095C	Bat Surveys	SWCA Environmental Consultants	0	1	0
1455D	BCCE DT Telemetry and Health Assessments	Great Basin Institute	0	1	0
2005E	BCCE Maintenance	Gothic Landscape, Inc	1	0	0
1710G	BCCE Maintenance Project	Gothic Landscape, Inc	1	0	0
2005D	BCCE Weed Survey	National Park Service (NPS)	1	0	0
2080A	Blue Diamond Cholla Surveys	Ironwood Consulting, Inc.	1	1	0
917R	Cavada Land Aquisition	Acquisition	1	0	0
917B	Cedar Development Ct Land Acquisition (35.92 Acres)	Acquisition	1	0	0
917Q	Costa Land Acquisition	Acquisition	1	0	0
803F	DT Health Assess and Pickup Svc Support	Ecocentric, LLC	0	1	0
1741A	Eldorado Valley Post Translocation Surveys	Great Basin Institute	0	1	0
2070A	Evaluation of Screwbean Mesquite Ecosystem	EcoCulture	1	0	0
1460A	HCP Consultant for the MSHCP Amend w/901	WRA Environmental Consultants	1	1	1
1782C	Model Updates 2023	University of Nevada Reno (UNR)	1	1	0
1915L	Mojave Max Mascot Appearances	Las Vegas Character Parties	0	0	1
2085A	Mojave Poppy Bee Surveys	US Dept of Agriculture (USDA) -Agri Rsrch Service	1	1	0
1570D	MR Habitat Restoration Implementation	American Conservation Experience	1	0	0
1750L	Muddy River Easements Review	NV Energy	1	0	0
1570C	Muddy River Habitat Restoration	Natural Channel Design, Inc	1	0	0
2090A	Niles Herbarium Data	Nevada Division of Natural Heritage	1	0	0
2095D	Pocket Mouse Landscape Genomics	BEC Environmental, Inc.	0	1	0

Project Number	Contract Title	Contractor	Goal 1	Goal 2	Goal 3
2045A	Predator - Prey Dynamics Phase 2	US Geological Survey (USGS) -Western Eco Rsrch Ctr	0	1	0
1942A	Rare Plant and Milkweed Surveys	Ironwood Consulting, Inc.	1	1	0
1990A	Rare Plant Propagation Research (w/809)	US Geological Survey (USGS) -Western Eco Rsrch Ctr	1	1	0
2075A	Rare Plant Propagation Research Phase II	US Geological Survey (USGS) -Western Eco Rsrch Ctr	1	0	0
1755A	Rare Plant Surveys	Ironwood Consulting, Inc.	1	1	0
1760C	Reevaluating Desert Upland Habitat Restoration	University of Nevada LV (UNLV) -School of Life Sci	1	0	0
2040B	Reptile Monitoring and Surveys	Great Basin Institute	0	1	0
2065A	Riparian Plant-Pollinator Ecology Phase 2	University of Nevada (UNLV) - Board of Regents	1	1	0
1910E	Riparian Reserves Maintenance	Eagle View Contractors, Inc.	1	0	0
1750J	Riparian Reserves Plant Propagation	National Park Service (NPS)	1	0	0
2042A	Road Warriors DT Mortality & Fence Survey	Tortoise Group	1	1	1
2020G	DT Data Management	Great Basin Institute	1	1	0