Wildlife Habitat and Invasive Plant Species Prioritization

Diné Native Plants Program

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CONTENTS

INTRODUCTION

Globally, invasive plant species negatively affect native ecosystems in many ways by out-competing native species, disrupting nutrient cycling, decreasing water availability, and changing fire regimes (Mooney et al. 2005). These impacts can lead to a loss of biodiversity and disruption of important ecosystem services that humans rely on for basic necessities. Furthermore, in the United States alone, billions of dollars are lost every year to the cost of invasive species management and decreases in forest and agricultural productivity (Pimentel et al. 2005). The Navajo Nation, encompassing 27,000 square miles of the southern Colorado Plateau, is no exception to the environmental impacts of invasive species. Invasive plants such as Russian thistle (*Salsola kali*) and cheat grass (*Bromus tectorum*) can be found in virtually every ecosystem of the Navajo Nation. These and a multitude of other invasive plants have caused significant changes to the landscape that not only affect natural systems, but also the Diné (The People) way of life. Invasive plants on the Navajo Nation decrease livestock forage and overall rangeland health, degrade wildlife habitat, and uptake water in an already arid and drought-stricken region.

Partially to address degraded environmental conditions of the Navajo Nation, the Bureau of Indian Affairs (BIA) established a Noxious Weed program in 1988 to fund projects aimed at managing targeted invasive species. Since then, the BIA has initiated several projects, in conjunction with other organizations, to map the distribution and abundance of invasive plant species across the Navajo Nation. More recently, in 2016, the BIA Navajo Region published a comprehensive Integrated Weed Management Plan (IWMP) that identifies 46 invasive plant species of concern, outlines removal strategies, provides best management practices and prioritizes sites for invasive species management (U.S. Department of the Interior Bureau of Indian Affairs, Navajo Region 2016). One major criterion for site prioritization outlined in the IWMP focuses on areas of high wildlife value where invasive plant species are compromising habitat. The Navajo Nation Department of Fish and Wildlife (NNDFW) is responsible for managing wildlife resources of the Navajo Nation, and is therefore a key stakeholder in identifying important wildlife species and habitat that are negatively impacted by invasive plant species.

The purpose of this report is to synthesize the BIA's invasive plant species mapping data and targeted invasive species of concern with NNDFW's prioritization of wildlife resources, in order to identify priority areas for invasive species treatment. In 2019 and 2020 we asked NNDFW biologists which wildlife resources and habitat on the Navajo Nation were being the most effected by invasive plant species. By overlaying their responses with BIA data and creating priority areas where important habitat and significant invasion overlap, this report will allow organizations treating invasive species on Navajo land to select sites that will maximize the benefits of treatment efforts on the biological resources of the Navajo Nation. We expect this document to act as a site selection tool for the invasive species removal efforts the BIA is currently undertaking as well as help any other local, tribal, state, or federal entity seeking to address invasive plant species issues on the Navajo Nation.

DATA SOURCES

We used the GIS software ArcMap 10.5 to compile and analyze the mapping, topographic, vegetation, and hydrologic data for this report. While steps were taken to ensure accuracy of the spatial data in the results, this report is not intended to replace in-person site assessments and fine scale mapping. Rather, this report is meant to provide general guidance to areas of importance for the selected species and habitat. Furthermore, the Navajo Nation Department of Fish and Wildlife should always be consulted directly and appropriate federal, state, and

tribal permits obtained before any invasive species treatment is carried out, especially for actions occurring within habitat for sensitive species.

BIA Invasive Plant Species Data

Invasive Species Distribution (Mapping)

We obtained invasive plant species (noxious weeds) distribution data for the Navajo Nation from the BIA Navajo Regional Office. This data is a compilation of various collaborative weed mapping projects between the BIA and other organizations such as the Southwest Conservation Corps (SCC) and the United States Geological Survey's (USGS) Southwest Exotic Plant Mapping Program (SWEMP). The mapping focused primarily on road right-of-way's, construction, and other high use areas of the Navajo Nation. The data is not a comprehensive inventory of the invasive species of the Navajo Nation, but rather a compilation of surveys from various projects. Therefore, mapping protocols differed between projects and the types and amount of data recorded varies. The most comprehensive survey obtained was the SWEMP data, which maps several invasive species across the entire Navajo Nation ("Navajo_Nation_utm83_SWEMP" in geodatabase included with report). The data we utilized in this report consists of polygons, lines, and points with, for the most part, measures of species, location, and size of invasion. In total, there were 105 invasive species, mapped at varying effort across the Navajo Nation. (see Appendix A for the full list of species). The most common species mapped were saltcedar, Russian olive, Russian knapweed, cheatgrass, and Russian thistle (Table 1 and Figure 1).

Target Invasive Species

The BIA Integrated Weed Management Plan (IWMP) identified 46 target species of concern on the Navajo Nation, 43 of which have mapping data. Additionally, the target species were categorized into three groups based on their abundance on the Navajo Nation. Category "A" species have limited distribution or only occur near the Navajo Nation, Category "B" species have limited range (although more prevalent than Category A species), and Category "C" species are wide-spread and well established. The BIA's priority in managing invasive plants is to focus on Category A and B species in order to prevent the spread of invasive species on the Navajo Nation (U.S. Department of the Interior Bureau of Indian Affairs, Navajo Region 2016). In addition to prioritizing species, the BIA recommends prioritizing sites based on several factors such as importance to wildlife, but also factoring in elevation, prevailing wind direction, wildfire potential, etc. These and other criteria are outlined in Section 5 "Approach for Prioritization Actions and Sites" in the IWMP.

Table 1. Common species (10) included in BIA invasive plant species (noxious weeds) mapping data with respective categorization of target species from the BIA Integrated Weed Management Plan (IWMP). Category "A" species have limited distribution or only occur near the Navajo Nation, Category "B" species have limited range, and Category "C" species are wide-spread and well established.

Scientific Name	Common Name	IWMP Category
Acroptilon repens	Russian knapweed	B
Alhagi maurorum	Camelthorn	A
Bromus tectorum	Cheatgrass	C
Carduus nutans	Musk thistle	A
Convolvulus arvensis	Field bindweed	C
Elaeagnus angustifolia	Russian olive	B
Erodium cicutarium	Stork's bill	
Salsola kali	Russian thistle	C
Solanum elaeagnifolium	Silverleaf nightshade	
Tamarix spp.	Saltcedar	A, B

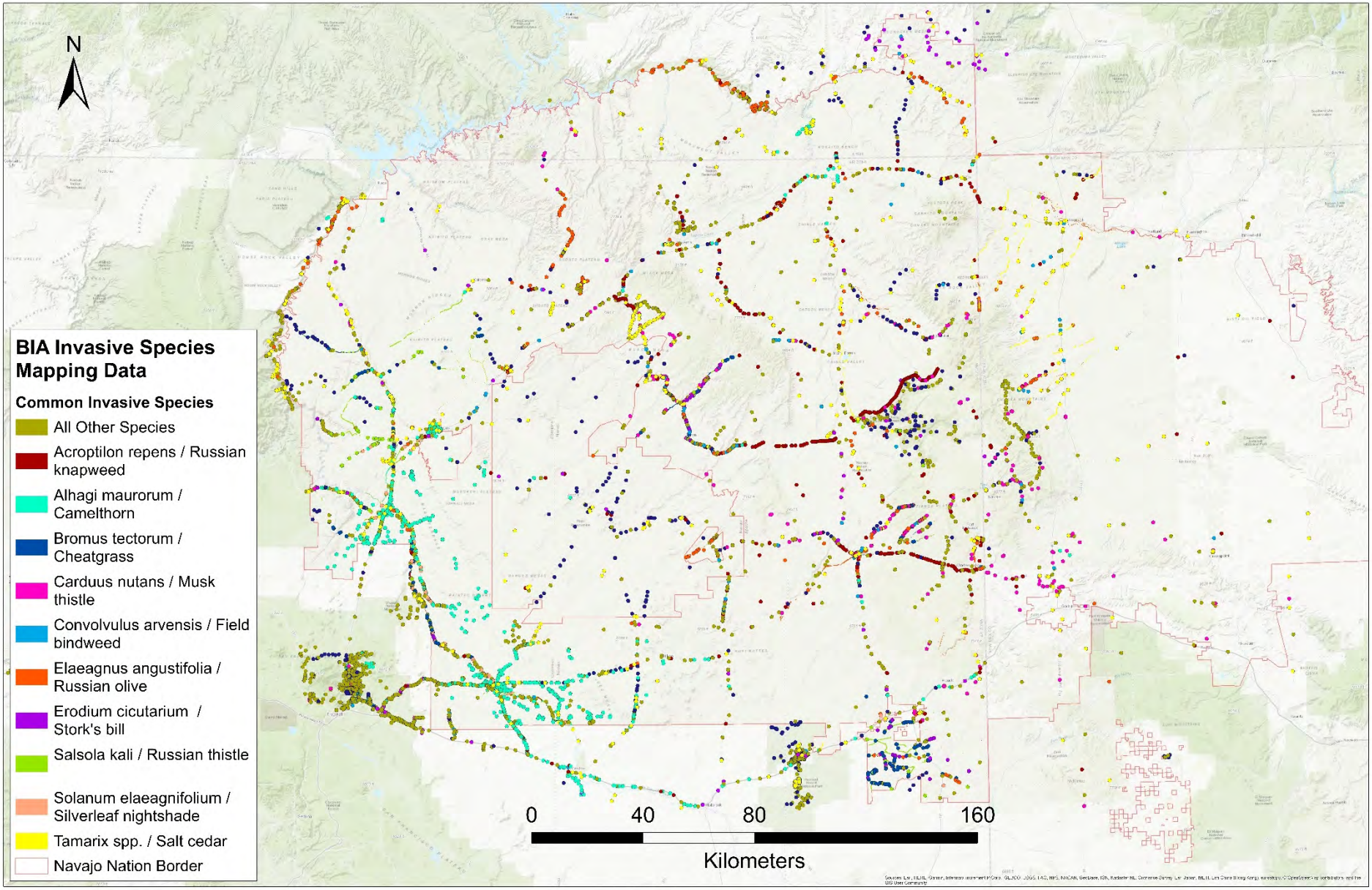

Figure 1. Compilation of all BIA invasive plant species distribution data for the Navajo Nation. Colors represent the most commonly mapped species.

Navajo Nation Wildlife Resources

We consulted key personnel within the Navajo Nation Department of Fish and Wildlife (NNDFW) in order to determine priority species and habitat being affected by invasive species on the Navajo Nation. The individuals consulted for this report are listed in Table 2.

Table 2. NNDFW biologists consulted to determine priority biological resources and habitat on the Navajo Nation.

Name	Position
Jessica Fort	Wildlife Biologist
David Mikesic	Zoologist
Glenn Selby	Fish Biologist
Nora Talkington	Botanist
Kim Yazzie	Fish Biologist

Topography

We used the U.S. Geological Survey (USGS) National Elevation Dataset (NED) to derive topographic features of the Navajo Nation including elevation and slope. We utilized the 10-meter resolution digital elevation model publicly available through the U.S. Department of Agriculture (USDA)/Natural Resources Conservation Service (NRCS) Geospatial Data Gateway (U.S. Geological Survey 1999).

Vegetation

We used Level 4 Ecoregions, designated by the US Environmental Protection Agency to delineate various vegetation types in our analysis (U.S. Environmental Protection Agency 2013). Level 4 is the finest scale delineation of ecoregions and groups similar areas based on geology, soils, vegetation, climate, land use, and hydrology.

Hydrology

We used the USGS National Hydrography Dataset (NHD) to analyze the hydrologic features of the Navajo Nation. This dataset is 1:100,000 scale and includes information on surface water features including rivers, streams, lakes, and springs (U.S. Geological Survey 2019).

Priority Resources Identified By NNDFW Biologists

We developed a scoring system to rank the importance of habitat across the Navajo Nation for the various plant and wildlife resources. Based on information from NNDFW Biologists (Table 2), we attempted to assign each resource "High" priority areas where known populations exist and "Moderate" priority areas where there is potential habitat. "High" priority areas were assigned a score of two (2), "Moderate" priority as one (1), and all other areas zero (0). Using GIS software, we created maps delineating the scores for each individual resource. We were then able to overlay each map and combine (sum) the overlapping individual scores to create a unique total score for the entire the Navajo Nation (Figure 10).

Disclaimer: This process identifies high priority habitat for wildlife, including sensitive and endangered species. Therefore, it is paramount that extreme care be taken so that invasive species treatment, whether mechanical or chemical, be conducted in a way that does not harm wildlife species in the process. NNDFW should be consulted before any invasive species treatment on the Navajo Nation. See NNDFW Consultation section for more information.

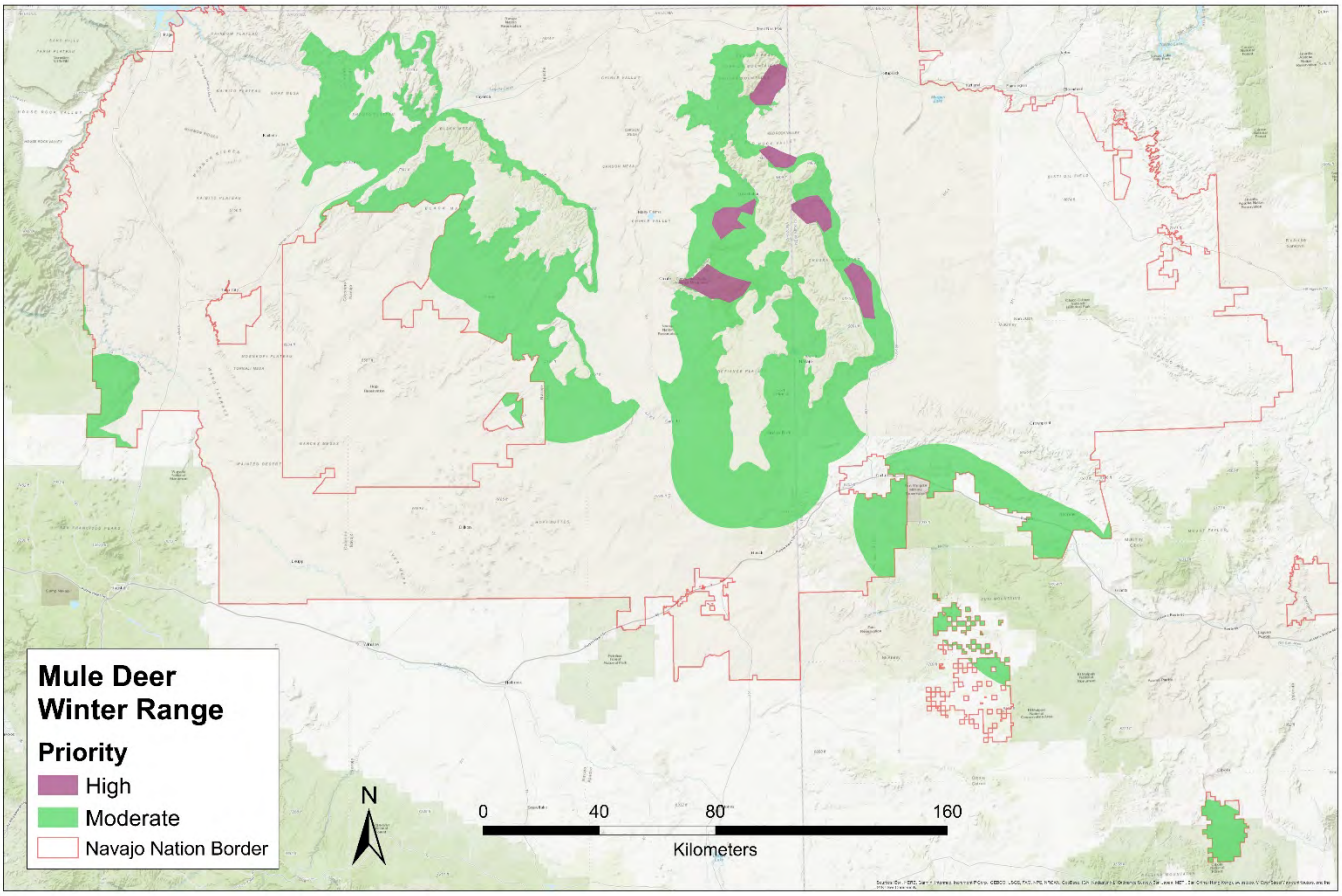

Figure 2. "High" (purple) and "Moderate" priority (green) winter range habitat for mule deer on the Navajo Nation, consisting of piñon-juniper/sagebrush dominated vegetation.

Big Game and Recreational Fishing Resources:

Mule Deer

Mule deer (*Odocoileus hemionus*) are an incredibly important big game species on the Navajo Nation. The Diné, as well as other Southwestern tribes, have relied on mule deer for food, clothing, tools, ceremonial, and medicinal purposes for as long as they have lived in the region. To this day, mule deer are frequently hunted for subsistence and cultural purposes across the Navajo Nation. The NNDFW manages mule deer populations on the Navajo Nation by monitoring disease and mortality, tracking deer migrations, assessing population size, and improving habitat. Hunting permit numbers are adjusted based on population data collection each year.

Mule deer are browsers, feeding primarily on forbs, shrubs and trees of conifer forests (Hoffmeister 1986, Watkins et al. 2007). Most mule deer on the Navajo Nation migrate seasonally from higher elevation mixed conifer forests in the summer to lower elevation montane shrub, ponderosa forest, piñon-juniper woodland, and sagebrush steppe in the winter (Watkins et al. 2007). Because winter forage is less nutritious and harder to find, deer populations in their winter ranges are the most vulnerable. Malnutrition can lead to fawn mortality, predation, and disease, and is considered a major factor in population decline (Watkins et al. 2007). Several non-native plants including knapweed (*Centaurea spp.*), thistles (*Cirsium arvense, Carduus nutans, Onopordum acanthium*), and cheatgrass (*Bromus tectorum*) have invaded important winter range habitat on the Navajo Nation (J. Fort, personal communication, 2019). Cheatgrass in particular is of major concern because of its ability to out-compete more nutritious deer forage and alter fire regimes to encourage further establishment of unpalatable invasive species (Watkins et al. 2007).

We prioritized piñon-juniper and sagebrush habitat for cheat grass and other invasive species management to benefit mule deer in their winter range on the Navajo Nation (Figure. 2). “High” priority was given to known areas of important winter range, determined by high mule deer densities observed during annual aerial surveys conducted by NNDFW. Using EPA level 4 ecoregions we identified areas of similar piñon, juniper, and sagebrush vegetation and designated “Moderate” priority to those areas within 20 km of mixed conifer forest, which is summer range for mule deer.

Lakes

The Navajo Nation has several lakes that are important parts of the arid landscape for both wildlife and the Diné. They range in size with some smaller lakes drying out during prolonged droughts, while larger lakes remain full year-round. Nearly all of the lakes on the Navajo Nation are man-made. The smaller lakes consist of earthen dams and were constructed primarily to provide water for livestock. The larger lakes with stone and concrete dams were constructed to irrigate local Navajo farms and have since become popular for fishing and recreation. The NNDFW sells fishing/boating permits and stocks several lakes with sport fishes for recreational fishing.

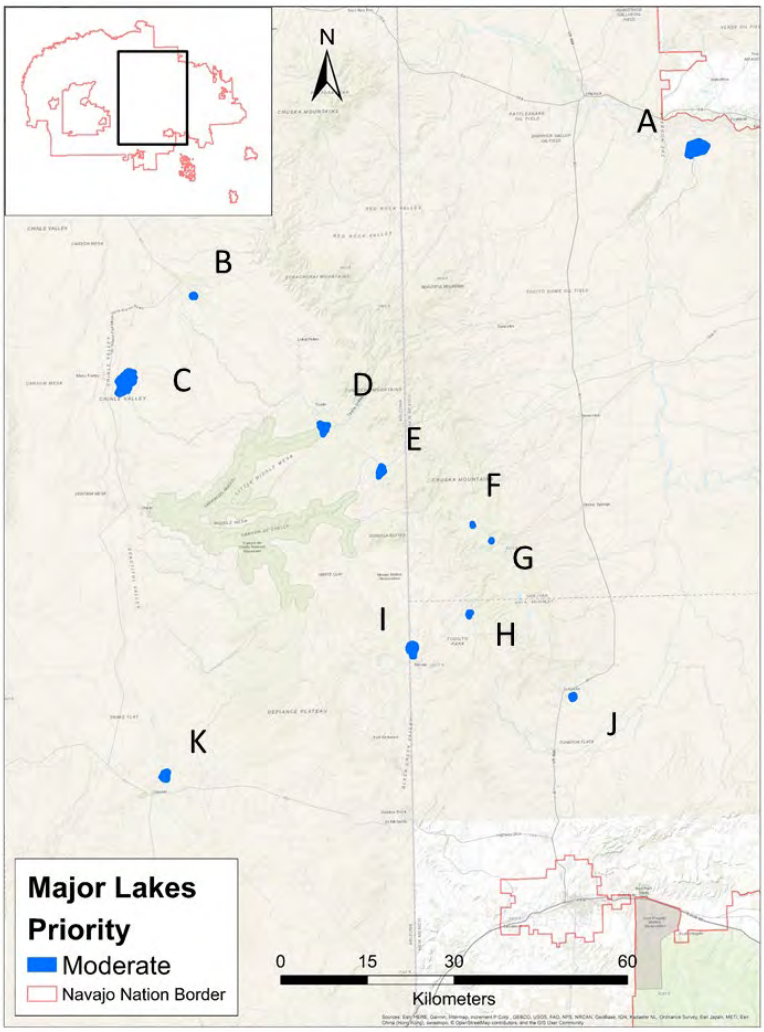

Figure 3. Major lakes: A) Morgan Lake, B) Round Rock Reservoir, C) Many Farms Lake, D) Tsaile Lake, E) Wheatfields Lake, F) Berland Lake, G) Todacheene Lake, H) Bowl Lake, I) Red Lake, J) Chuska Lake, K) Ganado Lake.

The lakes on the Navajo Nation are also critical habitat for many important wildlife species. Beavers, migratory birds, waterfowl, and raptors, including bald eagles, all utilize the lakes for food and/or shelter. Surveys of Morgan Lake in New Mexico recorded over 200 species of birds (Reeves & Nelson 1996). However, there are also large populations of non-native, invasive plants, such as Russian olive and saltcedar, which compete with native species, form dense thickets, and uptake relatively large amounts of water (Tamarisk Coalition 2009, Sing & Delaney 2014). A survey of Black Mesa, Arizona found that invasive tamarisk species were the most common plants occurring around ponds (LaRue 1994).

There were 11 lakes identified as important resources by the NNDFW, mostly occurring in the Chuska Mountain region on the border of Arizona and New Mexico (Figure 3). We did not have access to data on invasive aquatic species such as Eurasian watermilfoil (*Myriophyllum spicatum*) that may be impacting water quality and wildlife habitat within the lakes themselves, and therefore focused on the lakeshore and adjacent wetlands. We designated land surrounding major lakes (with a 500 meter buffer) as “Moderate” priority for invasive

species treatment because although several lakes such as Morgan Lake, Red lake, and Ganado lake are significantly infested with Russian olive and saltcedar, research shows that these stands in some cases are suitable habitat for Navajo Endangered Species List (NESL) bird species Southwestern willow flycatcher (*Empidonax traillii extimus*, also federally endangered) and yellow-billed cuckoo (*Coccyzus americanus*, candidate for federal listing, Bateman et al. 2009). Therefore, any invasive species removal on shorelines would have to be carried out iteratively with active replacement planting of native species to maintain habitat structure for these rare birds.

Navajo Endangered Species Priorities:

Biological Resource Land Use Clearance Policy & Procedure Map (RCP)

The Biological Resource Land Use Clearance Policy and Procedure map, also known as the RCP, was developed by the Navajo Natural Heritage Program (NNHP) in 2008 in order to help the Navajo Nation chapters and developers remain in compliance with federal and Navajo laws regarding the protection of wildlife and plants, specifically those found on the Navajo Endangered Species List (NESL). The RCP map protects wildlife and plants by directing infrastructure development to areas where there will be minimal impact to sensitive species and their habitat. The map is divided into six categories of land sensitivity based on a compilation of known locations and potential distributions of endangered species and their habitats monitored by NNDFW. We used the high and moderate wildlife sensitivity areas of the RCP as "High" and "Moderate" priority areas for potential invasive treatment (Figure 4).

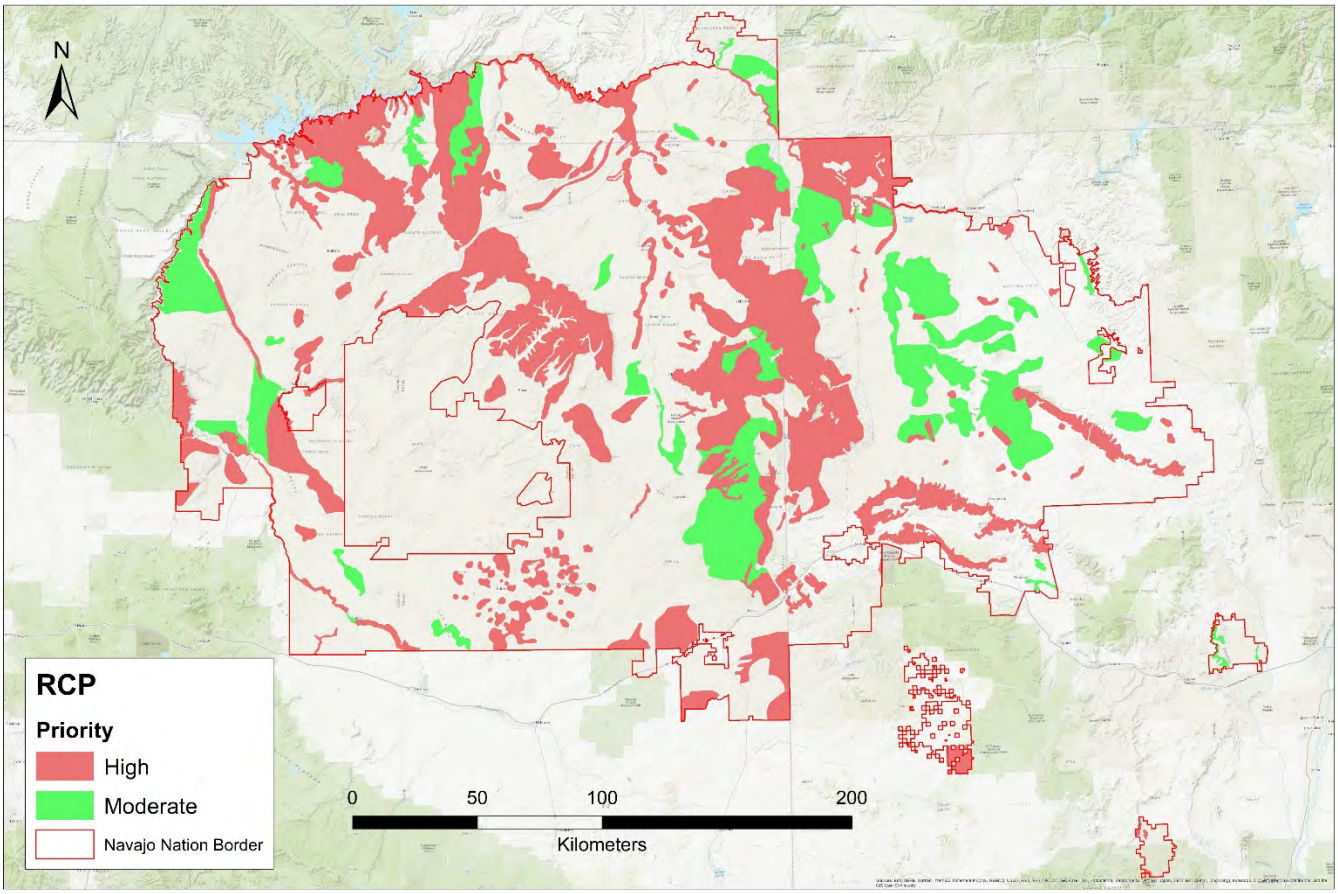

Figure 4. RCP "High" and "Moderate" priority areas determined by known and potential habitat of species on the Navajo Endangered Species List (NESL).

Hanging Gardens

Hanging gardens are unique, insular plant communities that occur on sandstone cliffs and alcoves of the Colorado Plateau region, including the Navajo Nation. Hanging gardens occur at seeps where water slowly flows

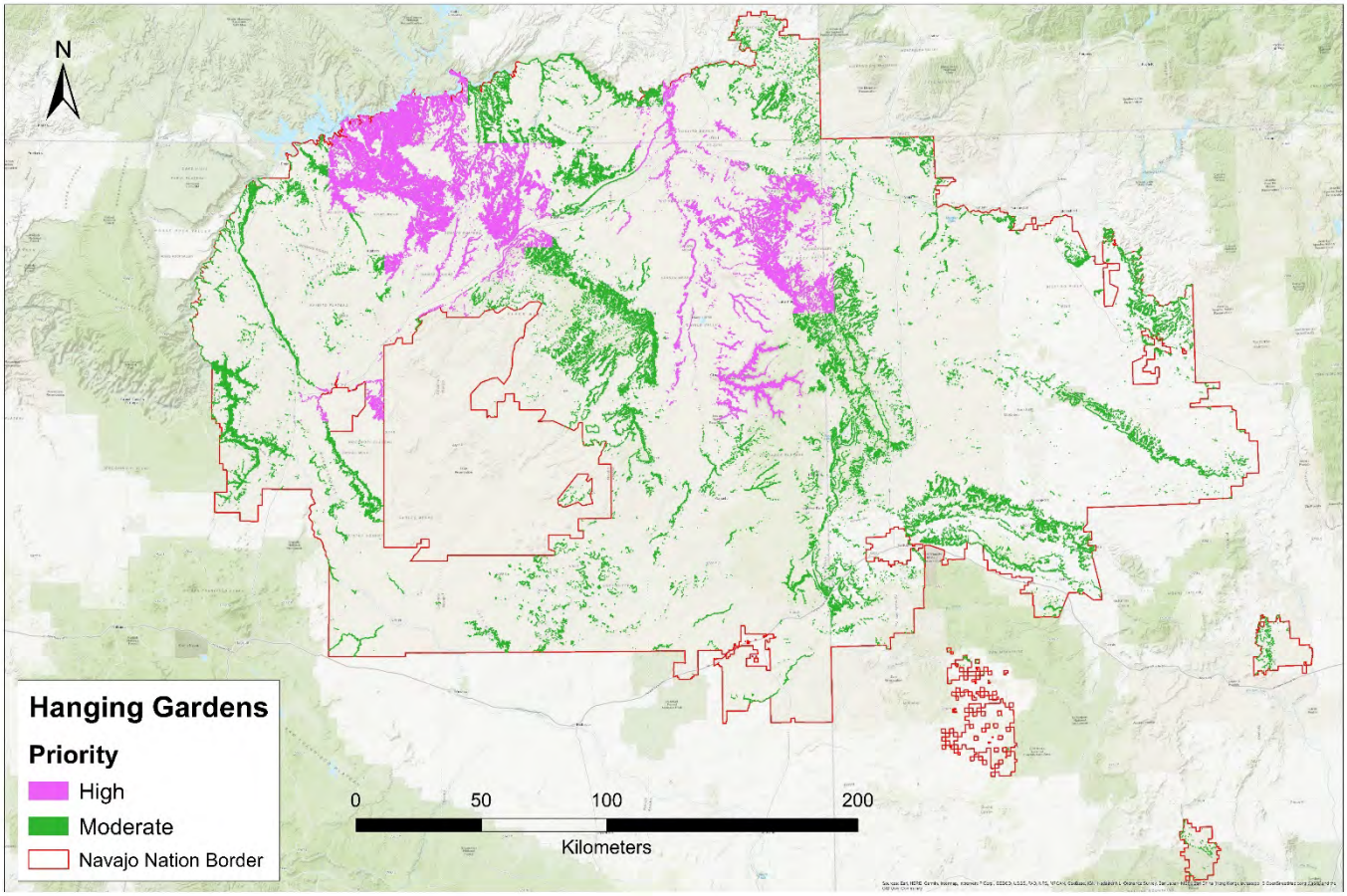

Figure 5. Hanging garden priority habitat consisting of canyons and cliffs with steep slopes greater than 40˚. "High" priority is assigned to areas where known hanging garden communities occur, and "Moderate" priority was assigned to areas where potential habitat exists.

from the rock where porous sandstone meets less permeable formations (Malanson 1980). The seeps along with periodic shading from canyon walls lead to characteristic shallow, moist soils, and vegetation in sharp contrast to the surround arid ecosystems (Stanton et al. 1994). Because of their unique microclimates, hanging gardens are often home to rare and endemic plant species such as alcove death camas (*Anticlea vaginatus*), Navajo sedge (*Carex specuicola)*, alcove rock daisy (*Perityle specuicola*), and alcove bog-orchid (*Platanthera zothecina*). These species are also on the Navajo Endangered Species List (NESL) and are protected under Navajo law.

Inventories of hanging garden communities on the Navajo Nation also revealed sometimes significant non-native species invasions, which can out-compete sensitive hanging garden species for limited resources and space (N. Talkington, personal communication, 2019). According to associated species lists from monitoring by NNHP botanists of hanging gardens containing NESL species, the most common invasive species recorded in these communities was cheatgrass (*Bromus tectorum*). Additional frequently recorded species were common dandelion (*Taraxacum officinale*), red brome (*Bromus rubens*), saltcedar (*Tamarix spp.*), Russian olive (*Elaeagnus angustifolia*), and pampas grass (*Cortaderia selloana*). These invasive species, especially cheatgrass, can out-compete native species for resources and create negative feedback that promotes the establishment of more invasive species over natives (Mooney et al. 2005, Geronimo et al. 2016). NNHP considers invasive treatments within the entire canyon where hanging gardens occur as priority treatment areas because non-native species will continue to recruit into these gardens if prevalent across the landscape.

In order to prioritize areas for invasive species treatment to benefit hanging garden plant communities we attempted to isolate canyons and cliffs through topographic queries. We isolated areas of the Navajo Nation with steep slopes greater than 40 degrees and created 200-meter buffer zones around these features. “High” priority was assigned to areas within a 7.5-minute quadrangle of known hanging gardens monitored by NNHP, while potential hanging garden habitat was designated as “Moderate” priority (Figure 5). Hanging garden habitat could be further refined by isolating specific sandstone formations such as the Navajo and Entrada formations. However, we did not perform this function because geological data was not easily accessible. Because hanging gardens are often in precarious, hard to reach locations, we recommend treating the areas surrounding hanging garden habitat to eliminate invasive species seed sources and prevent further encroachment.

Zuni Bluehead Sucker

Bluehead sucker (*Catostomus discobolus*) is a species of fish found in the major rivers and streams of the Navajo Nation (Mikesic & Roth 2008). A subspecies, the Zuni bluehead sucker (*Catostomus discobolus yarrowi*) was listed as a federally endangered species in 2014 (79 FR 43131 43161). The extent and distribution of *C. discobolus yarrowi* on the Navajo Nation was previously poorly understood and it was unclear which populations shared genetic and phenotypic traits that existed in the Zuni bluehead populations found in the Zuni River. NNDFW submitted bluehead sucker samples to a genetic and morphological study which determined that subspecies *yarrowi* does exist on Navajo Nation in drainages to the Little Colorado River (C. Smith, personal communication, April 2019). In 2019, *Catostomus discobolus yarrowi* was up listed to G2 (endangered) on the NESL. The Zuni bluehead sucker is only known to a few populations in perennial streams of the Defiance Plateau on the Navajo Nation (other populations exist in the Zuni river watershed). The suckers occupy perennial, largely shaded pool and riffle stream habitat with clean, hard cobble/bolder/bedrock substrate (Carman 2004).

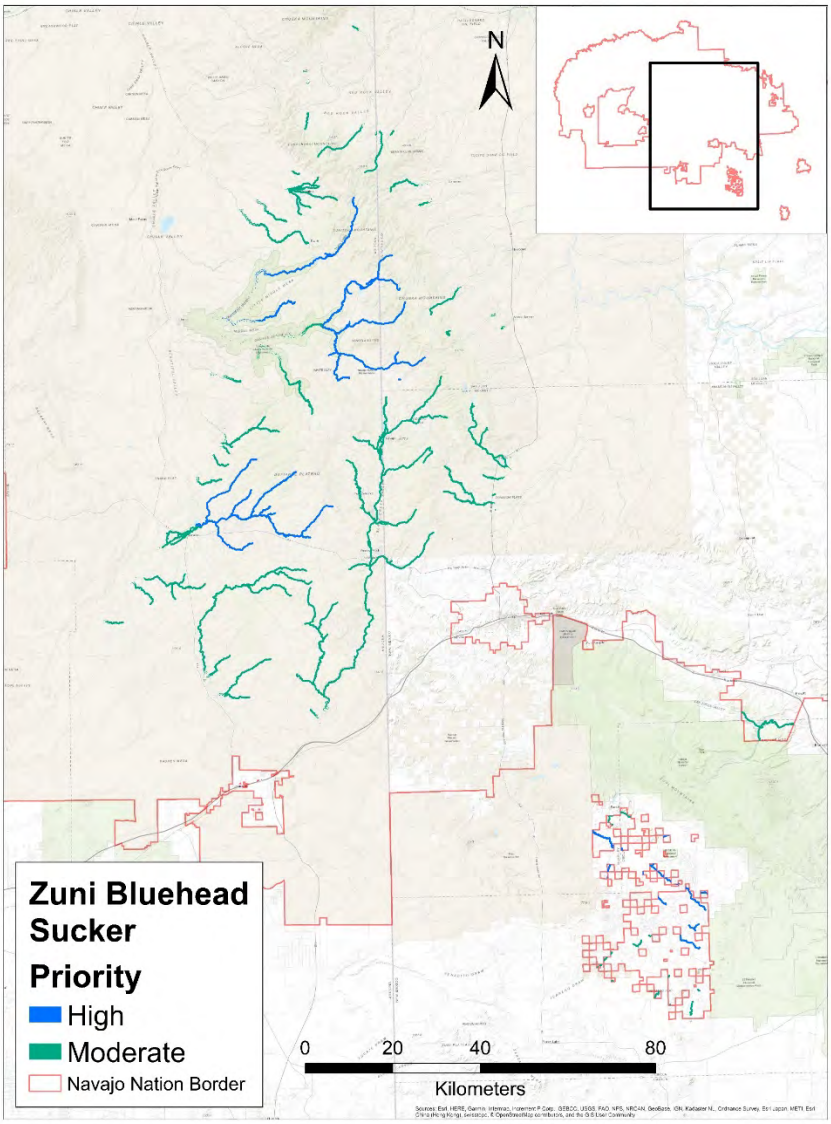

Figure 6. Bluehead sucker priority perennial stream habitat in the Chuska Mountains, Defiance Plateau, and Zuni River watershed.

Saltcedar and Russian olive pose a significant threat to bluehead suckers (and endangered subspecies) because of their tendency to invade riparian habitat and dry out perennially flowing streams (G. Selby, personal communication, 2019). We prioritized bluehead sucker habitat by establishing a

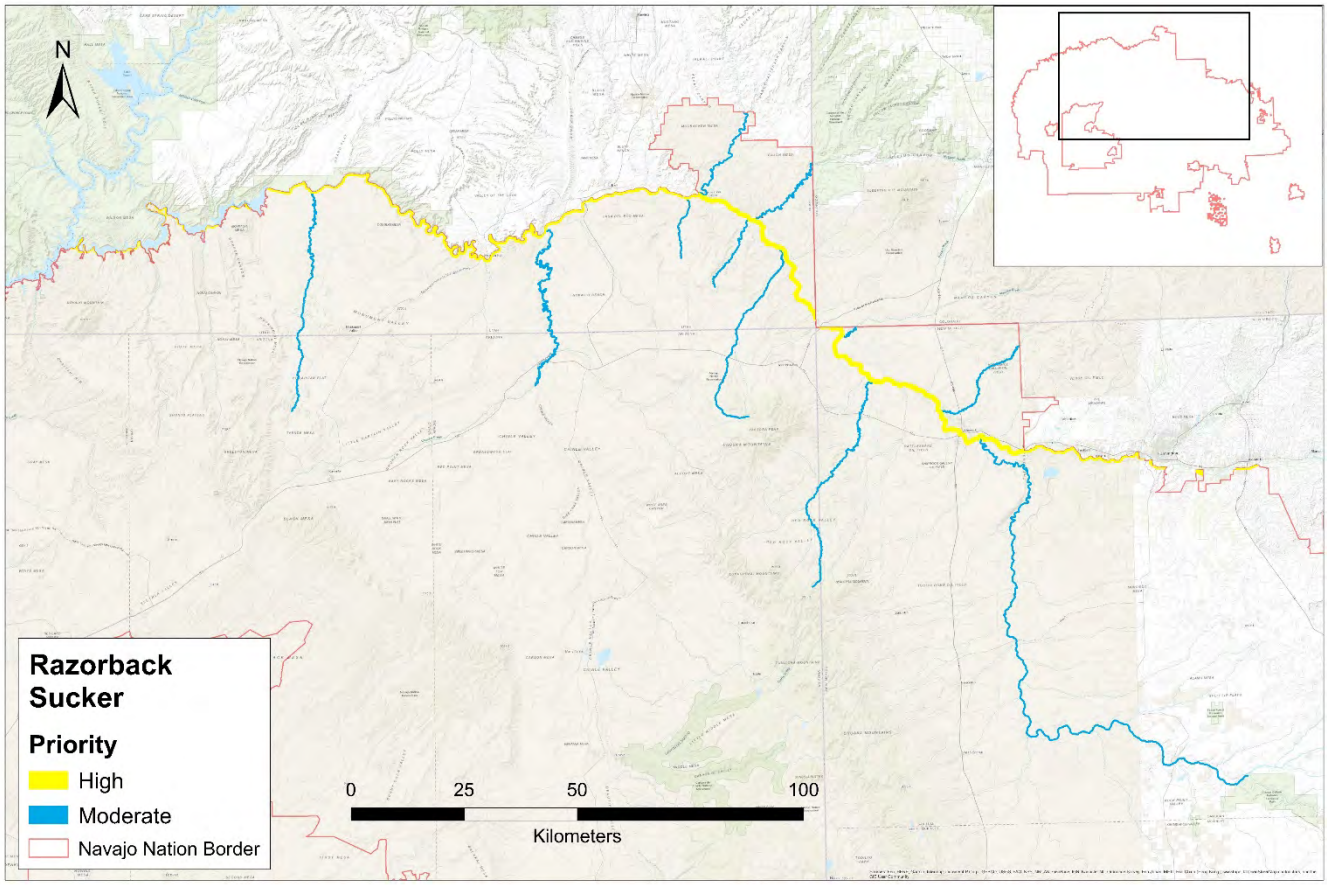

Figure 7. Razorback sucker priority river and stream habitat. The San Juan River was designated "High" (yellow) priority and its major tributaries were designated "Moderate" (blue) priority.

200-meter buffer around all perennial streams in the Chuska Mountains, Defiance Plateau, and Zuni River watershed (Figure 6). "High" priority was assigned to streams where known populations of bluehead suckers exist, all other areas were designated "Moderate" priority. Restoration in these areas would also benefit other native fishes such the speckled dace (*Rhinichthys osculus*).

Razorback Sucker

Razorback sucker (*Xyrauchen texanus*) is a Federally Endangered and NESL G2 (Endangered) species of fish that occurs in various sized populations throughout the San Juan River on the northern border of the Navajo Nation. NNDFW pond rears and stocks thousands of razorback suckers every year to help augment the population in the San Juan River. Razorback suckers occupy different habitat niches depending on the stage of their life cycle. However, low velocity backwaters over sand and silt substrate are critically important habitat for spawning adults and young-of-year suckers (Tyus 1998).

The primary invasive species threatening to razorback sucker in the San Juan River is Russian olive and saltcedar because of their tendency to cut off valuable backwater and secondary channel habitat for young-of-year fish (K. Yazzie, personal communication, 2019). As with many major rivers in the Southwest, the flow of the San Juan River has been significantly altered by the invasion of these two tree species and man-made structures. Russian olive and saltcedar change the hydrology of the river by unnatural stabilization of the bank and sand bars which contributes to a reduction of channel width, increase in flow velocity, and a decrease in low-velocity backwaters that the suckers need to spawn (Wick et al. 1982, Tyus 1998). Furthermore, Russian olive and saltcedar can cause smaller tributaries used for spawning to dry up (K. Yazzie, personal communication, 2019).

In order to prioritize razorback sucker habitat, we designated a 500-meter buffer around the San Juan River (limited to the section of river forming the border of the Navajo Nation) as "High" priority for invasive species removal. Smaller, immediate tributaries to the San Juan occurring on the Navajo Nation were designated as "Moderate" priority (Figure 7). Any riparian restoration of Russian olive and tamarisk will have to take into account the habitat needs of Southwestern willow flycatcher and yellow-billed cuckoo, as research shows they utilize Russian olive and tamarisk stands for breeding (Durst et al. 2007).

Southwestern Willow Flycatcher

The Southwestern willow flycatcher (*Empidonax traillii extimus*) is a Federally Endangered and NESL G2 (Endangered) subspecies of bird that nests and breeds in dense riparian areas of the southwest United States (Finch and Kelly 1999). The Southwestern willow flycatcher (SWFL) spends their 3-4 month breeding season (April-July) in riparian areas with surface water or saturated soil, where they feed primarily on insects. SWFL need dense stands of riparian trees in order to construct and protect their nests. Research shows that while most SWFL territories are found in native willow (*Salix spp.*) dominated stands, they are able to utilize stands with a mosaic of native and exotic tree species, saltcedar in particular (Durst 2007).

While saltcedar and Russian olive invaded riparian areas are adequate breeding/nesting habitat for SWFL, other effects of the invasion may have significant negative impacts on the birds. Wildfire is considered one of the major threats to SWFL and saltcedar may increase the likelihood and intensity of fire in heavily infested areas, especially in stands where saltcedar have been wholly or partially killed by tamarisk beetles (*Diorhabda spp.*)

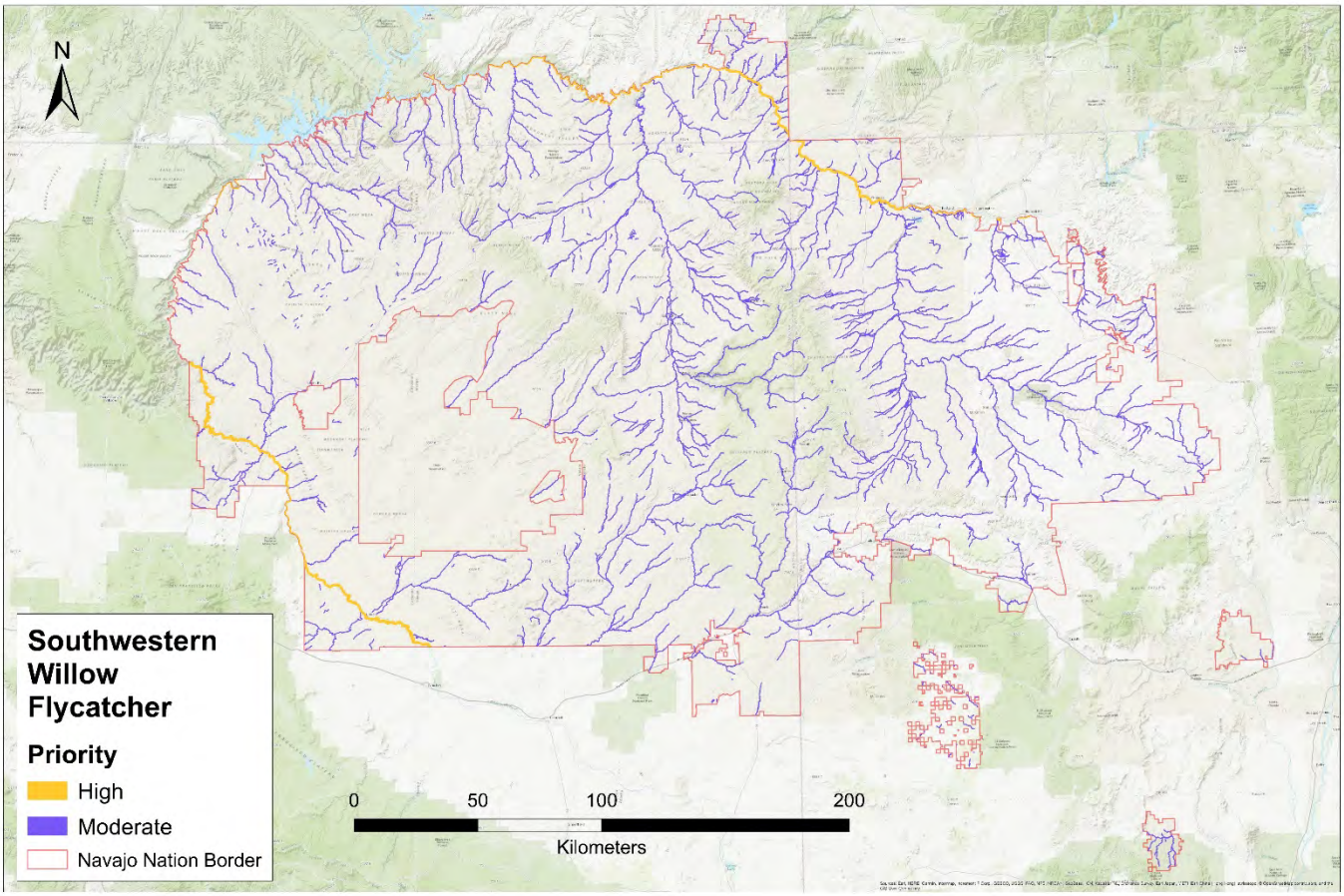

Figure 8. Southwestern willow flycatcher priority areas. The San Juan and Little Colorado Rivers are designated as "High" priority (yellow) and major streams and washes are designated as "Moderate" priority (purple) for invasive species treatment.

released for biocontrol (Brooks et al. 2008, Shafroth et al. 2010). For this reason, we consider saltcedar and Russian olive invasion as significant threats to Southwestern willow flycatcher populations.

We designated areas (500-meter buffer) along the Little Colorado and San Juan River as "High" priority for invasive species treatment. We designated areas (200-meter buffer) around perennial and intermittent streams within the interior of the Navajo Nation, lower than 2600 meters in elevation as "Moderate" priority (Figure 8). Because of the utilization of saltcedar and Russian olive as nesting sites, any invasive removal within these areas should be accompanied by substantial replacement with native willow and cottonwood species, so that habitat for SWFL is maintained and ideally improved in treated areas.

Great Basin Silverspot

The Great Basin silverspot (*Speyeria nokomis nokomis*) is a butterfly species listed as vulnerable in the United States (National Heritage Status) and as a G3 (Threatened) species on the NESL. On the Navajo Nation, it is known to less than 10 populations in the Chuska Mountains and Defiance Plateau where it occupies perennial wet meadows associated with springs and streams (Mikesic & Roth 2008). Adult silverspots utilize several species of flowers as nectar (food) sources. They have been known to utilize blue and yellow flowers in the Asteraceae (sunflower) family and have shown strong preference for thistles (Selby 2007). Bog violet (*Viola nephrophylla*) is the host plant for Great Basin silverspot larva (larva only feed on the bog violet) and is also a critical component of their habitat. Habitat loss and degradation due to invasive plant encroachment coupled with cattle grazing is the primary threat to Great Basin silverspot populations (Selby 2007). Encroachment by Russian olive and saltcedar is

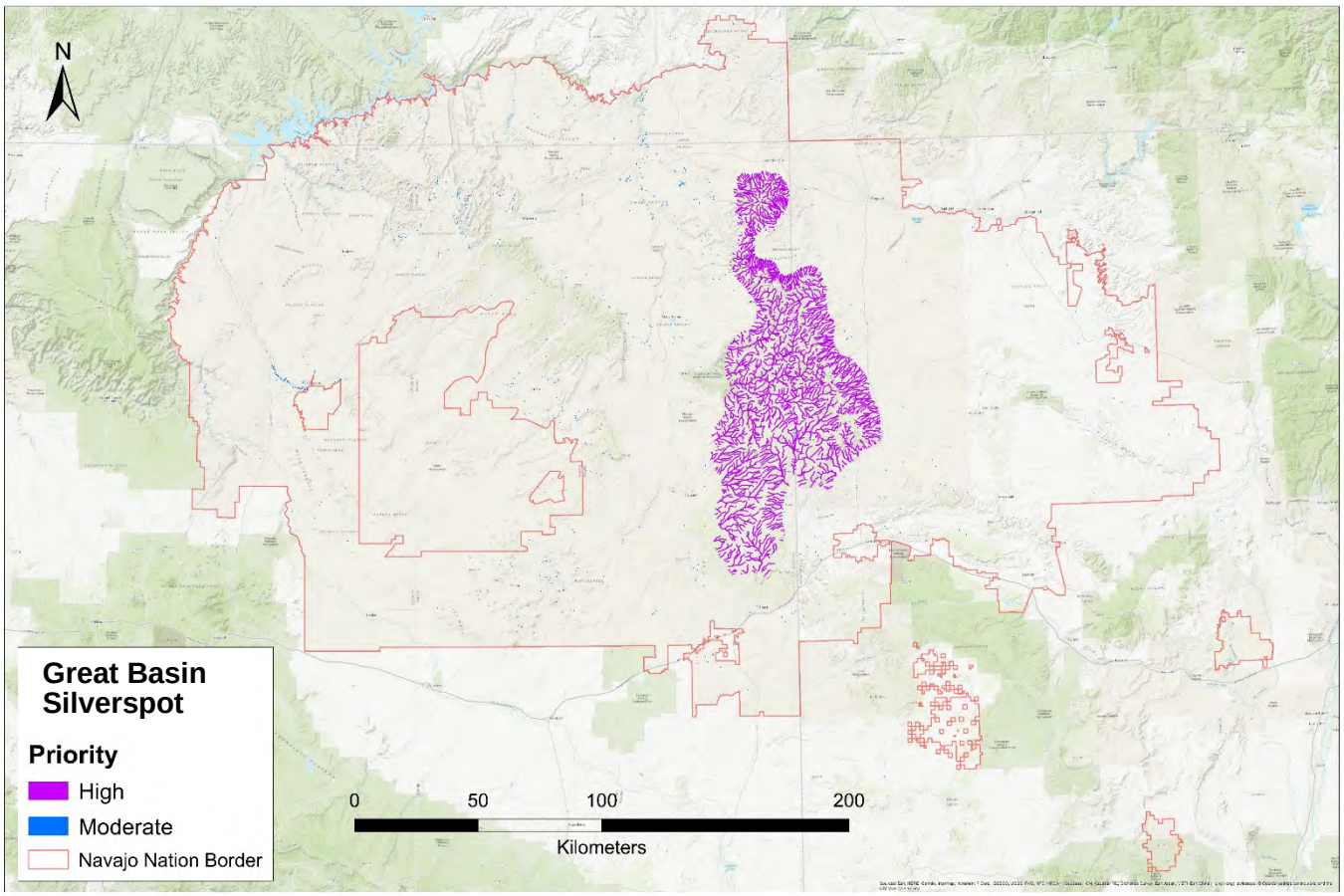

Figure 9. Great Basin silverspot priority areas. Springs and perennial/intermittent streams of the Chuska Mountains, Defiance Plateau, and Carrizo Mountains were designated as "High" priority (purple) for invasive species treatment. Springs across the rest of the Navajo Nation are "Moderate" priority (blue).

a significant threat to the availability of water in these habitats and thus the presence of adult and larval food sources. Furthermore, invasive herbaceous species such as Canada thistle (*Cirsium arvense*), that form dense monocultures, can outcompete violets and other native nectar sources. On the other hand, invasive thistles can also serve as important nectar sources for this species, and silverspots on the Navajo Nation have often been observed feeding on both native and non-native Cirsium spp. (personal communication, N. Talkington August, 2020).

We designated springs and perennial/intermittent streams (with a 200-meter buffer) in the Chuska Mountains, Defiance Plateau, and Carrizo Mountains as "High" priority for the Great Basin silverspot because they either contain known populations or are at an elevation that constitutes high-likelihood potential habitat for this species of butterfly (Figure 9). Springs across the rest of the Navajo Nation were designated as "Moderate" priority for lower-likelihood potential habitat. When treating invasive species in (potential) Great Basin silverspot habitat, it must be taken into account that often the only nectar source in an area will be an invasive species (D. Mikesic, personal communication, 2019). Therefore, any invasive species treatment should involve replacement with native nectar sources.

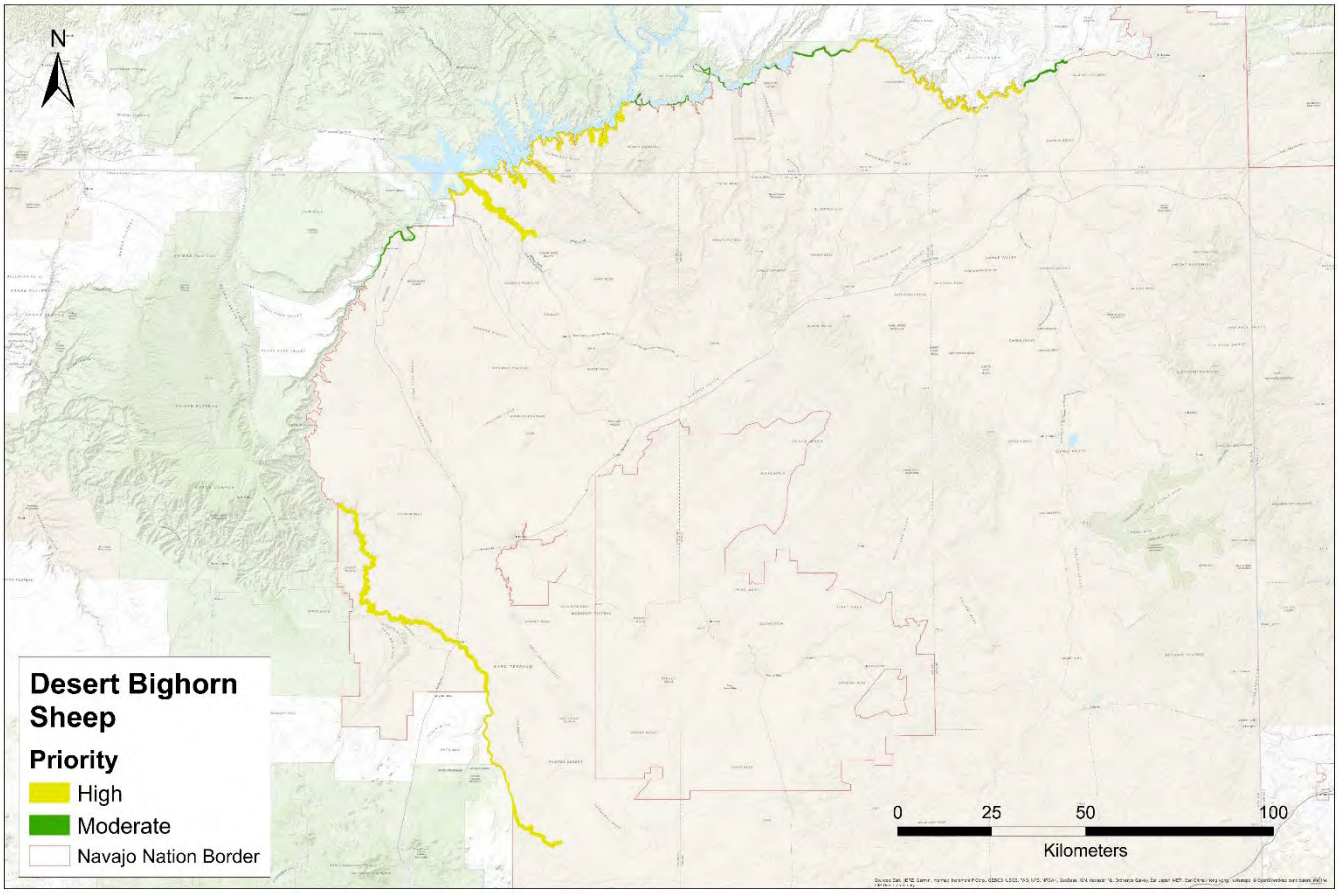

Figure 10. Desert bighorn sheep priority areas. Sections of Lake Powell, San Juan, and Little Colorado Rivers where known populations exist are designated as "High" priority (yellow) for saltcedar and Russian olive treatment. Similar areas without known populations are designated "Moderate" priority (green) for potential habitat.

Desert Bighorn Sheep

Desert bighorn sheep (*Ovis canadensis*) are found in small populations on the Navajo Nation along the San Juan and Little Colorado Rivers (Goodson et al. 2007). The NNDFW actively manages these populations through issuing hunting permits, monitoring movement and disease, and in the past has transplanted individuals into new suitable habitat. Desert bighorn sheep habitat consists of steep rocky slopes and cliffs, where they feed primarily on

grasses and shrubs such as galleta grass (*Pleuraphis jamesii*) and black brush (*Coleogyne ramosissima*) (Irvine 1969, Hoffmeister 1986). Desert bighorn also utilize riparian areas to access water and high value forage (Goodson et al. 2007).

Saltcedar and Russian olive, which typically form dense stands along river banks, can restrict Bighorn sheep access to these important water and foraging areas (J. Fort, personal communication, 2019). We designated riparian areas along Lake Powell, the San Juan, and Little Colorado Rivers where there are known populations of desert bighorn sheep, as "High" priority for saltcedar and Russian olive treatment (Figure 10). "Moderate" priority is assigned to similar habitat on the Navajo Nation along the San Juan River, Little Colorado River, and Colorado River and that is potentially suitable habitat.

PRIORITY WILDLIFE HABITAT TOTAL SCORE

By overlaying all nine priority wildlife habitat areas and adding each layer's score, we were able to create a map of the total priority score for the entire Navajo Nation (Figure 11). Higher total scores occur where multiple priority areas overlap and the higher the score, the more target wildlife resources will likely benefit from invasive plant species treatment in that area. Conversely, lower scores occur where few wildlife resources considered in this analysis will be affected. Low scoring areas, which were generally dry, topographically simple, flat, and low elevation, are still heavily impacted by invasive species such as cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola kali*). Although these areas are less important for NNDFW priority wildlife resources, they constitute important rangeland with high economic and cultural value for the Diné, and remain vital to natural hydrologic and ecosystem function on the Navajo Nation.

In general, the highest scores, i.e., the most overlap in priority wildlife areas, occur along waterways (riparian habitat) especially in canyons such as along the San Juan and Little Colorado River. Much of Canyon de Chelly also scored relatively high because of the presence of perennial water, steep slopes/cliffs, and potential habitat for several endangered species. Riparian habitats are known for having high density/diversity of plants and thus provide critical habitat for up to 80% of vertebrate species in the arid West, including 50% of bird species in the Southwest (Krueper 2000). Unfortunately, riparian habitats in the region are also among the most heavily degraded by several invasive species including saltcedar (*Tamarix spp.*) and Russian olive (*Elaeagnus angustifolia*). Researchers found that saltcedar and Russian olive are now the second and fifth most abundant woody species along Western U.S. rivers (Friedman et al. 2005) and are the focus of millions of dollars of removal efforts, including here on the Navajo Nation.

Research has found that while incurring several negative impacts to native ecosystems, saltcedar and Russian olive can provide adequate habitat for some species of wildlife. A recent review of literature found that many species in the Southwest, especially birds, will utilize riparian habitat with a mixture of native cottonwood/willow and non-native saltcedar/Russian olive (Bateman et al. 2009). This includes the endangered Southwestern willow flycatcher, which prefers native cottonwood/willow-dominated habitat but will also utilize habitat with a significant component of saltcedar and Russian olive (Durst et al. 2007). Use of invasive species for food and/or habitat has been documented for other sensitive wildlife as well, such as the Great Basin silverspot butterfly feeding on several species of invasive thistle. So, while the initial thought may be to eradicate all invasive species in riparian corridors on the Navajo Nation, this may actually be harmful to many wildlife species. Taking this into consideration, we recommend any invasive species treatment, especially in riparian habitat, be accompanied by re-vegetation with deliberately beneficial native species.

NNDFW Consultation

The maps and information in this report are meant to provide general guidance to areas of importance for target species and habitat. This report should be used in the initial planning stages of invasive species treatment projects prior to in-person site visits. Furthermore, by law, all invasive species removal projects need to obtain appropriate federal, state, and tribal permits. NNDFW will need to be consulted directly before any on the ground work is initiated.

The Diné are a sovereign tribe with established tribal laws in place to manage their land, therefore, any invasive species treatment projects on the Navajo Nation will need to obtain a Biological Resource Compliance Form (BRCF) from the Navajo Natural Heritage Program (NNHP). In order to obtain a BRCF the applying organization must consider all NESL species potentially affected by the proposed work in the project site. Depending on the species and scope of work, a Biological Evaluation, including species surveys, may be necessary before the project can proceed. This process is intended to ensure any work conducted does not harm NESL species or their habitat.

Conclusion

Invasive plant species affect every ecosystem of the Navajo Nation and cause significant changes to the delicate balance of natural resources in this arid landscape. Because of the size of the Navajo Nation and the limited resources of land managers, such as the BIA and Navajo Nation, it is not feasible to treat every infestation of invasive plants at once. Rather, land managers need to prioritize sites and species to focus treatment efforts to have the most impact on the natural ecosystems and processes they are attempting to rehabilitate. With the information gathered and maps created in this report, land managers now have a tool to help guide treatment based on the importance of habitat to priority wildlife resources managed by the Navajo Nation Department of Fish and Wildlife.

Based on the wildlife resources analyzed in this report, invasive plant species management on the Navajo Nation should focus on heavily impacted riparian habitat to have the most impact. Despite their relatively small area within the boundaries of the Navajo Nation, these habitats are imperative for a multitude of plants and animals including many threatened, endangered, and culturally-important species. Invasive plant species treatment conducted responsibly with appropriate planning, timing, methods, and re-vegetation practices will not only benefit the wildlife considered in this report, but also all other plant and animal species of the Navajo Nation. Responsible management will improve rangeland health, increase native species diversity, improve riparian health, and improve water quality for the benefit of the land and the Diné.

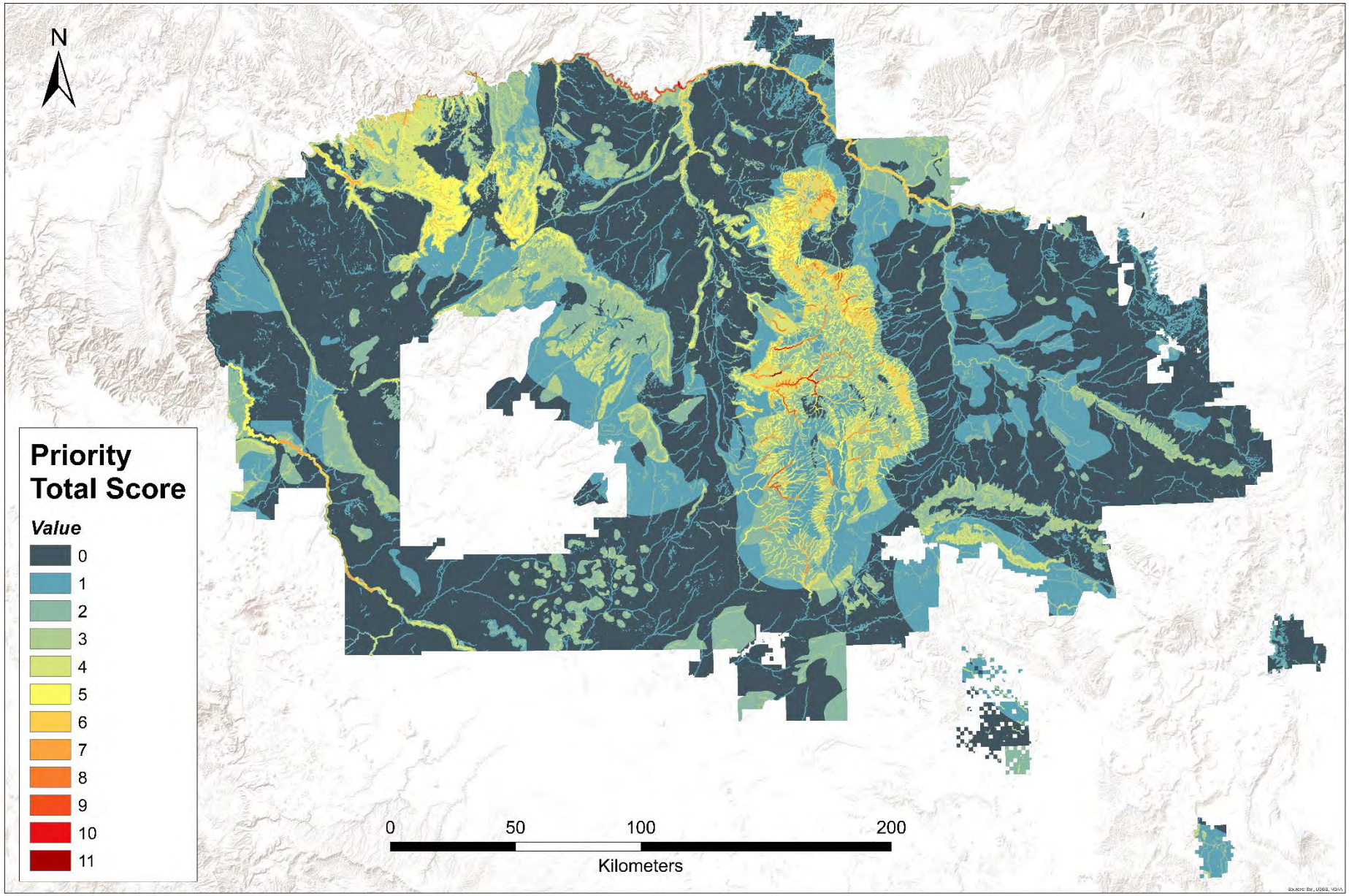

Figure 11. Summation of "High" and "Moderate" priority habitat and invasive species treatment area scores of nine target wildlife resources on Navajo Nation. Higher scores (warmer colors) indicate overlap in priority invasive species treatment areas and thus the wildlife resource benefits. Lower scores (cooler colors) indicate areas with low priority for the wildlife habitat evaluated.

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APPENDIX A

Scientific and common name of all species included in BIA invasive species (noxious weed) mapping data (organized by IWMP Category). IWMP Category and Management refer to recommendations on 43 target species of concern in the BIA Integrated Weed Management Plan. The extent of mapping varies between species depending on the scope and region of mapping project.

Scientific Name	Common Name	IWMP Category	IWMP Management Goal
Ailanthus altissima	Tree of heaven	A	Prevent
Alhagi maurorum	Camelthorn	A	Eradicate
Brassica tournefortii	Asian mustard	A	Eradicate
Cardaria draba	Whitetop	A	Eradicate
Carduus nutans	Musk thistle	A	Eradicate
Centaurea maculosa	Spotted knapweed	A	Eradicate
Centaurea solstitialis	Yellow star-thistle	A	Eradicate
Centaurea virgata	Squarrose knapweed	A	Prevent
Chorispora tenella	Crossflower	A	Eradicate
Cirsium arvense	Canada thistle	A	Eradicate
Cirsium vulgare	Bull thistle	A	Eradicate
Cortaderia selloana	Uruguayan pampas grass	A	Eradicate
Cyperus esculentus	Yellow nutsedge	A	Eradicate
Lepidium latifolium	Broadleaved pepperweed	A	Eradicate
Linaria dalmatica	Dalmatian toadflax	A	Eradicate
Onopordum acanthium	Scotch cottonthistle	A	Eradicate
Peganum harmala	African-rue	A	Prevent
Potentilla recta	Sulphur cinquefoil	A	Eradicate
Saccharum ravennae	Ravenna grass	A	Eradicate
Schismus barbatus	Common Mediterranean grass	A	Eradicate
Tamarix spp.	Saltcedar	A	Eradicate
Acroptilon repens	Russian knapweed	B	Contain & long term eradicate
Centaurea diffusa	Diffuse knapweed	B	Contain & long term eradicate
Elaeagnus angustifolia	Russian olive	B	Contain & long term eradicate
Halogeton glomeratus	Saltlover	B	Contain & long term eradicate
Sorghum halepense	Johnsongrass	B	Contain & long term eradicate
Tamarix ramosissima	Saltcedar	B	Contain & long term eradicate
Ulmus pumila	Siberian elm	B	Contain & long term eradicate
Aegilops cylindrica	Jointed goatgrass	C	Local contain & monitor
Bassia scoparia	Kochia	C	Local contain & monitor
Bromus arvensis	Field brome	C	Local contain & monitor
Bromus catharticus	Rescue brome	C	Local contain & monitor
Bromus diandrus	Ripgut brome	C	Local contain & monitor
Bromus inermis	Smooth brome	C	Local contain & monitor
Bromus racemosus	Bald brome	C	Local contain & monitor
Bromus rubens	Red brome	C	Local contain & monitor

Bromus tectorum	Cheatgrass	C	Local contain & monitor
Convolvulus arvensis	Field bindweed	C	Local contain & monitor
Erysimum repandum	Spreading wallflower	C	Local contain & monitor
Marrubium vulgare	Horehound	C	Local contain & monitor
Medicago polymorpha	Burclover	C	Local contain & monitor
Salsola kali	Russian thistle	C	Local contain & monitor
Tribulus terrestris	Puncturevine	C	Local contain & monitor
Agropyron cristatum	Crested wheatgrass		
Agropyron desertorum	Desert wheatgrass		
Amaranthus blitoides	Mat amaranth		
Apium graveolens	Wild celery		
Arctium minus	Lesser burdock		
Avena fatua	Wild oat		
Bromus japonicus	Field brome		
Capsella bursa-pastoris	Shepherd’s purse		
Carduus acanthoides	Spiny plumeless thistle		
Cenchrus incertus	Coastal sandbur		
Centaurea spp.	Knapweed		
Centaurea stoebe ssp. micranthos	Spotted knapweed		
Centaurea virgata ssp. squarrosa	Squarrose knapweed		
Cichorium intybus	Chicory		
Cynodon dactylon	Bermudagrass		
Cynoglossum officinale	Gypsyflower		
Dactylis glomerata	Orchargrass		
Descurainia sophia	Herb sophia		
Echinochloa crus-galli	Barnyard grass		
Eragrostis cilianensis	Stinkgrass		
Erodium cicutarium	Stork’s bill		
Grindelia squarrosa	Gumweed		
Hordeum murinum	Mouse barley		
Lactuca serriola	Prickly lettuce		
Lepidium perfoliatum	Clasping pepperweed		
Linaria vulgaris	Butter and eggs		
Lolium perenne	Perennial ryegrass		
Malcolmia africana	African mustard		
Malva neglecta	Common mallow		
Medicago lupulina	Black medick		
Medicago sativa	Alfalfa		
Melilotus officinalis	Sweetclover		
Morus alba	White mulberry		
Plantago lanceolata	Narrowleaf plantain		
Poa annua	Annual bluegrass		

Poa bulbosa	Bulbous bluegrass		
Poa compressa	Canada bluegrass		
Poa pratensis	Kentucky bluegrass		
Polygonum aviculare	Prostrate knotweed		
Polypogon monspeliensis	Annual Rabbitsfoot grass		
Polypogon viridis	Beardless Rabbitsfoot grass		
Rumex crispus	Curley dock		
Salsola collina	Slender Russian thistle		
Salsola tragus	Prickly Russian thistle		
Schedonorus phoenix	Tall fescue		
Setaria viridis	Green bristlegrass		
Silene vulgaris	Maidenstears		
Sisymbrium altissimum	Tall tumble mustard		
Sisymbrium irio	London rocket		
Solanum elaeagnifolium	Silverleaf nightshade		
Sonchus arvensis	Field sowthistle		
Sonchus asper	Spiny sowthistle		
Sonchus oleraceus	Common sowthistle		
Taeniatherum caput-medusae	Medusahead		
Tamarix chinensis	Five-stamen tamarisk		
Tamarix parviflora	Smallflower tamarisk		
Taraxacum officinale	Common dandelion		
Tragopogon dubius	Yellow salsify		
Trifolium repens	White clover		
Verbascum blattaria	Moth mullein		
Verbascum thapsus	Mullein		
Xanthium Strumarium	Cocklebur		