Double E Ranch Riparian Assessment

A Survey of Current Ecological Conditions
to
Support Resource Management Planning

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Double E Ranch Riparian Assessment

A Survey of Current Ecological Conditions to Support Resource Management Planning[1]

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Executive Summary

The New Mexico Department of Game and Fish (NMDGF) is developing a natural resources management plan for its newly acquired Double E Ranch property along Bear Creek in Grant County, NM. The long-term goals for the Double E Ranch are to maintain and improve riparian habitat for all wildlife species, including species of greatest conservation need (SGCN) and listed threatened and endangered species. To help meet these goals and support the planning process, this riparian assessment was conducted on Double E Ranch September 15 to 17, 2015 to provide baseline data on biotic and abiotic habitat conditions using the New Mexico Rapid Assessment Method for Lowland Riverine Wetlands (NMRAM). The NMRAM is a semi-quantitative and efficient approach to sampling and assessing the ecological status of riverine wetland and riparian areas. The NMRAM assessment uses a combination of mapping analysis and field surveys to measure 13 metrics that reflect landscape context, biotic, and abiotic attributes of the riparian ecosystem. These in turn are rolled-up into an overall ecological condition score by sampling area (SA) and averaged for the site as a whole.

Double E Ranch is located approximately 27 km (16 mi) northwest of Silver City, NM, and 8 km (5 mi) east of Gila, NM, in the north central portion of Grant County. The Double E property includes 5 km (3 mi) of Bear Creek, a tributary of the Gila River. Bear Creek on the Double E has sections which are perennial, however, surface flow in much of the canyon can be intermittent. The Double E Ranch has a diversity of riparian vegetation communities. Along the canyon edges and high terraces there are small patches of mature woodland stands dominated by Fremont's Cottonwood (*Populus fremontii*), Arizona sycamore (*Platanus wrightii*), and Goodding's willow (*Salix gooddingii*). Along some riverbanks and low terraces are shrublands, and on many of the sandy bars and terraces are mixed herbaceous stands of forbs and grasses. Associated with this diversity of vegetation communities is a wealth of fauna including the

[1] Final report Project Work Order Number EEP-150817, New Mexico Department of Game and Fish to the University of New Mexico.

endangered loach minnow (*Tiaroga cobitis*) and the threatened Chiricahua leopard frog (*Lithobates chiricauhuensis*).

On the Double E Ranch the most recent land uses were livestock grazing and tourism. The ranch also contains many archeological sites going back approximately 6,000 years. The previous ranch owner graded a road into the canyon bottom that crosses Bear creek in several places.

Based on the NMRAM assessment the Double E Ranch riparian wetlands overall are currently in excellent condition. The ranch average for both landscape context and abiotic metrics was also excellent. The biotic metrics were rated in the good category. The data from some individual metrics points out areas where management is recommended to maintain or improve the condition status of the ranch. The biggest concern hydrologically is protecting water sources, both surface and groundwater to sustain the biological resources of the riparian corridor. Additionally, soil and channel disturbance is a concern. The grading of the dirt road disturbed the channel structure and portions of the riparian zone. It is recommended that the road not be repaired, and future vehicle traffic be limited and kept out of the channel and riparian zone as much as possible. This will support channel morphology to recovery and help protect the two federally listed species that are active-channel dependent. Finally, two patches of tree of heaven, a pernicious State listed weed species, were observed during the NMRAM survey. It is strongly recommended that these patches be treated and removed, along with any other patches on the Double E. Spot treatment of Siberian elms is also recommended, although elms do not pose as great a threat to the ecosystem as a whole.

The recommendations from this assessment are:

1. Maintain maximum possible base flows in the active river channel. In keeping with the property water rights, this should include protection from ground water pumping.
2. Do not maintain, or re-grade, the dirt road in the canyon bottom. Keep vehicles out of the active channel, and limit ORV traffic within the canyon.
3. If grazing of the Double E is considered, livestock use should be carefully monitored, and access to the riparian zone and active channel should be limited to specific areas that can tolerate impacts or else be excluded.
4. Removal of the few patches of tree of heaven and Siberian elm individuals on the ranch is recommended to prevent expansion of these species and future ecosystem disruption.

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Cover: View downstream along Bear Creek near the west end of the Double E Ranch property (Photo by Y. Chauvin).

Introduction

The New Mexico Department of Game and Fish (NMDGF) is developing a natural resources management plan for its newly acquired Double E Ranch property along Bear Creek in Grant County, NM (Fig. 1). The long-term goals for the Double E Ranch are to maintain and improve riparian habitat for all wildlife species as well as species of greatest conservation need (SGCN) and listed threatened and endangered species (ONRT 2013). To help meet these goals and support the planning process, this riparian assessment was conducted on Double E Ranch September 15 to 17, 2015 to provide baseline data on biotic and abiotic habitat conditions using the New Mexico Rapid Assessment Method for Lowland Riverine Wetlands (NMRAM)[2].

The NMRAM is a semi-quantitative and efficient approach to sampling and assessing the ecological status of riverine wetland and riparian areas. For Double E Ranch, three sampling areas (SAs) were established for the assessment, distributed such that they captured the range of variation in riparian ecological conditions. The NMRAM assessment uses a combination of mapping analysis and field surveys to measure 13 metrics that reflect landscape context, biotic, and abiotic attributes of the riparian ecosystem. These in turn are rolled-up into an overall ecological condition score by SA and averaged for the site as a whole. Based on the information gathered in the NMRAM process—the individual metric scores and other observations made while on the site—we provide an assessment of current conditions with a discussion of the implications for maintaining and improving the riparian habitat of the ranch.

Figure 1. Bear Creek near the center of the Double E Ranch.

[2] The most current version of the NMRAM Handbook and Field Guides can be downloaded from the New Mexico Environment Department, Surface Water Quality Bureau, Wetlands Program website at https://www.env.nm.gov/swqb/Wetlands/NMRAM/. The Lowland draft manual should be available from the site in the late fall of 2015.

Study area

Location and hydrology

Figure 2. Scour pools are scattered within the canyon.

Double E Ranch is located approximately 27 km (16 mi) northwest of Silver City, NM, and 8 km (5 mi) east of Gila, NM, in the north-central portion of Grant County (Fig. 3). The Double E property includes 5 km (3 mi) of Bear Creek, a tributary of the Gila River. Bear Creek on the Double E includes perennial and intermittent sections, as well as few large scour pools that may hold water longer than the rest of the channel (see Fig. 1; Fig. 3). Below Double E the creek runs only intermittently, during periods of significant precipitation or spring snow melt (Menzie and Hopkins, 2009). Throughout the Double E, Bear Creek is confined to a canyon that has a width varying from 50-220 m (164-722 ft), and averaging 100 m (328 ft). There are five large, and many small, ephemeral tributaries that feed into Bear Creek within the property, the largest of which are Stone Canyon and Brushy Canyon. Within the property Bear Creek has an elevation range of 1,500 m (4,920 ft) at the eastern (upstream) boundary to 1,457 m (4,780 ft) at the western (downstream) boundary, resulting in a relatively low stream gradient (approximately 0.9%). The Double E is located in the lower portion of Bear Creek's drainage basin, which is approximately 420 km^2 (162 mi^2).

The Double E Ranch is in a semiarid hilly landscape, where mean annual temperatures range from 13° C to 20° C (55 ° F to 70° F) and mean annual precipitation ranges from 20 cm to 32 cm (8 in to 13 in). Additionally, precipitation is annually widely variable, with some years receiving only six inches of precipitation, and other years receiving more than 25 inches (Soles 2003).

There are no stream gages on Bear Creek. The nearest gage is on the Gila River at the town of Gila, NM (Gage Station 09430500) approximately 8 km (5 mi) west of the study site. It was used to provide a general understanding of the local hydrological regime and stream-flow history necessary to some of the NMRAM metric evaluations. Gage data was available for the years 1928 to Sept 2014. Stream flow shows bi-modal peak flows, with one peak occurring between February and March, and the other occurring in August (Fig. 4). The system is driven by both winter snowmelt and late summer/early fall precipitation, with both capable of

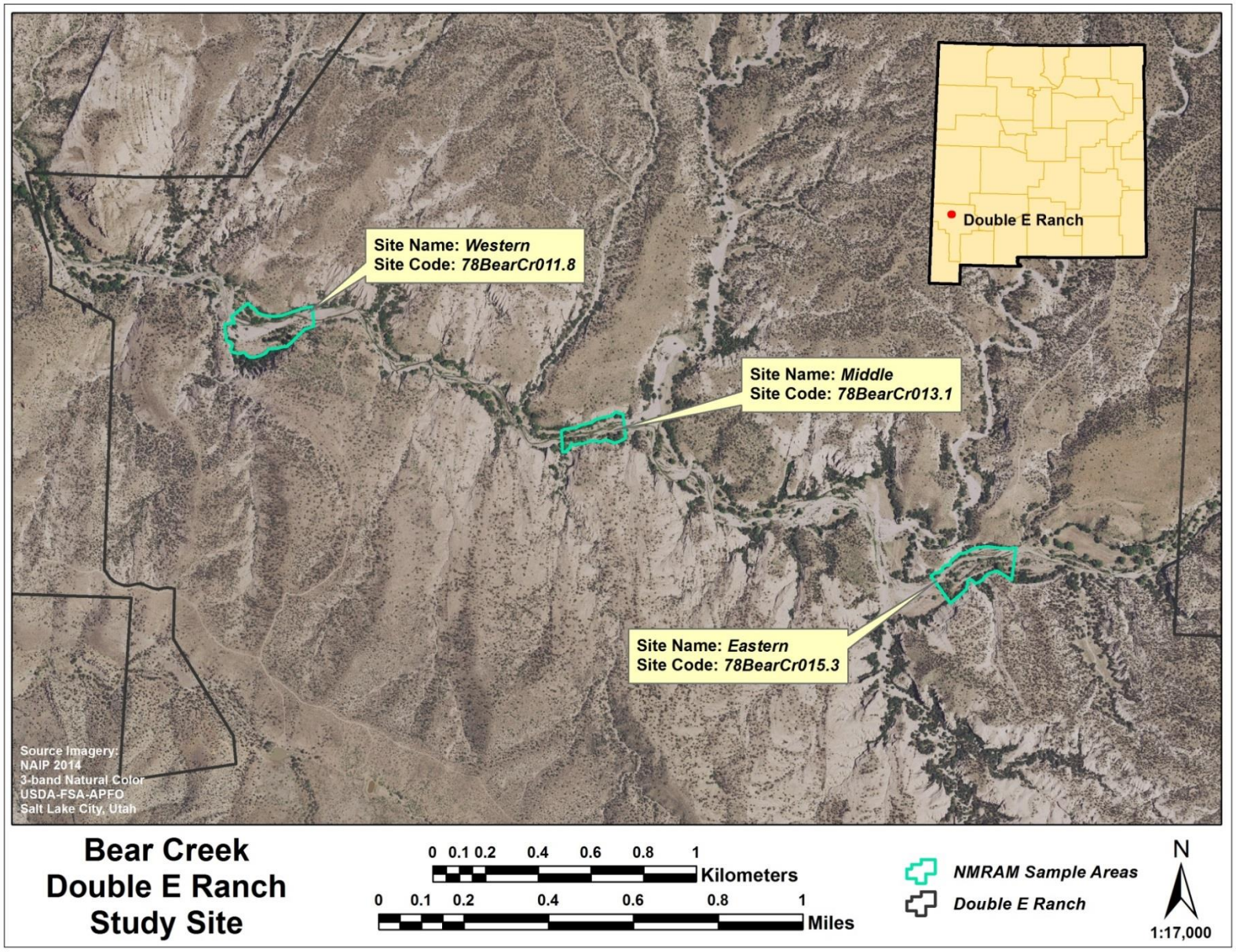

Figure 3. Double E Ranch study area showing three NMRAM Sampling Areas (SAs). Note that there is little development in or around the riparian corridor and that most of the surrounding landscape is open rangeland comprised of grasslands and woodlands.

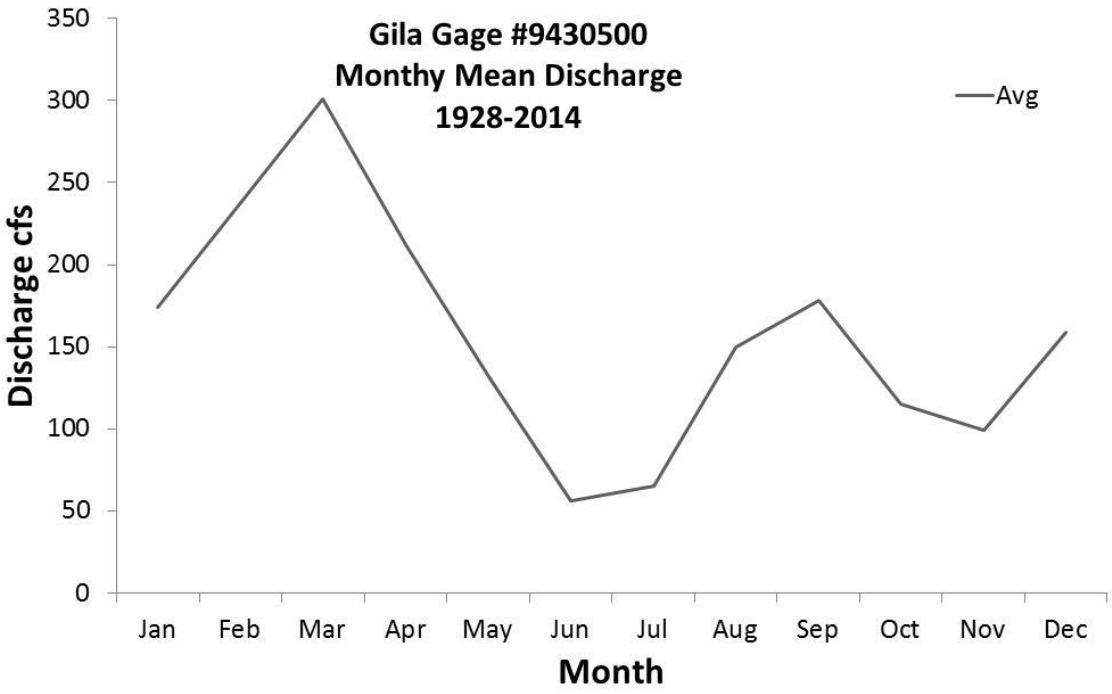

Figure 4. Average monthly discharge on the Gila River at Gila, NM (Gage Station 08477110). Gage period 1928 to 2014.

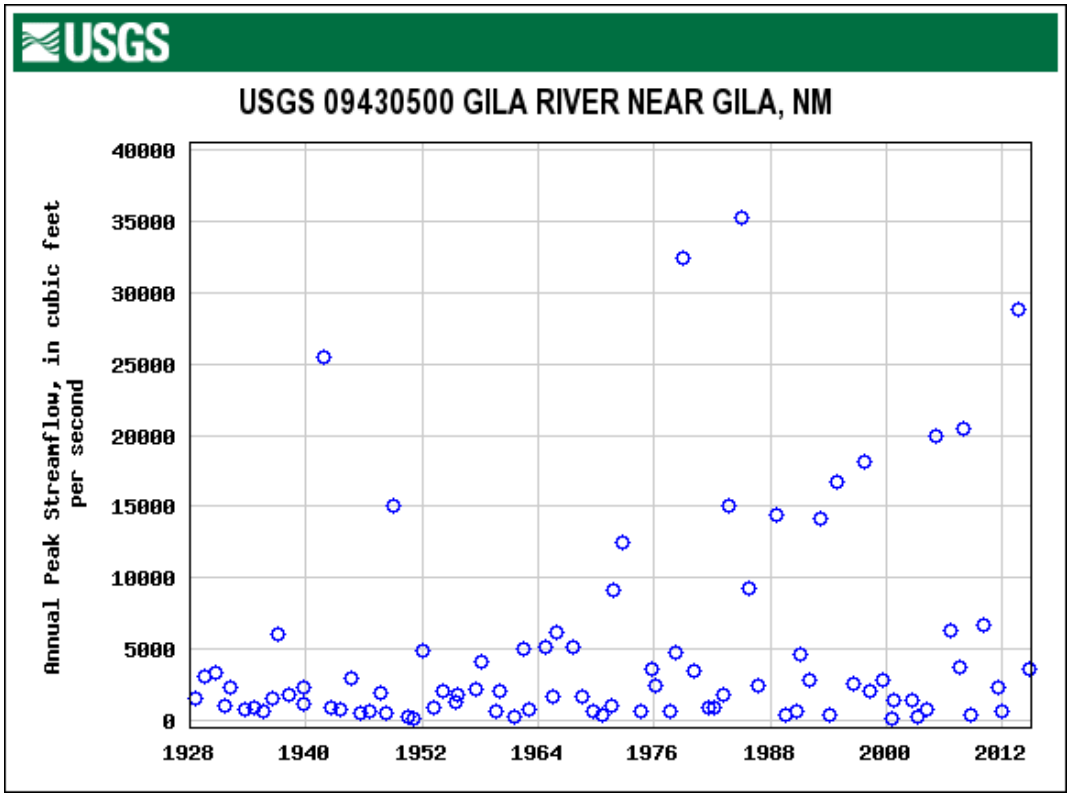

Figure 5. Annual peak flow in cfs for Gila gage from 1928 to 2014

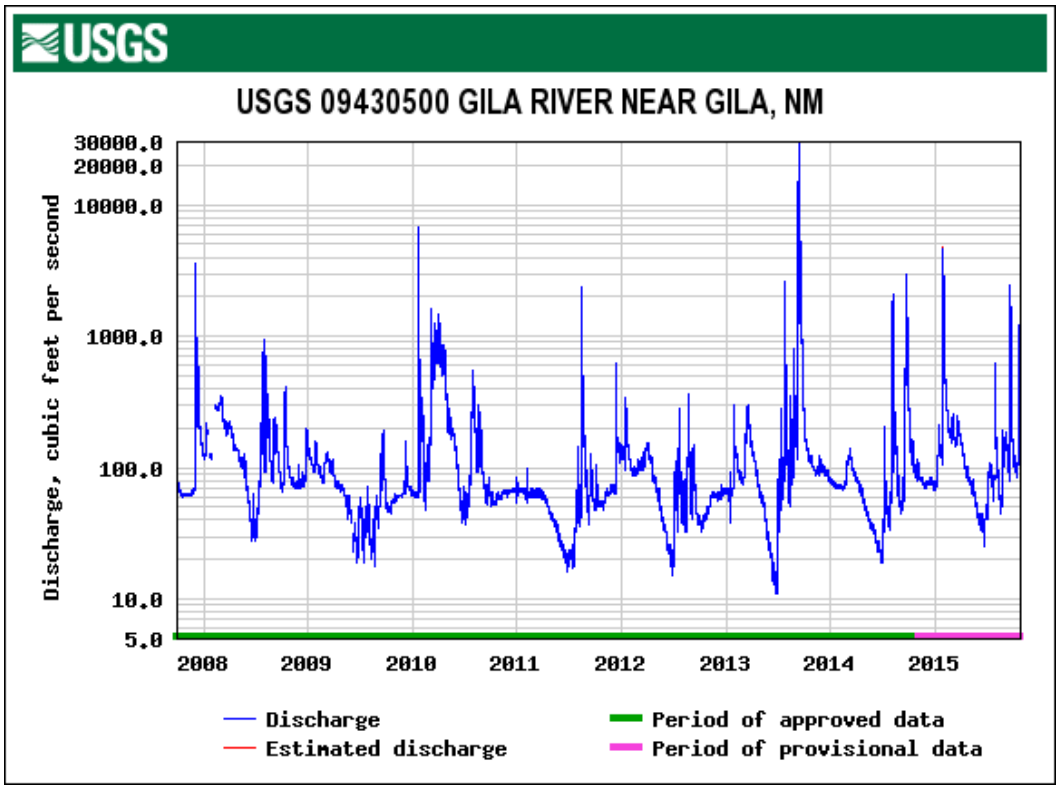

Figure 6. Daily discharge at Gila gage from Oct 2007 to Oct 2015.

producing large-magnitude flows. On September 15, 2013, the Gila gage recorded a peak-flow event of 28,800 cfs, (Figs. 5 and 6). Using the Gila gage return intervals provided in the Lowland NMRAM (Table 1) this is a 25-50-year return interval. The September 2013 event was driven by a state-wide major precipitation event, and Bear Creek likely had peak flows that were within the 25-50-year recurrence as well. Additionally, the Gila gage data indicates that there was a 3,590 cfs event on September 23, 2014 which is in the 2-10-year recurrence interval (Table 1). A similar event likely occurred on Bear Creek as evidenced by the removal of several portions of the dirt road graded into the canyon bottom.[3]

Table 1. Peak discharge (cfs) recurrence intervals that correspond to the rating tables for the Floodplain Hydrologic Connectivity metric (excerpted from NMRAM Lowland Field Guide, Appendix B).

Gage No.	Gage	Recurrence Interval (years)				
		Range	1-2	2-10	10-25	25-50
9430500	GILA RIVER NEAR GILA, NM	Min		2,140	11,800	22,500
		Max	<2,140	11,800	22,500	34,300

[3] Personal communication from Mark Watson, New Mexico Department of Game Fish.

Vegetation and Fauna

Figure 7. Bear Creek though the Double E Ranch supports a wide variety of riparian habitats.

The Double E Ranch has a diversity of riparian vegetation communities. There are scattered small patches of mature woodland dominated by Fremont's Cottonwood (*Populus fremontii*), Arizona sycamore (*Platanus wrightii*) and Goodding's willow (*Salix gooddingii*) (Fig. 7, see also Figs. 11-13). These communities are considered globally imperiled with a NatureServe status rank of G2[4] (Faber-Langendoen et al. 2012). There are also scattered shrublands along the river bank and on some alluvial terraces. These are dominated by seepwillows (*Baccharis salicifolia*) and young riparian trees. The native wetland herbaceous species water speedwell (*Veronica anagallis-aquatica*) dominates the active channel. In addition to the woodlands and shrublands, there are open herbaceous patches dominated by mixed ruderal herbaceous species such as yellow sweetclover, weakleaf bur ragweed, Canadian horseweed, tarragon, and bermudagrass. These occur on areas of sandy soil on high bars and terraces that are likely frequently disturbed by flooding. Nineteen vegetation patch types were identified and cross-walked to 13 plant associations of the U.S. National Vegetation Classification[5] (Table 2).

Associated with this diversity of vegetation communities is a wealth of fauna. For the ranch, 159 species have been reported, including 100 birds, 20 mammals, 13 reptiles and amphibians, and 26 dragonflies and damselflies.[6] Among these, 20 are on the New Mexico Species of Greatest Conservation Need list (SGCN).[7] Additionally, two species present on the Double E are listed as threatened or endangered by the U.S. Fish and Wildlife Service. The endangered loach minnow (*Tiaroga cobitis*) occurs in Bear Creek (Menzie and Hopkins 2009), and a portion of Bear Creek on the Double E is designated by USFWS as loach minnow critical habitat.[8] Additionally, the threatened Chiricahua leopard frog (*Lithobates chiricahuensis*) has been recorded from within Bear Creek throughout the ranch (Fig. 8).

[4] NatureServe Explorer: http://explorer.natureserve.org/servlet/NatureServe?sourceTemplate=tabular_report.wmt&loadTemplate=assoc_RptComprehensive.wmt&selectedReport=RptComprehensive.wmt&summaryView=tabular_report.wmt&elKey=687971&paging=home&save=true&startIndex=1&nextStartIndex=1&reset=false&offPageSelectedElKey=687971&offPageSelectedElType=communities&offPageYesNo=true&post_processes=&radiobutton=radiobutton&selectedIndexes=687971

[5] See http://usnvc.org/.

[6] Personal communication, Double E Ranch species list as of September 2015. Mark Watson, New Mexico Department of Game and Fish.

[7] Draft State Wildlife Action Plan June 24, 2015, New Mexico Department of Game and Fish.

[8] Personal communication Mark Watson, New Mexico Department of Game and Fish.

Table 2. Double E Ranch vegetation communities mapped in the 2015 survey, cross-walked to plant associations of the U.S. National Vegetation Classification (http://usnvc.org/).

1 Forest & Woodland		
1.B Temperate & Boreal Forest & Woodland		
1.B.3 Temperate Flooded & Swamp Forest		
D013 Interior Lowland West Flooded Forest Division		
M036 Interior Warm & Cool Desert Riparian Forest Macrogroup		
G797 Western Interior Riparian Forest & Woodland Group		
A3801 Platanus wrightii Flooded Forest & Woodland Alliance		
NVC Code	Plant Asoociations	Map Units
CEGL000937	*Platanus wrightii* Woodland	Woodland: Arizona sycamore - Oneseed juniper
		Woodland: Arizona sycamore - Goodding's willow
		Woodland: Arizona sycamore - Goodding's willow / Seepwillow
A3803 Populus fremontii - Fraxinus velutina - Salix gooddingii Flooded Forest & Woodland Alliance		
NVC Code	Plant Asoociations	Map Units
CEGL000661	*Populus fremontii* Forest	Woodland: Fremont's cottonwood - Oneseed juniper / Seepwillow
		Woodland: Fremont's cottonwood - Oneseed juniper
CEGL000665	*Populus fremontii - Platanus wrightii* Forest	Woodland: Fremont's cottonwood - Arizona sycamore
CEGL000944	*Populus fremontii - Salix gooddingii* Woodland	Woodland: Fremont's cottonwood - Goodding's willow
CEGL002683	*Populus fremontii - Salix gooddingii / Baccharis salicifolia* Forest	Woodland: Fremont's cottonwood - Goodding's willow/Seepwillow
CEGL003778	*Salix gooddingii* Woodland	Woodland: Goodding's willow / Seepwillow
M298 1.B.3.Nd.90 Interior West Ruderal Flooded & Swamp Forest		
G510 Interior West Ruderal Riparian Forest & Scrub		
NVC Code	Plant Asoociations	Map Units
Provisional	*Ailanthus altissima* Woodland	Woodland: Tree of heaven - Oneseed juniper

2 Shrub & Herb Vegetation									
	2.C Shrub & Herb Wetland								
		2.C.4 Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland							
			D032 Southwestern North American Warm Desert Freshwater Bosque & Marsh						
				M076 Warm Desert Lowland Freshwater Shrubland, Meadow & Marsh					
					G533 North American Warm Desert Riparian Low Bosque & Shrubland				
						A0933 Baccharis salicifolia Riparian/Wash Shrubland Alliance			
							NVC Code	Plant Asoociations	Map Units
							CEGL003549	*Baccharis salicifolia* Riparian Shrubland	Shrubland: Seepwillow/Gravel Bar
			D031 2.C.4.Nb Western North American Freshwater Shrubland, Wet Meadow & Marsh						
				M301 Western North American Ruderal Wet Shrubland, Meadow & Marsh					
					G524 Western North American Ruderal Wet Shrubland, Meadow & Marsh				
							NVC Code	Plant Asoociations	Map Units
							CEGL005463	*Cynodon dactylon* Western Ruderal Herbaceous Vegetation	Herbaceous: Bermudagrass/Sparse
							Provisional	*Aristida ternipes Ruderal Herbaceous Vegetation*	Herbaceous: Spidergrass / Goosefoot
							Provisional	*Artemisia dracunculus* Ruderal Herbaceous Vegetation	Herbaceous: Tarragon - Ragweed
							Provisional	*Melilotis officinalis* Ruderal Herbaceous Vegetation	Herbaceous: Sweetclover - Ragweed
5 Aquatic Vegetation									
	5.B Freshwater Aquatic Vegetation								
		5.B.2 Temperate & Boreal Freshwater Aquatic Vegetation							
			D049 North American Freshwater Aquatic Vegetation						
				M109 Western North American Freshwater Aquatic Vegetation					
					G544 Western North American Temperate Freshwater Aquatic Bed				
							NVC Code	Plant Asoociations	Map Units
							Provisional	*Veronica anagallis-aquatica* Aquatic Vegetation	Herbaceous: Water speedwell / Sweetclover
									Herbaceous: Water speedwell / Seep monkeyflower

Land use history

Figure 8. A Chiricahua leopard frog on water speedwell in Bear Creek on the east side of the Double E Ranch.

The upper watershed of Bear Creek includes the Pinos Altos Mining District, as well as the village of Pinos Altos. Accordingly, there has been intensive land use in the upper watershed that includes mining, residential development, roads, recreation and grazing. Gold was discovered in the Pinos Altos Mining District in 1870, which resulted in significant alterations to the upper watershed. Mining left waste rock and mill tailings, which are potential stream contaminants. At the same time high livestock numbers and timber removal, both to support the mining, denuded the uplands (Menzie and Hopkins 2009). Additionally, some mining activities directly altered the channel and stream banks. Some of the mines have been reclaimed, while others are being developed for residential homes. However, many old mines remain as potential sources of watershed pollution. Groundwater diversion for the residential development of Pinos Altos is an additional threat in the upper Bear Creek watershed.

Figure 9. One of many places within the canyon where the road has been graded through the active river channel.

In addition, the prehistoric Mimbreño people built settlements within Bear Creek canyon, and surrounding canyons. Bear Creek canyon within in the Double E has archeological sites spanning 6,000 years to the present.[9] Within the historic period there were small Apache settlements and sacred sites, as well as homestead sites indicating ranching use. In the very recent past grazing and recreation were the major land uses, but the ranch also contains a few areas that have been

[9] Draft archeological report to NMDGF from Jack Young, personal communication from Mark Watson, NM Department of Game and Fish.

leveled either for use as home sites or fields, although all are now abandoned. The prior ranch owner graded a road through the riparian zone, following the canyon bottom, crossing Bear Creek multiple times from the western to the eastern boundary of the ranch (Fig. 9).

Sampling Design and Analysis

The New Mexico Rapid Assessment Method for Riverine Wetlands (NMRAM) was used to assess the current condition of the Riparian Wetlands on the Double E Ranch. This assessment method examines landscape context, biotic and abiotic attributes of a wetland of interest, and is based on a combination of mapping and field observations. Currently there are two modules of the NMRAM for unconfined riverine systems. One is for smaller montane streams with gradients above one percent occurring at higher elevations and associated with montane riparian vegetation; the other for larger lowland rivers with gradients less than one percent and dominated by desert riparian vegetation. Lower Bear Creek, while a relatively small river, occurs in a lowland setting with the type of vegetation and stream gradient that is consistent with the requirements of the Lowland module. Hence, data was collected using the Lowland module (version 1.0). Yet, because it is a small river we also employed a few components of the Montane module we thought might help in the assessment as supplemental information. Although the Lowland module was the best available fit, Bear Creek deviates somewhat from the assumptions on which the model is based, in that it is intermittent and its floodplain is moderately confined by the canyon, while the Lowland riverine NMRAM is designed for perennial rivers with broad floodplains.

NMRAM data collection occurs in discrete Sampling Areas (SA) with defined boundaries. For the Double E Ranch, three SAs were created. These SAs were distributed more or less equally from east to west across the property to obtain a representative sample of conditions on the ranch and to capture the range in variation across the property (see Fig. 3). There are 13 metrics distributed across three attribute categories: landscape context, biotic, and abiotic (Table 2). Each metric is assessed and assigned a rating based on the data. The data and the scores themselves are entered onto the NMRAM datasheets. The datasheet contains a roll-up table which takes all the individual scores and calculates overall scores by attribute categories, with the entire SA score then based on the attribute scores. The SA scores for a site are then averaged to produce an overall project score. Finally, the NMRAM datasheets include a series of stressor checklists, which although not used in calculating the final SA score, are included as ancillary information on factors that may be affecting the conditions of the wetland. Copies of the complete NMRAM datasheets along with all of the data collected are provided as part of the Digital Addendum, and summaries of the data are reported below.

All NMRAM metrics are rated using a ranking scale of A to D (4 to 1), with A representing a riparian wetland in Excellent ecological condition, B indicating Good condition, C indicating Fair condition, and D a riparian wetland in Poor condition. The implication is that wetlands in excellent condition are providing all of their expected functions and services, while wetlands in

poor condition are providing few to none of their expected functions and services. The NMRAM guidance documents that contain full descriptions of the methods for collecting NMRAM data and metric descriptions and rationale (NMRAM Montane Riverine Manual and Field Guide Version 2.0; Lowland Riverine Field Guide 1.0) can be obtained from the New Mexico Environment Departments website. (https://www.env.nm.gov/swqb/Wetlands/NMRAM/)

As part of the NMRAM biotic metric assessment process, a vegetation patch map was created for each SA. These were digitized in GIS and are provided as shapefiles in the Digital Addendum. Additionally, photographs of each vegetation patch were taken, as well as photographs of channel cross-sections, and other features. All photographs are provided in the digital addendum included with the report. The locations of some vegetation and abiotic features, as well as the channel cross-sections were recorded with a Garmin GPS with an accuracy of +/- 3 m (Digital Addendum). An electronic Data Addendum to this report contains all of the raw data in PDF files, along with the photo files and a PDF of this report.

Table 3. NMRAM Lowland Version 1.0 List of Metrics.

Attribute categories and metrics		*Score weights*	
		Attributes	*Metrics*
Landscape Context Metrics		**0.3**	
	1. Buffer Integrity Index		0.25
	2. Riparian Corridor Connectivity		0.25
	3. Relative Wetland Size		0.25
	4. Surrounding Land Use		0.25
Biotic Metrics		**0.35**	
	1. Relative Native Plant Community Composition		0.2
	2. Vegetation Horizontal Patch Structure		0.2
	3. Vegetation Vertical Structure		0.2
	4. Native Riparian Tree Regeneration		0.2
	5. Invasive Exotic Plant Species Cover		0.2
Abiotic Metrics		**0.35**	
	1. Hydrologic Connectivity		0.3
	2. Physical Patch Diversity		0.3
	3. Soil Surface Condition		0.1
	4. Channel Mobility		0.3

Results

NMRAM Scores

The NMRAM rating scores by attribute category and metric for each sampling area and the overall site scores are provided in Table 3. Each of the metrics measures a different aspect of riparian condition. Below we will present a summary of each metric measured on the ranch, along with the conditions that led to the scores.

Landscape Context

Landscape context metrics are designed to measure the conditions surrounding an SA, and are primarily assessed using a GIS with field confirmation. Since most of the landscape surrounding Double E is natural vegetation (mostly range land), the sites score high across all metrics, i.e., Excellent condition (see Fig. 3).

Buffer Integrity Index, which is composed of two sub-metrics*, Buffer Percent* and *Buffer Width*, is a measure of the amount of natural and semi-natural vegetated buffer on the lateral sides of the SA out to 250 m from the SA boundary (e.g., open range land). Vegetated buffers enhance wetland function and protect the wetland from anthropogenic environmental stressors. Overall, the buffers on the Double E Ranch were all intact and in excellent condition due to the lack of development in the surrounding landscape.

Riparian Corridor Connectivity measures the connectivity versus fragmentation of the riverine corridor upstream and downstream of the SA. Intact riparian corridors allow for unimpeded movement of wildlife, intact habitat, and propagation of plant communities. The ranch riparian corridor was intact except for a two-track road down the channel, but this was not considered a major fragmentation feature.

Relative Wetland Size is an index of reduction of the current wetland size relative to its estimated historical extent due to human-induced disturbances, particularly land-use conversions. Large reductions of area can alter hydrology and ecosystem processes, and may create ecological instability or reduce viability. On the ranch there was little evidence of housing or agriculture conversion, although there was one location on the very eastern edge where the floodplain had been reduced by an old field. This field was not large enough to reduce the rank from A-Excellent.

Surrounding Land Use measures the amount and intensity of human land use in the buffer zone surrounding the SA. The intensity of human activity in the landscape has a proportionate impact on the ecological processes of the riparian ecosystem. Beyond the one field and the two-track road there was little evidence of land-use impacts.

Table 4. NMRAM scores for all metrics by attribute categories for each sampling area and the overall ranch average.

River Ranch NMRAM Scores

	Sampling Areas			
	East	**Mid**	**West**	
	15.3	**13.1**	**11.8**	**Avg.**
Landscape Context Attributes				
Buffer Integrity Index	4	4	4	**4**
Buffer Percent	4	4	4	**4**
Buffer Width	4	4	4	**4**
Riparian Corridor Connectivity	4	4	4	**4**
Relative Wetland Size	4	4	4	**4**
Surrounding Land Use	4	4	4	**4**
Biotic Metrics				
Relative Native Plant Community Composition	3	3	2	**2.7**
Vegetation Horizontal Patch Structure	4	3	3	**3.3**
Vegetation Vertical Structure	3	3	3	**3**
Native Riparian Tree Regeneration	3	3	3	**3**
Invasive Exotic Plan Species Cover	3	4	3	**3.3**
Abiotic Metrics				
Hydrologic Connectivity (Multi-channel)	3	3	3	**3**
Physical Patch Diversity	4	4	4	**4**
Soil Surface Condition	3	3	3	**3**
Channel Mobility	4	4	4	**4**
Additional Montane Abiotic Metrics (Not in score roll-up)				
Hydrologic Connectivity (Montane)	*3*	*3*	*4*	***3.3***
Channel Stability	*3*	*3*	*4*	***3.3***
Stream Bank Stability and Cover	*3*	*3*	*4*	***3.3***
Landscape Context Score	4	4	4	**4**
Biotic Score	3.2	3.2	2.8	**3.1**
Abiotic Score	3.6	3.6	3.6	**3.6**
SA Weighted Wetland Condition Score	**3.58**	**3.58**	**3.44**	**3.53**
SA Wetland Rank	**A**	**A**	**A**	**A**

Biotic metrics

Biotic metrics measure key biological attributes within the wetland that reflect ecosystem integrity. These are primarily based on field mapping of vegetation communities (Figs. 11, 12, and13)

Relative Native Plant Community Composition is an index of the abundance of native-dominated versus exotic-dominated vegetation communities based on the most abundant species within each vegetation patch that was mapped. High native-plant species diversity generally indicates overall high biotic diversity, stability of wetland biotic communities, increased wildlife habitat and species diversity. The ranch received a Good score on relative native-plant community composition. There were large herbaceous patches dominated or co-dominated by exotic forbs and grasses. Woody dominants throughout the ranch were predominantly native, with the exception of one patch in the western SA dominated by tree of heaven (*Ailanthus altissima*), an introduced State listed noxious weed (Fig. 10).

Figure 10. Tree of heaven on the western SA.

Vegetation Horizontal Patch Structure is an assessment of general vegetation patch diversity and pattern complexity (interspersion) across an SA. Multiple plant patches that are more or less equally distributed across the SA indicate high biotic diversity and a history of dynamic fluvial processes. The ranch as a whole earned a Good rating on this metric. There was a moderate amount of different vegetation patches, but the amount of area per patch was often not equally distributed and interspersion of patches was low (i.e., patches were not highly intermixed) (see Figs. 11 and 12).

Vegetation Vertical Structure is an assessment of the vertical structural complexity and richness of the vegetation canopy layers across the SA. Vertical vegetation structure is an integral part of habitat diversity and is correlated with overall faunal biodiversity. The ranch earned a Good rating on this metric. The two most common structure types throughout the canyon were non-wetland herbaceous and patchy mature woodlands. There were also scattered young woodlands and shrublands, but these were never a majority structure type, which kept the rating from being higher.

Native Riparian Tree Regeneration assesses the abundance of riparian tree reproduction across the SA. Healthy functioning riverine wetlands should consist of a mosaic of woody

vegetation stands that include stands of both mature and young regeneration trees. Absence of young trees may indicate ecological dysfunction. Young trees were present throughout the canyon, but patches of recent reproduction were scattered, leading to a Good score rather than Excellent. Seedling native trees were often observed in the active channel as well as more isolated patches of saplings outside the channel, but the survivorship capacity was uncertain.

Invasive Exotic Plant Species Cover is a measure of the total percent cover of a set of exotic plant species that are considered invasive based on the New Mexico list of noxious weeds.[10] Invasive non-native species can have a significant impact on community diversity and function. High levels of invasive exotic species within a riparian plant community are a direct threat to maintaining wetland function and biodiversity. The ranch earned a Good rating on this metric. There were isolated Siberian elms observed throughout the canyon but of particular concern were two patches of tree of heaven (see Fig. 10). One patch was inside the western SA and is identified on the vegetation map (Fig. 11-13). The other patch was at the upstream end of the eastern SA and is noted on the field map.

Abiotic Metrics

The abiotic metrics address observable hydrological conditions, physical ecological complexity, and anthropogenic disturbances. The metric assessments are based on a combination of a reconnaissance survey (prescribed in the Lowland Riverine RAM) and stream channel cross-sections (per the Montane Riverine RAM).

Floodplain Hydrologic Connectivity is an assessment of the ability of water to flow into or out of the wetland or to inundate adjacent areas. Surface hydrological connectivity between a river and riverine wetlands formed on its floodplain supports key ecological functions and plant and wildlife habitat diversity by promoting an exchange of water, sediment, nutrients and organic carbon (Collins et al. 2008). For this metric on the Double E Ranch we used a combination of the Lowland module narrative rating protocol and channel cross-sections. The narrative approach is designed to detect evidence of recent (within five years) inundation of side channels and the floodplain and hence connectivity with the main channel surface flows. Using this method the ranch rated Good on Hydrologic Connectivity as a whole. The majority of back and side channels showed evidence of flow from the fall 2014 flood event, which was estimated to be a 2-10-year return event based on the Gila gage data (see Figs. 5 and 6, Table 1). Some large woody debris and older side-channel flood evidence observed was suspected to be from the September 2013 flood event, which was estimated as a 25-50-year return event. The rating of this metric is dependent on the return interval of the peak flood that has occurred within the last five years. Since the Gila gage data is our best approximation of return intervals locally, we opted for a conservative approach and used the 10-25 year ratings table that reflects the intermediate magnitude of the two largest recent flooding events in the basin. Of note, the

[10] List maintained by the New Mexico Department of Agriculture, last updated 2009. Available on the website http://www.nmda.nmsu.edu/apr/noxious-weed-information/.

Western SA showed more evidence of water flow through its floodplain and side channels and thus rated Excellent on Floodplain Hydrologic Connectivity.

In order to get a more complete picture of the Floodplain Hydrologic Connectivity, we also measured entrenchment of the active channel using the cross-section protocols from the Montane module. The degree of entrenchment, defined here as the ratio of flood-prone width to bankfull width, speaks to the ease or difficulty for water to move out of the main active channel and inundate the adjacent floodplain—as the quotient of the ratios goes up overbank flooding should be more prevalent, leading to greater connectivity. The Bear Creek SA entrenchment ratios with their ratings from the Montane module are provided in Table 4. As a whole, the ranch scored a Good rating on Floodplain Hydrologic Connectivity as measured by this method (only two suitable cross-section sites per SA were found and measured versus the three suggested by the protocol). However, there was enormous variability between cross-section scores, with every SA having one cross-section that scored a Poor rating and one that scored higher. The widest variability came from the Western SA, which had one D and one A.

Table 5. Entrenchment Ratios measured for cross-section and average for each SA. U=Upper cross-section, M=Middle cross-section, L=Lower cross section.

SA	Cross Section	Entrenchment Ratio	NMRAM Rating
Eastern (15.3)	U	2.17	3 (B)
	M	1.44	1 (D)
	L	-	-
	SA Average	**1.81**	**2 (C)**
Middle (13.1)	U	1.39	1 (D)
	M	1.85	2 (C)
	L	-	-
	SA Average	**1.62**	**2 (C)**
Western (11.8)	U	3.27	4 (A)
	M	-	-
	L	1.45	1 (D)
	SA Average	**2.36**	**4 (A)**
Bear Creek Average		**1.93**	**3 (B)**

Physical Patch Diversity describes the physical structural richness of riverine wetlands and associated channels (e.g., debris jams in channel, swales, depressional fluvial features on floodplains, woody wrack piles on the floodplain, pits and mounds, etc.). Variety in physical features leads to a varied and complex habitat that fosters biological diversity. Overall, Bear Creek had an Excellent rating for physical patch diversity, due in part to the high number of side and back channels as well as other physical patch types spread across the floodplain.

Soil Surface Condition is a measure of anthropogenic disturbance to the wetland and riparian soils which results in modification of soil characteristics. Disturbance to the soil can affect biological, physical and chemical processes and impede wetland function. All three SAs scored a Good rating on soil surface condition as a function of the dirt road graded into the river bottom by the prior owner (see Fig. 9). Outside of this, no other significant soil disturbances were observed.

Channel Mobility is an assessment of the dynamic capacity of a channel to laterally migrate or avulse. A channel that is armored by either anthropogenic means (levees, rip wrap, and jetty jacks) or non-native woody vegetation is unable to migrate or avulse and thus unable to create a dynamic patch mosaic of fluvial landforms that support wetland and riparian communities. Bear Creek scored an Excellent rating on channel mobility—there were no indications of anthropogenic modification of the channel banks and no armoring by non-native woody species.

Per the Montane module, we also collected *Channel Stability*, and *Stream Bank Stability and Cover* metric data. *Channel Stability* assesses the degree of channel aggradation or degradation based on the departure from characteristic pattern, profile, and dimension. Large, persistent changes to the flow or sediment regime caused by upstream land-use changes, alterations of the watershed, or climatic changes tend to destabilize the channel and cause it to change form (Collins et al. 2008). Channel Stability is rated using a series of indicator checkboxes based on features you might observed in a Montane stream system. Because of the difference in substrate (sand versus cobble/boulder), many of the indicator checkboxes were not applicable to Bear Creek. However, based on those indicators that were applicable, Bear Creek as a whole rated a Good on this metric, due to mild indications of aggradation.

Stream Bank Stability and Cover is a measure of stream bank soil/substrate stability and stream bank erosion potential that reflect overall stream bank stability. Greater stability and cover generally indicate less anthropogenic disturbance. Stable stream banks should support more perennial vegetation and more stable and healthy wetland communities. The ranch overall scored in the Good category on this metric, because, while generally well vegetated and stable, there were intermittent patches of poorly vegetated and unstable banks.

Overall Site Score

In summary, each SA had an overall rating of Excellent (see Table 4) with an overall average score for the site of 3.53, which places the Double E Ranch riparian wetlands in the lower third of the Excellent (A) ecological condition category (Table 6). This was bolstered by the natural-lands landscape context that offset lower scores of other metrics, particularly among the biotic attributes.

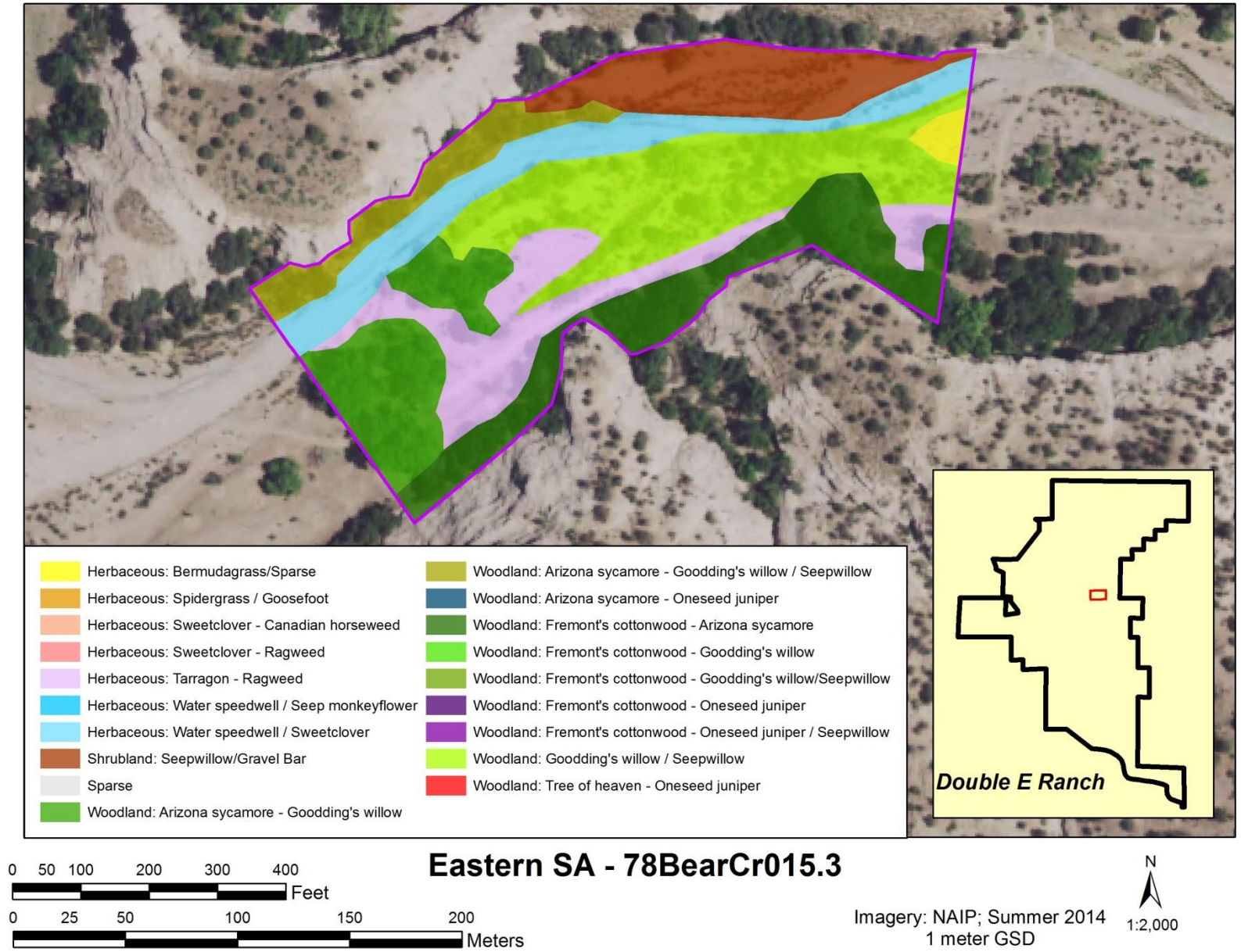

Figure 11. Vegetation Polygon Map for Eastern SA – 78BearCr015.3.

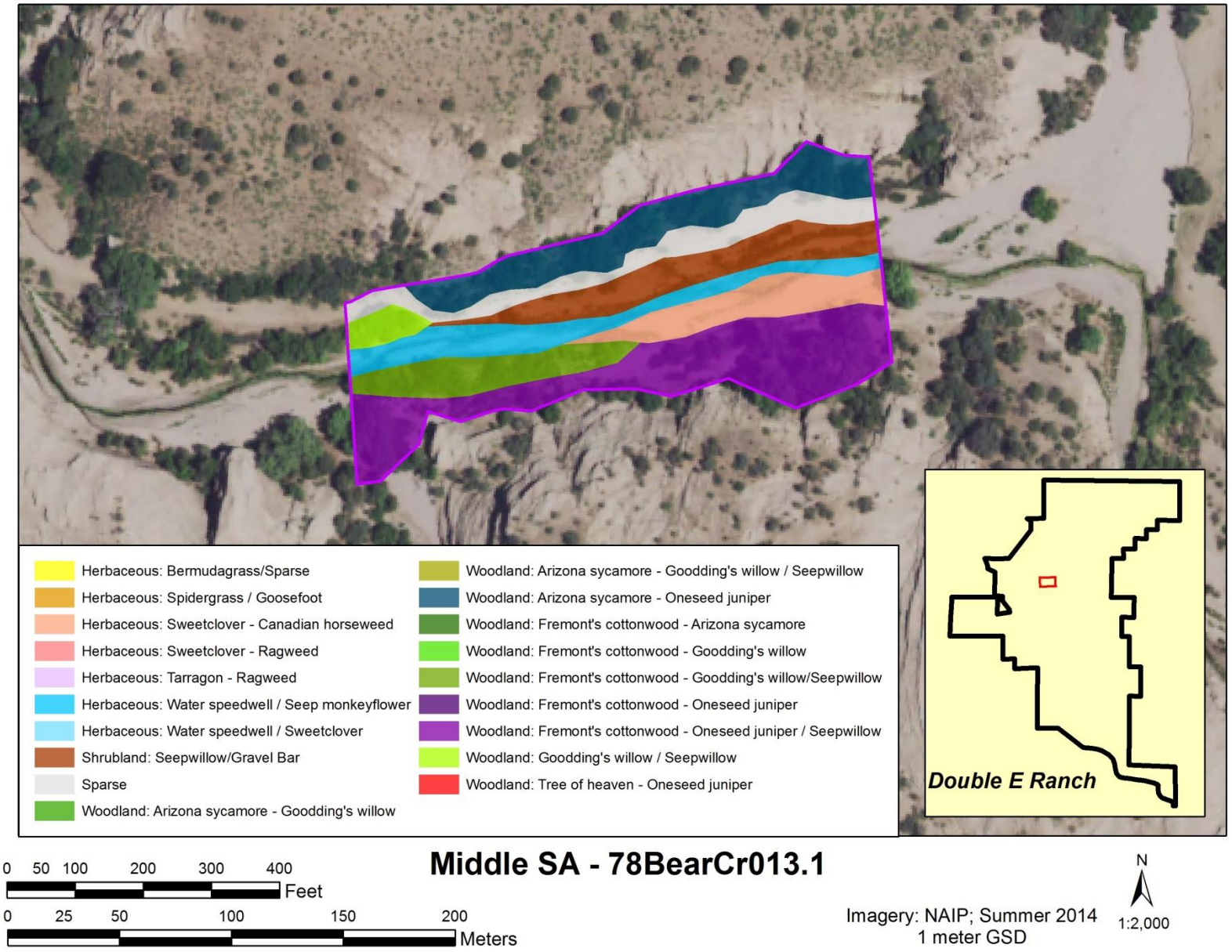

Figure 12. Vegetation Polygon Map for Middle SA – 78BearCr013.1.

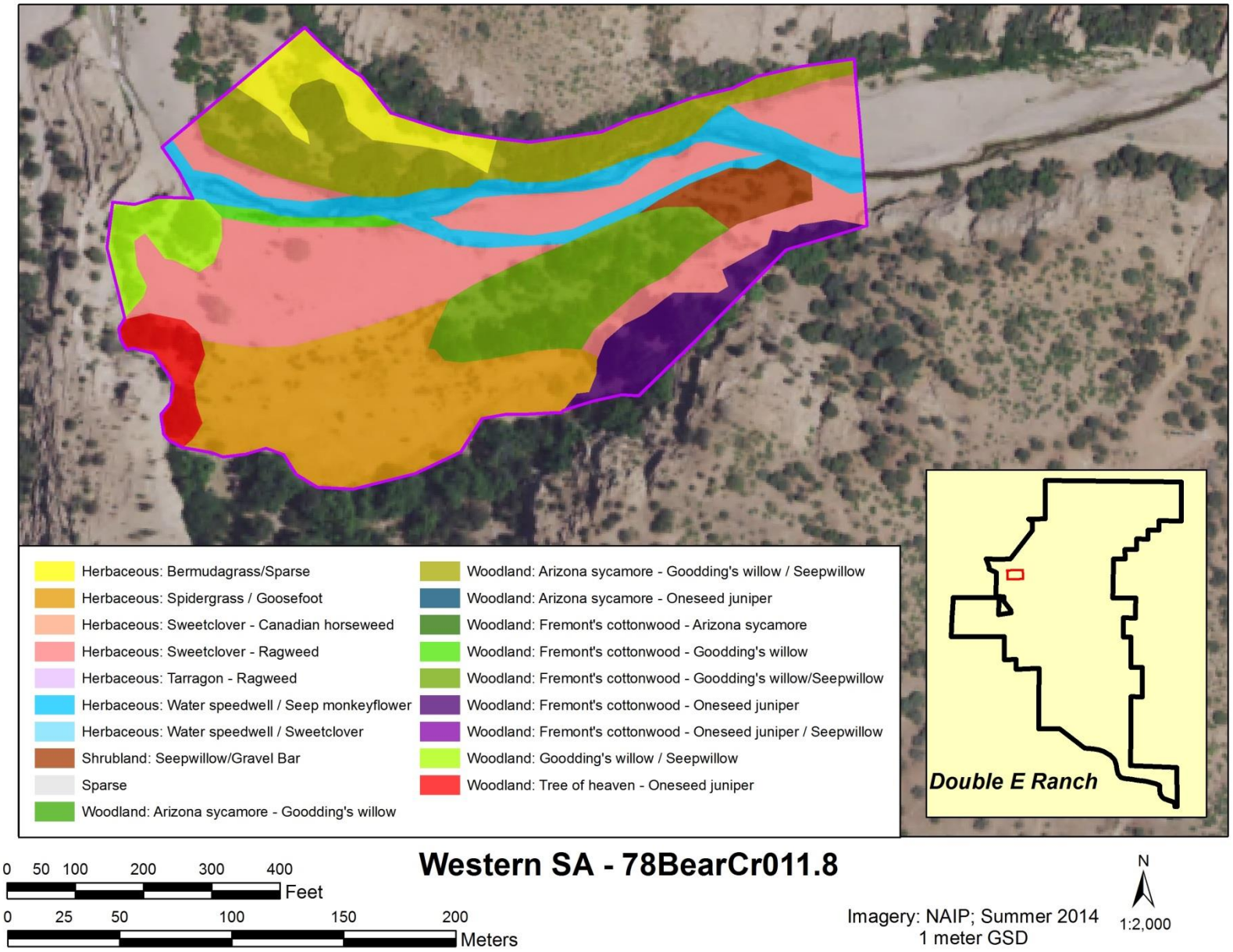

Figure 13. Vegetation Polygon Map for Western SA – 78BearCr011.8.

Table 6. Overall NMRAM site scoring rating table.

Rank	Score	Description
A	>3.25-4.0	Excellent Condition
B	>2.5-3.25	Good Condition
C	>1.75-2.5	Fair Condition
D	1.0-1.75	Poor Condition

Discussion

The remoteness of the Double E Ranch from urban and town centers provides favorable landscape context for the site and this is reflected by the high Landscape Context ratings. While the ranch is in overall excellent condition, and should remain so as long as it is protected from development, there are areas where particular management intervention is needed to maintain condition. The abiotic and biotic data point to a history of highly dynamic fluvial processes that lent to the inherent riparian vegetation and habitat diversity on the ranch. However, the biotic data indicate concerns over invasive species, while the abiotic data indicate protection of the water sources and limitation of anthropogenic soil disturbance are key to continued ecosystem health.

Bear Creek within the Double E has a narrow floodplain and an intermittent flow regime during portions of the year. Hence, it lies at the limit of what the NMRAM defines as a lowland, unconfined, perennial stream. Regardless, the Lowland NMRAM provides the best fit available for this system, however the NMRAM scores should be interpreted with the understanding that this is a system that deviates from the Lowland reference type. The narrower floodplain constrains to some degree the development of a complex vegetation patch mosaic, and this in turn lowers biotic and abiotic metrics such as Vegetation Horizontal Patch Structure, Vegetation Vertical Structure, and Physical Patch Complexity. In addition, because of the narrowness of the canyon and the large number of ephemeral tributaries, flash flooding on the Double E is probably both frequent and of a magnitude sufficient to fill the majority of the floodplain. This excessive disturbance may further limit the development of complex vegetation patches, particularly with regard to vertical vegetation complexity. Large flood events likely remove many young trees, shrubs and perennial herbaceous vegetation. This would explain why young woodland and shrubland patches throughout the canyon were small, and patchily distributed. The general lack of well-developed perennial herbaceous vegetation may also be due to the disruptive effect of large ephemeral flood events. The degree to which these ephemeral flash flood events exceed normal conditions as a function of upper watershed alterations is unknown at this time. That is, lowered scores could be a function of both the natural confinement of the canyon that limits wetland expression in the floodplain and watershed-scale stressors.

There were 19 different vegetation patch types mapped as part of the Biotic Metric data collection process (Figs. 11 to 13). These patches represent eight recognized plant communities and five provisional plant communities in the U.S. National Vegetation Classification[11] (Table 2). Although detailed community composition data was not collected as part of the NMRAM process, there is a wealth of published data available on the majority of the vegetation communities observed on the Double E Ranch. The ranch's forest communities, dominated by Fremont's cottonwood, Arizona sycamore and Goodding's willow, are all considered globally rare and highly threatened due to altered hydrologic regimes, flood control structures, and land conversion.

Figure 14. Very large Fremont's cottonwood in the Eastern SA, typical of scattered very large individuals throughout the canyon.

Small stands of globally rare and important riparian forest habitat types are scattered throughout the Bear Creek canyon on the Double E (see Figs. 11 to 13). While the size of these stands is limited by the narrowness of the canyon and the frequency of flood events, there are stands of both very large old trees and younger regeneration trees (see Fig. 11-13; Fig. 14). Shrublands throughout the ranch also tend to be small and patchy. While the frequency of large flood events likely plays a role, past livestock browsing and off-road vehicle traffic may have also reduced their extent. Accordingly, protecting the canyon from disturbance by livestock and off-road vehicles will allow shrub layers to reach the maximum extent possible within the physical and hydrological limitations of the canyon. Herbaceous wetlands were limited to communities dominated by water speedwell within the active channel and weedy (ruderal) communities on adjacent bars and terraces. The ruderal nature of the bar and terrace herbaceous communities may also be driven by flash-flood events through the narrow canyon. It was the prevalence of these ruderal herbaceous communities, often dominated or co-dominated by exotic species, that caused the Relative native plant community composition score for the ranch to be in the Good, rather than Excellent, category.

Invasive exotic weeds are a potential threat. While scattered individual Siberian elms were recorded in all three SAs, they are not as much of a concern as the two patches of tree of heaven (see Fig. 10). Tree-of-heaven is a pernicious root-sprouter, and can rapidly take over an area. Once established, tree of heaven is hard to eradicate and requires treatment with

[11] Available on http://usnvc.org/

herbicide, followed by mechanical removal, and repeated herbicide treatment on all resprouts.[12] We would recommend that the observed patches be treated to prevent their expansion and disruption of native habitat. We would also recommend a careful survey of the whole canyon for tree of heaven prior to treatment, to assure that all individuals are removed.

From the perspective of a multi-channel lowland system, the ranch appeared to be relatively well connected hydrologically (Good rating). A primary concern is that the ranch water sources be protected to ensure long-term sustainability of its biological resources. With two surface-water-dependent listed species present (loach minnow and Chiricahua leopard frog), keeping surface water in the channel throughout the year should be a priority. In addition, protecting the groundwater from being depleted by water withdrawals, and management aimed at limiting disturbance to the active channel and floodplain within the ranch should aid hydrologic connectivity in the long term.

The metrics for Hydrologic Connectivity, Channel Stability, and Stream Bank Stability and Cover all show a low level of impairment (Good rather than Excellent). But the intermittent nature of Bear Creek is not well understood for the riparian corridor of the ranch and the intermittency of flow is not well reflected in the NMRAM metrics designed for perennial rivers reference conditions. It is not known if Bear Creek has always been intermittent in this reach, or if it became intermittent due to upstream land uses (mining, fire suppression, past logging practices, grazing, etc) that altered run-off and sediment loads in the watershed. We know that there have been major changes in the upper watershed over the past 150 years. It is possible that lower Bear Creek was once perennial throughout and, thus, may have had more stable channel morphology, densely vegetated banks, and no aggradation. These questions are beyond the scope of an NMRAM assessment, but could be addressed by a more detailed hydrological analysis. The benefits of such an analysis would be a deeper understanding of the nature of the system, and better guidelines for management and potential restoration.

The presence of the legacy road graded through the stream channel should be addressed. Maintaining this road and re-grading it is a threat not only to overall soil surface condition and erosion, but also through the alteration of channel geometry, which may impact hydrological connectivity, vegetation patch structure on adjacent bars and terraces, and surface water availability. In addition, road repair and traffic on the road could lead to direct impacts on habitats and individuals of federally listed species. Thus, we recommend that the road be decommissioned through active restoration or simply not be repaired, and that vehicle traffic of all kinds be limited and kept out of the active channel wherever possible.

Summary of Recommendations

In summary, we make the following recommendations for riparian habitat management on the ranch:

[12] Personal communication from Chad McKenna, GeoSystems Analysis, Inc.

1. Protect the base flow in the active river channel throughout the year in keeping with the property's water rights. This will also help protect the ground water resources that are key to sustainability of the wetland ecosystems of the ranch.

2. Do not maintain the dirt road in the canyon bottom and develop a roadway restoration plan. As much as possible keep motorized vehicle traffic out of Bear Creek canyon, especially out of the active channel.

3. If grazing of the Double E is considered, livestock use should be carefully monitored, and access to the riparian zone and active channel should be limited or excluded.

4. Removal now of the scattered patches of tree of heaven, a highly invasive and exotic tree species, could save money and environmental disruption in the future when it may become more pervasive. Treatment should follow established protocols for tree of heaven, and be repeated for at least one growing season to be effective. If left in place these trees may interfere with native riparian tree reproduction.

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