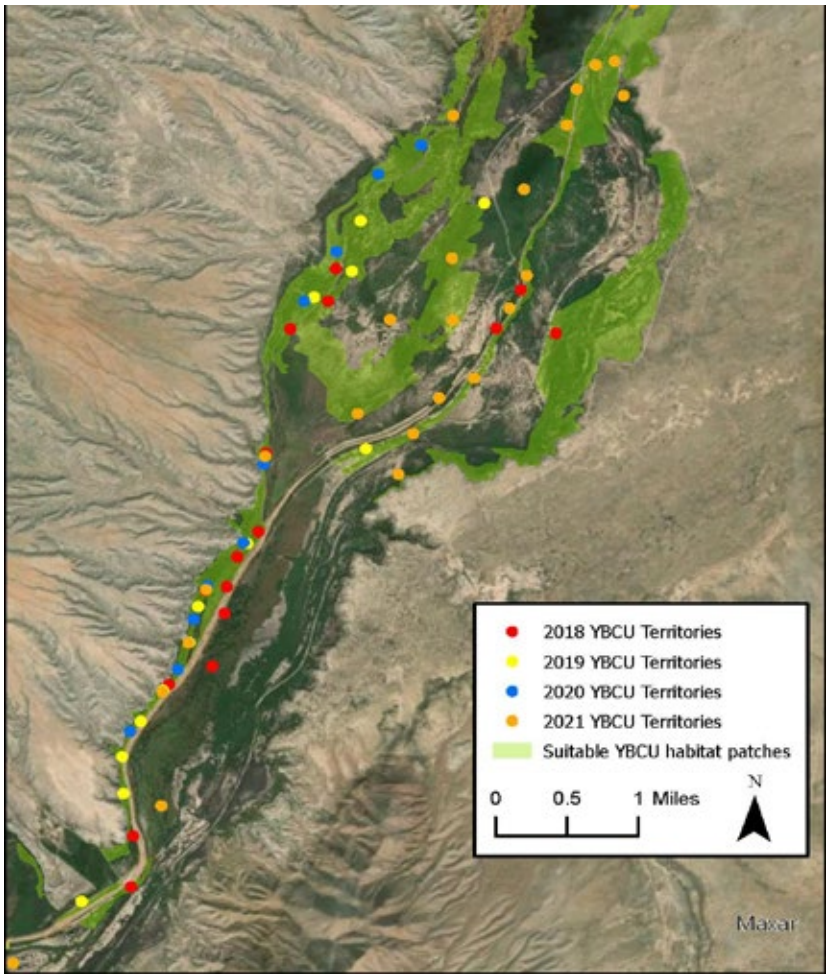
BUREAU OF RECLAMATION

Technical Report No. ENV-2022-058

Western Yellow-billed Cuckoo Breeding Habitat Suitability

Middle Rio Grande, New Mexico
Upper Colorado Basin



U.S. Department of the Interior **May 2022**

Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Cover Photo – Western yellow-billed cuckoo territories and suitable habitat patches in a portion of Elephant Butte Reservoir delta.

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Prepared by:

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Acronyms and Abbreviations

ac	acres
ft	feet
GIS	Geographic Information Systems
ha	hectares
m	meters
MRG	Middle Rio Grande
Reclamation	Bureau of Reclamation
RM	River miles
SWFL	Southwestern willow flycatcher
USFWS	U.S. Fish and Wildlife Service
YBCU	Western yellow-billed cuckoo

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Introduction/Background

The western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), hereafter YBCU or cuckoo, is a neotropical migratory bird whose population has been in steep decline due primarily to habitat loss and degradation (Dillon and Moore 2021). This species nests in large, dense patches of riparian vegetation, particularly with a Goodding's willow (*Salix gooddingii*)/ cottonwood (*Populus deltoides*) overstory (Ehrlich et al. 1988, Hughes 1999, USFWS 2014). Populations of breeding YBCUs have historically occupied the Rio Grande riparian corridor (Howe 1986). The Bureau of Reclamation (Reclamation) Technical Service Center (TSC) began formal surveys for the YBCU in the Middle Rio Grande (MRG) in 2006 and has continued annual surveying and monitoring efforts since that time. The YBCU was listed as threatened under the Endangered Species Act in 2014 and critical habitat was formally designated in 2021. Habitat modeling and monitoring are required by the USFWS to meet the obligations of the MRG Biological Opinion (USFWS 2016).

In 2021, Reclamation conducted field-based vegetation mapping as a basis for the required habitat modeling. Mapping was carried out in conjunction with a Geographic Information Systems (GIS)-based inventory in riparian areas along the Rio Grande from Los Lunas to Elephant Butte Reservoir in New Mexico (Figure 1). Mapping methods employed a classification system created by the MRG Biological Survey (Hink and Ohmart 1984) with minor modifications. Hink and Ohmart conducted an exhaustive biological analysis of the Rio Grande that included a classification of vegetation community and structure in the riparian zone of the river (levee to levee). In addition, bird and mammal abundance were correlated with vegetation types, making this system useful for determining wildlife and habitat associations.

Prior to vegetation mapping in 2021, six previous mapping projects were conducted by Reclamation along the MRG:

1. *San Acacia Diversion Dam to Elephant Butte Reservoir; 1998 (Ahlers and White 1999).* The initial maps were basic and the beginning stages in creating the SWFL habitat model; data collected and protocol applied have evolved with time.
2. *Chama River in New Mexico from El Vado Dam to the confluence with the Rio Grande and continuing south along the Rio Grande to Elephant Butte Reservoir; 2002-2004 (Callahan and White 2004).* This effort was specific to Upper Rio Grande Water Operations (URGWOPS).
3. *Full pool elevation of Elephant Butte Reservoir (4407 feet) to Monticello Bay; 2005.* Data collected were to update previous information as the reservoir receded.
4. *Highway 60 to Elephant Butte Reservoir; 2008 (Ahlers et al. 2010).* This map was the first to be used to formally develop the current SWFL habitat suitability model.
5. *Los Lunas, New Mexico to Elephant Butte Reservoir; 2012 (Siegle et al. 2013).* This map was specific to the SWFL habitat suitability model.

6. *Los Lunas, New Mexico to Elephant Butte Reservoir; 2016 (Siegle and Ahlers 2017).* This map was the first to be used to formally develop the YBCU habitat suitability model.

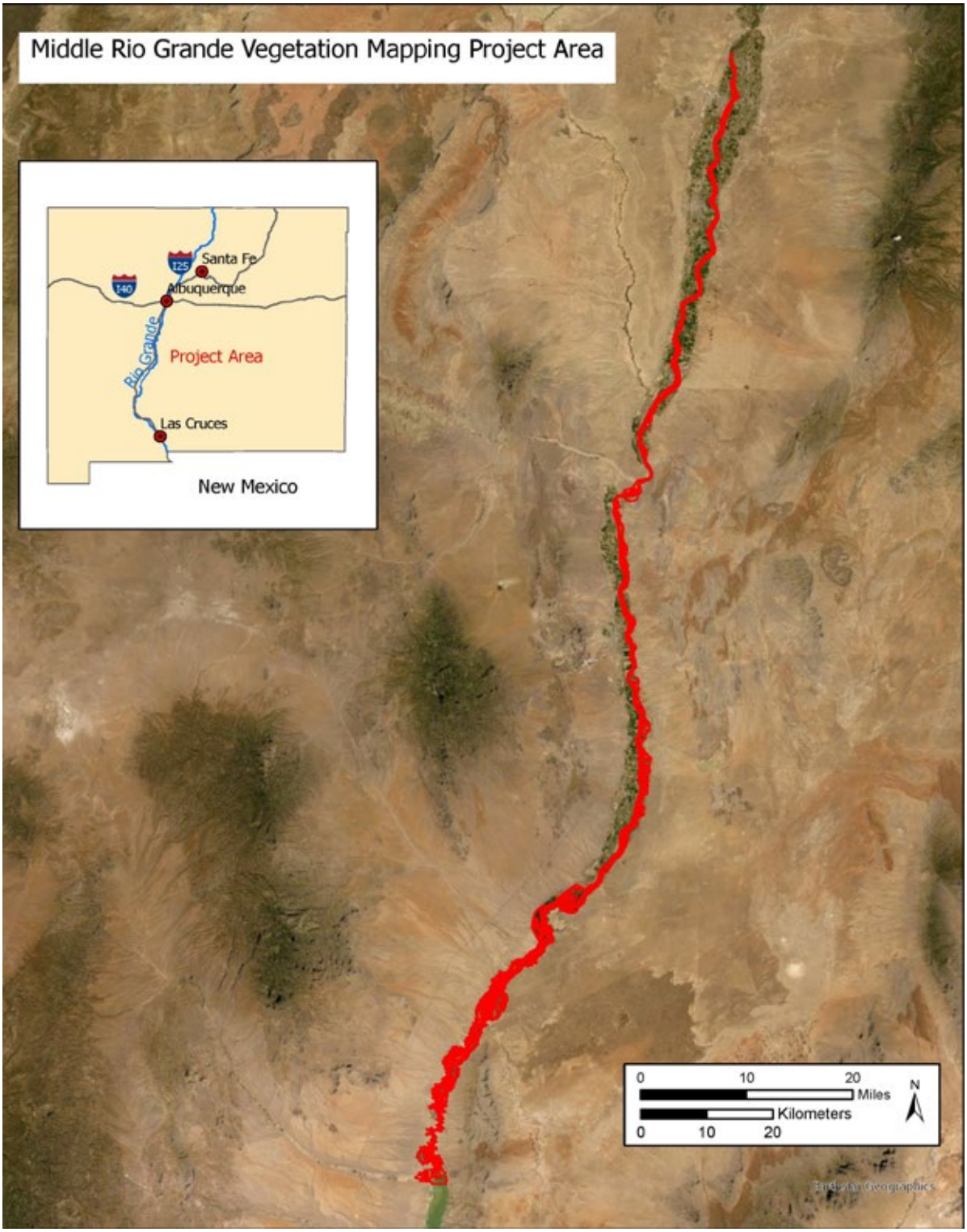


Figure 1. Vegetation Mapping Project Area.

The objectives of these mapping projects were to capture trends in the development of vegetation within the study area as well as to identify potentially suitable habitat for the endangered Southwestern willow flycatcher (*Empidonax traillii extimus*; SWFL). Development of a SWFL habitat suitability model was initiated in 1998 and has been updated with each mapping period. In 2016, the focus of the project was expanded to include the cuckoo and a habitat suitability model was developed in 2018 (Siegle et al. 2018). Although YBCU territory data were available since TSC surveys began in 2006, and these data were used to develop the model, this report only includes data for the two mapping periods to which the habitat suitability model was applied (i.e., 2016 vegetation map with 2013 to 2016 YBCU territories, and 2021 vegetation map with 2018 to 2021 YBCU territories).

The intent of the model was to provide data that could be used for making land management decisions in areas that were either occupied or likely to be occupied by YBCUs. These data provide information for determining the extent of improving or deteriorating habitat conditions and the amount of suitable habitat that is available, and to assist in guiding restoration efforts within the study area.

Evaluation of habitat conditions is an ongoing process carried out through comparisons of past and present mapping efforts. Assessment of vegetation mapping data over time can aid in identifying factors that may cause trends in vegetation development, such as changes in density, structure, and species composition. As the SWFL habitat model has evolved over time, it has become apparent that an adaptive management approach to applying the model is essential; the same approach for the YBCU habitat suitability model is anticipated. This model was developed for general planning purposes and was not intended to be used as a substitute for site specific assessment. The model is also specific to YBCUs occupying the MRG and may not be applicable to other areas in which cuckoos have been detected.

Methods

There were two stages of this mapping project: vegetation mapping and habitat modeling. The vegetation mapping phase began with on-the-ground verification, during which biologists were in the field collecting information pertaining to characteristics of the vegetation within the mapping area. Aerial imagery was used to delineate different vegetation types as data were gathered. These data were then used to classify each vegetation community type. GIS was used to produce vegetation maps with the recently collected data.

In the modelling phase, YBCU detections from 2018 to 2021 were overlaid onto the vegetation maps to apply the habitat suitability model, which was developed using YBCU telemetry and detection data and vegetation maps from 2007 to 2016.

Both English and metric measures are used in this report based on differing measures in protocol, other MRG studies, and literature. Conversions are shown the first time the measure is used.

Vegetation Mapping

Fieldwork was conducted between May and August 2021 along the MRG. The project area consisted of approximately 127 river miles (RM) – from RM 166 (Los Lunas, NM) downstream to RM 37 (Elephant Butte Reservoir). There were 725 acres (ac; 293 hectares [ha]) of private property within the project area that were not mapped.

Aerial imagery was used for base maps in the field. Aerial photography was acquired in 2020 by the U.S. Department of Agriculture, National Agriculture Imagery Program (NAIP New Mexico 1 meter [m] Natural Color). A field map was created using 2020 aerial imagery overlaid with polygons from the previous mapping effort. Polygon boundaries were revised as needed based on photo interpretation of the recent imagery. Center points were marked for each polygon, which provided a waypoint to navigate towards while evaluating vegetation in the respective polygon.

Biologists used Apple iPad 8th generation units onto which the polygon map (created in ArcGIS Online) and ArcGIS Collector version 21.0.1 app were downloaded. These devices allowed mappers to navigate towards waypoints with the ability to know their location on the ground and their proximity to the mapped polygons at all times. If ground-truthing proved that vegetation boundaries had changed since previous mapping, polygons were revised on the field map and the extent of similar vegetation was estimated. In general, polygons larger than 1 acre were mapped. The Collector app was used to mark locations that best represented the polygon (typically near the center of the polygon). A photograph was taken at the waypoint to document the vegetation community and structure of each polygon.

Biologists entered data into Collector for each polygon. Data that were gathered included parameters shown in Figure 2. A hard copy of this data sheet was used in cases where new polygons were created since Collector did not have the capability to enter data for polygons that were not already loaded onto devices. Collector was synced with ArcGIS Online daily to update the vegetation polygon map with the recently collected data.

The Modified Hink and Ohmart vegetation classification process included categorizing vegetation polygons into community types and structure classes using an alphanumeric descriptive code. Each woody riparian plant species was assigned a letter code (i.e., the species code, see Table 1 which also includes scientific names for all species detected). Codes were also assigned for non-woody vegetation and non-vegetated land types which were considered non-habitat (Table 2).

The Modified Hink and Ohmart code consisted of species codes for the canopy layer, species codes for the understory layer, and a community type number signifying the height and density of each layer. Community type classifications are described in Table 3. Overall, Types 1 and 2 were mature forest, Types 3 and 4 were intermediate aged forest or woodland, and Types 5 and 6 were shrub habitats (Hink and Ohmart 1984). Types 1 and 3 had a substantial understory while Types 2 and 4 had sparse understory.

In the field, the mapping process began by estimating total percent canopy cover in 4 layers of woody vegetation which included 2 overstory layers (i.e., >40 feet (ft) and 15-40 ft; >12 m and 4.6-12 m) and 2 understory layers (i.e., 5-15 ft and 0-5 ft; 1.5-4.6 m and 0-1.5 m). Plant species were recorded based on relative percentage of cover within each layer, with the most dominant species listed first. Species within the same layer were separated by a hyphen (-). Canopy and understory layers were separated by a back-slash (/). Typically, one or two species were recorded for each layer, but as many as 4 species could qualify. Each height category in both layers (i.e., canopy and understory) had to comprise at least 25 percent total cover to qualify as a component in classification types and only one of the height categories in each layer was used for classification purposes (whichever was dominant). Each species had to cover at least 25 relative percent of the vegetation to be included in the Modified Hink and Ohmart classification code. Plant cover, along with tree and shrub height, was determined by visual estimates.

The Modified Hink and Ohmart code was written in the following format:

When a canopy and understory layer of $\geq$ 25% total cover were present:
Canopy Layer / Understory Layer + Type (1 or 3)
Example: C-TW/SC3

When a canopy layer was present with less than 25% total understory cover:
Canopy Layer + Type (2 or 4)
Example: C2

When a canopy layer was not present and understory layer was $\geq$25% total cover:
Shrub or Young Growth Layer + Type (5 or 6)

Example: SC-B5

H&O Classification Form						
Date			**Recorder**			
Polygon ID						
Photo Number						
UTM NAD 83 Coordinates	**x**					
	y					
Riparian Woody Vegetation						
	Overstory					
	>40 ft	Total % Cover	1-24%	**25**-49%	**50**-74%	**75**-100%
		Total % Dead	1-24%	**25**-49%	**50**-74%	**75**-100%
	Species (Relative foliage cover) - Circle one for each species present with most dominant 1st then decreasing dominance					List
Species Codes	>40 Species #1		1-24%	**25**-49%	**50**-74%	**75**-100%
ATX = Fourwing saltbush	>40 Species #2		1-24%	**25**-49%	**50**-74%	**75**-100%
B = Baccharis spp.	>40 Species #3		1-24%	**25**-49%	**50**-74%	**75**-100%
C = Cottonwood	**15-40 ft**	Total % Cover	1-24%	**25**-49%	**50**-74%	**75**-100%
CAT = Cattail		Total % Dead	1-24%	**25**-49%	**50**-74%	**75**-100%
CR = Creosote	**Species (Relative foliage cover) -** Circle one for each species present					
CW = Coyote willow	15-40 Species #1		1-24%	**25**-49%	**50**-74%	**75**-100%
HMS = Honey mesquite	15-40 Species #2		1-24%	**25**-49%	**50**-74%	**75**-100%
MB = Mulberry	15-40 Species #3		1-24%	**25**-49%	**50**-74%	**75**-100%
NMO = New Mexico olive	15-40 Species #4		1-24%	**25**-49%	**50**-74%	**75**-100%
RO = Russian olive	***Understory***					
SBM = Screwbean mesquite	**5-15 ft**	Total % Cover	1-24%	**25**-49%	**50**-74%	**75**-100%
SC = Saltcedar		Total % Dead	1-24%	**25**-490%	**50**-74%	**75**-100%
SE = Siberian elm	**Species (Relative foliage cover) -** Circle one for each species present					
TH = Tree of heaven	5-15 Species #1		1-24%	**25**-49%	**50**-74%	**75**-100%
TW = Tree willow	5-15 Species #2		1-24%	**25**-49%	**50**-74%	**75**-100%
WB = Wolfberry	5-15 Species #3		1-24%	**25**-49%	**50**-74%	**75**-100%
	5-15 Species #4		1-24%	**25**-49%	**50**-74%	**75**-100%
	<5 ft*	Total % Cover	1-24%	**25**-49%	**50**-74%	**75**-100%
		Total % Dead	1-24%	**25**-490%	**50**-74%	**75**-100%
	Species (Relative foliage cover) - Circle one for each species present					
	<5 Species #1		1-24%	**25**-49%	**50**-74%	**75**-100%
	<5 Species #2		1-24%	**25**-49%	**50**-74%	**75**-100%
	<5 Species #3		1-24%	**25**-49%	**50**-74%	**75**-100%
	<5 Species #4		1-24%	**25**-49%	**50**-74%	**75**-100%
*Circle cover type for areas with woody vegetation < 25 %						
Wetlands/Herbaceous Vegetation /Non-vegetated						
MH = Cattail marsh	MH = Wet Meadow (sedges, rushes)		MS = Grass Meadow			
OW = Open Water	OP = Open Area (<25% woody vegetation cover)					
Notes:						

Figure 2. Data form used for the Modified Hink and Ohmart vegetation classification and mapping**.**

Table 1. Plant species codes

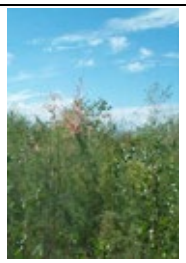
Species code	Common name	Scientific name
ATX	Fourwing saltbush	*Atriplex canescens*
B	Seep willow/willow baccharis	*Baccharis salicifolia, B. salicina*
C	Cottonwood	*Populus* spp
CAT	Cattail	*Typha* spp
CR	Creosote	*Larrea tridentata*
CW	Coyote willow	*Salix exigua*
HMS	Honey mesquite	*Prosopis glandulosa*
MB	Mulberry	*Morus* spp
NMO	New Mexico olive	*Forestiera pubescens*
RO	Russian olive	*Elaeagnus angustifolia*
SBM	Screwbean mesquite	*Prosopis pubescens*
SC	Saltcedar	*Tamarix* spp
SE	Siberian elm	*Ulmus pumila*
TH	Tree of heaven	*Ailanthus altissima*
TW	Goodding's willow*	*Salix gooddingii*
WB	Wolfberry	*Lycium torreyi*

*Hink and Ohmart referred to this species as tree willow, thus TW code

Table 2. Codes used for non-woody vegetation and land types

Code	Non-woody vegetation or land type
MS	Dry meadow (grasses)
MH	Wet meadow/marsh with cattail, sedge, rush or other wetland species
OP	Open area (woody vegetation <25% aerial coverage)
OW	Open water
Channel	Rio Grande
LFCC	Low Flow Conveyance Channel
Road	Road
RR	Railroad

Table 3. Descriptions of community types used in the Modified Hink and Ohmart

Classification		
Type 1 Tall/mature trees with well-developed understory	Tall or mature-aged trees (>40 ft) with canopy covering ≥ 25% of the area of the community (polygon) ***and*** understory layer (0-15 ft) covering ≥ 25% of the area of the community (polygon). *Type 1d* – Type 1 with ≥ 50% total cover of one of the layers (canopy or understory)	
Type 2 Tall/mature trees with little or no understory	Tall or mature-aged trees (>40 ft) with canopy covering ≥ 25% of the area of the community (polygon) ***and*** understory layer (0-15 ft) covering < 25% of the area of the community (polygon) *Type 2d* – Type 2 with ≥ 50% total cover of the canopy layer	
Type 3 Intermediate-sized trees with well-developed understory	Intermediate-sized trees (15-40 ft) with canopy covering ≥ 25% of the area of the community (polygon) ***and*** understory layer (0-15 ft) covering ≥ 25% of the area of the community (polygon) *Type 3d* – Type 3 with ≥ 50% total cover of one of the layers (canopy or understory)	
Type 4 Intermediate-sized trees with little or no understory	Intermediate-sized trees (15-40 ft) with canopy covering ≥ 25% of the area of the community (polygon) ***and*** understory layer (0-15 ft) covering < 25% of the area of the community (polygon) *Type 4d* – Type 4 with ≥ 50% total cover of the canopy layer	
Type 5 Shrub-sized stands	Understory layer (5-15 ft) covering ≥ 25% of the area of the community (polygon) with no overstory layer. *Type 5d* – Type 5 with ≥ 50% total cover of the understory layer	
Type 6 Very young and/or low growth	Understory layer (0-5 ft) covering ≥ 25% of the area of the community (polygon) with no overstory layer.	

As aforementioned, the Hink and Ohmart methodology was modified to meet the needs of this particular mapping effort (i.e., to provide data for the SWFL and YBCU breeding habitat models). The following describes these modifications that were either exceptions or revisions to the original Hink and Ohmart study.

a) Typically, polygons were greater than 1 acre in size, but if there was exceptional existing avian habitat or potential for avian habitat to develop, smaller polygons were delineated.

b) For all "non-woody" vegetation classes (i.e., non-habitat), no community type number was attached to the code. "MH" was defined to mean "marsh" or an area that was inundated with water for most of the survey season (i.e., wetland).

c) Only live canopy trees and understory shrubs were included in the classification. The Modified Hink and Ohmart classification pertained solely to green, growing woody vegetation. The percentage of dead woody vegetation in the stand was documented.

d) If a polygon had either two canopy or two understory layer components that were greater than 25 percent in cover, the community type fell under the height/age class of the layer with the highest cover. For example, if an overstory layer that was greater than 40 ft in height had a canopy cover of 25-50 percent and an overstory layer that was 15-40 ft in height had a canopy cover of 51-75 percent, then the polygon was classified as a 'Type 3 or 4' depending on whether or not the understory was over 25 percent in cover. If both height categories in each of the canopy or understory layers were < 25%, then that layer was not classified.

e) A "d" qualifier was added to the Modified Hink and Ohmart code following type number if total vegetative cover was equal to or greater than 50 percent. The "d" signified "dense" and was meant to be an indicator for potential SWFL habitat (density did not appear to be a vital characteristic for YBCU habitat).

Field maps were digitized with ArcGIS Pro software. Using the digital aerial imagery as a backdrop, the 2016 polygon boundaries were revised if necessary based on the current field maps. This part of the process involved photo interpretation. In many places, the polygon boundary was clearly delineated on the aerial photo by an obvious change in vegetation that was not distinguished by biologists in the field. In areas where the boundary was not distinct, the location of the line was estimated based either on mapping notes and drawings or photo interpretation.

Vegetation maps were produced incorporating the updated information with each polygon assigned a classification code and a major plant community type code. Vegetation maps were then used to determine YBCU habitat suitability of the vegetation types that were classified in the study area.

Habitat Modeling

Criteria for the habitat suitability model were developed by evaluating the distribution and habitat use of cuckoos along the MRG based on 1) telemetry studies and 2) single detections and territory estimations identified in presence/absence surveys. Modeling focused on nesting habitat requirements, not other habitat variables such as foraging.

During the summers of 2007 and 2008, 13 cuckoos within the study area were captured and affixed with radio transmitters in an effort to determine daily and seasonal movements, and to estimate the extent of home ranges and habitat use (Sechrist et al. 2009). Of the 13 birds, 10 provided usable information. In formal surveys from 2009 to 2016, single detections were defined as the documented presence of a YBCU during a survey, thus a single individual may have multiple detections over the season (Dillon and Moore 2021). YBCU detection data becomes the primary source of territory estimation data, determined by analyzing distribution patterns of single detections over the entire breeding season. For analysis purposes pertaining to the habitat suitability model, a 150 m (492 ft) buffer surrounding each territory point was used to create a plot approximately 7 ha (17.3 ac) in area. The 2007/2008 telemetry studies found that the average 50 percent kernel home range size of YBCUs along the Rio Grande was 7.14 ha. Single detection points and territory plots were overlaid on vegetation maps to assess habitat types in which YBCUs were most commonly found. Detection and territory data were analyzed based on three collection periods in association with vegetation mapping: 1) 2009 YBCU data overlaid on the 2008 vegetation map; 2) YBCU data from 2011 to 2013 overlaid on the 2012 vegetation map; and 3) 2015 and 2016 YBCU data overlaid on the 2016 vegetation map. For the purposes of creating the model, the available territory data were matched to vegetation maps that were the most closely correlated with respect to time. Accordingly, the most recent vegetation is represented at the time cuckoos were detected. This approach did, however, result in territory data collected more than a year before or after mapping dates to be eliminated from analysis. Detection point data were analyzed as counts while territory polygon data were analyzed using area by vegetation type within the 7-ha plots.

Many studies have documented important characteristics of YBCU habitat, which were used to focus on certain variables in creating the model. Most information indicates the importance of specific, finite, patch-level vegetation community composition and structure, generally consisting of multi-structured or multi-layered riparian vegetation with substantial canopy cover provided by native riparian trees, particularly willows and cottonwoods (Johnson et al. 2017). Riparian patches used by breeding cuckoos vary in size and shape, ranging from a relatively contiguous stand of mixed native/exotic vegetation to an irregularly shaped mosaic of dense vegetation with open areas (Halterman et al. 2015). Patch size has generally been documented to be within a range of 15 to 80 ha (37 to 198 ac; Halterman et al. 2015; Johnson et al. 2017) of contiguous riparian habitat. YBCUs have not been found nesting in isolated patches 0.4–0.8 ha (1-2 ac) or narrow, linear riparian habitats that are less than 10-20 m (33-66 ft) wide (Halterman et al. 2015). Studies on the Sacramento River in California and the Verde River in Arizona identified a minimum patch width for YBCU habitat as 100 m (330 ft; Holmes et al. 2008;

Girvetz and Greco 2009). Based on the literature, variables examined in creating the YBCU habitat suitability model for the MRG were plant species composition; stand structure and density; and patch size and width. The methods of analysis used in determining model thresholds are described in detail in the previous YBCU habitat suitability report (Siegle et al. 2018).

The importance of native overstory in YBCU habitat was clearly supported by both detection and territory data collected along the MRG. Based on this information, and supported by literature, native overstory criteria became the foundation from which to build the rest of the model. Further analysis to estimate size (i.e., area and width) of suitable YBCU habitat patches was carried out using "native overstory patches", defined as contiguous native dominated overstory. A patch typically included a number of the Hink and Ohmart polygons that were delineated in vegetation mapping; if adjacent Hink and Ohmart polygons were composed of native overstory then those polygons were grouped into a patch. A patch could potentially be composed of a single Hink and Ohmart polygon if that polygon was not surrounded by others with a native overstory. The habitat suitability model used native overstory patches as a measure for determining the extent of YBCU habitat.

Thresholds for the YBCU habitat suitability model were established using the criteria developed in data analyses while simultaneously recognizing the goals of the project. The main objectives of the model were to capture key habitat variables that YBCU seem to prefer in nesting habitat, in turn helping resource managers understand the distribution and abundance of suitable YBCU habitat within the MRG while working towards preserving or creating this type of habitat. It was not intended to quantify the extent of *all* potential nesting patches nor was it intended to illustrate only the optimal habitat, which would be unrealistic to recreate in today's landscape.

Based on these parameters, habitat variable criteria were identified to define "suitable" YBCU nesting habitat used in the model:

- Patches with native overstory
- Patch size $\geq$ 8 ha (19.8 ac)
- Patch width > 30m (98.4 ft)
- Goodding's willow component

All four of these criteria must be met for a patch to qualify as suitable YBCU breeding habitat. For clarification, a Goodding's willow component was determined if any of the polygons within a patch included the species in Hink & Ohmart vegetation classifications. Inclusion of Goodding's willow in the under- or overstory layers of the classification codes required that relative percent cover of the species was 25 percent or greater. Figure 3 presents an example of suitable patch creation. Note that not all Hink and Ohmart polygons contain Goodding's willow (TW) in this figure, however the contiguous native patch does.

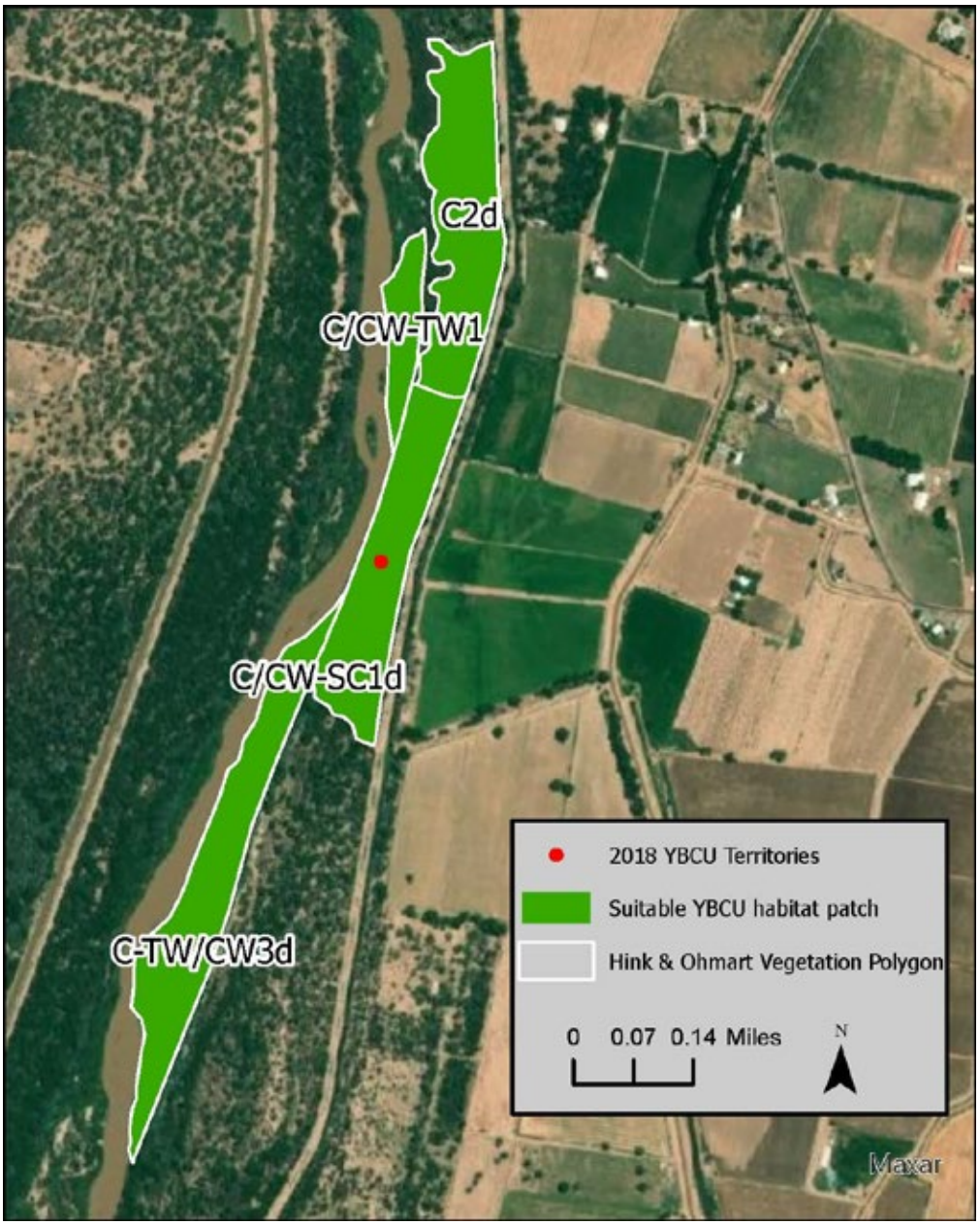


Figure 3. An example of Goodding's willow inclusion in native overstory patches composed of four Hink and Ohmart vegetation polygons.

From 2017 to 2019, telemetry studies in the MRG provided additional YBCU habitat data following development of the model in 2018. Fourteen cuckoos provided usable data and eight cuckoo nests were found. Habitat within 50 meters (164 ft) of the nests was sampled and analyzed to better characterize breeding habitat. Parameters measured included woody species composition, cover, and height. Although these data were not available until after development of the model, they do provide supplemental information for characterizing cuckoo breeding habitat and results are presented in this report.

Results and Discussion

Results of 2021 vegetation mapping and YBCU habitat suitability modeling are provided in the Appendix. This information is organized by river reach (Figure 4) and by river mile. Data are summarized by reach and include the number of acres and hectares of suitable, unsuitable, and non-habitat; the number of acres of each dominant vegetation type; the number of YBCU territories from 2018 to 2021; and vegetation community and YBCU habitat suitability maps.

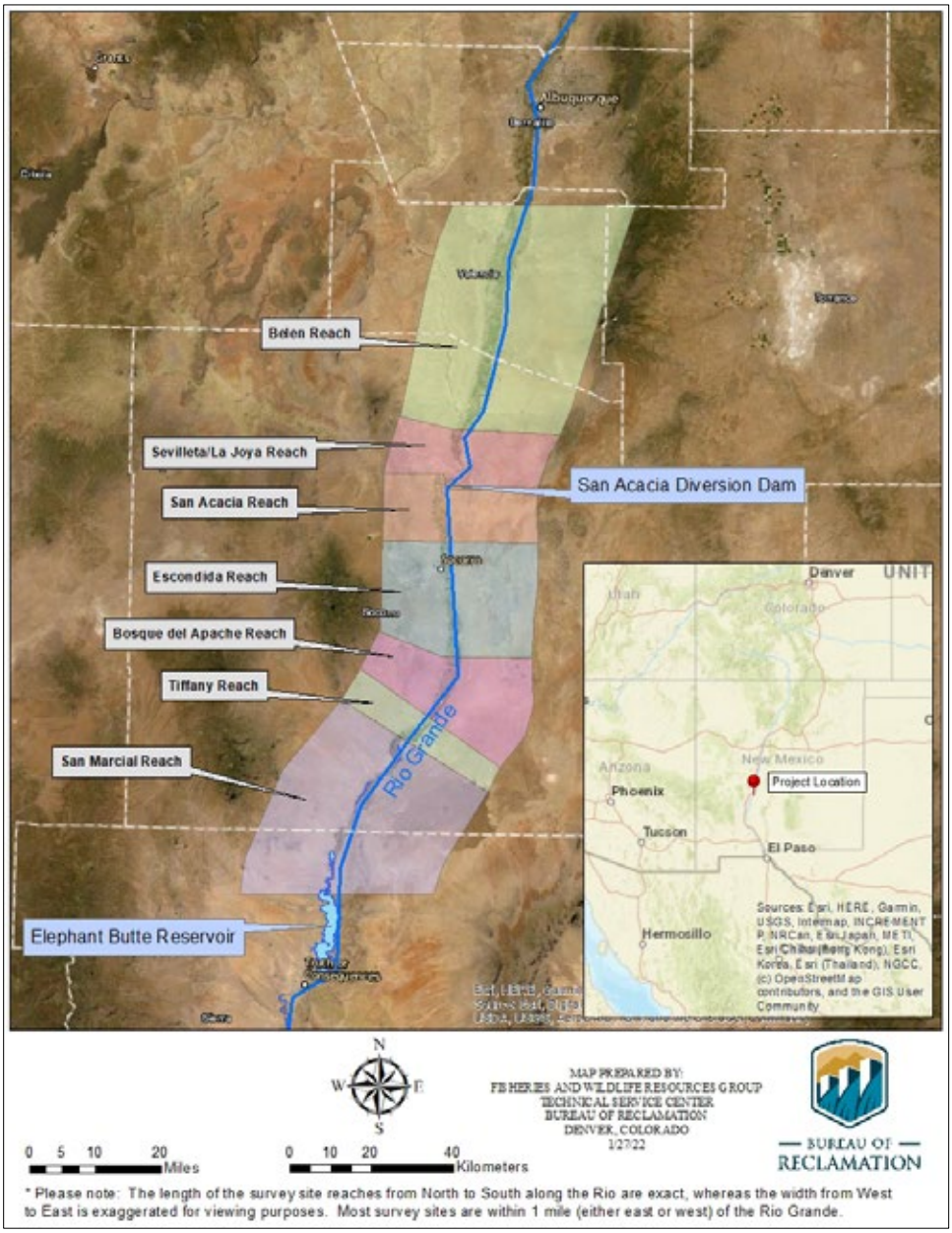


Figure 4. Survey reaches within the project area along the Middle Rio Grande.

Suitable YBCU habitat delineated in the maps was that which included habitat variable criteria outlined above. Unsuitable habitat was defined as all areas in which woody vegetation was greater than 25 percent total cover but did not meet criteria for suitable habitat. Non-habitat included marsh, open water, open vegetation (i.e., areas with < 25 percent woody vegetation), roads, and railroads. Open areas in non-habitat are subdivided into "recently burned" areas, which signifies that fires were recent enough to eliminate vegetation from Hink & Ohmart classification (i.e., woody vegetation less than 25 percent total cover). If YBCU territories are missing from the map legend, that indicates that there were no territories in the mapped area, or that the area was not surveyed in certain years. Survey information is provided in the reach tables in the Appendix.

Table 4 lists the vegetation community types identified within the 49,064 ac (19,860 ha) mapped in 2021. Non-habitat types are also included (i.e., marsh, open, and open water). The project area included 725 ac (293 ha) of private land, located within the four upper reaches (Figure 3), that was not mapped. The four most common vegetation community types across the landscape were:

1) Exotic Understory (11,416 ac [4,620 ha], predominantly variations of saltcedar monocultures in the 5 to 15 ft [1.5 to 4.6 m] height range);

2) Native Canopy (4,705 ac [1,904 ha], predominantly cottonwood in the greater than 40 ft [12.2 m] height range with no understory);

3) Mixed Understory (4,149 ac [1,679 ha], predominantly saltcedar and/or coyote willow and Baccharis in the 5 to 15 ft height range); and

4) Native Canopy/Mixed Understory (3,825 ac [1,548 ha], predominantly cottonwood in the greater than 40 ft height range with saltcedar combined with a variety of native species in the understory).

Open water, which is considered non-habitat and included the river channel, covered the largest area of all types (14,456 ac [5,850 ha]). Figure 5 presents these data graphically.

Table 5 presents the vegetation community types most commonly occupied by YBCUs from 2018 to 2021 by detections (points) and territories (hectares within polygons). The table also shows a comparison of the current values to the data used to create the model (i.e., the average of data collected from 2009, 2011-2013, 2015-2016 [Siegle et al. 2018]). Figure 6 graphs these results for the 2018 to 2021 time period. When interpreting cuckoo presence/ absence data for the current mapping and modeling effort, an important consideration is that the 2020 and 2021 avian surveys did not include all survey sites due to limited staff under COVID restrictions. As such, the actual number of detections and territories and associated habitat types across the entire survey area were not captured, which skews comparisons to other years.

Table 4. Dominant plant communities identified within the MRG in 2021 by area and percentage of the total area mapped

Plant Community	Ac	Ha	%	Plant Community	Ac	Ha	%
Native Canopy / Native Understory Total	**1563**	**633**	**3.2**	**Mixed Canopy / Mixed Understory Total**	**825**	**334**	**1.7**
Canopy >40 ft	683	277	1.4	Canopy >40 ft	0	0	0.0
Canopy 15-40 ft	880	356	1.8	Canopy 15-40 ft	825	334	1.7
Native Canopy / Exotic Understory Total	**3422**	**1384**	**7.0**	**Native Canopy Total**	**4699**	**1902**	**9.6**
Canopy >40 ft	2791	1129	5.7	Canopy >40 ft	3222	1304	6.6
Canopy 15-40 ft	631	255	1.3	Canopy 15-40 ft	1477	598	3.0
Native Canopy / Mixed Understory Total	**3824**	**1548**	**7.8**	**Exotic Canopy Total**	**2124**	**859**	**4.3**
Canopy >40 ft	2682	1085	5.5	Canopy >40 ft	3	1	0.0
Canopy 15-40 ft	1143	462	2.3	Canopy 15-40 ft	2121	858	4.3
Exotic Canopy/ Native Understory Total	**126**	**51**	**0.3**	**Mixed Canopy Total**	**1499**	**607**	**3.1**
Canopy >40 ft	0	0	0.0	Canopy >40 ft	5	2	0.0
Canopy 15-40 ft	126	51	0.3	Canopy 15-40 ft	1494	605	3.0
Exotic Canopy / Exotic Understory Total	**649**	**263**	**1.3**	**Native Understory Total**	**1746**	**707**	**3.6**
Canopy >40 ft	0	0	0.0	Understory 5-15 ft	1424	576	2.9
Canopy 15-40 ft	649	263	1.3	Understory 0-5 ft	322	130	0.7
Exotic Canopy/ Mixed Understory Total	**262**	**106**	**0.5**	**Exotic Understory Total**	**11193**	**4530**	**22.8**
Canopy >40 ft	0	0	0.0	Understory 5-15 ft	11011	4456	22.4
Canopy 15-40 ft	262	106	0.5	Understory 0-5 ft	182	74	0.4
Mixed Canopy / Native Understory Total	**230**	**93**	**0.5**	**Mixed Understory Total**	**4146**	**1678**	**8.4**
Canopy >40 ft	0	0	0.0	Understory 5-15 ft	3556	1439	7.2
Canopy 15-40 ft	230	93	0.5	Understory 0-5 ft	590	239	1.2
Mixed Canopy / Exotic Understory Total	**321**	**131**	**0.7**	**Marsh/Wetland**	**930**	**377**	**1.9**
Canopy >40 ft	1	1	0.0	**Open, Road, Railroad**	**7293**	**2952**	**14.9**
Canopy 15-40 ft	320	130	0.7	**Channel, open water**	**4212**	**1705**	**8.6**
				Total mapped*	**49064**	**19860**	**100**

Height classes for each vegetation type are broken out; the totals for each community type are in bold.
Non-habitat types are also listed (marsh, open, and open water).
*There were 725 ac (293 ha) of unmapped private land within project area

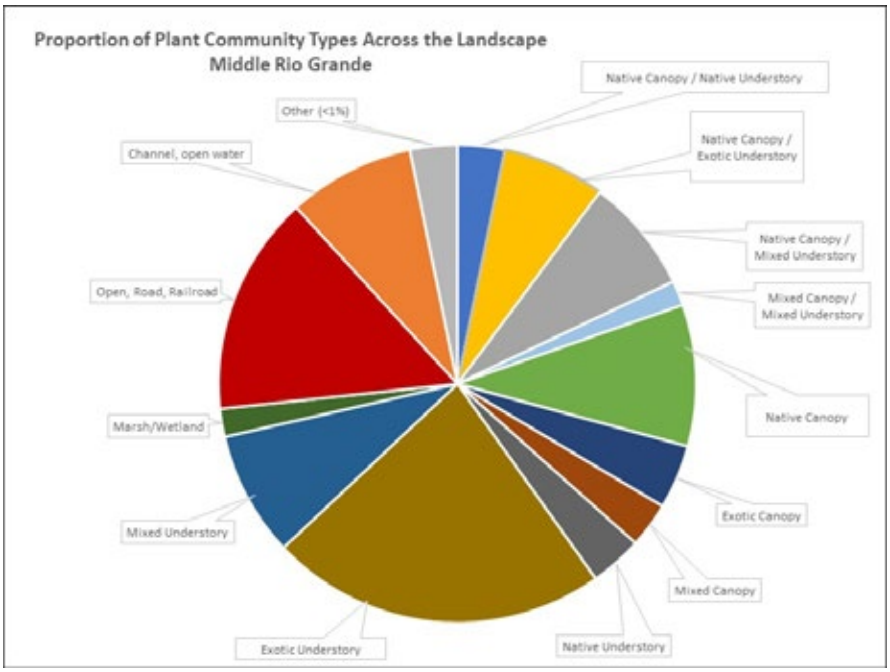


Figure 5. Proportion of plant communities across the landscape, Middle Rio Grande, NM.

Table 5. Percentage of plant communities used by YBCU based on detection points and territory plots (7 ha) from 2018 to 2021 compared to the average percentages used in 2009, 2011 to 2013 and 2015 to 2016 along the Middle Rio Grande, NM. In 2021 there were 7 detections and 40 territory ac (16 ha) that fell in private land that was not mapped

Plant Community	YBCU Detections			YBCU Territories			
	2018-2021 (n=1196)		Avg 2009, 2011-2013, 2015-2016 (n=2173)	2018-2021 (n=282)			Avg 2009, 2011-2013, 2015-2016 (n=634)
	#	%	%	Ac	Ha	%	%
Native Canopy / Native Understory	96	8.0	12.0	269	109	5.5	7.6
Native Canopy / Exotic Understory	193	16.1	14.9	561	227	11.5	11.1
Native Canopy / Mixed Understory	278	23.2	18.1	731	296	15.0	11.3
Exotic Canopy/ Native Understory	12	1.0	0.7	37	15	0.8	0.2
Exotic Canopy / Exotic Understory	31	2.6	2.7	72	29	1.5	2.1
Exotic Canopy/ Mixed Understory	15	1.3	0.8	42	17	0.9	0.5
Mixed Canopy / Native Understory	3	0.3	1.8	7	3	0.2	1.3
Mixed Canopy / Exotic Understory	8	0.7	3.0	17	7	0.4	2.0
Mixed Canopy / Mixed Understory	32	2.7	4.7	148	60	3.0	3.8
Native Canopy	217	18.1	9.5	576	233	11.8	5.4
Exotic Canopy	32	2.7	2.3	135	55	2.8	1.5
Mixed Canopy	92	7.7	3.9	277	112	5.7	2.1
Native Understory	28	2.3	4.6	146	59	3.0	4.7
Exotic Understory	62	5.2	10.5	299	121	6.1	9.9
Mixed Understory	54	4.5	6.9	220	89	4.5	6.4
Marsh	2	0.2	1.4	54	22	1.1	2.2
Open, Road, Railroad	25	2.1	1.6	398	161	8.1	8.2
Channel, open water	14	1.2	0.1	605	245	12.4	11.7
Upland	2	0.2	0.5	289	117	5.9	8.0
Total	**1196**	**100**	**100**	**4883**	**1977**	**100**	**100**

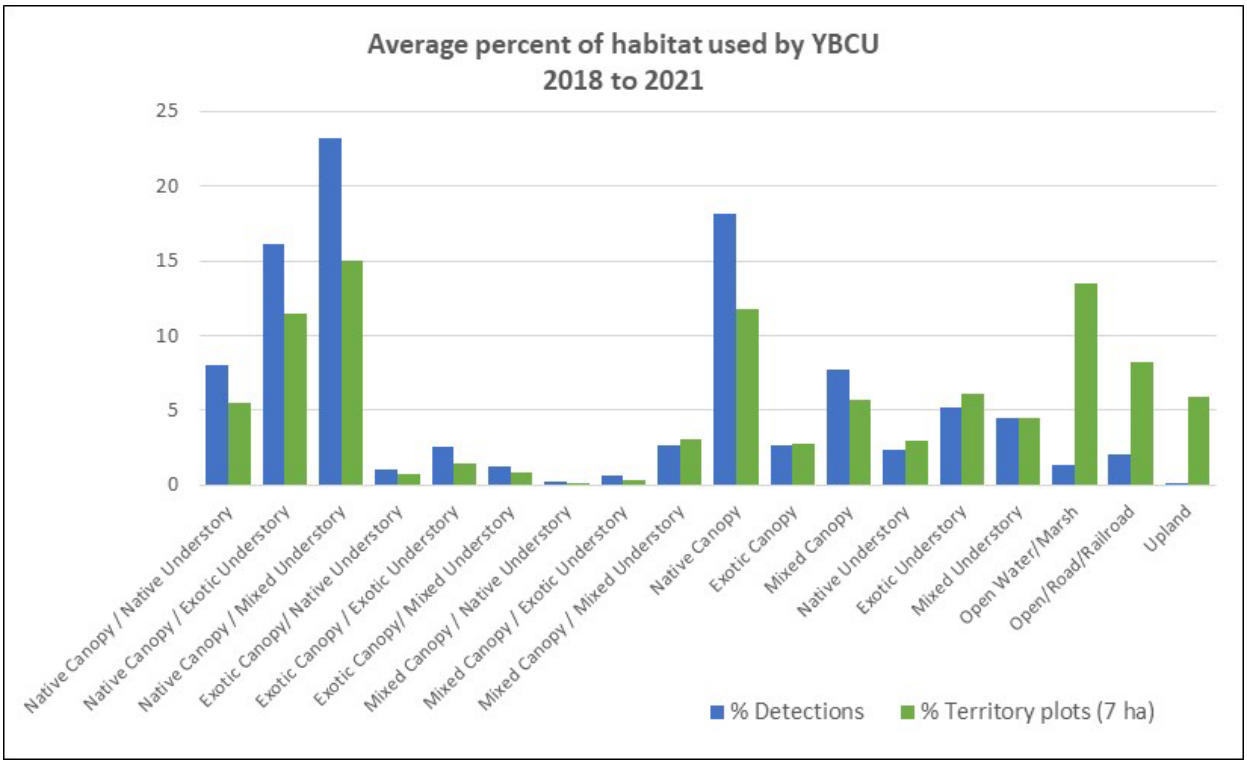


Figure 6. Average percent of dominant vegetation types used by YBCU based on detection points and territory plots (7 ha) 2018 to 2021 along the Middle Rio Grande, NM.

The most common vegetation types occupied by YBCUs were Native Canopy and Native Canopy/Mixed Understory, which correlated with common vegetation types available (Table 4). The relatively large increase in Native Canopy use from previous years is speculated to be a result of die-off in the understory layer (presumably from drought conditions), which led to a shift in classification of the stand and to an increase in the availability and use of an overstory canopy with sparse or no understory (i.e., Native Canopy vegetation type). Exotic and Mixed Understory types were highly available but were not as commonly used relative to other types. Results in Table 5 and Figure 6 demonstrate the importance of native canopy in breeding habitat. Of note, the presence of water and uplands within territory plots was relatively high as well.

Native overstory patch size and width are important variables in cuckoo habitat and were criteria included in the model. Figure 6 shows the average area of patches occupied by YBCUs, patches not occupied by YBCUs, and patches available across the landscape from 2018 to 2021. Results suggest cuckoos are likely to select larger patch sizes for breeding relative to the average size of all patches available across the landscape.

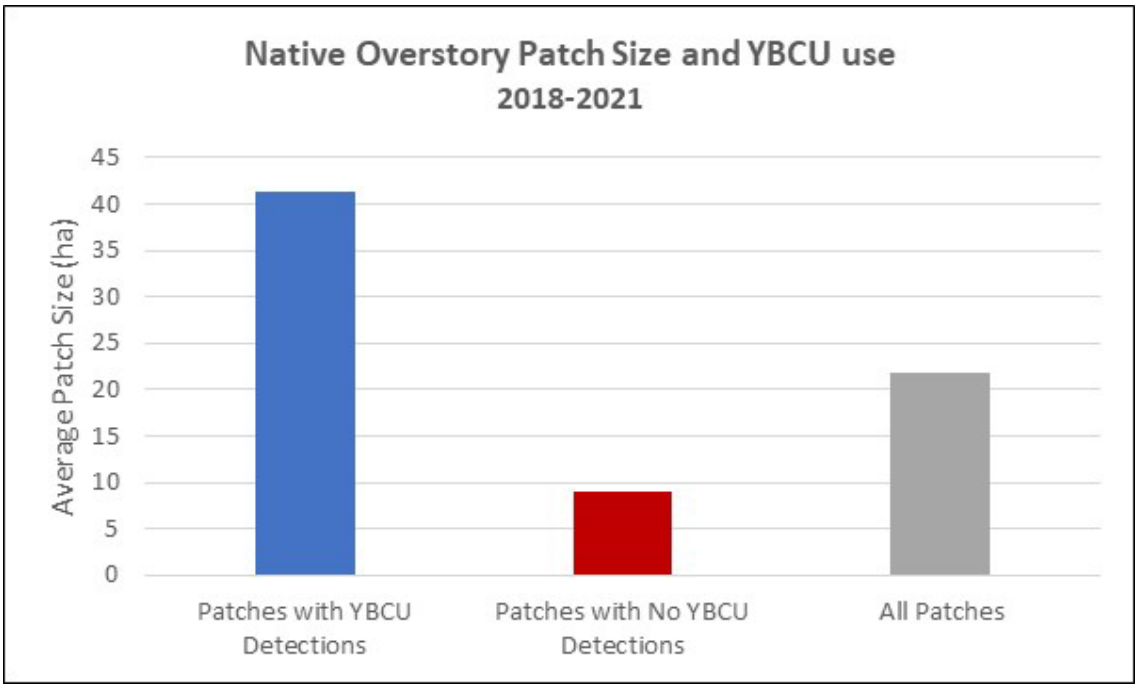


Figure 7. Average native overstory patch size of patches with YBCU detections, patches with no YBCU detections, and all patches across the landscape 2018 to 2021.

Percentage of native overstory patches with at least one YBCU detection that were less than or equal to 30 m in width and greater than 30 m in width from 2019 to 2021 are graphed in Figure 6. The threshold for meeting patch width suitability criteria was set at 30 m for the model and results show that the majority of occupied patches (23.4 percent of available patches) were greater than this width. In contrast, only 0.4 percent of available patches less than 30 m were occupied. Of note, when measuring overall width of patches, at least 75 percent of each patch had to measure greater than 30 m to qualify as suitable for this parameter in the original model. Consequently, individual detections and territories were sometimes in areas wider than 30 m but the overall patch width did not meet criteria, categorizing the patch as unsuitable. For this reason, the model was revised to remove sections from large patches that were less than 30 m wide rather than classifying the entire patch as unsuitable. This phenomenon was only noted in 2016 maps, however, and the revision was not necessary in 2021. Removal of narrow sections of polygons will be the methodology from this point forward.

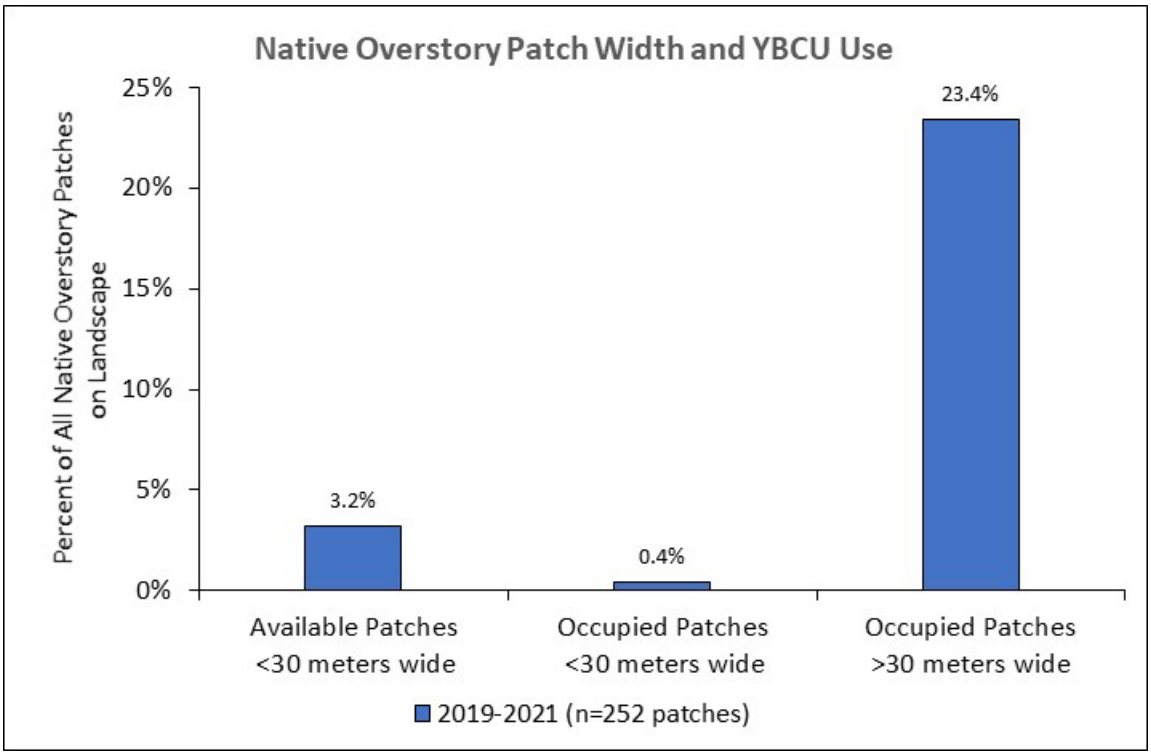


Figure 8. Percentage of native overstory patches with at least one YBCU detection and total available native overstory patches on the landscape less than or equal to 30m in width and native overstory patches with at least one YBCU detection greater than 30 m in width from 2019 to 2021 along the Middle Rio Grande, NM.

When examining the locations of YBCU territories with regards to habitat suitability as determined by the MRG model, almost half of the territory points fell within suitable habitat (45 percent; Table 6). The average percentage of suitable habitat within each territory polygon (i.e., the area within 150 m of the territory point) was 29 percent. Data suggest that the presence of suitable habitat within the cuckoos' breeding area is important. Nearly one third of each territory included suitable habitat, which is not a particularly high proportion, however, the landscape includes a number of vegetation types which are not always contiguous; therefore, when measuring within a standardized plot, vegetation types that may or may not be selected for will be present. Another consideration is that cuckoos do not always nest in what the model deems "suitable" habitat.

The term "suitable habitat" was not meant to imply that all other habitat is unsuitable for YBCU occupancy. The model was not all inclusive, keeping in mind that when aiming for a majority of the YBCU population in estimating habitat use, a fair proportion of the population was using alternative habitat. Another consideration is that "majority" was not necessarily defined as greater than half of YBCU detected because there were numerous plant communities in which they were documented (Table 5). The "suitable" designation is a means to estimate where cuckoos are likely to occur as well as providing guidance in managing habitat for the species.

Table 6. Habitat suitability of YBCU territories detected from 2018 to 2021

YBCU Territories and Habitat Suitability 2018-2021		
Territory points		
	#	%
Within suitable habitat	126	45
Within unsuitable habitat	156	55
Within unsuitable habitat but within native overstory patch	64	
Total	282	100
Territory polygons		
	Ac (Ha)	%
Within suitable habitat	1426 (577)	29
Within unsuitable habitat	3501 (1417)	71
Within unsuitable habitat but within native overstory patch	709 (287)	
Total	4927 (1994)	100

Territories that fell within native overstory patches but did not meet other suitability criteria (in gray) are a subset of unsuitable habitat

YBCU telemetry studies carried out in the MRG from 2017 to 2019 provided in depth information on habitat use of nesting cuckoos (Dillon and Moore 2019 and 2020). A summary of these data is provided in Table 7. There were notable differences in home range sizes when 2019 data was compared to data from the previous two years. Capture efforts in 2017 and 2018 were focused on The Narrows of Elephant Butte Reservoir between river mile 48 and 37. In 2019, capture efforts were in the San Acacia and Escondida Reaches, between river mile 116 and 87. Habitat in these upper reaches was generally constrained to smaller, more isolated patches where exotic species were more common, compared to the contiguous stretches of suitable habitat found in The Narrows.

Table 7. YBCU habitat telemetry data from 2017to 2018 and 2019. Ranges in parentheses

	2017/2018 (n=8)	**2019 (n=6)**
50% Kernel Home Range		
Average area	11 ha (2-36)	5 ha (2-9)
Percent of Habitat w/ Native Vegetation Component	72%	97%
Percent of Habitat w/ Native-dominated Canopy	55%	35%
Percent of Habitat w/ Goodding's Willow Component	48%	10%
Percent of Habitat w/ Cottonwood Component	31%	63%
Percent of Habitat w/ Overstory Structure	59%	96%
Percent of Habitat without Overstory Structure	41%	4%
95% Kernel Home Range		
Average Area	60 ha (7-216)	22 ha (4-69)
Percent of Habitat w/ Native Vegetation Component	68%	90%
Percent of Habitat w/ Native-dominated Canopy	41%	41%
Percent of Habitat w/ Goodding's Willow Component	37%	6%
Percent of Habitat w/ Cottonwood Component	26%	72%
Percent of Habitat w/ Overstory Structure	48%	84%
Percent of Habitat without Overstory Structure	52%	16%

The average area within the 50 percent kernel home range was approximately 8 ha (19.8 ac) over all three years, similar to the 7.14 ha area identified by Secrist et al. (2009), which was used to delineate YBCU territories of 7 ha in this study. The 50 and 95 percent kernel home range are defined as the area with 50 percent probability of YBCU use and area with 95 percent probability of YBCU use, respectively. Home range areas and percent of native dominated canopy and Goodding's willow component were larger in 2017 and 2018 than in 2019, a reflection of the available habitat. In turn, the percentage of overstory structure and cottonwood component were larger in 2019.

Eight nests were found in association with telemetry studies and nesting habitat was assessed using vegetation transect data within 50 m of each nest and incorporating GIS. The years that nest data were collected correlated with telemetry studies (i.e., habitat data were collected in The Narrows in 2017 and 2018 and in the San Acacia and Escondida reaches in 2019). The average of all 8 nests were used in analysis. Native vegetation comprised an average of 66 percent of habitat surrounding nests followed by 17 percent uplands (Figure 8).

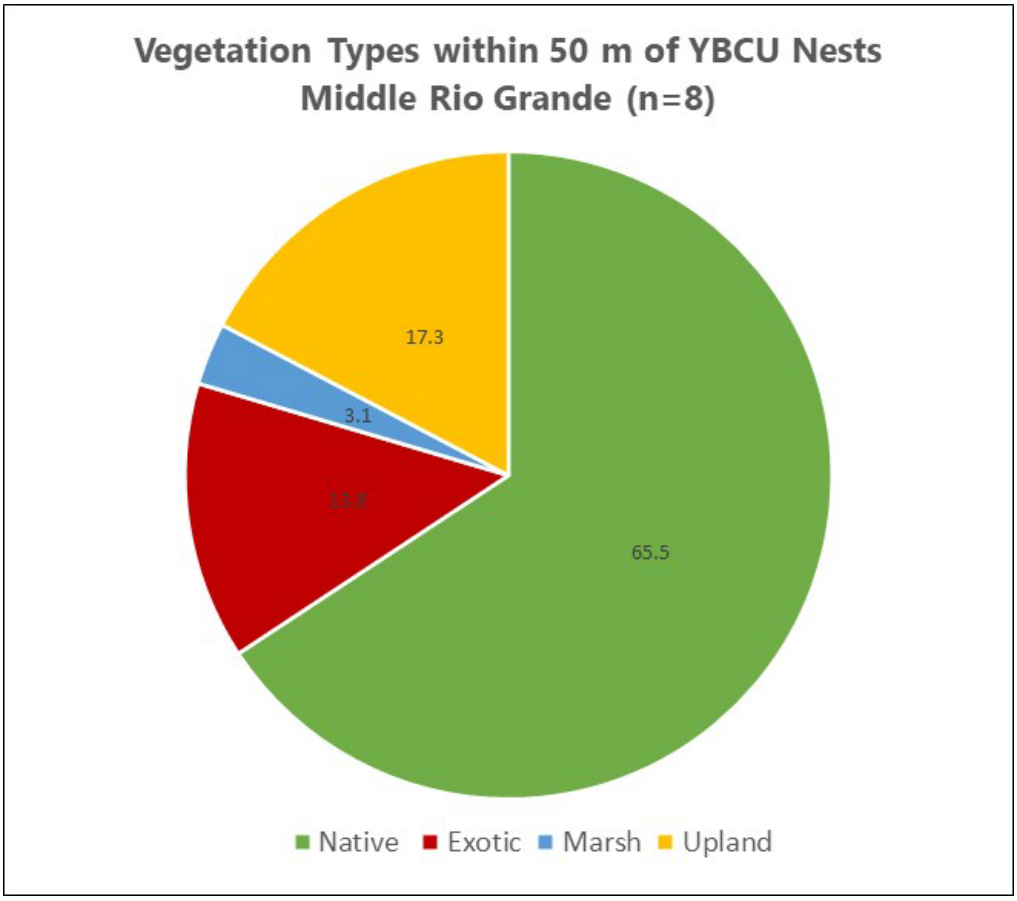


Figure 9. Average percent of vegetation types measured within 50 m of YBCU nests.

Figure 9 demonstrates that Goodding's willow 15 to 40 ft (4.6 to 12.2 m) in height was the most documented characteristic in YBCU nesting habitat. On average, canopy within the 15 to 40 ft height range covered 57 percent of the habitat, with stands greater than 40 ft in height covering 17 percent of the area, and an understory 0 to 15 ft (0 to 4.6 m) in height covering 20 percent of habitat. Coyote willow dominated in the understory layer (11 percent cover) and the only species in the upper canopy layer were cottonwood (11 percent) and Goodding's willow (6 percent). Mid-canopy species were dominated by Goodding's willow (25 percent) followed by coyote willow (11 percent) and Russian olive and cottonwood (9 percent each).

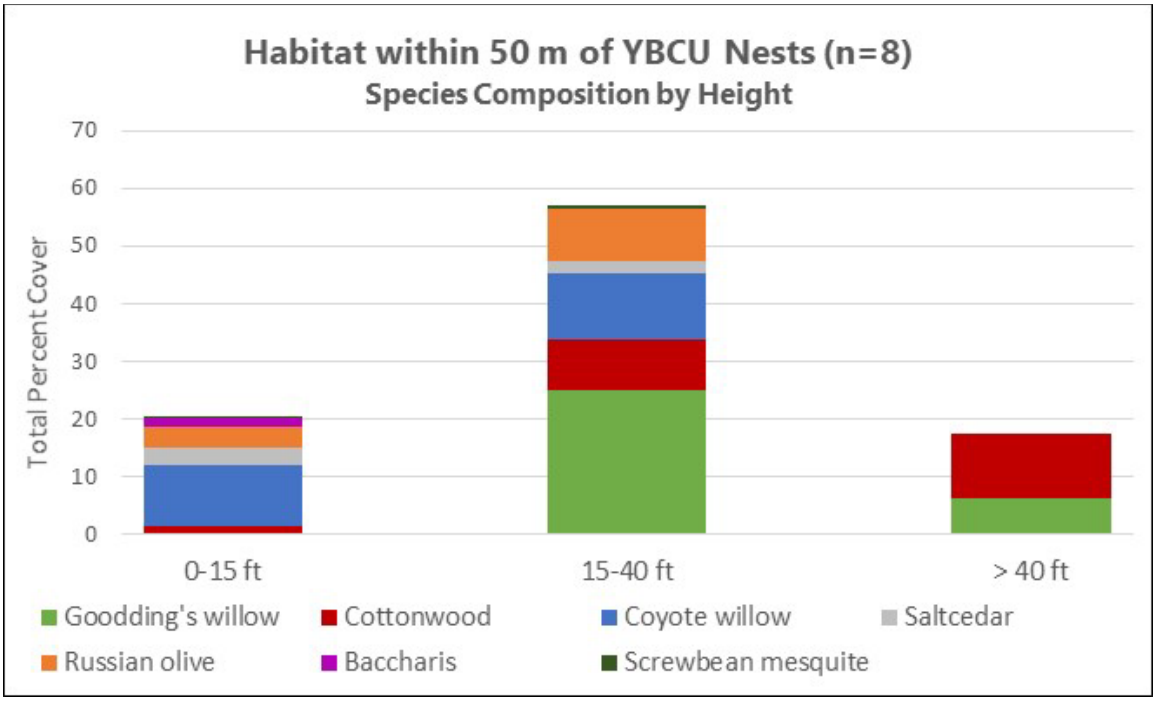


Figure 10. Species composition by cover and height in habitat within 50 m of YBCU nests.

Other data collected in the nest habitat assessment are listed in Table 8. The Hink and Ohmart vegetation classifications (see Tables 1 and 3 for interpretation) included Goodding's willow (TW) in four of the five nest habitats in 2017 and 2018, when nests were located in The Narrows. No Goodding's willow was detected at greater than 25 percent relative cover in 2019 nests located further upstream. The canopy cover (using a densiometer) averaged 90 percent over all nests. Distances to both water and uplands were variable. Distance to water ranged from 0 to 215 m (0 to 705 ft), averaging 79 meters (259 ft), while distance to uplands varied from 6 to 670 m (19.7 to 2,198 ft), averaging 238 m (781 ft).

Table 8. Results of nesting habitat assessments at eight nest sites from 2017-2018 (in The Narrows of Elephant Butte Reservoir) and in 2019 (in San Acacia and Escondida Reaches) along the Middle Rio Grande

Nest transect sampling					
Year-Nest	**H&O Classification**	**Canopy Cover (%)**	**Distance to Water (m)**	**Water Type**	**Distance to Upland (m)**
2017-1	TW4d	97	0	Standing water	116
2017-2	TW4d	80	60	Channel	88
2018-1	TW4d	100	109	Reservoir	670
2018-2	CW-TW4d	98	215	Channel	18
2018-3	CW5	62	109	Channel	27
2019-1	C/RO1d	97	71	Channel	641
2019-2	C-CW4	97	0	Irrigation ditch	6
2019-3	RO4d	90	67	Channel	337
Average		**90**	**79**		**238**
Model criteria					
Year-Nest	**Native Canopy**	**>8 ha in size**	**>30 m wide**	**Goodding's willow**	**Notes**
2017-1	Yes	Yes	No	Yes	Patch width 121 m at nest site
2017-2	Yes	Yes	Yes	Yes	
2018-1	Yes	Yes	Yes	Yes	
2018-2	Yes	Yes	Yes	Yes	
2018-3	No*	*	*	*	*Not native overstory patch
2019-1	Yes	Yes	Yes	No	
2019-2	Yes	*	*	*	*Not mapped
2019-3	No*	*	*	*	*Not native overstory patch
Nests that met criteria/Total nests included	**6/8**	**5/5**	**4/5**	**4/5**	

Table 8 also examines how well the known nesting habitat fits the habitat suitability model. One nest (2019-2) was located outside of mapping boundaries, adjacent to an irrigation ditch and private land so the extent of the patch was unknown and the model was not applied. Two of the nests (2018-3 and 2019-3) were not in native overstory and were therefore considered to be in unsuitable habitat. Of the remaining five nests, four were within suitable habitat per the model. The patch surrounding the nest that did not fall within suitable habitat (2017-1) was considered too narrow. Although less than 75 percent of the patch was greater than 30 m wide, the area in which the nest was located was 121 m in width, which would have met suitability criteria. As discussed, suitability criteria were applied to an entire patch, which may lead to these sorts of limitations. Therefore, the model was revised in 2021 to simply delineate narrow sections of larger patches as unsuitable.

Figure 10 shows the number of acres of suitable YBCU habitat as compared to acres of unsuitable habitat and of non-habitat by river reach in 2016 and 2021 (the two mapping periods in which the cuckoo habitat suitability model was applied). For clarification, the difference in total area between years in the uppermost reaches were due to private property mapped in 2016 but not in 2021 in Belen through Escondida Reaches. The differences in area between 2016 and 2021 in the San Marcial Reach were attributable to revised survey site boundaries adjacent to the reservoir in 2020, when the Delta Conveyance Channel below The Narrows was realigned, decreasing the mapped area.

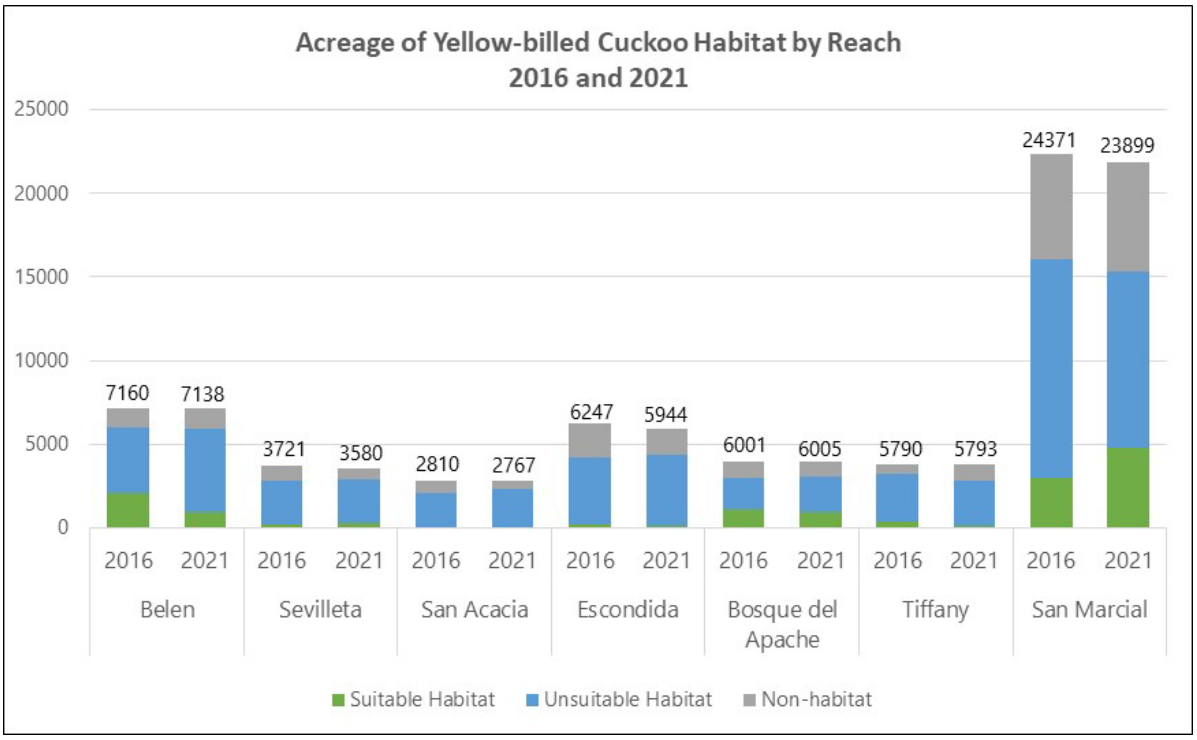


Figure 11. Acres of suitable YBCU habitat mapped in 2021 in proportion to hectares of unsuitable and non-habitat by river reach along the Middle Rio Grande, NM. Total hectares mapped are at top of columns.

Table 9 lists the number of hectares of suitable habitat as well as the percentage of suitable habitat as a proportion of available vegetation (including all vegetation types and excluding non-habitat) and of total area (including non-habitat) by river reach. The table also includes the total number of YBCU territories from 2018 to 2021 and the percentage of territory plots that intersected habitat classified as suitable. That is, if any part of a 7-ha territory plot fell within a suitable habitat patch, then that territory was counted as being within suitable habitat. There were 179 territories out of a total of the 282 detected that fell within suitable habitat, or 63 percent.

The San Marcial Reach was the largest of all reaches and contained a relatively high proportion of suitable habitat relative to its size (31 percent of available habitat; Figure 10 and Table 9). The proportion of suitable habitat increased from 18 percent in 2016 (Siegle et al. 2018). The San Marcial Reach provided the most YBCU suitable breeding habitat of all reaches along the MRG (4,804 ac; 1,944 ha). The Bosque del Apache Reach had the highest proportion of suitable habitat (32 percent of available vegetation) and provided 965 ac (391 ha) of suitable habitat. The Belen Reach was third in proportion of suitable habitat (16 percent of available vegetation), providing 967 ac (391 ha) of suitable habitat. The Sevilleta Reach contained 278 ac (113 ha) of suitable habitat, 10 percent of available vegetation, while the other reaches contained minimal suitable habitat.

Table 9. Total number of acres and acres of suitable habitat; percentage of suitable habitat as a proportion of available vegetation and of total area in 2021; and the total number of territories detected and percentage of YBCU territory plots (7 ha) that intersected habitat classified as suitable from 2018 to 2021 by river reach along the Middle Rio Grande, NM

Habitat by Reach	No. of a Acres in Total Area[1]	No. of Acres of Suitable Habitat	% Suitable Habitat out of Available Vegetation[2]	% Suitable Habitat out of Total Area[1]
Belen	7138	967	16	14
Sevilleta	3580	278	10	8
San Acacia	2767	56	2	2
Escondida	5944	113	3	2
Bosque del Apache	3984	965	32	24
Tiffany	3772	147	5	4
San Marcial	21878	4804	31	22
All Reaches	49063	7330	20	15
Territories by Reach	**Total No. of Territories detected**	**No. of Territory Plots that Intersect Suitable Habitat**	**% of Territory Plots that Intersect Suitable Habitat (% of Total, n=282)**	
Belen	14	6	2	
Sevilleta	14	4	1	
San Acacia	20	1	<1	
Escondida*	30	6	2	
Bosque del Apache	51	19	7	
Tiffany	0	0	0	
San Marcial	153	143	51	
All Reaches	282	179	63	

[1] Total Area = Suitable + Unsuitable + Non-habitat

[2] Available vegetation = Suitable + Unsuitable

* Escondida was the only reach in which all sites were surveyed in all years

Suitable habitat in the San Marcial Reach increased considerably over the two mapping periods in which the YBCU habitat suitability model was applied, from 2,966 ac (1,200 ha) in 2016 to 4,739 ac (1,918 ha) in 2021. The increase appeared to be related to maturation of vegetation within the Elephant Butte Reservoir delta. The height of many plant species in this area increased, shifting from understory to overstory, which resulted in a shift from unsuitable to suitable habitat. There were also increases in the area and width of some patches; as the more developed vegetation was added to previous smaller and narrower unsuitable patches, size of the patches increased, providing more potential to meet suitability requirements.

On the other hand, there was a considerable decline in the amount of suitable habitat in the Belen Reach, from 2,034 to 967 ac (823 to 391 ha). Further examination into the reason for the decrease found mature cottonwood in the overstory and Goodding's willow in either over- or understory were no longer a component in most of the areas that became unsuitable. In order to be categorized as suitable, a contiguous native overstory patch (e.g., mature cottonwood) must include Goodding's willow in any of the polygon Hink and Ohmart classifications within that patch (Figure 3). This situation illustrates a limitation in the model. That is, a small decrease in Goodding's willow has the potential to affect a larger patch of suitable habitat. For example, in Figure 3, if Goodding's willow decreased to below 25 percent of the species component in the two polygons where it was included, the entire patch would become unsuitable. There were also a few fires that destroyed habitat in the Belen Reach. The region suffered severe to extreme drought conditions in 2018 and 2021 (National Drought Mitigation Center 2022), a factor that appeared to affect vegetation based on mapping, other vegetation monitoring projects along the MRG (Siegle and Moore 2022), and direct observation, in particular by increasing saltcedar and decreasing native willow and cottonwood. Drought conditions likely contributed to decreases in the amount of suitable habitat within other MRG reaches as well.

Figure 11 presents the average number of YBCU territories per reach from 2013 to 2016 (2016 vegetation map) and from 2018 to 2021 (2021 vegetation map). The vast majority of territories were detected within the San Marcial Reach in all years. Approximately half of the 282 territories fell within habitat classified as suitable for YBCU breeding from 2018 to 2021 (Table 9). The number of territories detected decreased over time in most reaches, which was most likely due to more variable surveys from 2019 to 2021, in part due to staffing limitations related to COVID (2018 was the only year all sites were surveyed during the most recent mapping period).

The average number of territories in the Belen Reach dropped from 6.7 to 4.7 with a decrease in suitable habitat over the two mapping periods, while territories increased in the Bosque del Apache Reach from an average of 11 to 13, which was one of the two reaches that showed a rise in territory detections over the same period. Channel realignment to the east within the Bosque del Apache Reach affected the distribution of suitable habitat. All habitat that was classified as suitable on the west side in 2016, prior to realigning the channel, became unsuitable with the loss of Goodding's willow in the sites surveyed for cuckoos in 2021 (Siegle and Moore 2022). When the channel was moved to the east, the water table declined dramatically on the west side, which was presumably a major factor in the decrease of Goodding's willow. Most of the recent vegetation in areas where Goodding's willow dropped out was characterized by cottonwood over saltcedar. In turn, some suitable habitat was created on the east side. Total suitable YBCU breeding habitat within the whole Bosque del Apache Reach decreased by 87 acres over the two mapping periods. In 2021, 13 of 15 cuckoo territories were documented in "Unsuitable" habitat, however most of those were in habitat on the west side which was previously designated as suitable, perhaps returning due to site fidelity (see RM 80 to 84 in Appendix).

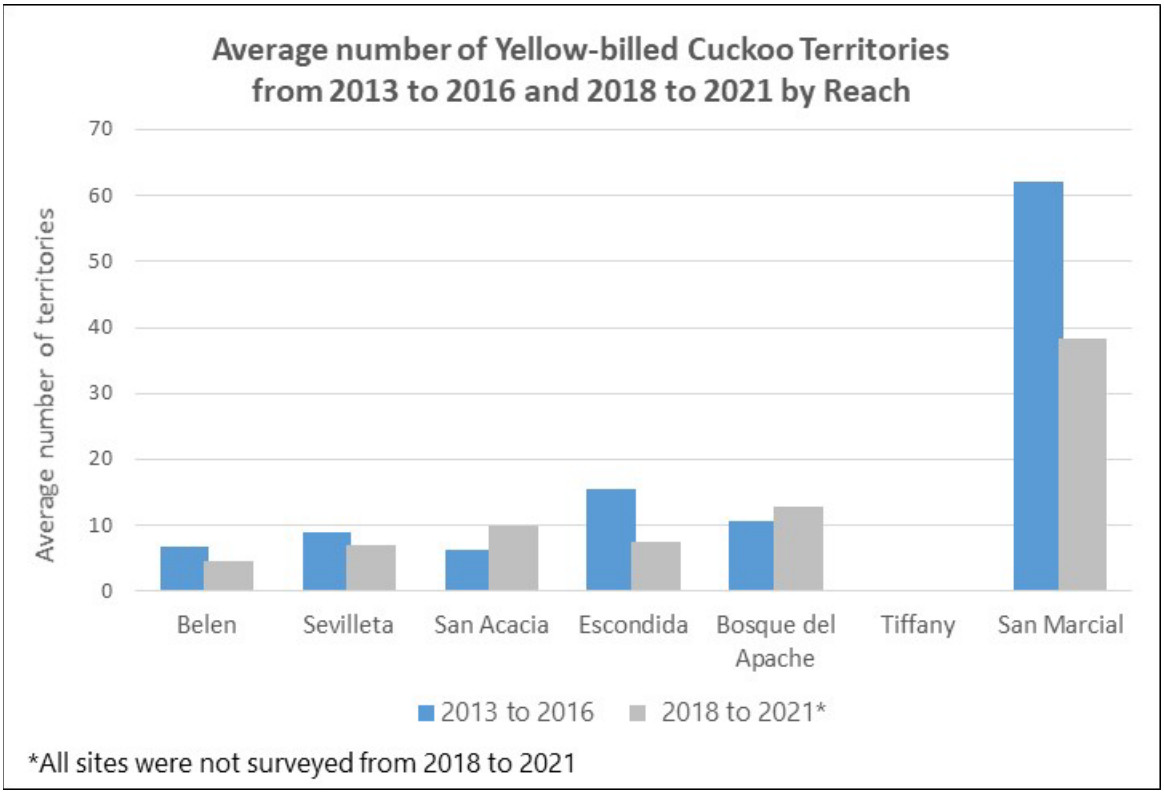


Figure 12. Average number of YBCU territories detected per year from 2013 to 2016 (2016 vegetation map) and from 2018 to 2021 (2021 vegetation map) by river reach along the Middle Rio Grande, NM.

The San Acacia Reach was the other reach showing an increase in territory numbers between the two mapping periods, from an average of 6.3 to 10.0. However, surveys were not conducted within this reach in 2020 and 2021 (see San Acacia tables in Appendix), therefore more recent trends were unknown.

Conclusions and Recommendations

When the YBCU breeding habitat suitability model was developed, it was anticipated to evolve based on trial and additional information gathered through telemetry studies. Now that the model has been applied to eight years of YBCU territory data, a limiting factor was recognized. In the original model, when measuring overall width of patches, at least 75 percent of each patch had to measure greater than 30 m to qualify as suitable for this parameter. Consequently, individual detections and territories were sometimes in areas wider than 30 m but the overall patch width did not meet criteria, categorizing the entire patch as unsuitable. The model was revised in 2021 to remove sections that were less than 30 m wide from large patches rather than classifying the entire patch as unsuitable. The revision was not applicable in 2021 as all patches that did not meet width criteria were small and width was consistent throughout the patch. Removal of narrow sections of patches will be the methodology going into future mapping efforts, however. More cuckoo telemetry studies are planned along the MRG for the next several years and data may provide further information to refine the model.

Overall, 7,330 ac (2,967 ha) were classified as suitable YBCU breeding habitat out of the 49,064 ac (19,860 ha) mapped in 2021, which was 15 percent of the mapped area and 20 percent of available vegetation (i.e., not including non-habitat). Changes in habitat from the 2016 to the 2021 mapping efforts were variable by reach. The greatest differences were in the Belen Reach, where suitable habitat decreased from 2,034 to 967 ac (823 to 391 ha) and in the San Marcial Reach, where suitable habitat increased from 2,966 ac (1,200 ha) to 4,739 ac (1918 ha). The decline in suitable habitat in the Belen Reach appeared to be caused by a decrease in Goodding's willow and cottonwood and to fire, while the increase in the San Marcial Reach appeared to be related to maturing vegetation in the Elephant Butte Reservoir delta.

Vegetation mapping along the Middle Rio Grande riparian corridor has shown that some areas have experienced significant changes in structure, density, and species composition while other areas have been far more static, experiencing little or no change. In general, due to the dynamic nature of habitat, the habitat suitability model output has a limited application of 3 to 5 years.

Periodic mapping of YBCU habitat should be conducted at a 5-year minimum, as required by the MRG Biological Opinion (USFWS 2016). Riparian areas subject to active changes, such as those found within the conservation pool of Elephant Butte Reservoir or those where construction activities occur, such as the Bosque del Apache NWR, should be considered as priority areas for future photography, mapping, and modeling efforts. Climatic conditions such as drought and flooding, as well as the effects from the saltcedar biological control beetle *Diorhabda* that has recently populated portions of the Rio Grande basin, can also lead to relatively rapid changes in vegetation.

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Appendix

Western Yellow-billed Cuckoo Habitat Suitability and Major Plant Communities Maps and Associated Tables

Belen Reach

Area by Habitat

Suitability Class	Acreage		
	No. of Acres	No. of Hectares	Percentage of Total
Suitable Habitat	967	391	14
Unsuitable Habitat	4914	1989	68
Total Habitat Area	5881	2380	82
Non-habitat	548	222	8
River channel	709	287	10
Total Area*	7138	2889	100

* Belen Reach also includes 29 ac (12 ha) unmapped private land (total 7167 ac / 2901 ha)

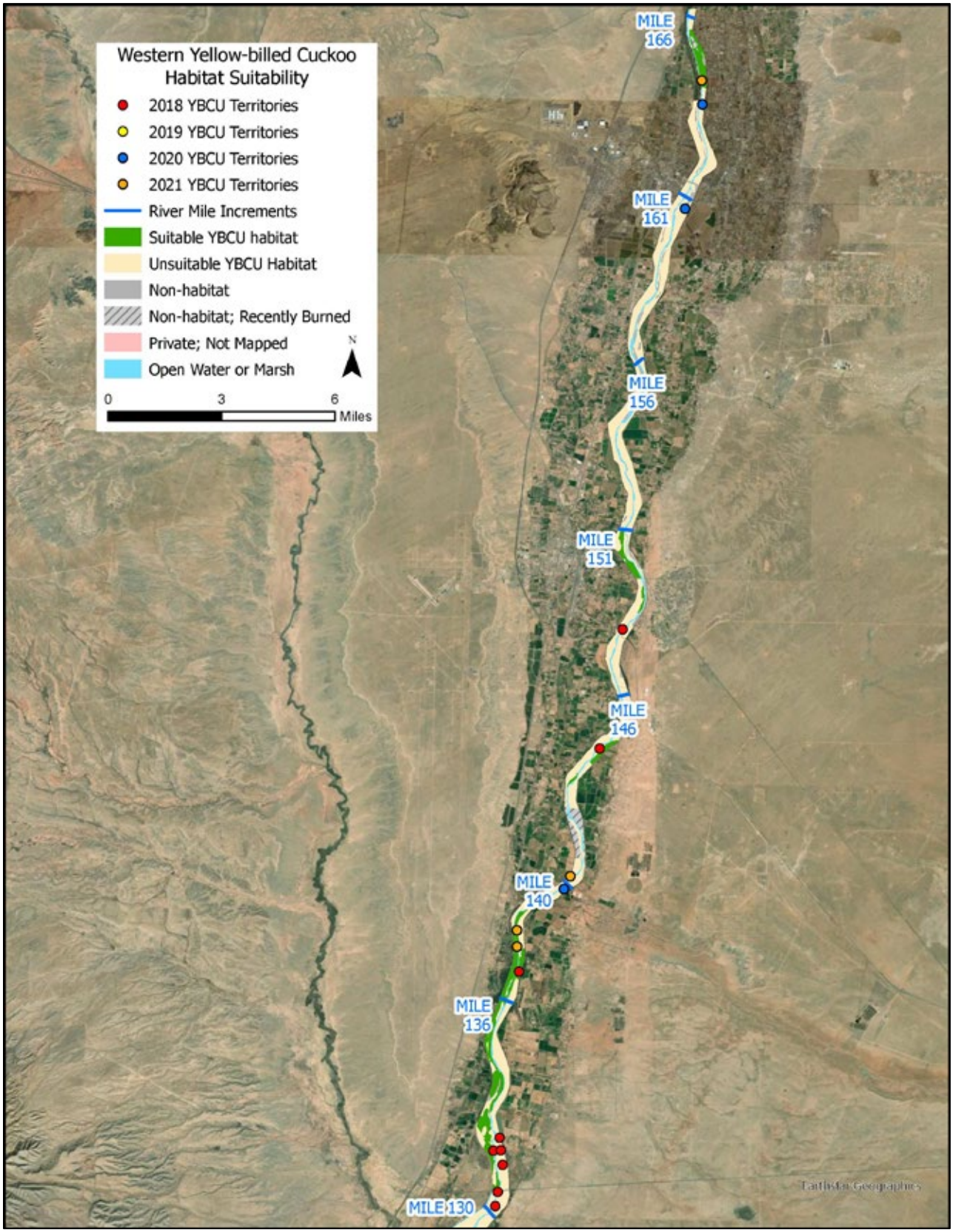
Acreage of Plant Communities within Reach

Community Type	Acres	Percentage of Habitat
Native Canopy/Native Understory	518	9
Native Canopy/Mixed Understory	567	10
Native Canopy/Exotic Understory	1178	20
Mixed Canopy/Native Understory	71	1
Mixed Canopy/Mixed Understory	157	3
Mixed Canopy/Exotic Understory	44	1
Exotic Canopy/Native Understory	31	< 1
Exotic Canopy/Mixed Understory	21	< 1
Exotic Canopy/Exotic Understory	71	1
Native Canopy	1445	24
Mixed Canopy	274	5
Exotic Canopy	485	8
Native Understory	459	8
Mixed Understory	163	3
Exotic Understory	397	7

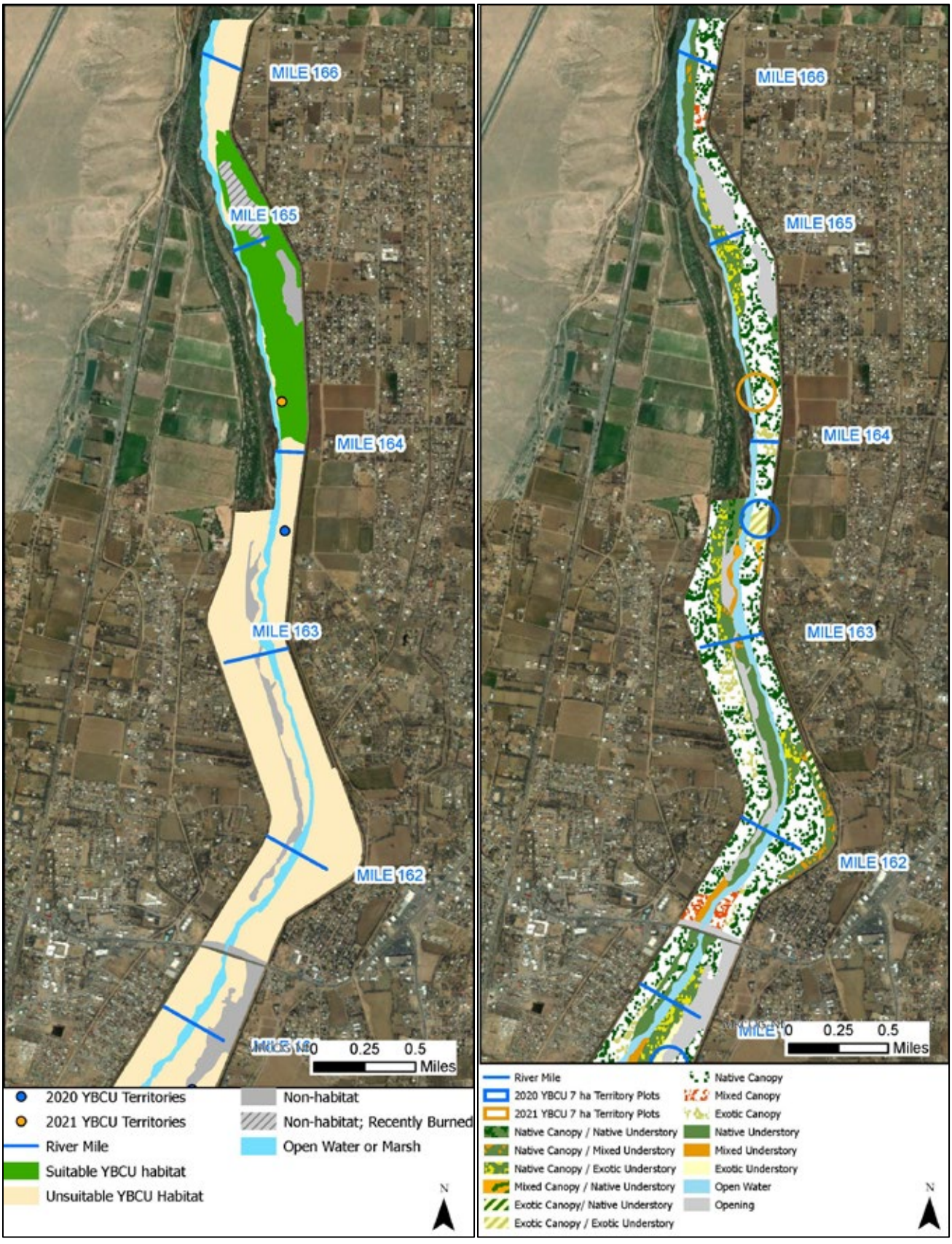
Western Yellow-billed Cuckoo Territories

Year	Total Number of Territories
2018	7
2019	Not surveyed
2020	3
2021	4

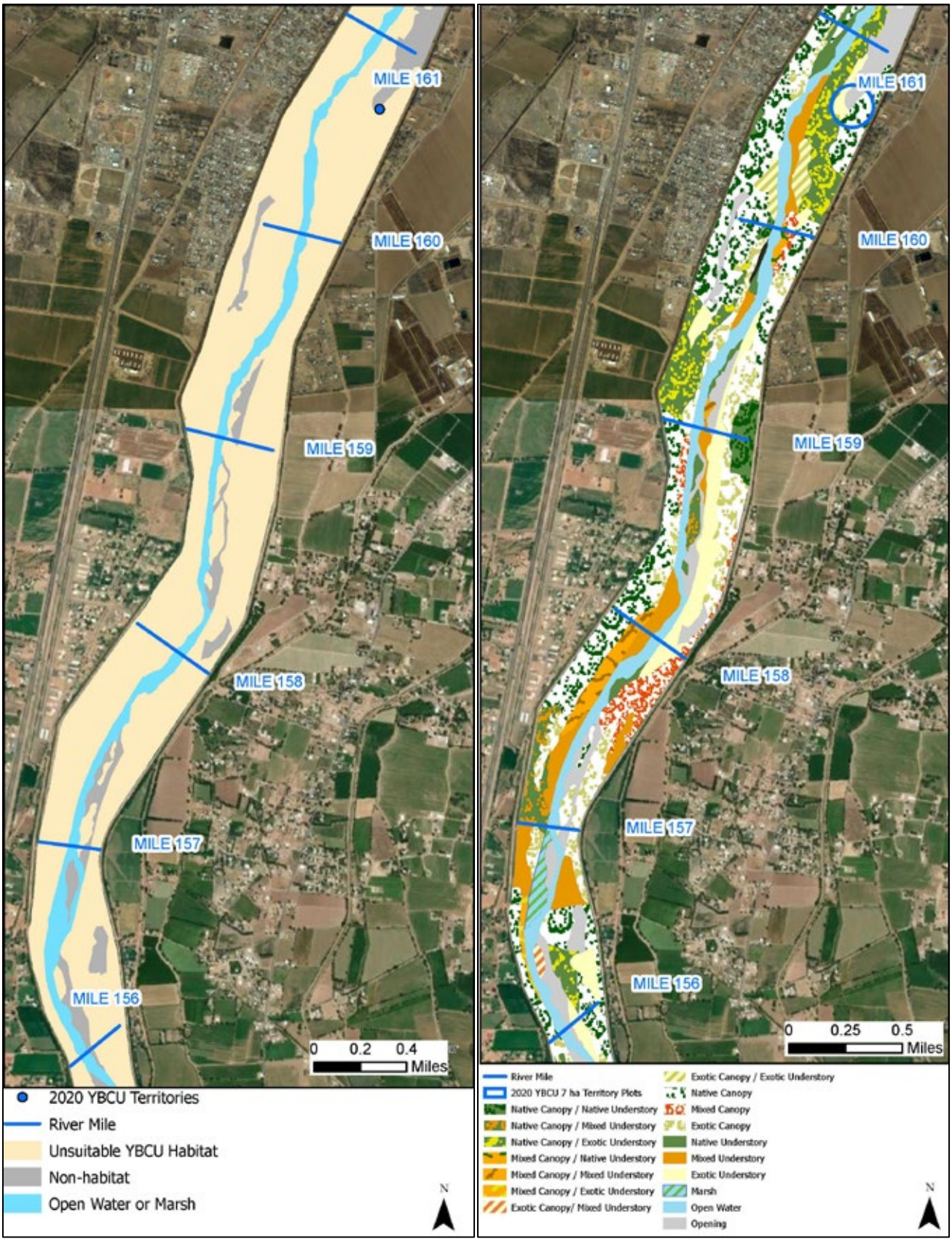
Belen Reach Maps



River Miles 161 to 166



River Miles 156 to 151



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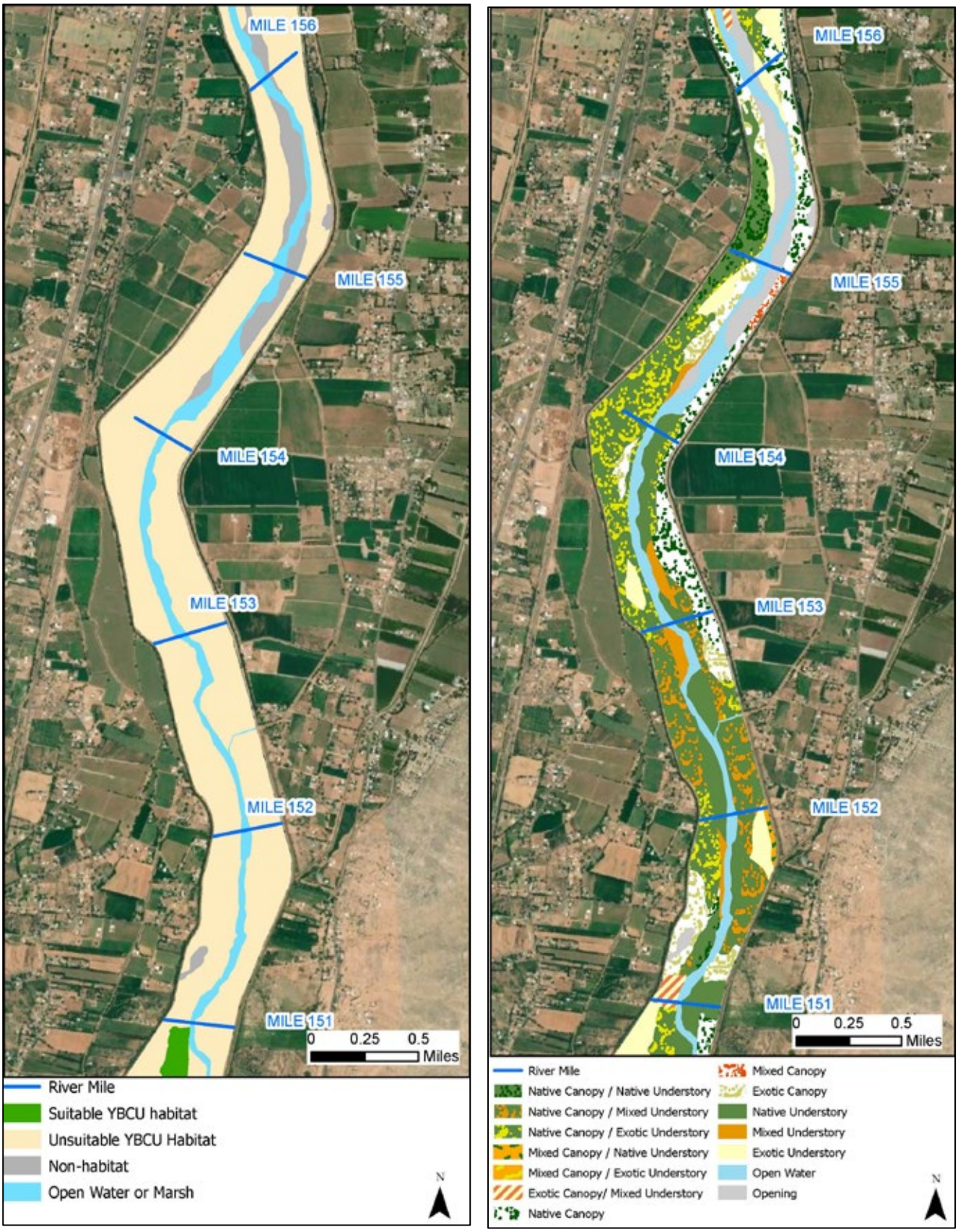
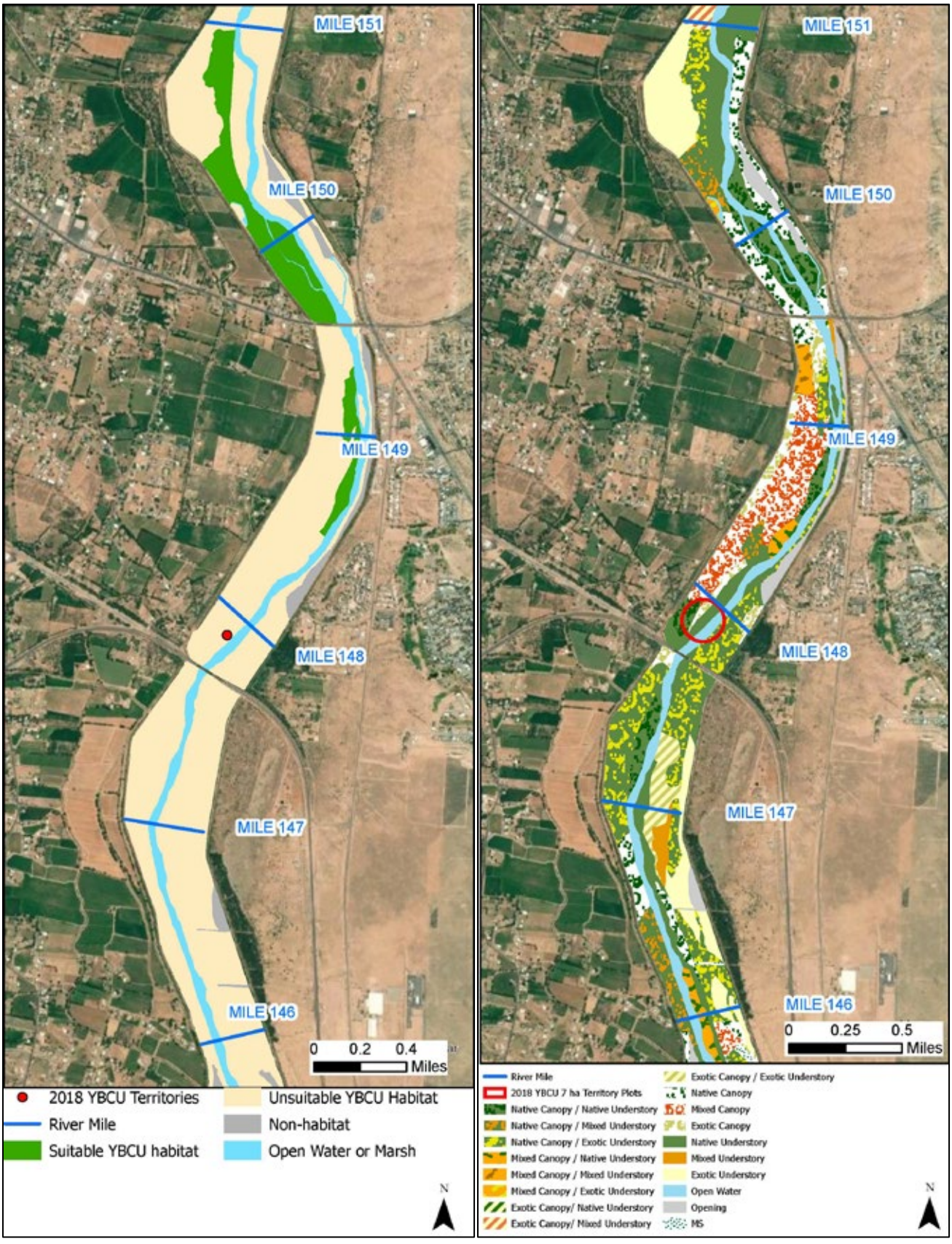
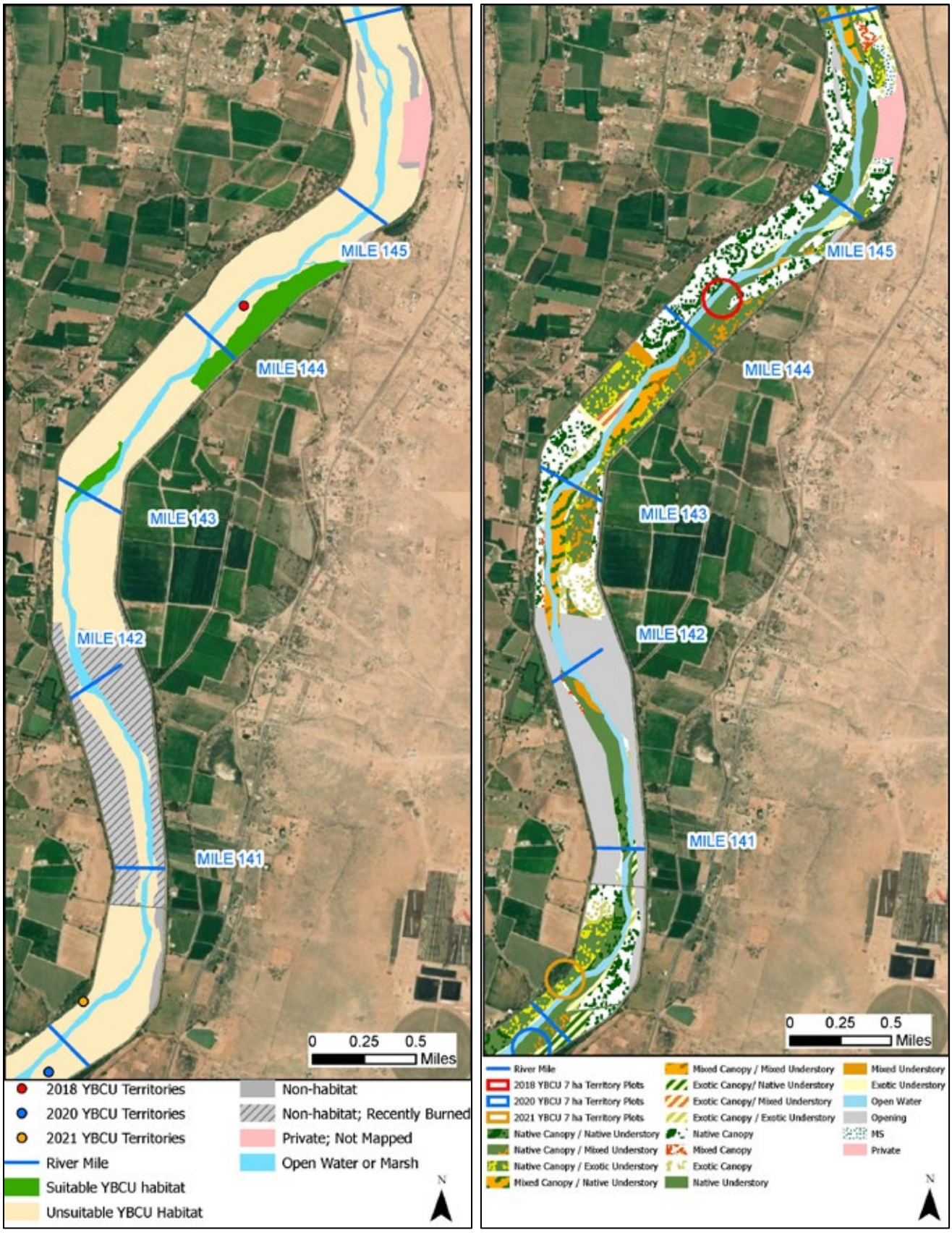


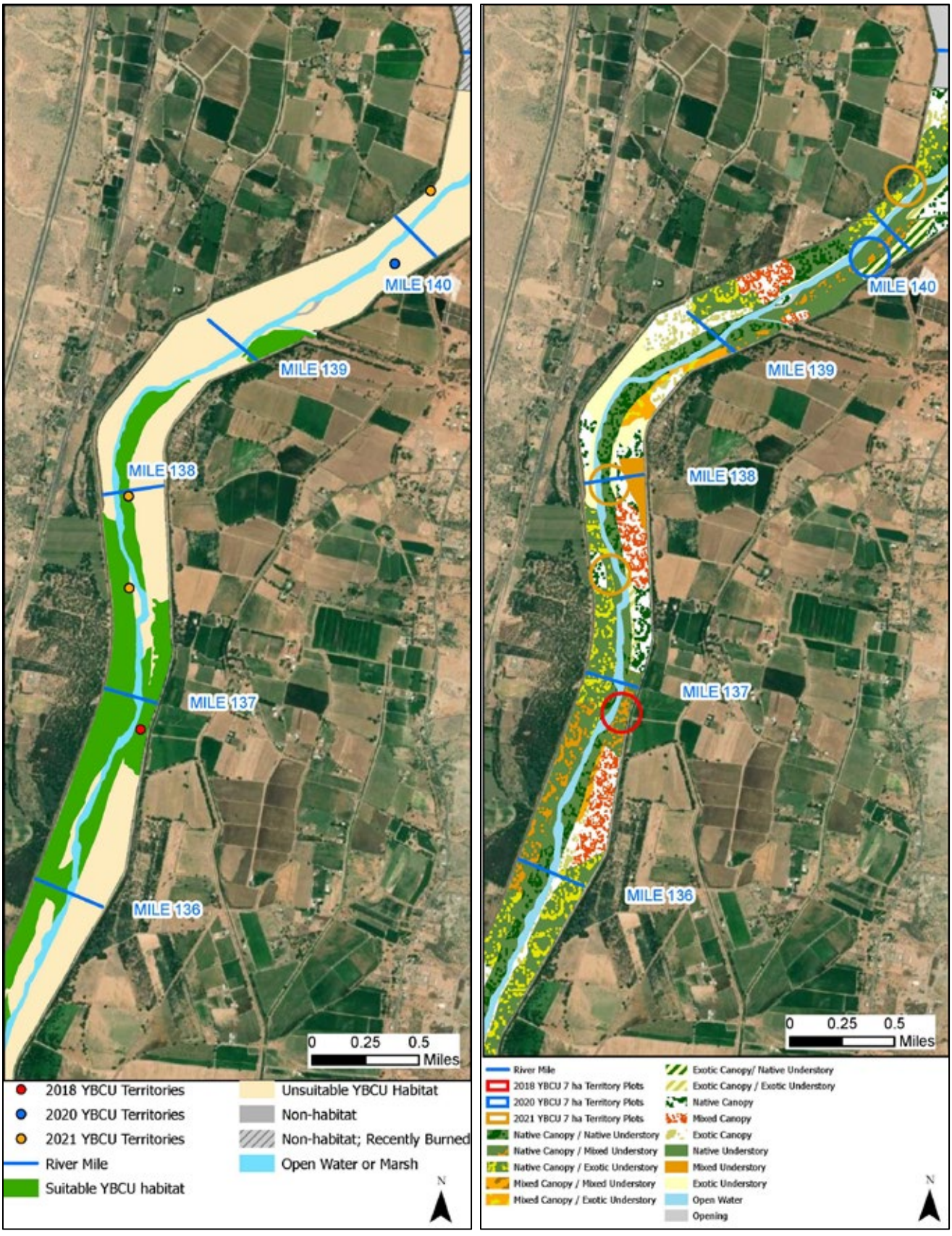
River Miles 146 to 151



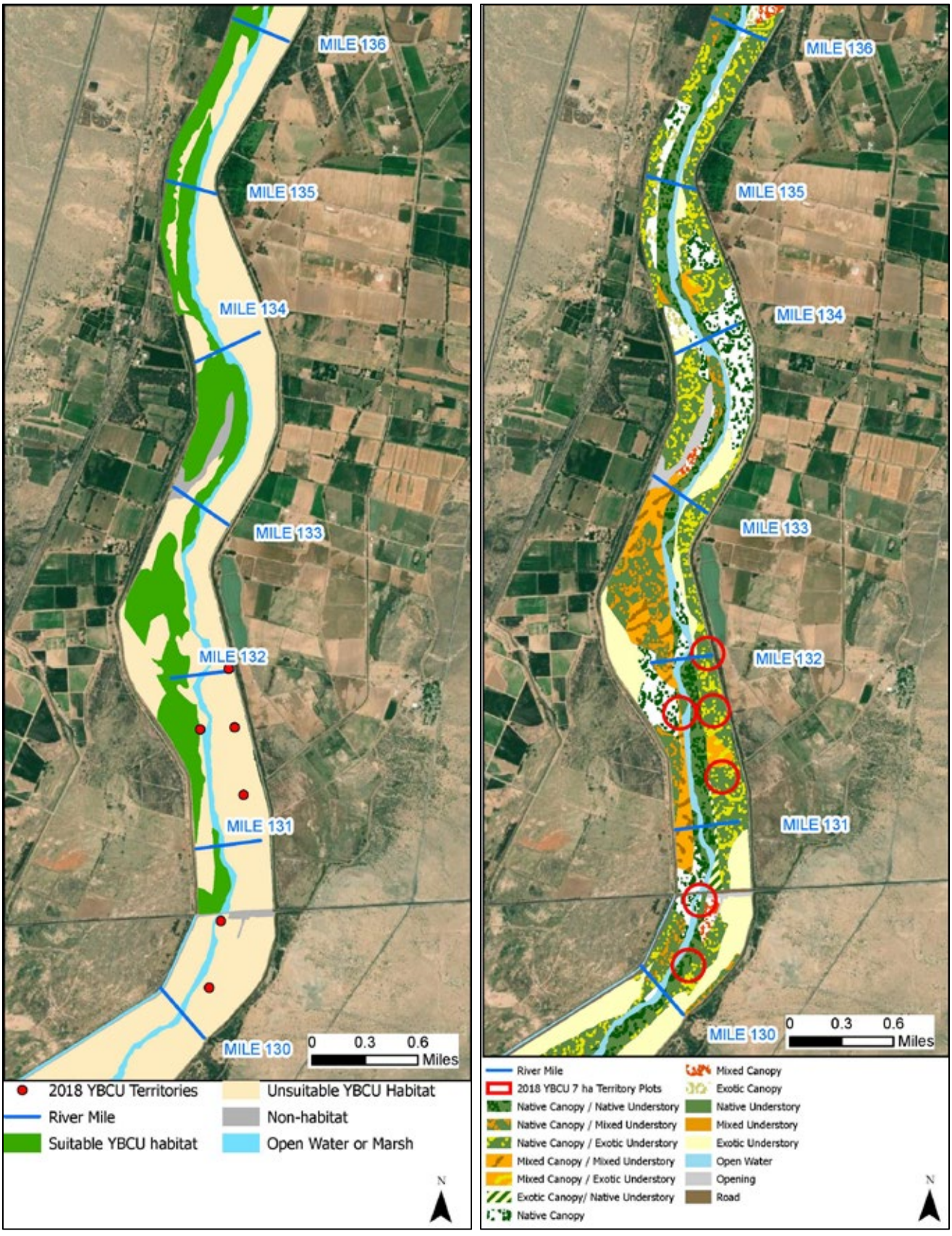
River Miles 140 to 146



River Miles 136 to 140



River Miles 130.5 to 136



Sevilleta/La Joya Reach

Area by Habitat

Suitability Class	Acreage		
	No. of Acres	No. of Hectares	Percentage of Total
Suitable Habitat	278	113	8
Unsuitable Habitat	2618	1059	73
Total Habitat Area	2896	1172	81
Non-habitat	371	150	10
River channel	313	127	9
Total Area*	3580	1449	100

*Sevilleta Reach also includes 363 ac (147 ha) unmapped private land (total 3943 ac / 1596 ha)

Acreage of Plant Communities within Reach

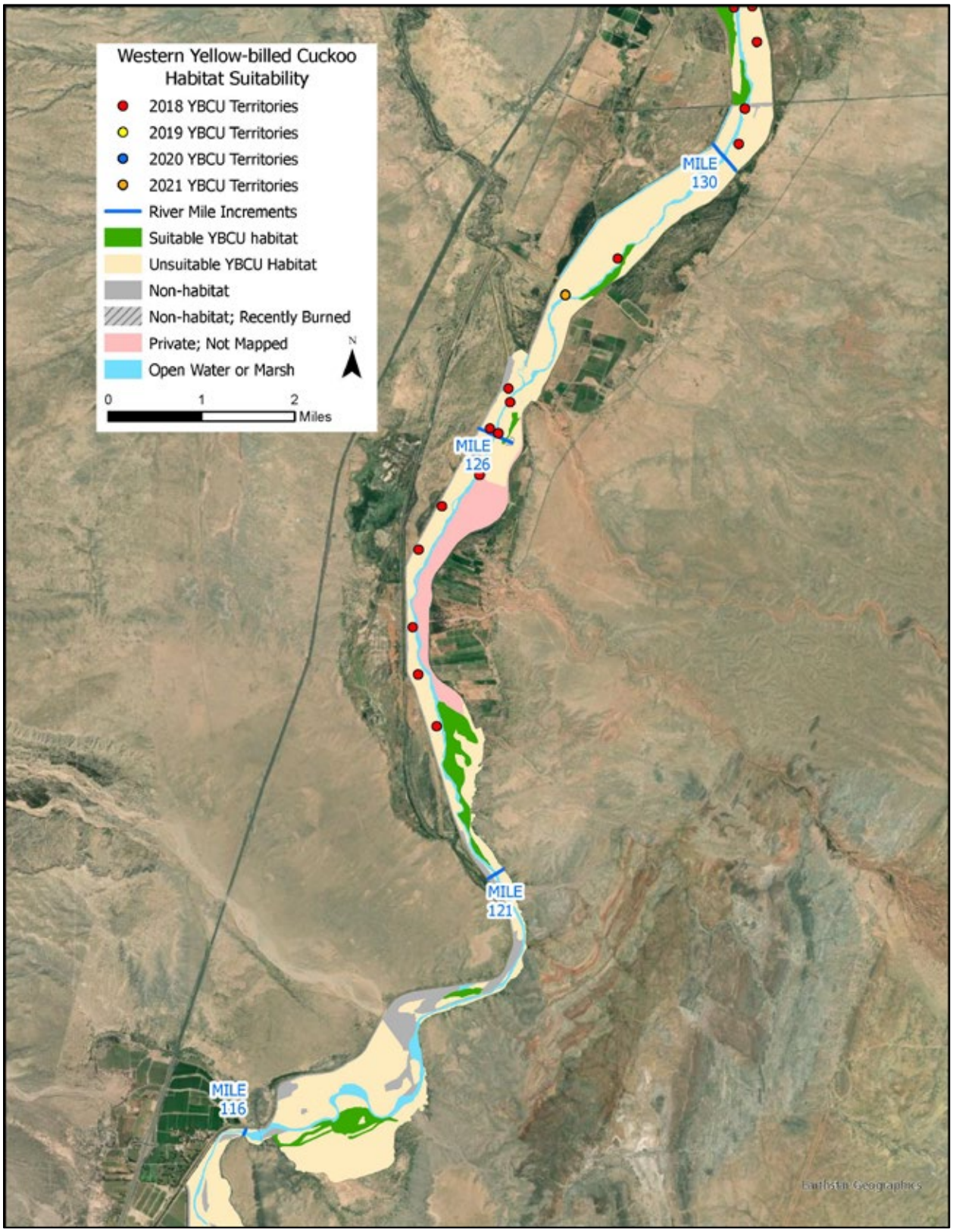
Community Type	Acres	Percentage of Habitat
Native Canopy/Native Understory	518	9
Native Canopy/Mixed Understory	567	10
Native Canopy/Exotic Understory	1178	20
Mixed Canopy/Native Understory	71	1
Mixed Canopy/Mixed Understory	157	3
Mixed Canopy/Exotic Understory	44	1
Exotic Canopy/Native Understory	31	<1
Exotic Canopy/Mixed Understory	21	<1
Exotic Canopy/Exotic Understory	71	1
Native Canopy	1445	24
Mixed Canopy	274	5
Exotic Canopy	485	8
Native Understory	459	8
Mixed Understory	163	3
Exotic Understory	397	7

Western Yellow-billed Cuckoo Territories

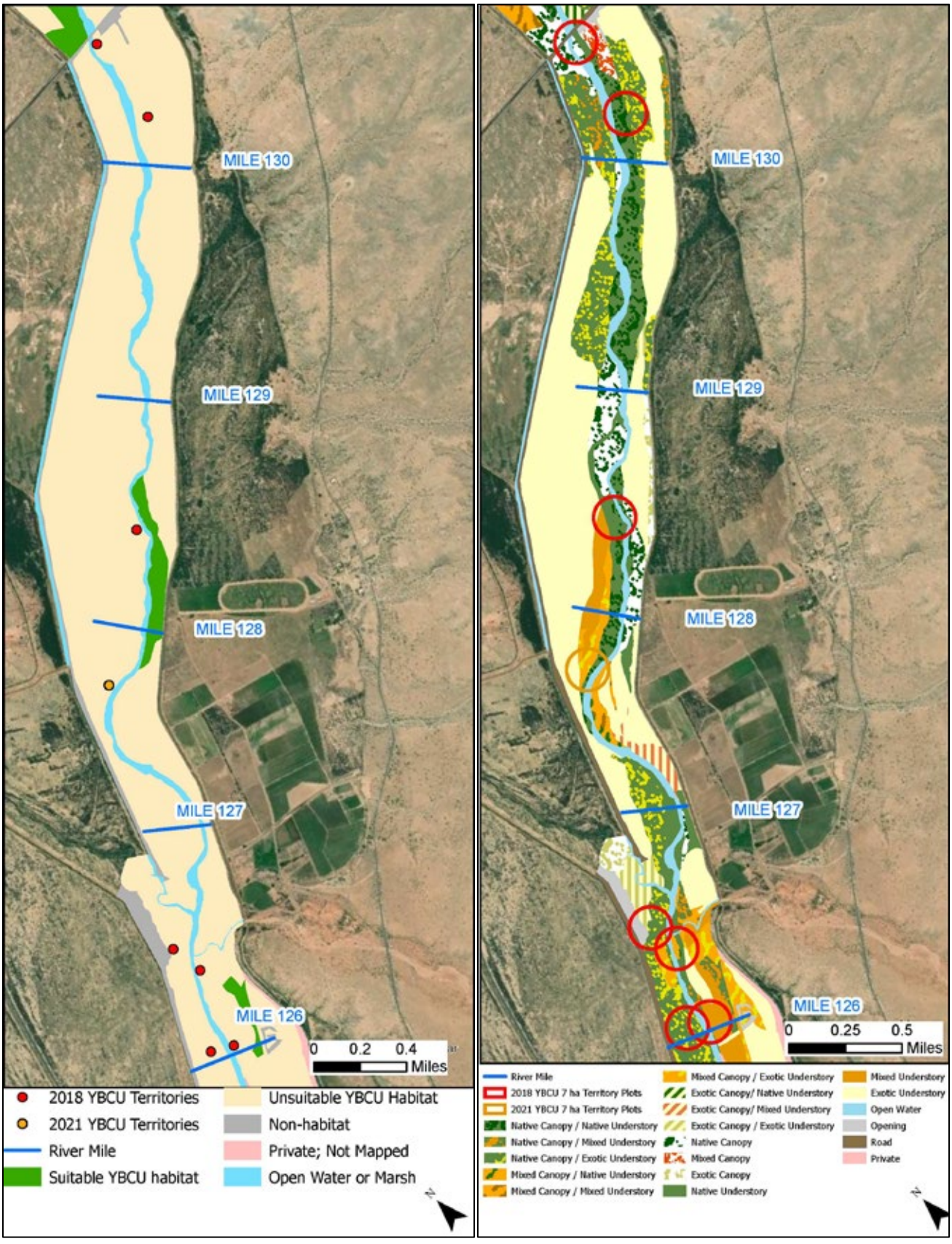
Year	Total Number of Territories
2018	13
2019	Not surveyed
2020	Not surveyed
2021*	1

*Incidental detections only

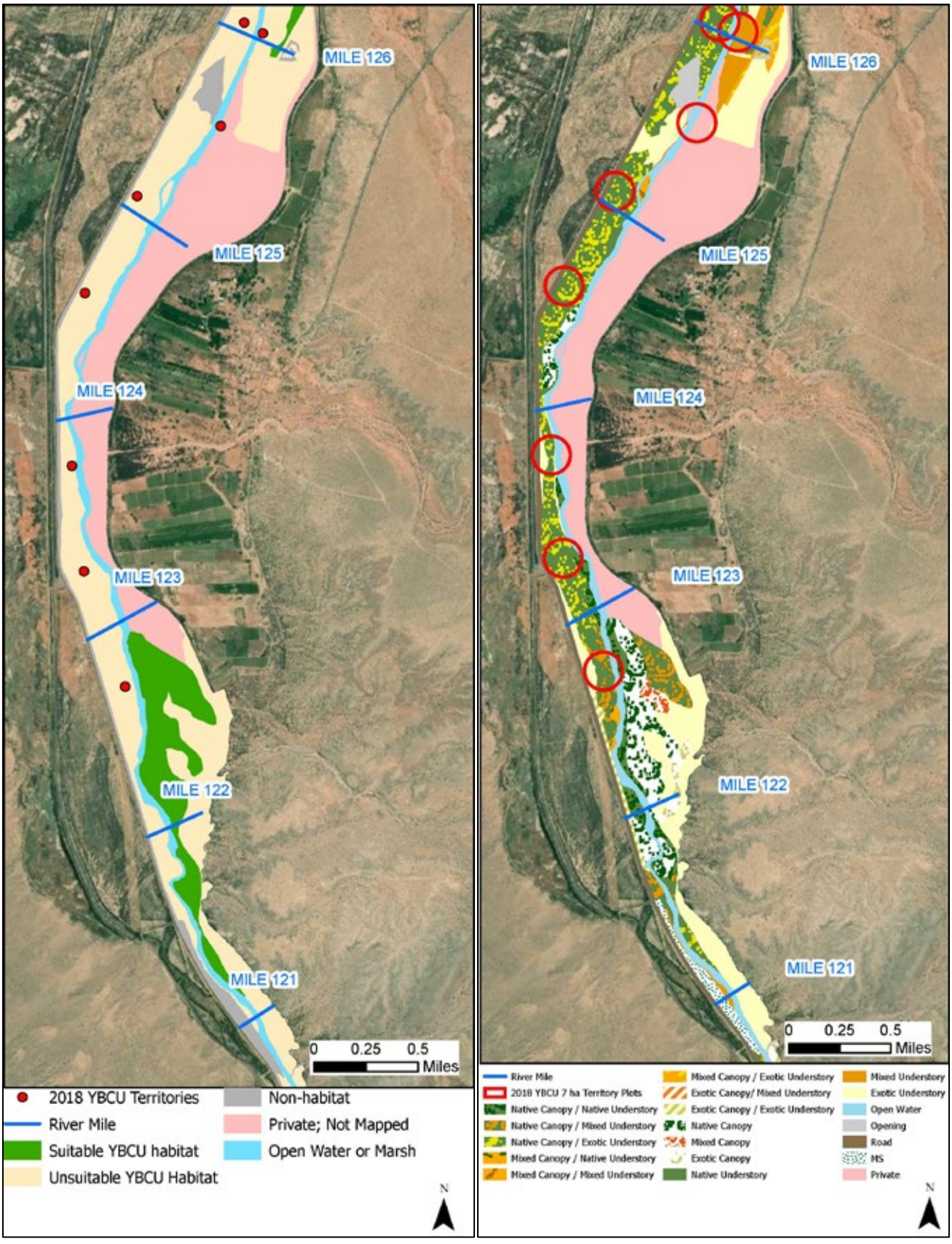
Sevilleta/La Joya Reach Maps


Western Yellow-billed Cuckoo
Habitat Suitability
2018 YBCU Territories
2019 YBCU Territories
2020 YBCU Territories
2021 YBCU Territories
River Mile Increments
Suitable YBCU habitat
Unsuitable YBCU Habitat
Non-habitat
Non-habitat; Recently Burned
Private; Not Mapped
Open Water or Marsh
N
0
1
2
Miles
MILE 130
MILE 126
MILE 121
MILE 116
Earthstar Geographics

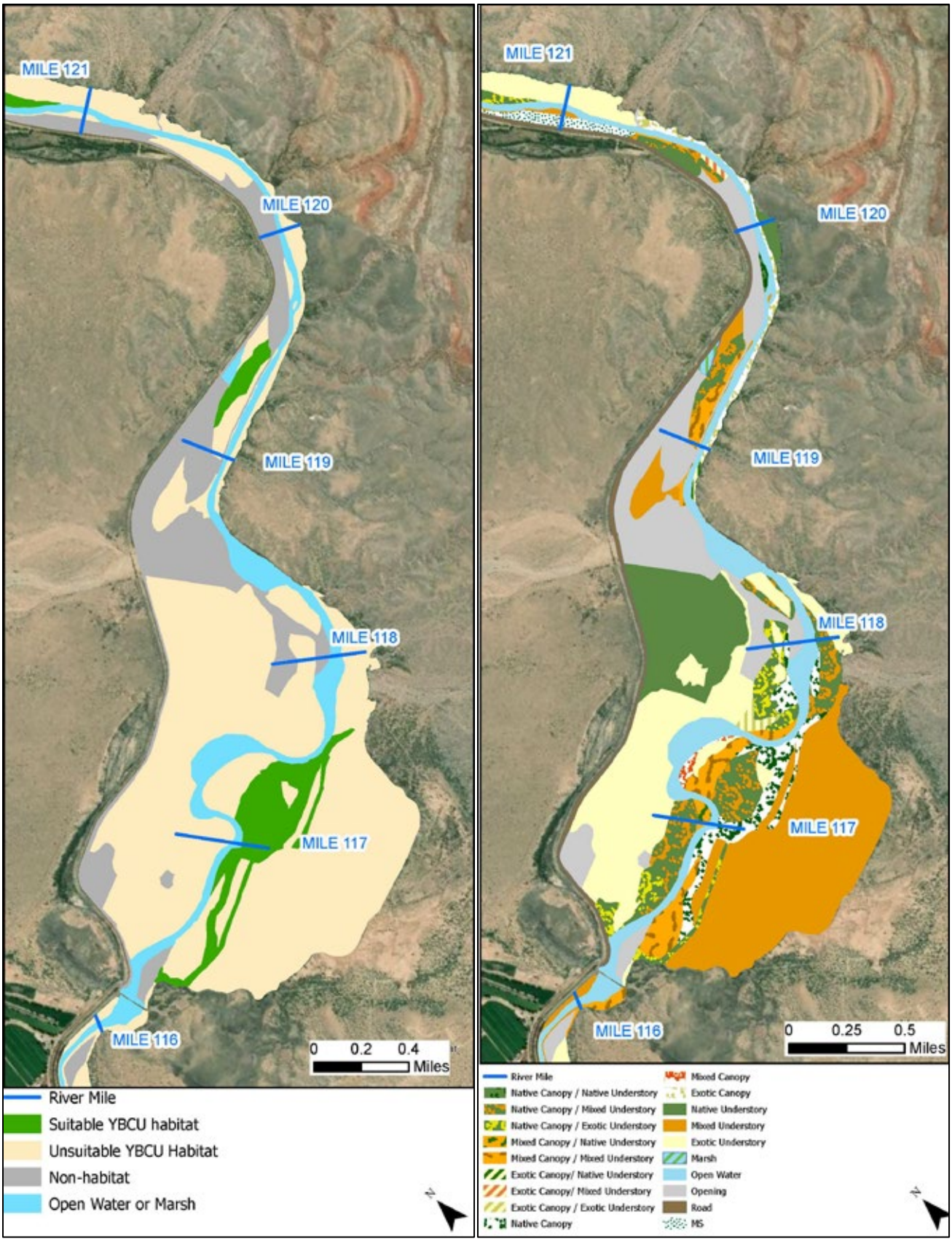
River Miles 126 to 130.5



River Miles 121 to 126



River Miles 116 to 121



San Acacia Reach

Area by Habitat

Suitability Class	Acreage		
	No. of Acres	No. of Hectares	Percentage of Total
Suitable Habitat	56	23	2
Unsuitable Habitat	2285	928	83
Total Habitat Area	2341	951	85
Non-habitat	182	70	6
River channel	244	99	9
Total Area*	2767	1120	100

* San Acacia Reach also includes 42 ac (17 ha) unmapped private land (total 2809 ac/ 1137 ha))

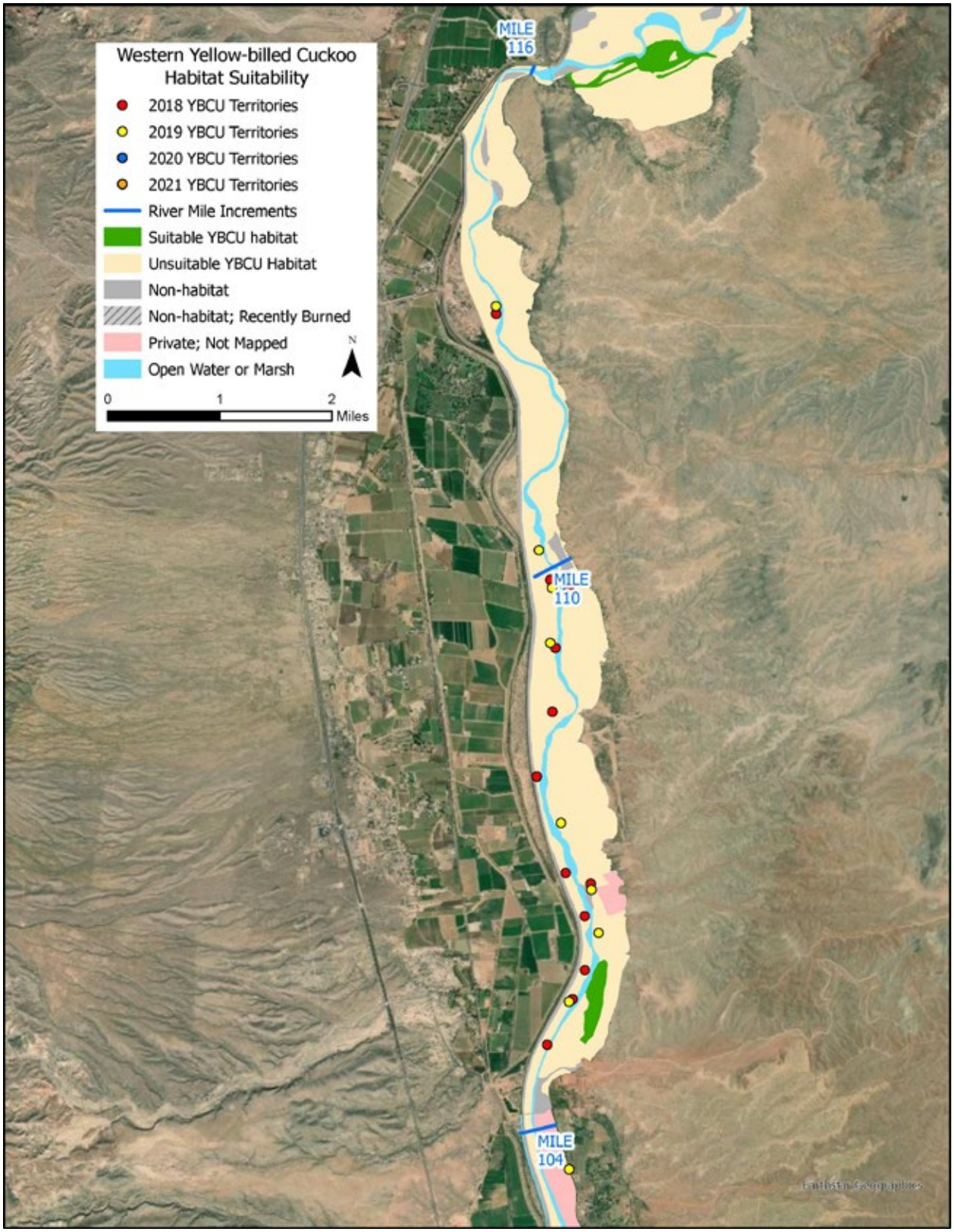
Acreage of Plant Communities within Reach

Community Type	No. of Acres	Percentage of Habitat
Native Canopy/Native Understory	106	4
Native Canopy/Mixed Understory	381	16
Native Canopy/Exotic Understory	201	9
Mixed Canopy/Native Understory	40	2
Mixed Canopy/Mixed Understory	173	7
Mixed Canopy/Exotic Understory	0	0
Exotic Canopy/Native Understory	9	<1
Exotic Canopy/Mixed Understory	0	0
Exotic Canopy/Exotic Understory	0	0
Native Canopy	68	3
Mixed Canopy	178	8
Exotic Canopy	45	2
Native Understory	36	2
Mixed Understory	396	17
Exotic Understory	716	30

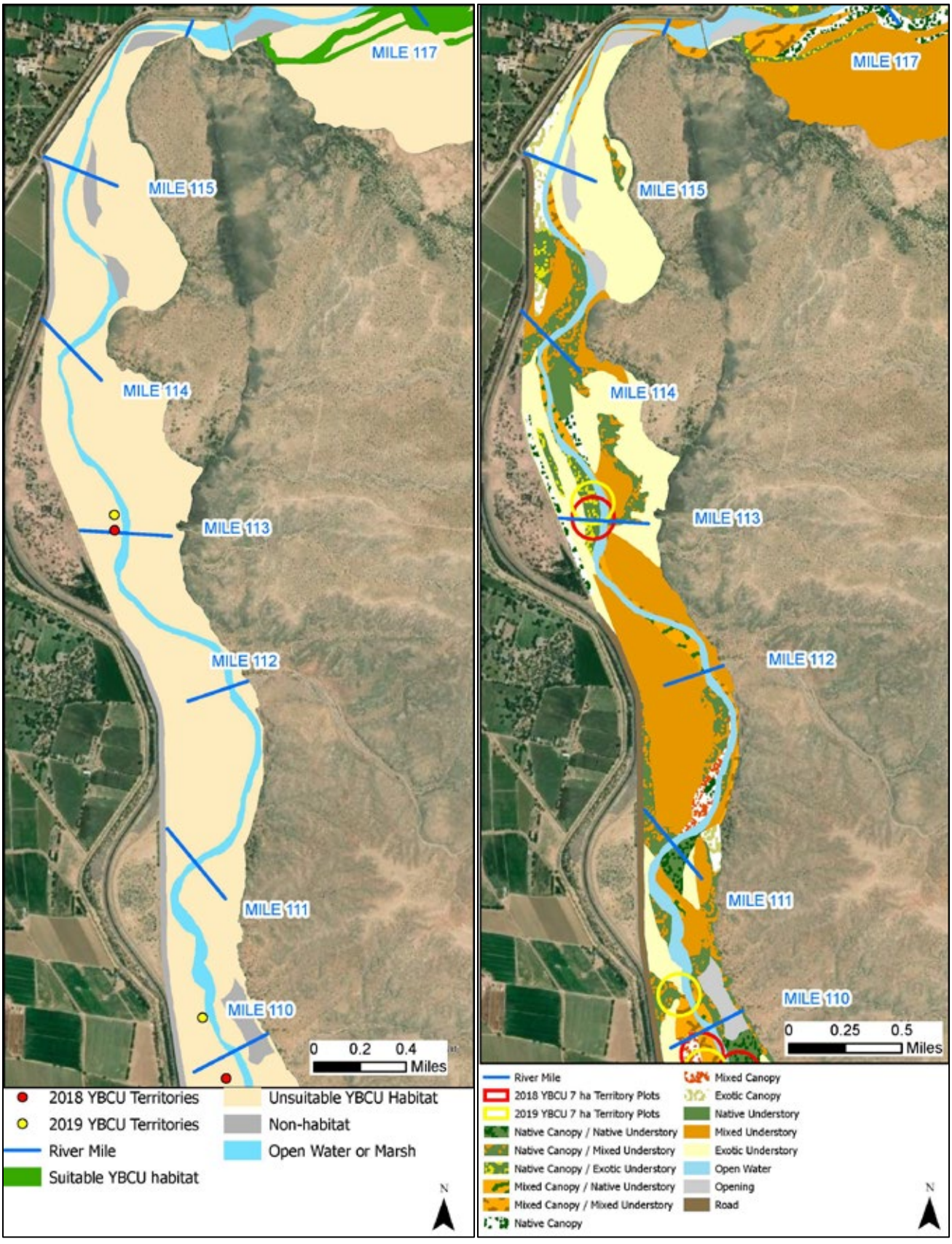
Western Yellow-billed Cuckoo Territories

Year	Total Number of Territories
2018	12
2019	8
2020	Not surveyed
2021	Not surveyed

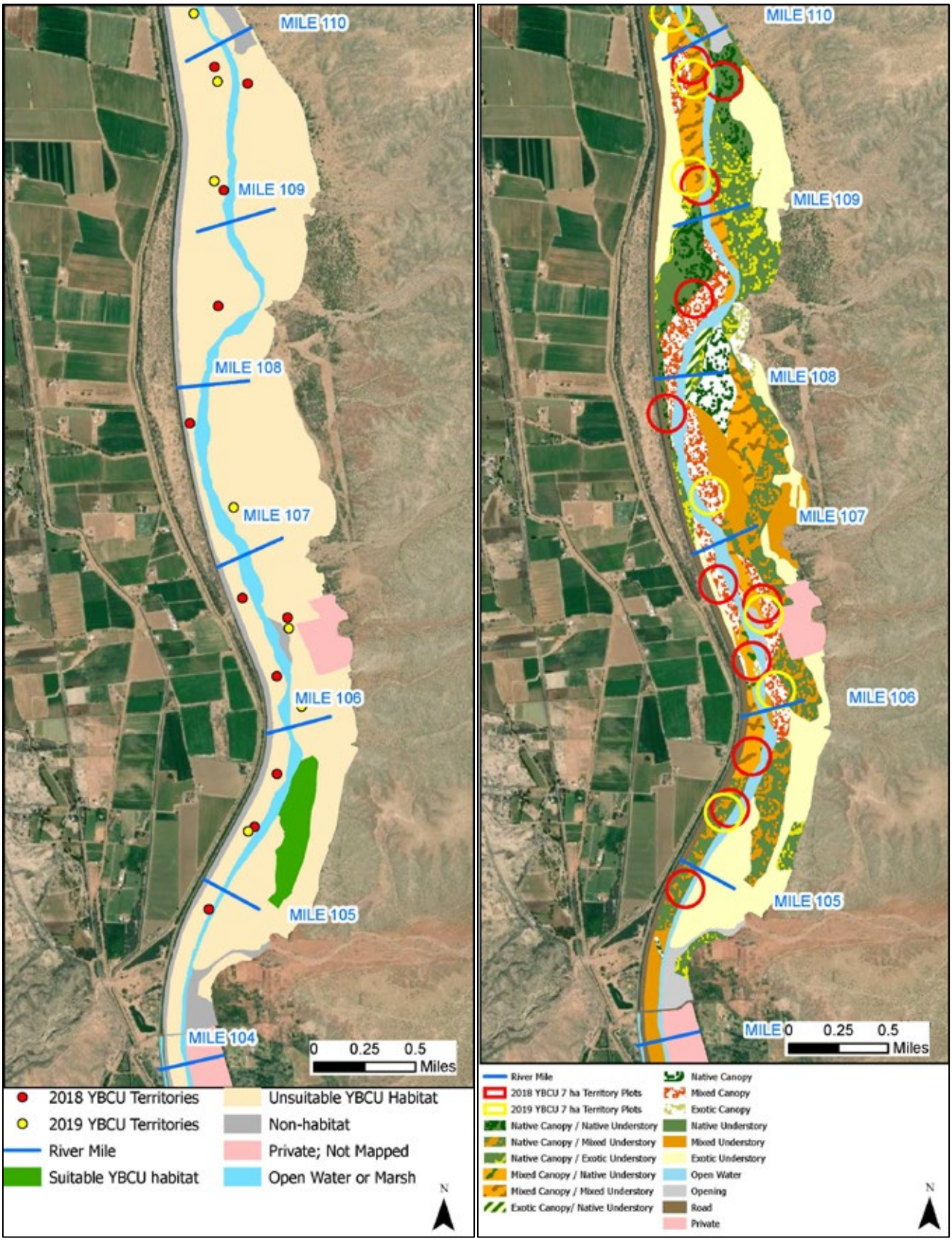
San Acacia Reach Maps



River Miles 110 to 116



River Miles 104 to 110



Escondida Reach

Area by Habitat

Suitability Class	Acreage		
	No. of Acres	No. of Hectares	Percentage of Total
Suitable Habitat	113	46	2
Unsuitable Habitat	4259	1723	72
Total Habitat Area	4372	1769	74
Non-habitat	1100	445	18
River channel	472	191	8
Total Area*	5944	2405	100

*Escondida Reach also includes 291 ac (118 ha) unmapped private land (total 6235 ac/ 2523 ha)

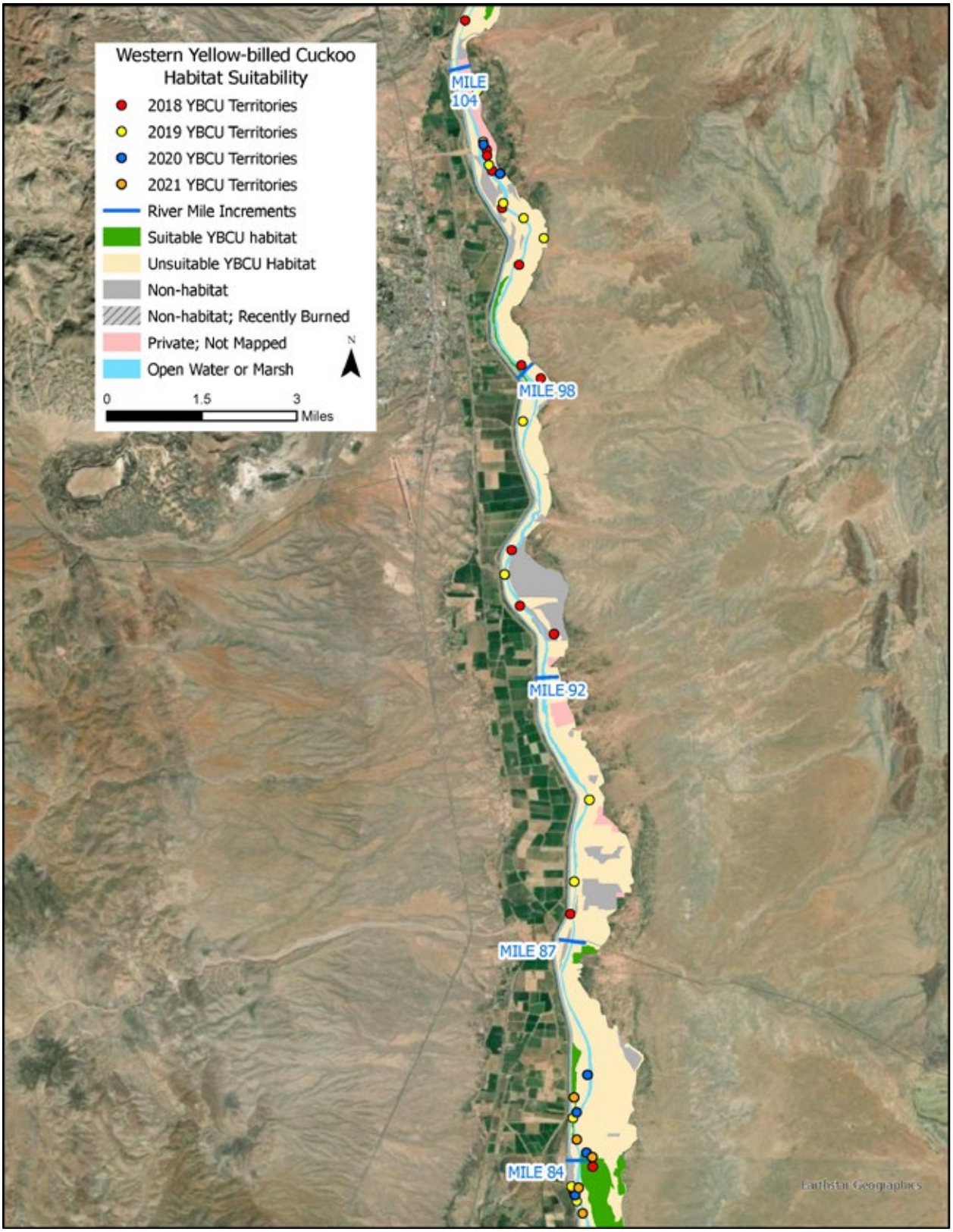
Acreage of Plant Communities within Reach

Community Type	No. of Acres	Percentage of Habitat
Native Canopy/Native Understory	78	2
Native Canopy/Mixed Understory	263	6
Native Canopy/Exotic Understory	275	6
Mixed Canopy/Native Understory	5	<1
Mixed Canopy/Mixed Understory	252	6
Mixed Canopy/Exotic Understory	9	<1
Exotic Canopy/Native Understory	32	1
Exotic Canopy/Mixed Understory	198	5
Exotic Canopy/Exotic Understory	415	9
Native Canopy	248	6
Mixed Canopy	166	4
Exotic Canopy	151	3
Native Understory	4	<1
Mixed Understory	526	12
Exotic Understory	1750	40

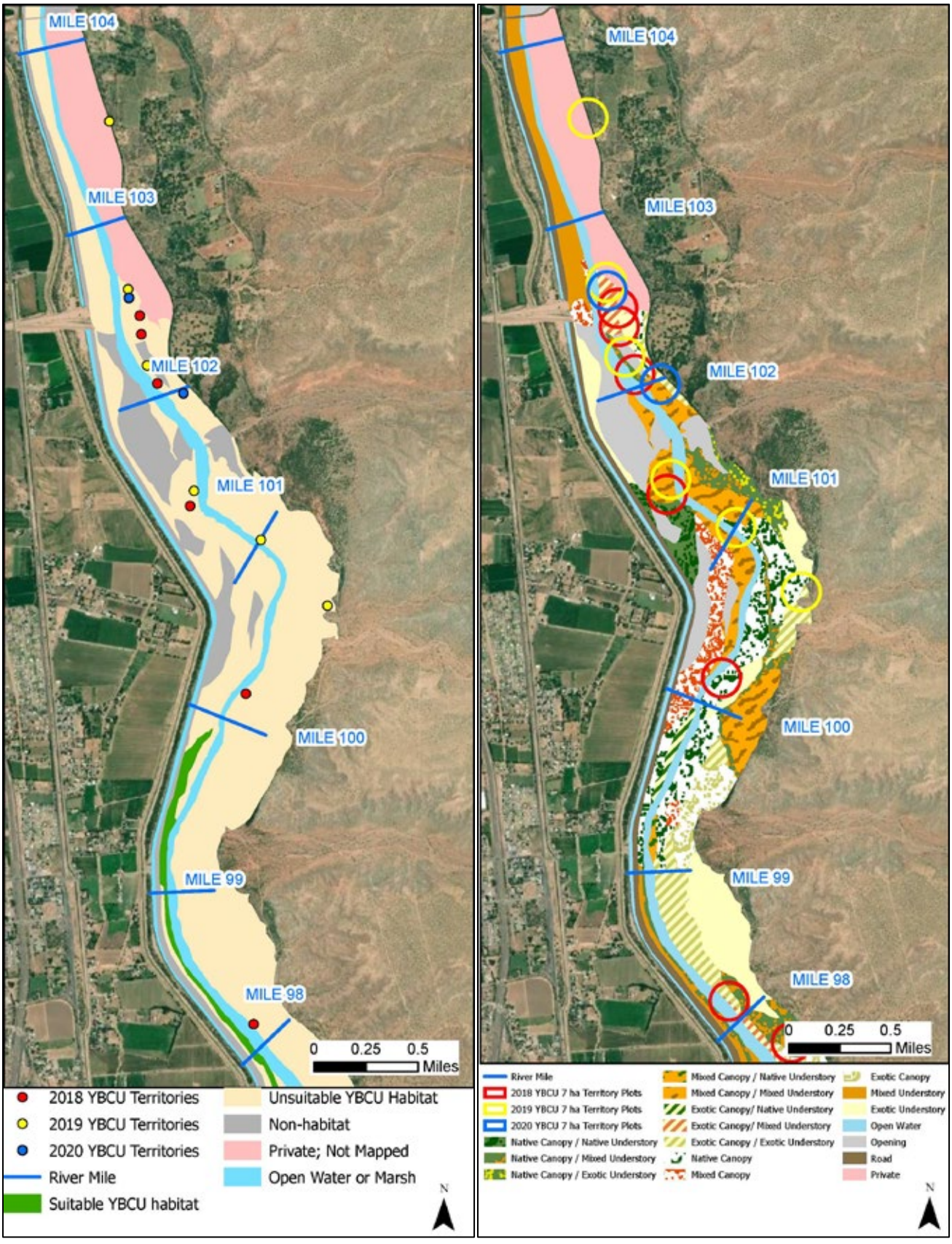
Western Yellow-billed Cuckoo Territories

Year	Total Number of Territories
2018	12
2019	11
2020	5
2021	2

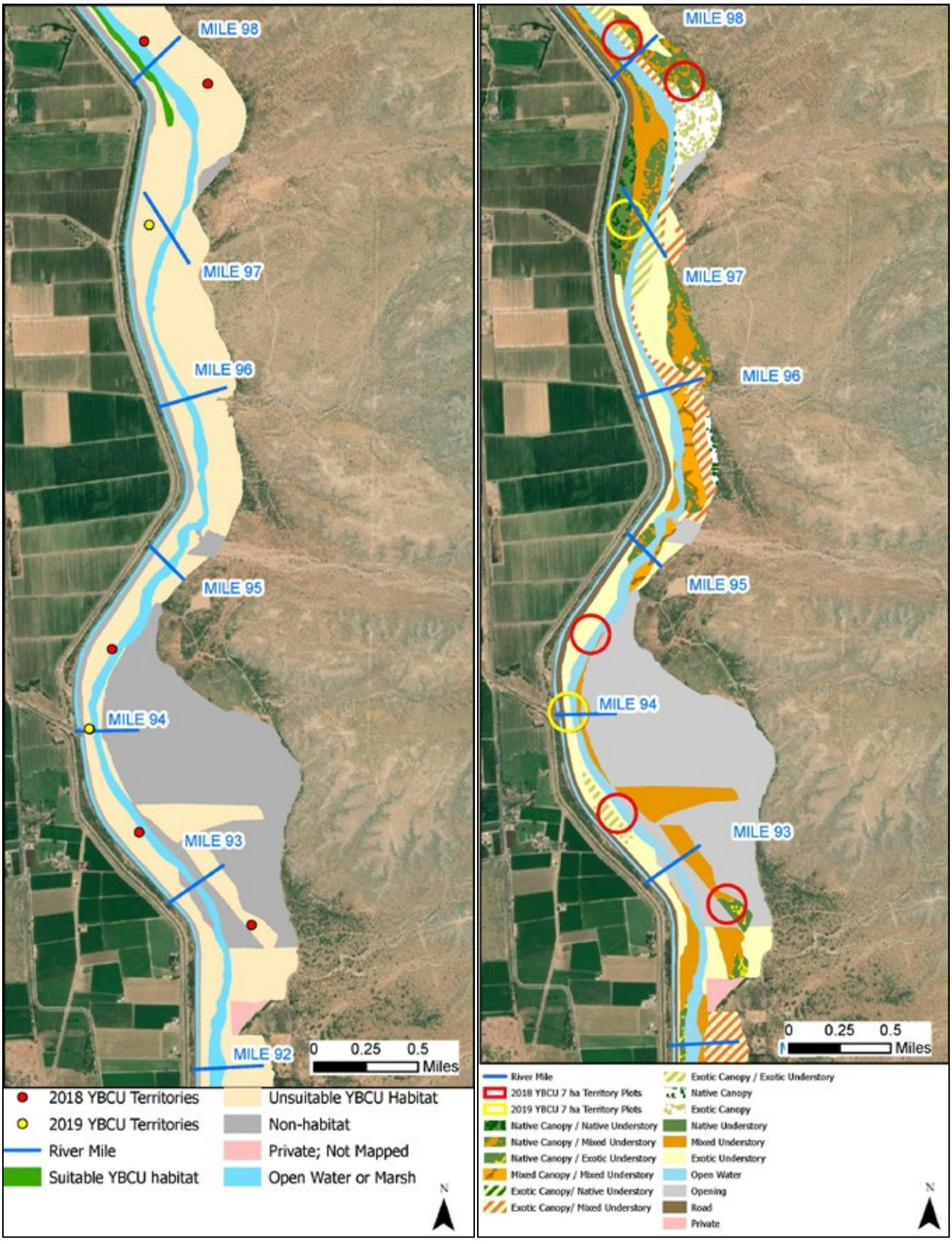
Escondida Reach Maps



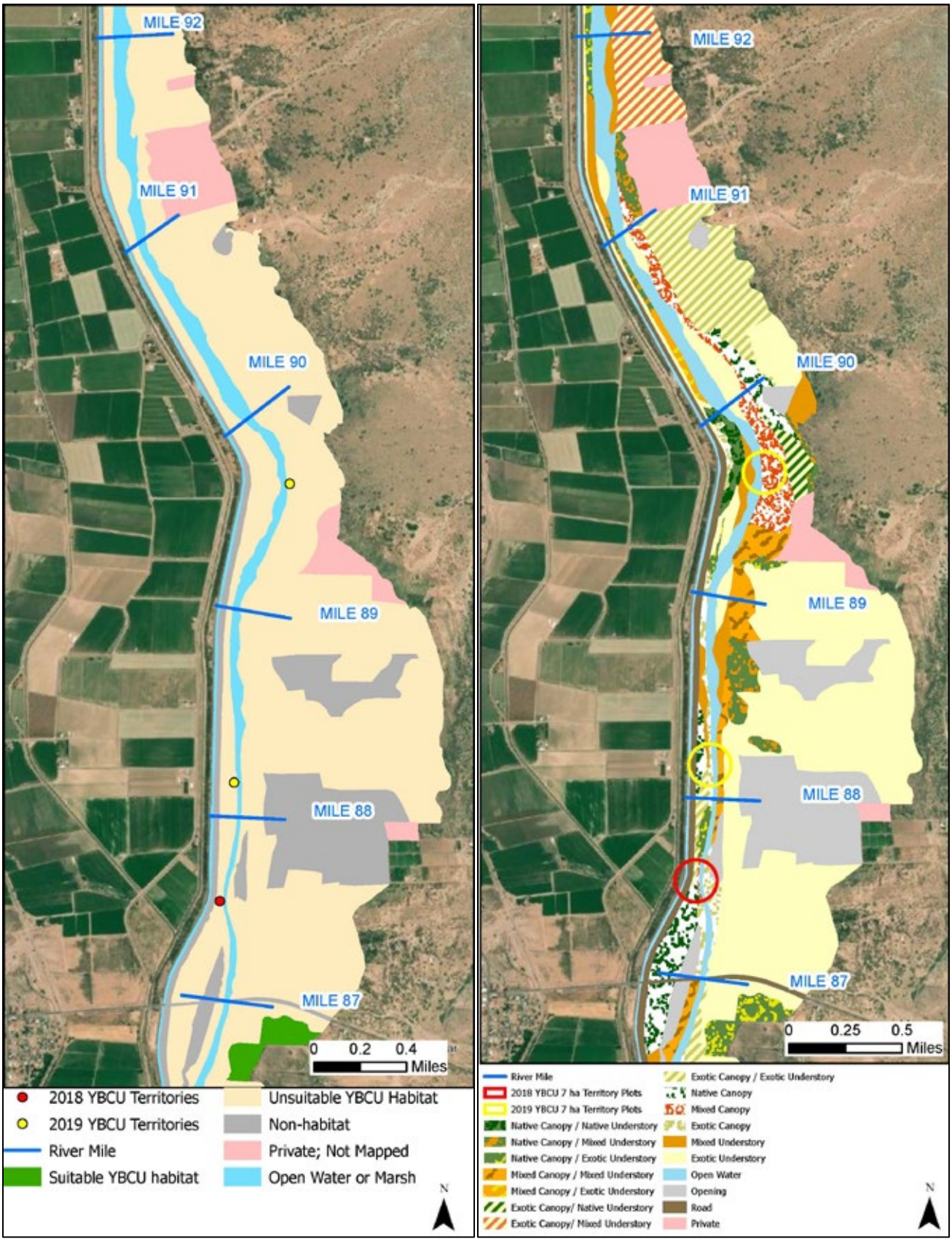
River Miles 98 to 104



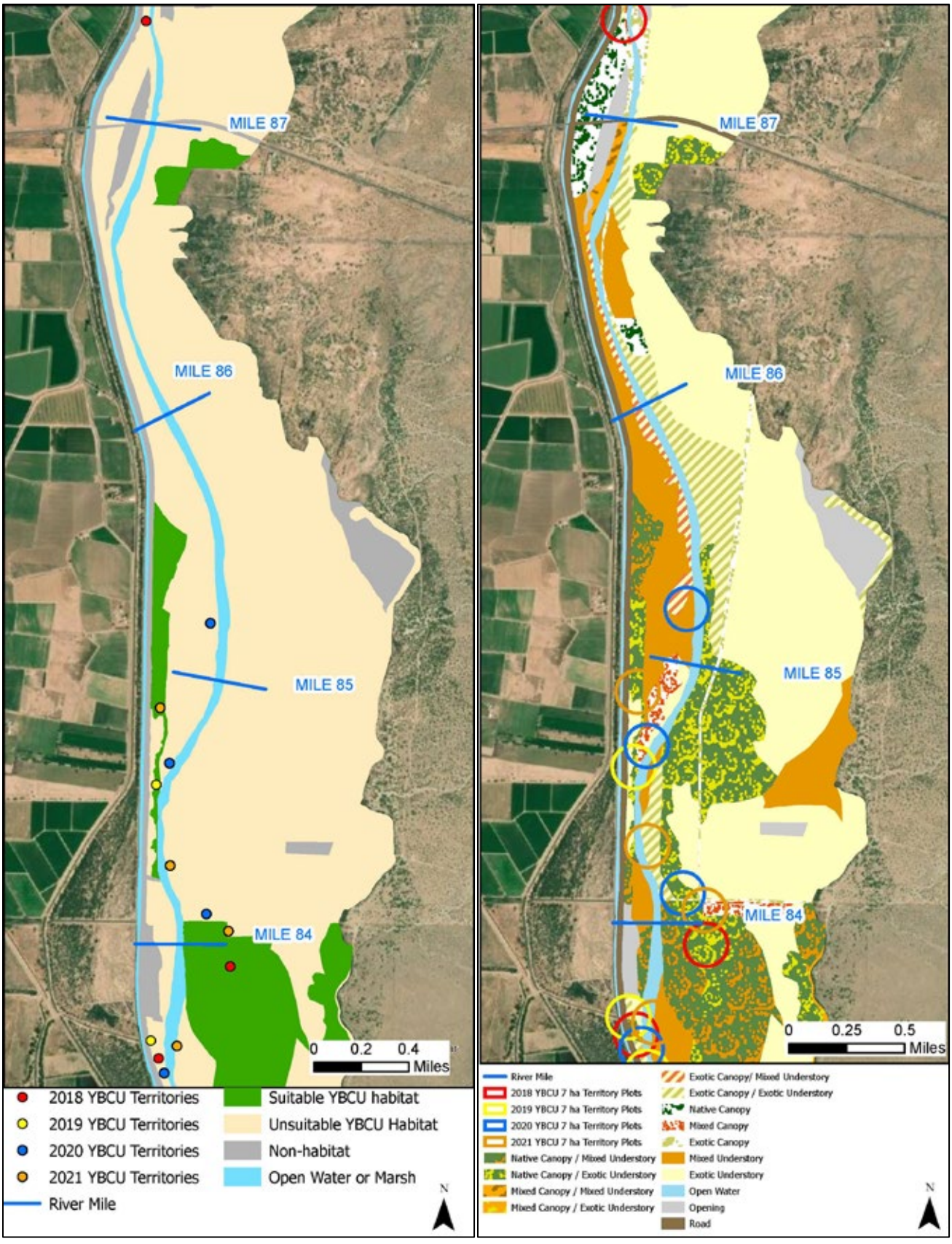
River Miles 92 to 98



River Miles 87 to 92



River Miles 84 to 87



Bosque del Apache Reach

Area by Habitat

Suitability Class	Acreage		
	No. of Acres	No. of Hectares	Percentage of Total
Suitable Habitat	965	390	24
Unsuitable Habitat	2068	837	52
Total Habitat Area	3033	1227	76
Non-habitat	684	277	17
River channel	267	108	7
Total Area	3984	1612	100

Acreage of Plant Communities within Reach

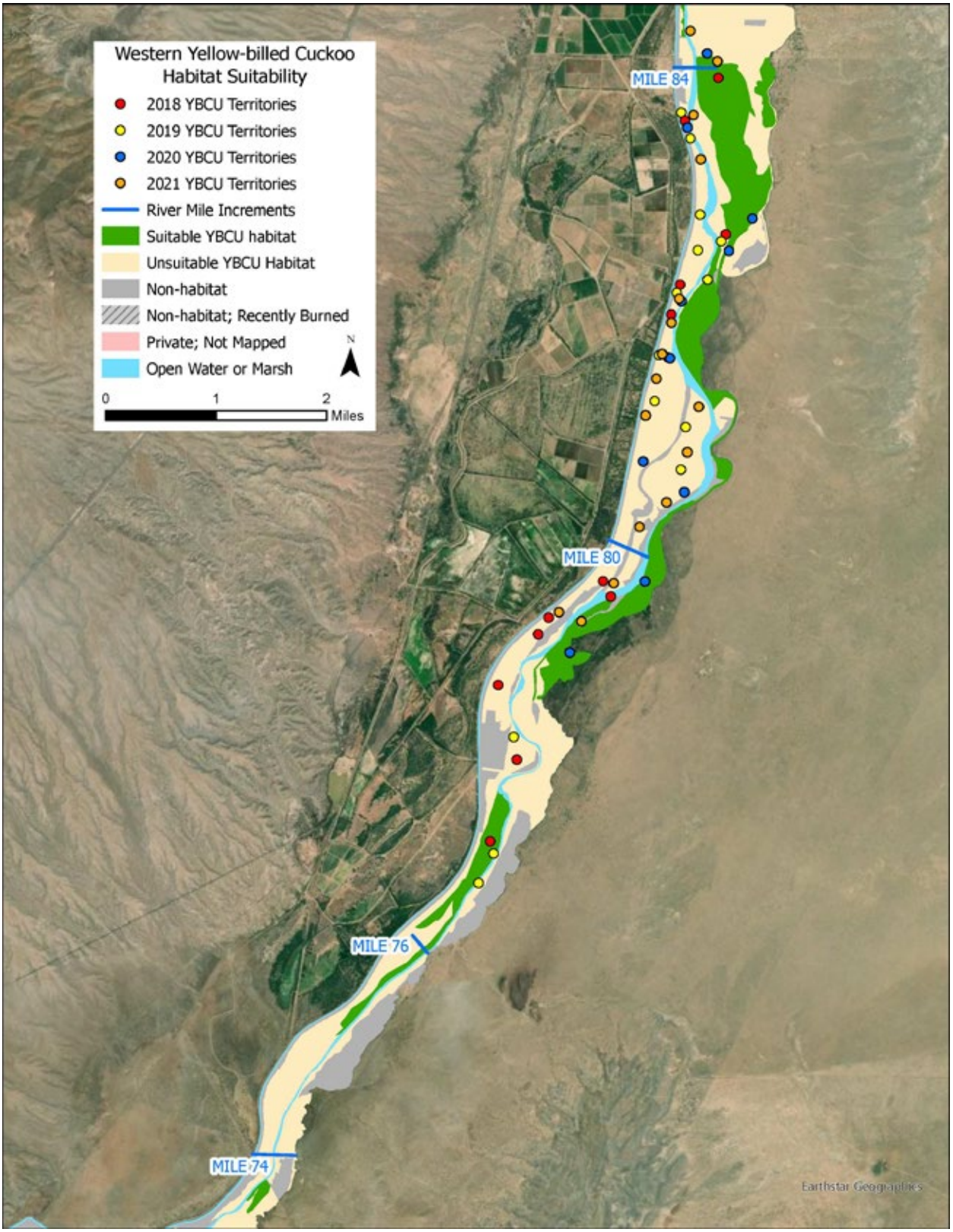
Community Type	No. of Acres	Percentage of Habitat
Native Canopy/Native Understory	104	3
Native Canopy/Mixed Understory	731	24
Native Canopy/Exotic Understory	613	20
Mixed Canopy/Native Understory	0	-
Mixed Canopy/Mixed Understory	29	1
Mixed Canopy/Exotic Understory	17	1
Exotic Canopy/Native Understory	36	1
Exotic Canopy/Mixed Understory	7	<1
Exotic Canopy/Exotic Understory	58	2
Native Canopy	324	11
Mixed Canopy	76	3
Exotic Canopy	129	4
Native Understory	196	7
Mixed Understory	343	11
Exotic Understory	370	12

Western Yellow-billed Cuckoo Territories

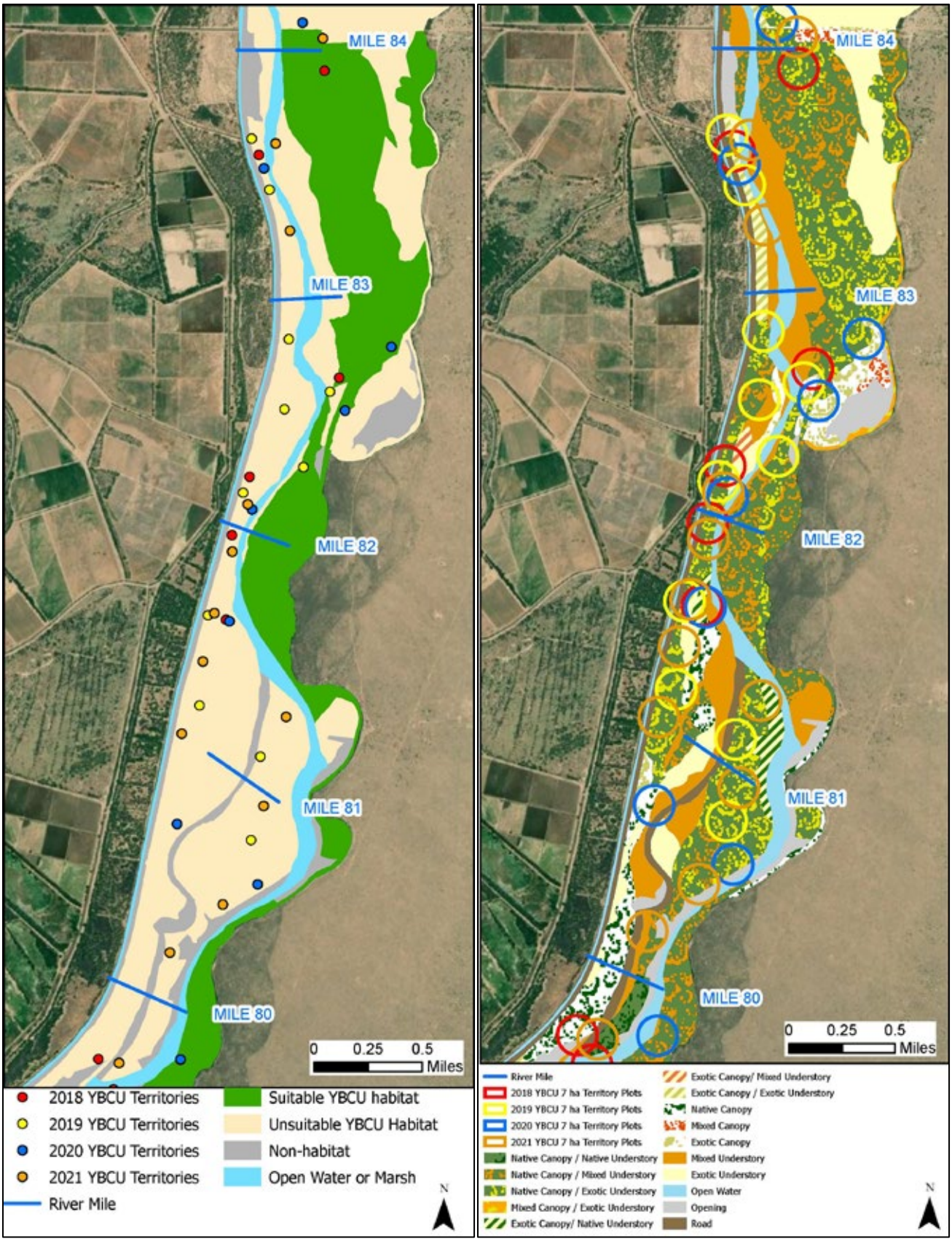
Year	Total Number of Territories
2018	13
2019	14
2020*	9
2021*	15

*Only Northern portion of site surveyed

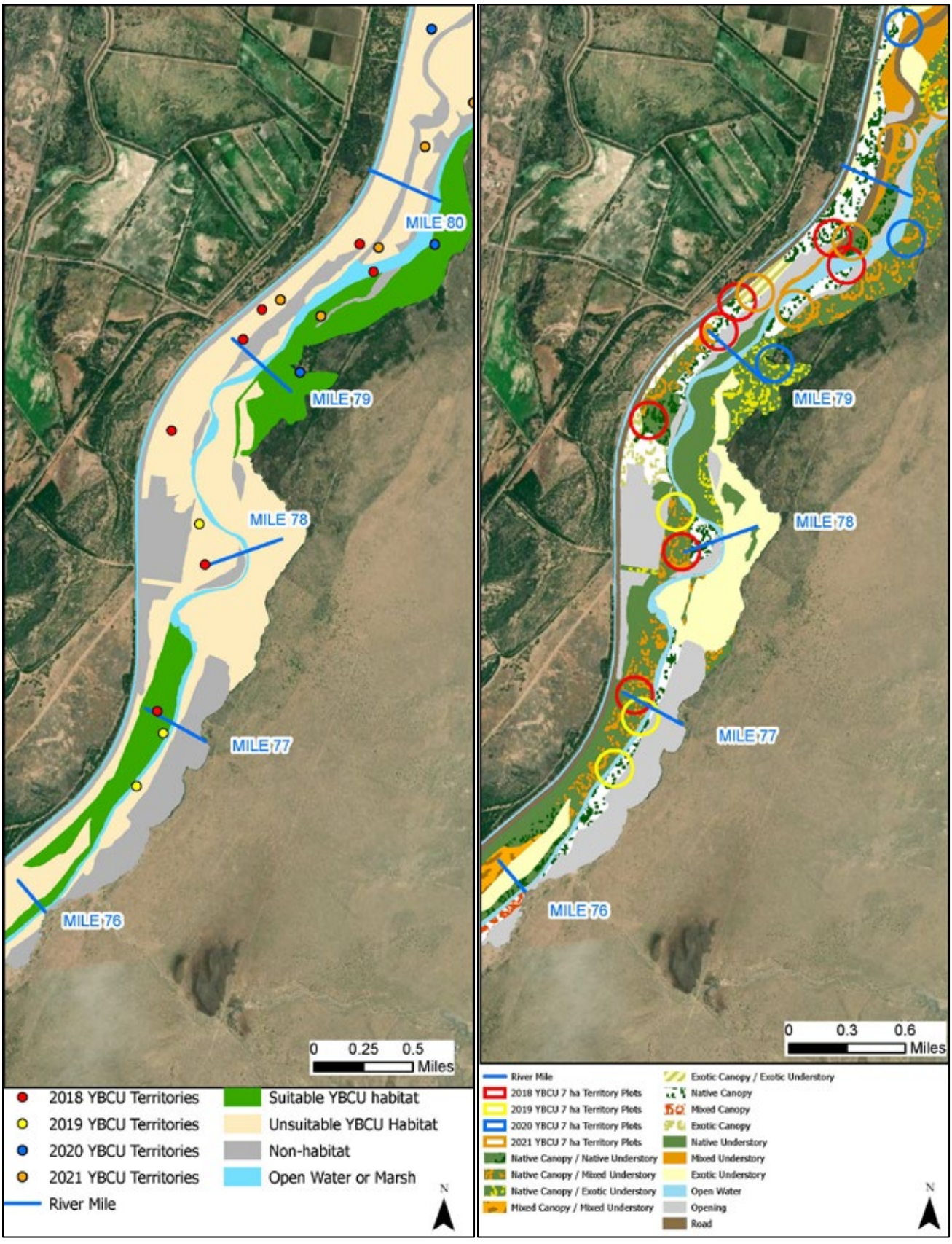
Bosque del Apache Reach Maps



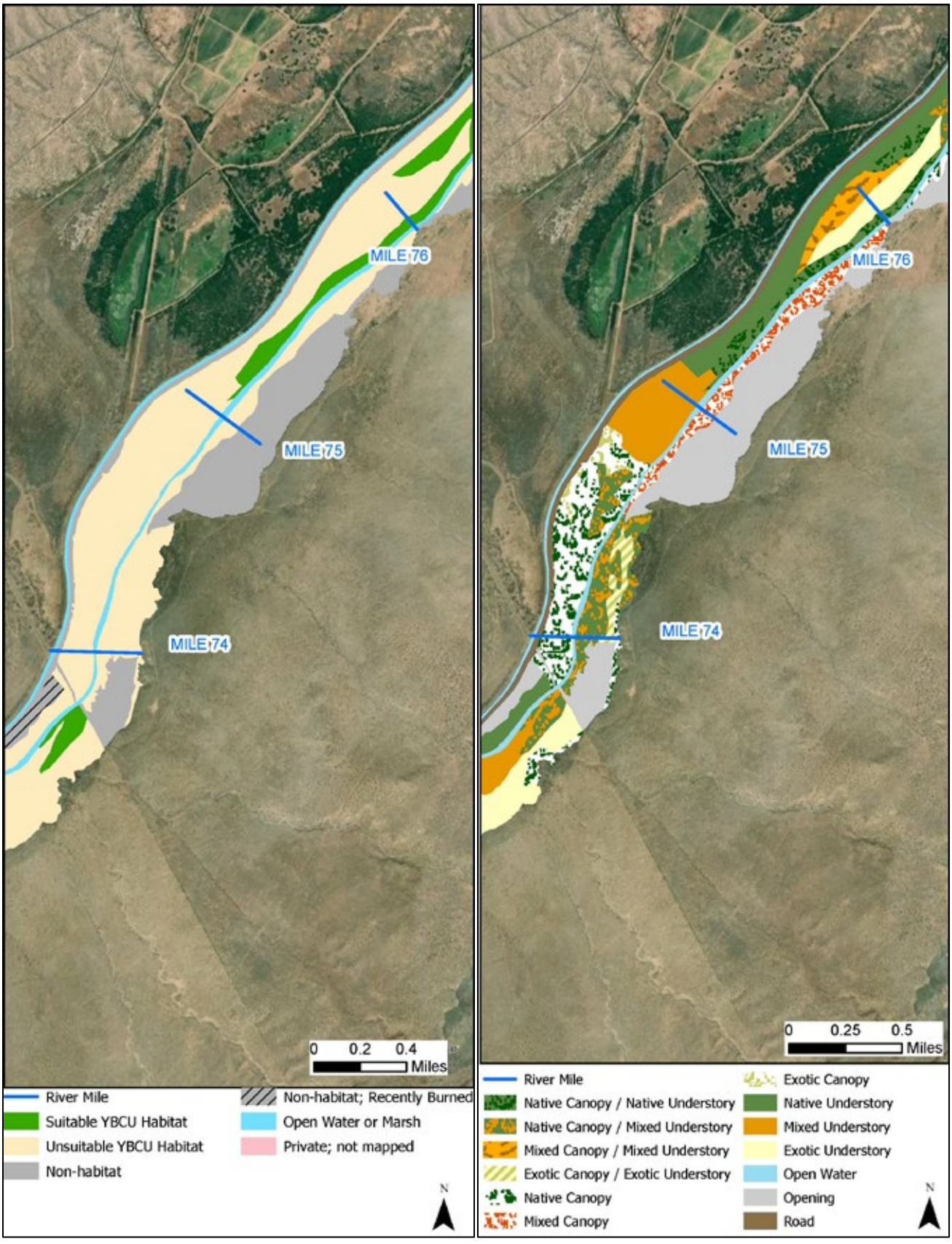
River Miles 80 to 84



River Miles 76 to 80



River Miles 74 to 76



Tiffany Reach

Area by Habitat

Suitability Class	Acreage		
	No. of Acres	No. of Hectares	Percentage of Total
Suitable Habitat	147	60	4
Unsuitable Habitat	2635	1066	70
Total Habitat Area	2782	1126	74
Non-habitat	905	366	24
River channel	85	34	2
Total Area	3772	1526	100

Acreage of Plant Communities within Reach

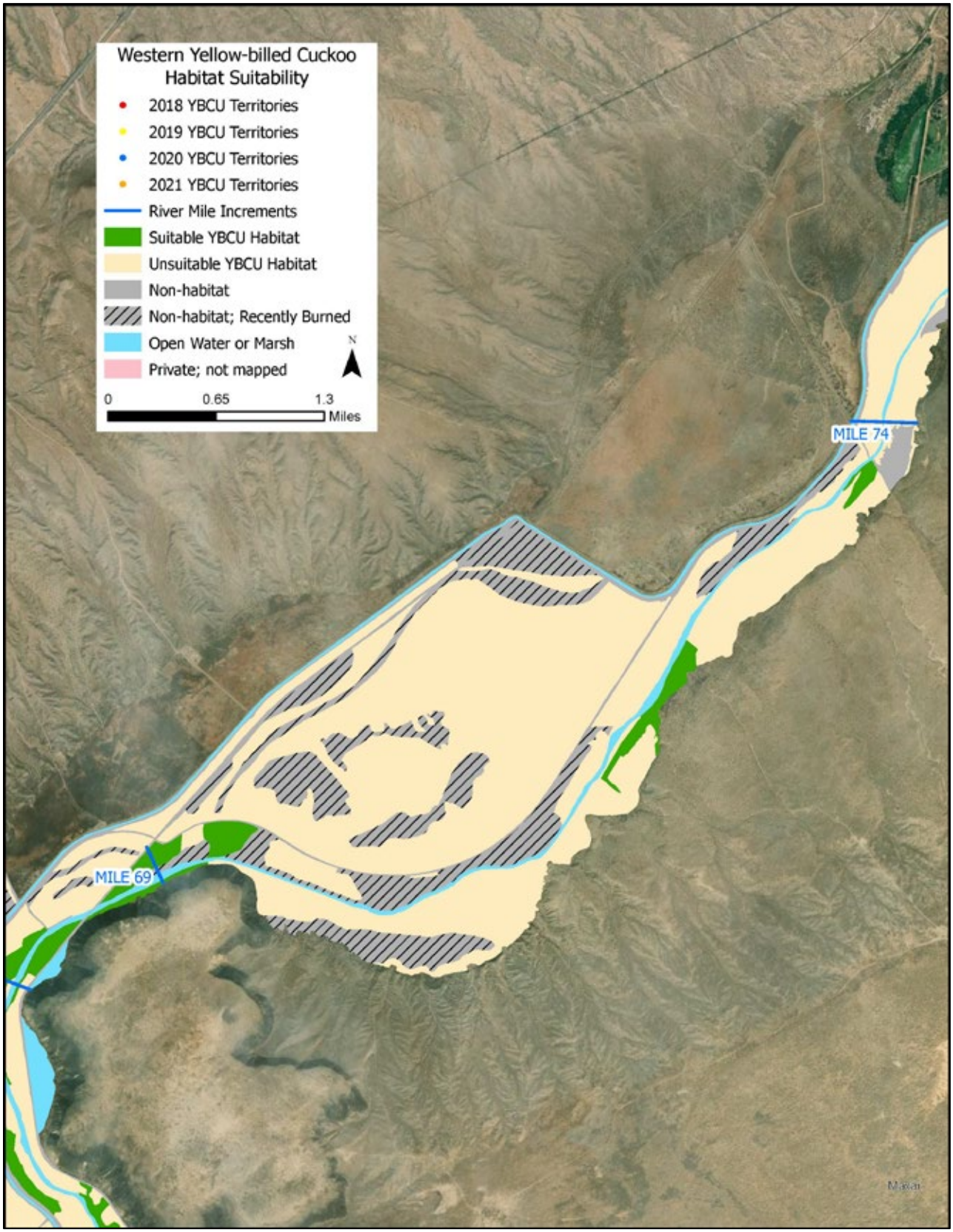
Community Type	No. of Acres	Percentage of Habitat
Native Canopy/Native Understory	82	3
Native Canopy/Mixed Understory	35	1
Native Canopy/Exotic Understory	42	2
Mixed Canopy/Native Understory	0	0
Mixed Canopy/Mixed Understory	0	0
Mixed Canopy/Exotic Understory	38	1
Exotic Canopy/Native Understory	0	0
Exotic Canopy/Mixed Understory	0	0
Exotic Canopy/Exotic Understory	0	0
Native Canopy	131	5
Mixed Canopy	40	1
Exotic Canopy	52	2
Native Understory	22	1
Mixed Understory	235	8
Exotic Understory	2105	76

Western Yellow-billed Cuckoo Territories

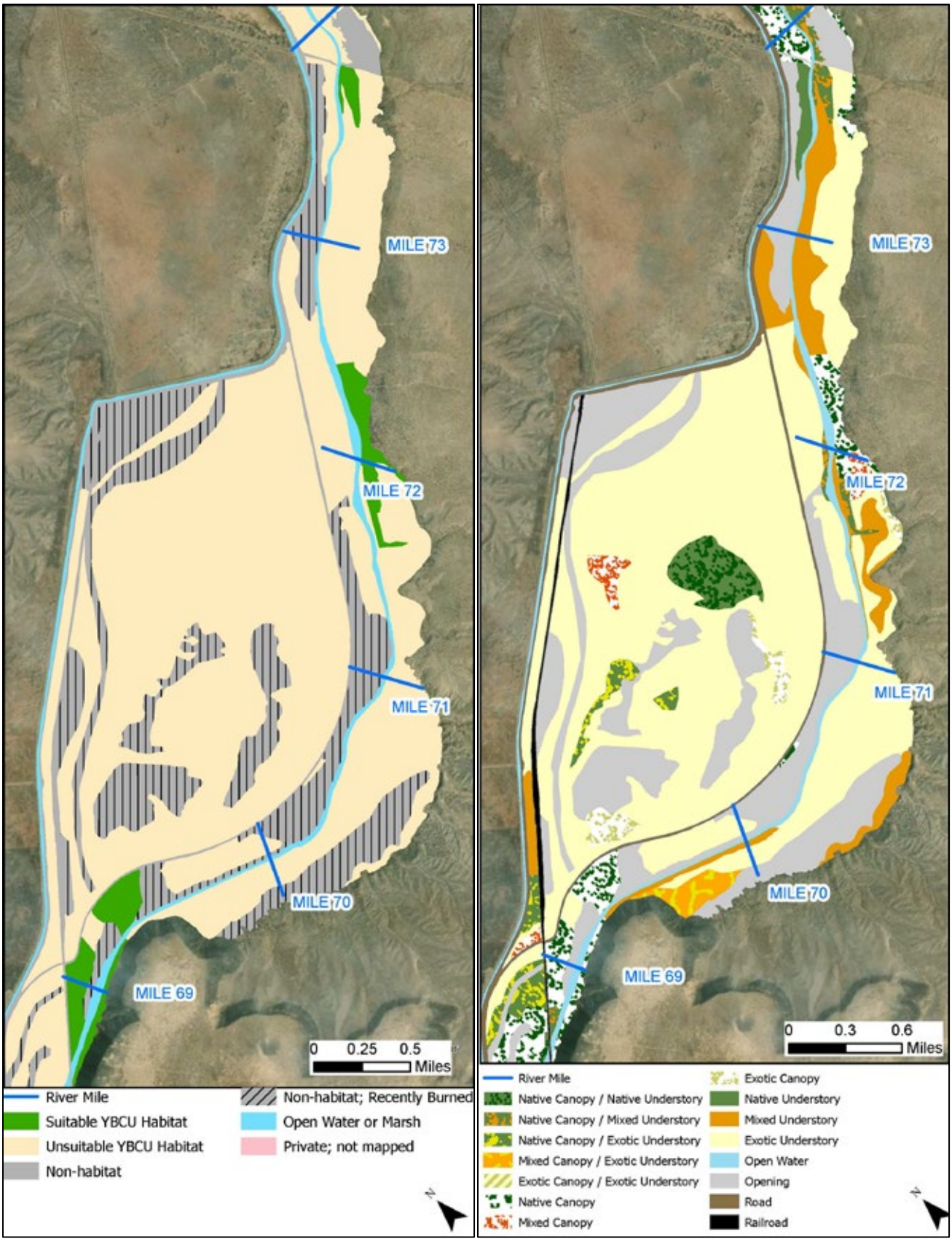
Year	Total Number of Territories
2018*	0
2019*	0
2020	Not surveyed
2021	Not surveyed

* Very little habitat due to fire in 2017

Tiffany Reach Maps



River Miles 68.5 to 74



San Marcial Reach

Area by Habitat

Suitability Class	Acreage		
	No. of Acres	No. of Hectares	Percentage of Total
Suitable Habitat	4804	1944	22
Unsuitable Habitat	10511	4254	48
Total Habitat Area	15315	6198	70
Non-habitat	6058	2452	28
River channel	505	204	2
Total Area	21878	8854	100

Acreage of Plant Communities within Reach

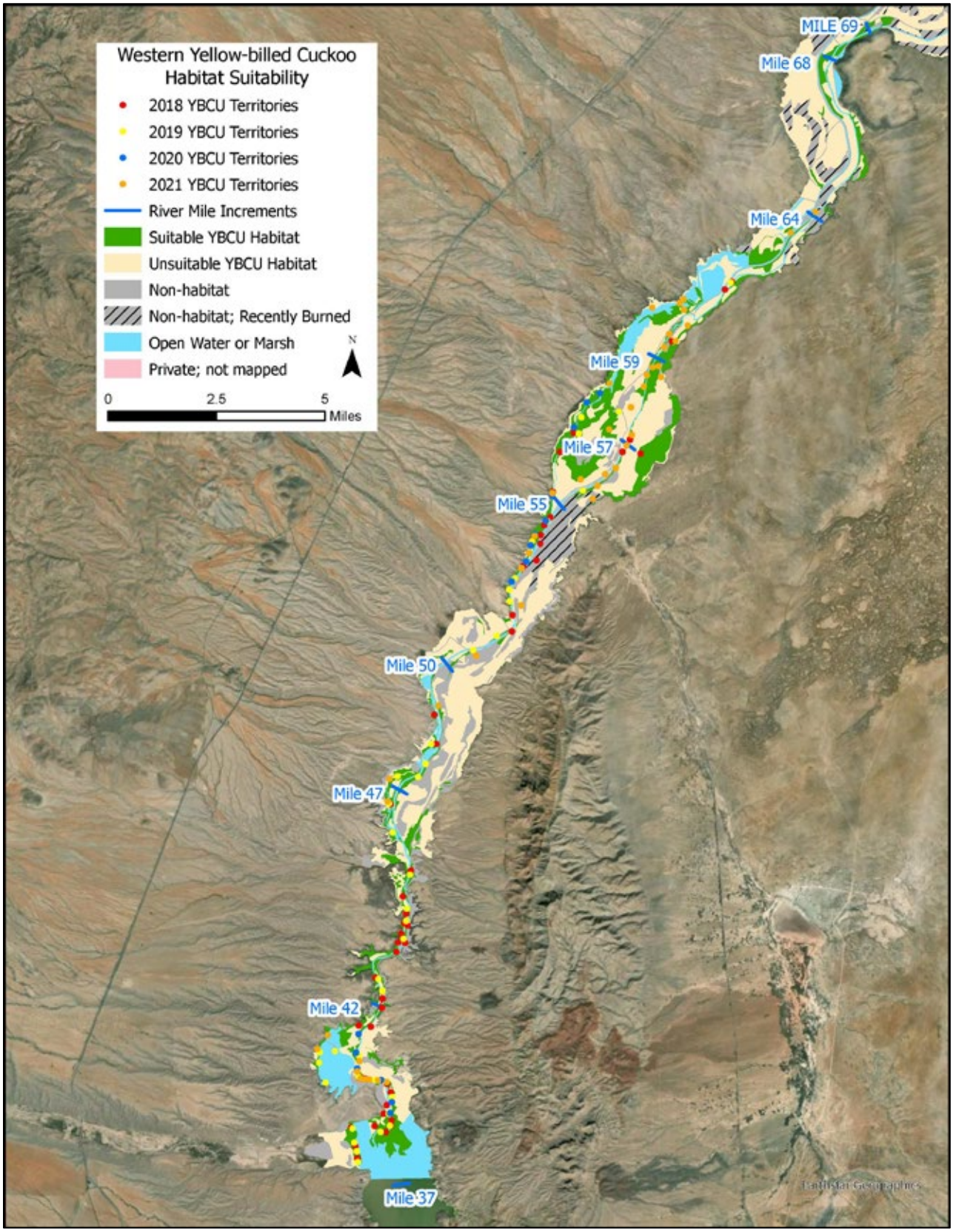
Community Type	Acres	Percentage
Native Canopy/Native Understory	522	3
Native Canopy/Mixed Understory	1627	11
Native Canopy/Exotic Understory	678	4
Mixed Canopy/Native Understory	102	1
Mixed Canopy/Mixed Understory	138	1
Mixed Canopy/Exotic Understory	165	1
Exotic Canopy/Native Understory	16	<1
Exotic Canopy/Mixed Understory	18	<1
Exotic Canopy/Exotic Understory	63	<1
Native Canopy	2254	15
Mixed Canopy	742	5
Exotic Canopy	1215	8
Native Understory	825	5
Mixed Understory	2068	13
Exotic Understory	4882	32

Western Yellow-billed Cuckoo Territories

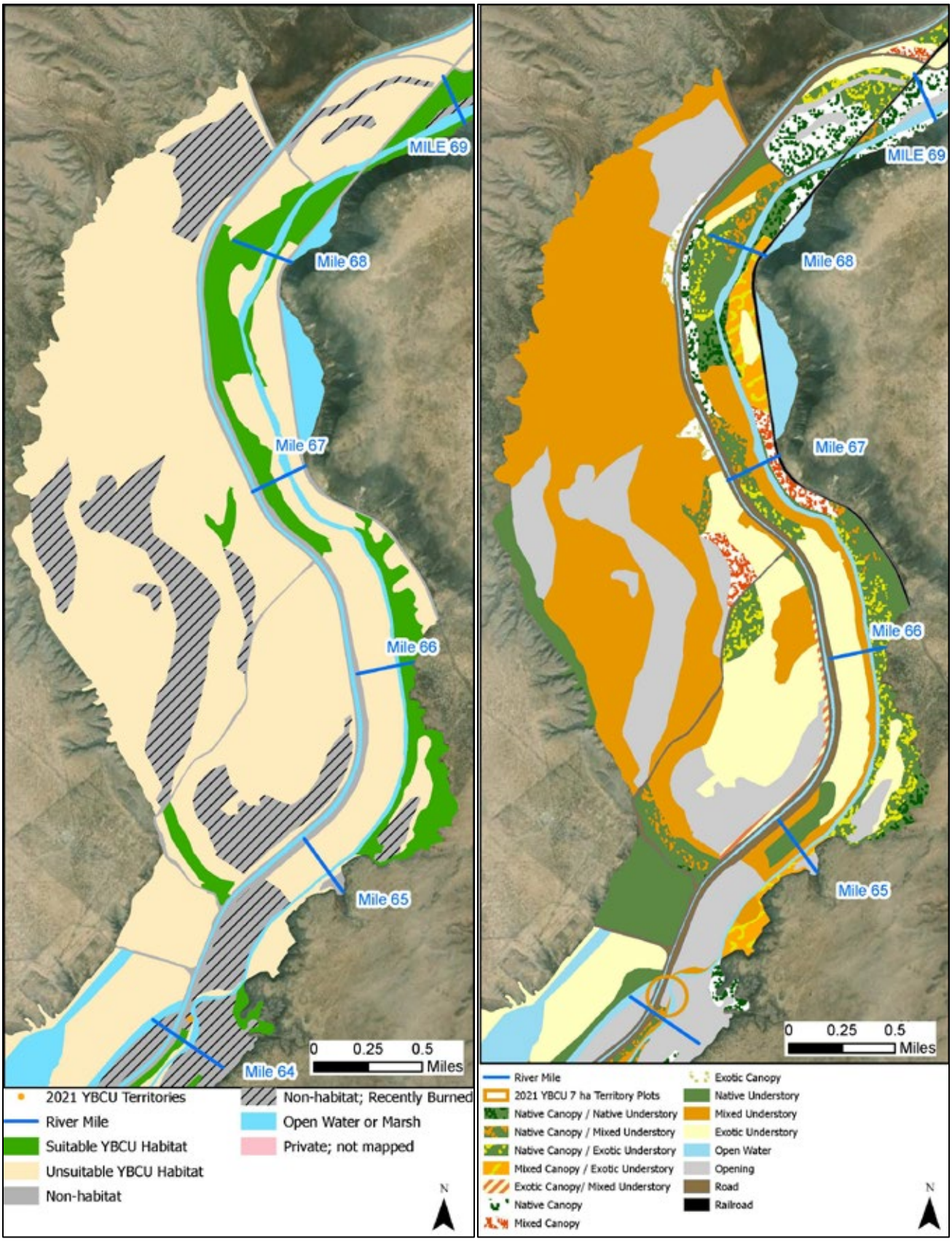
Year	Total Number of Territories
2018	49
2019	42
2020*	17
2021*	45

*Not all sites within San Marcial Reach were surveyed in 2020 and 2021

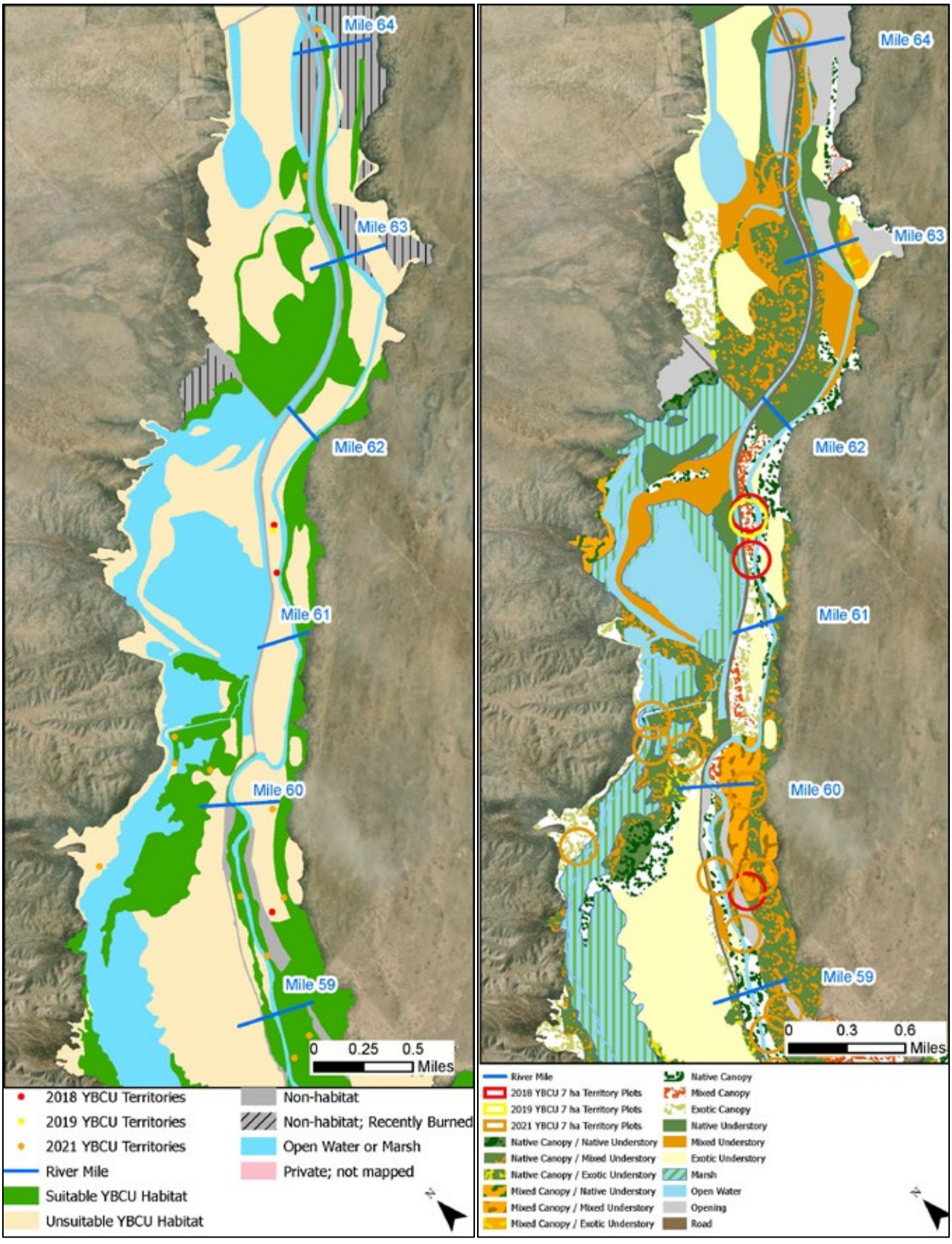
San Marcial Reach Maps



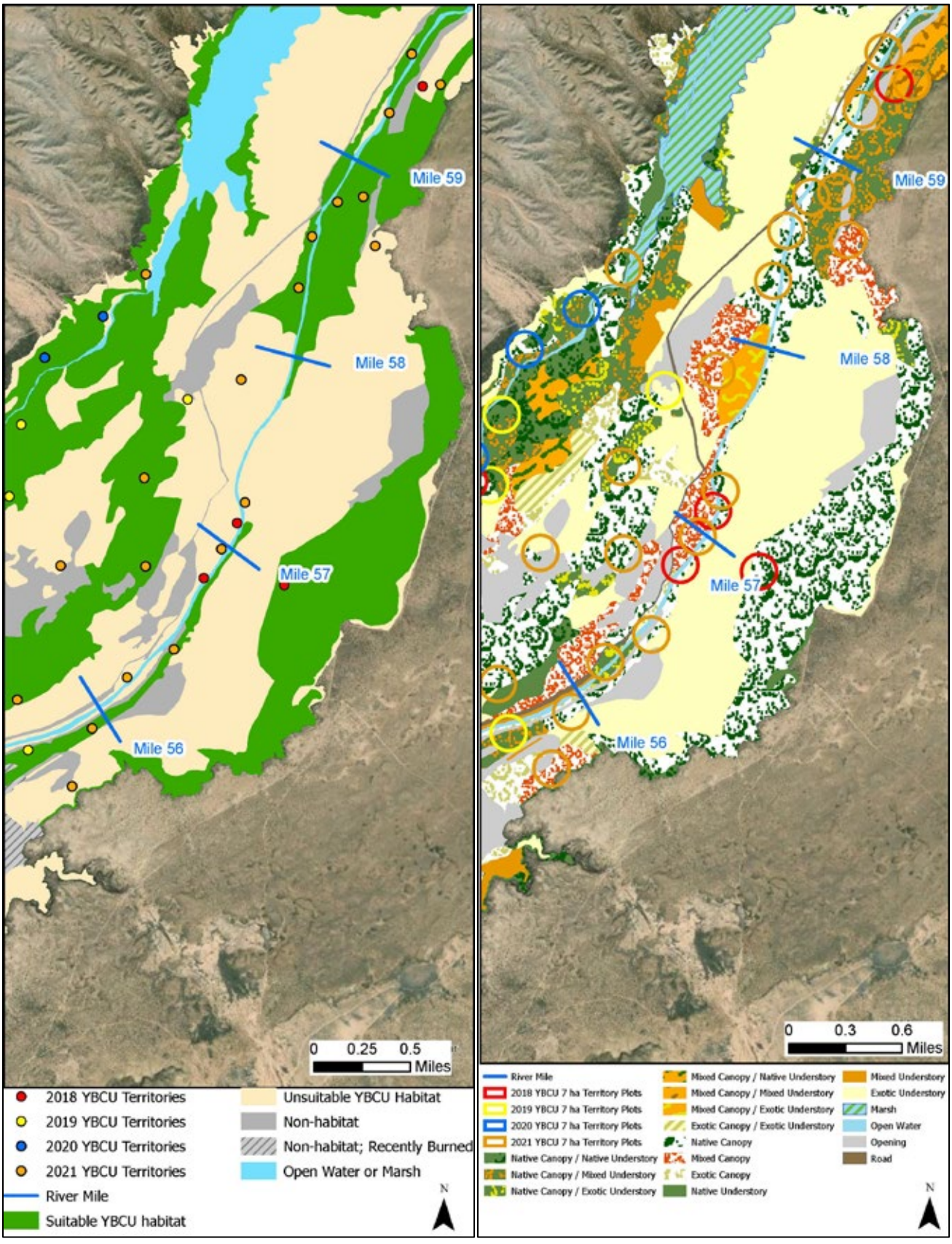
River Miles 64 to 69



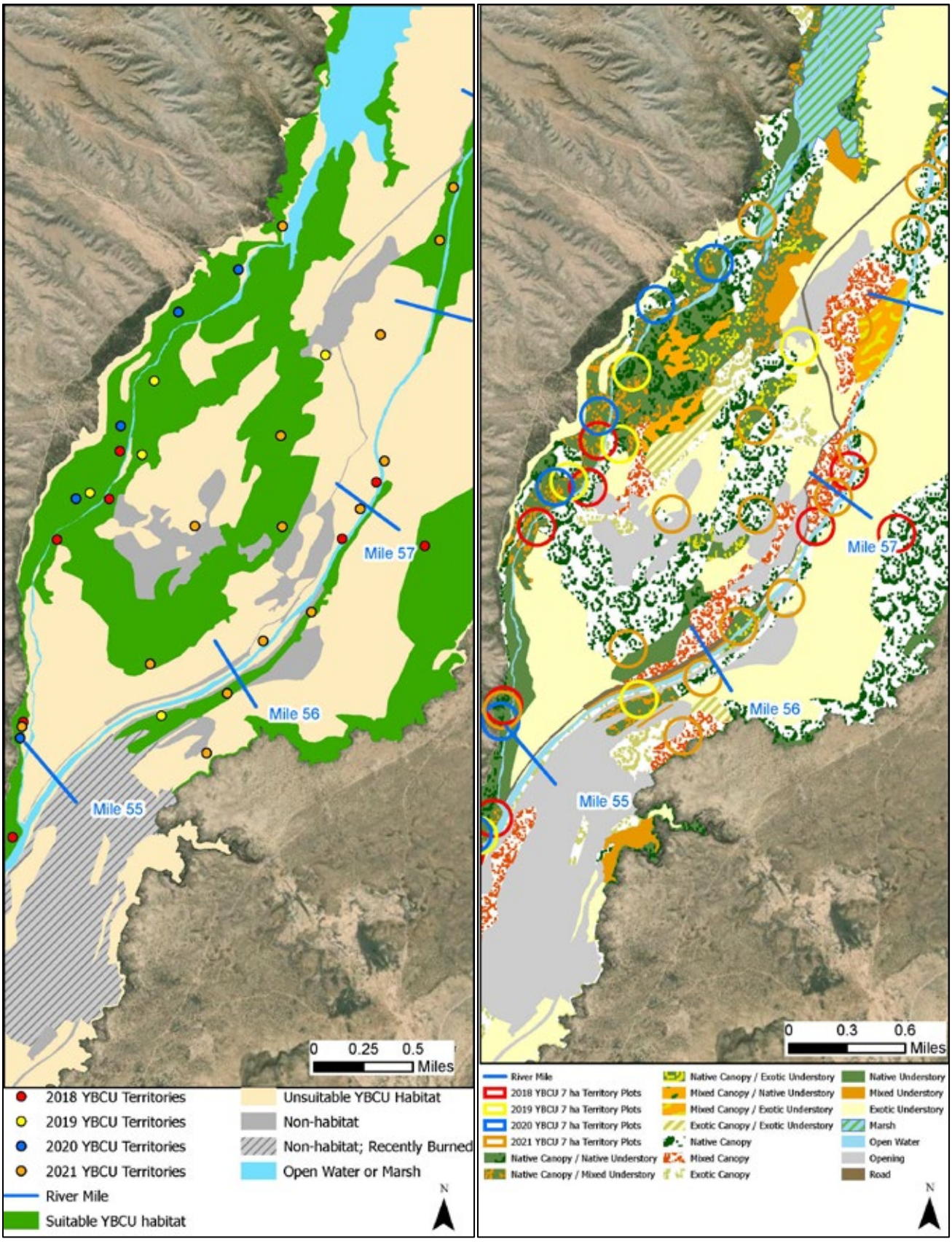
River Miles 59 to 64



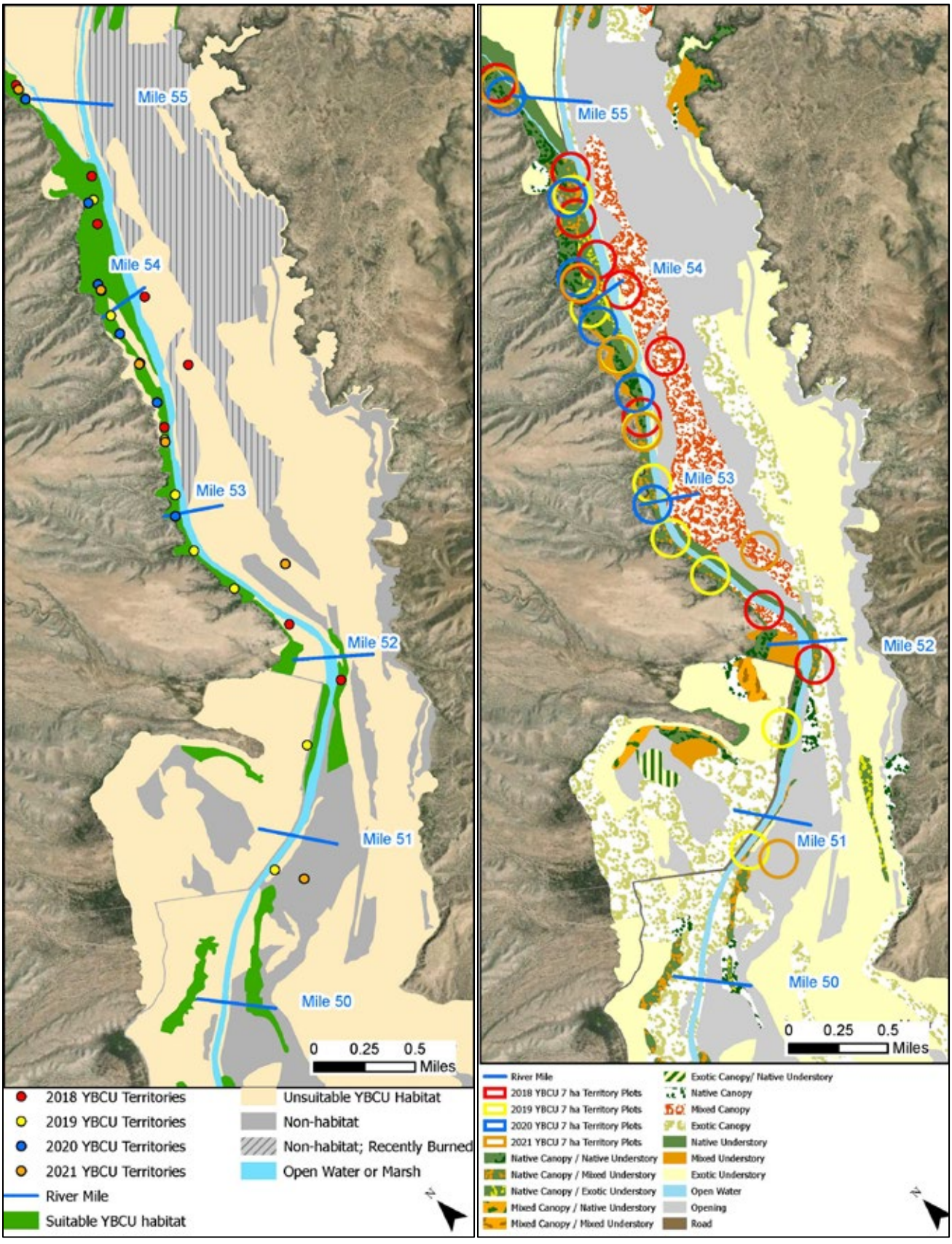
River Miles 57 to 59



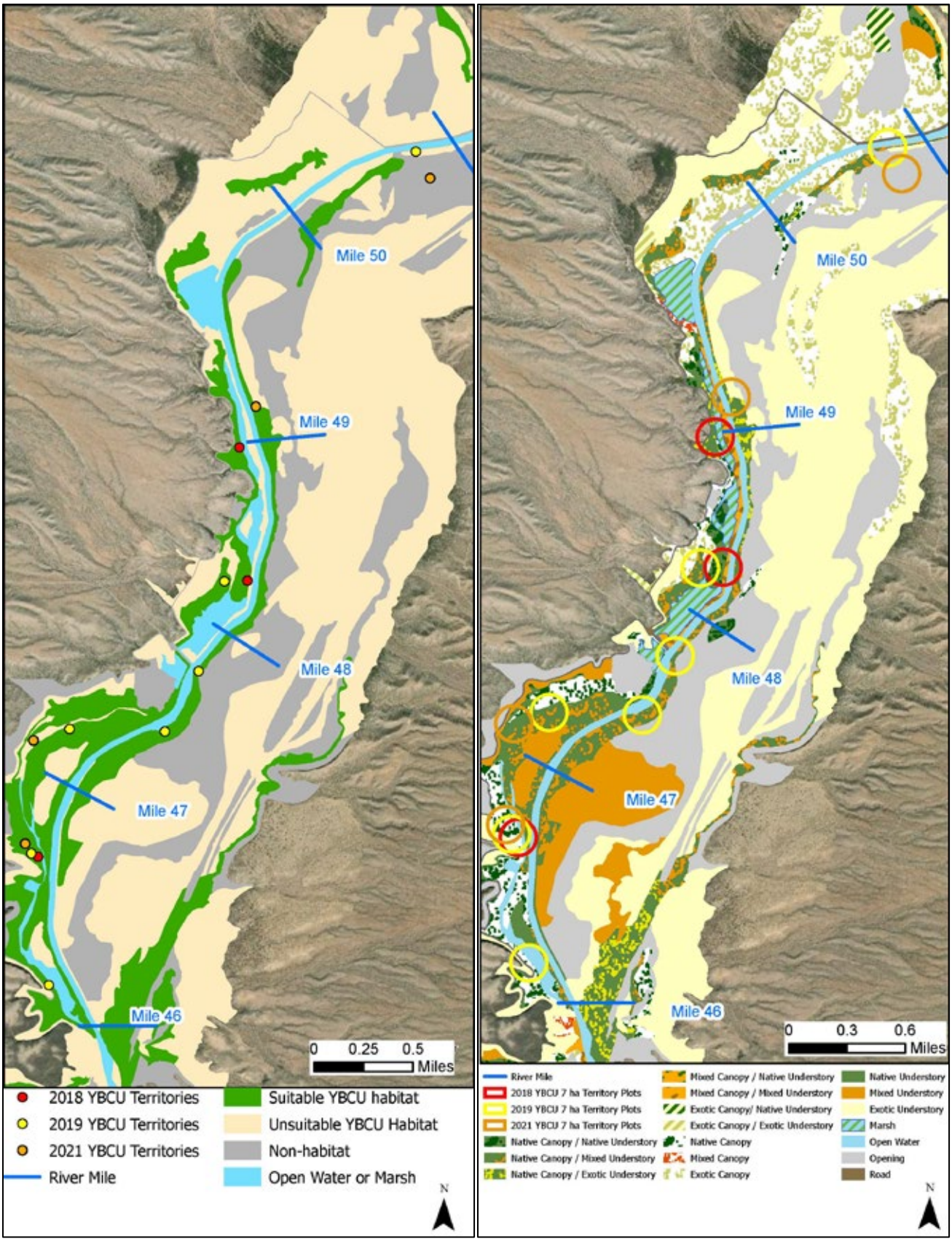
River Miles 55 to 57



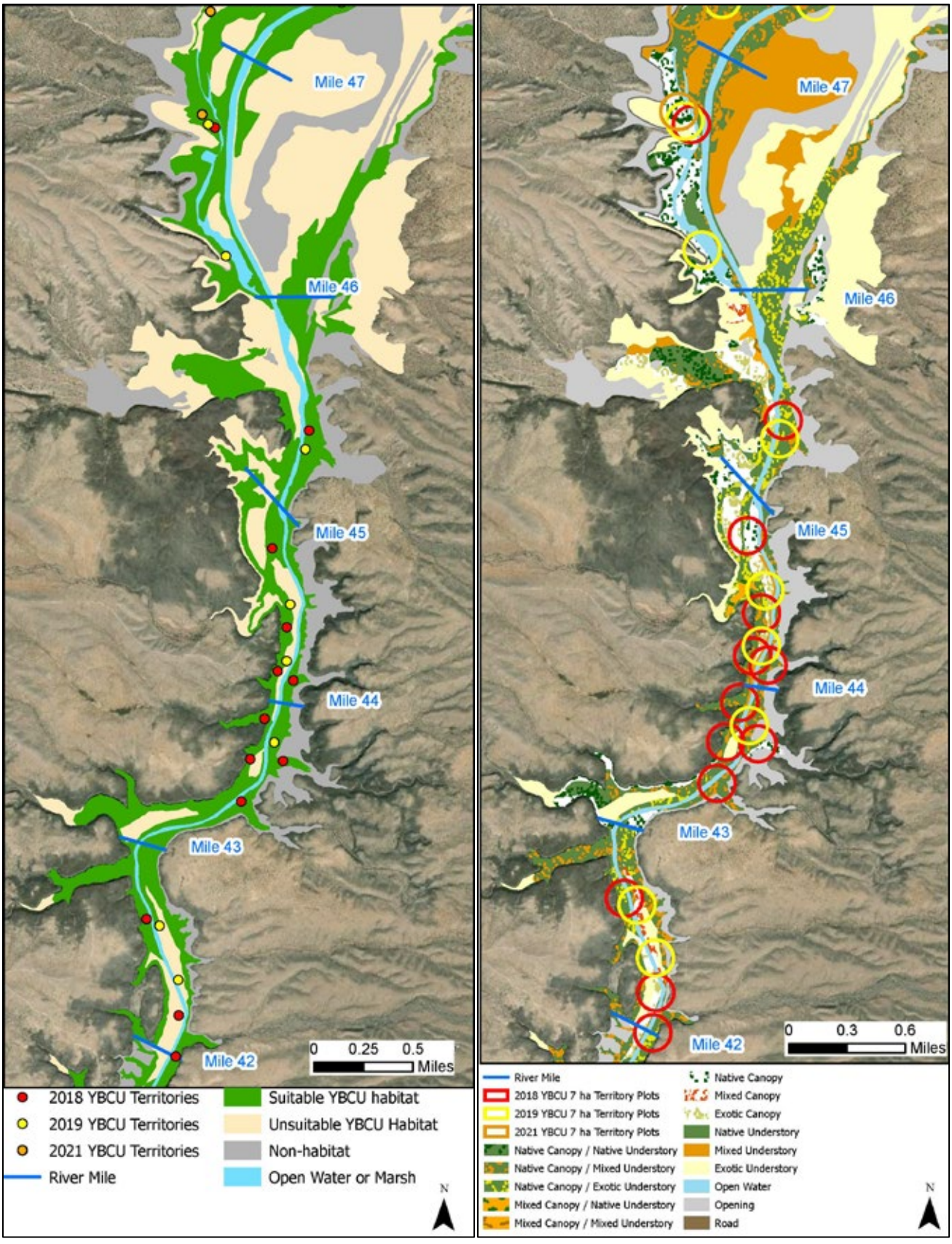
River Miles 50 to 55



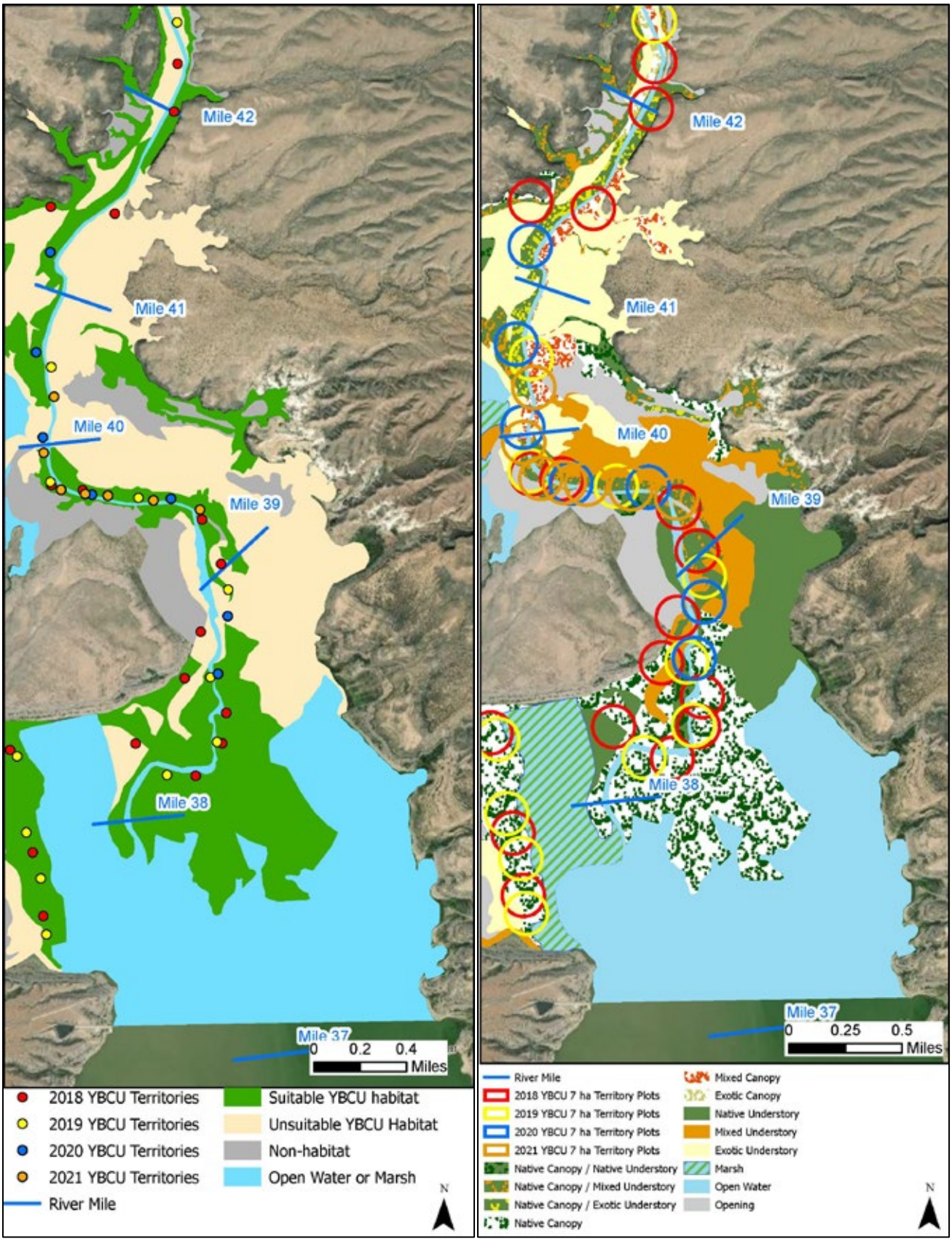
River Miles 47 to 50



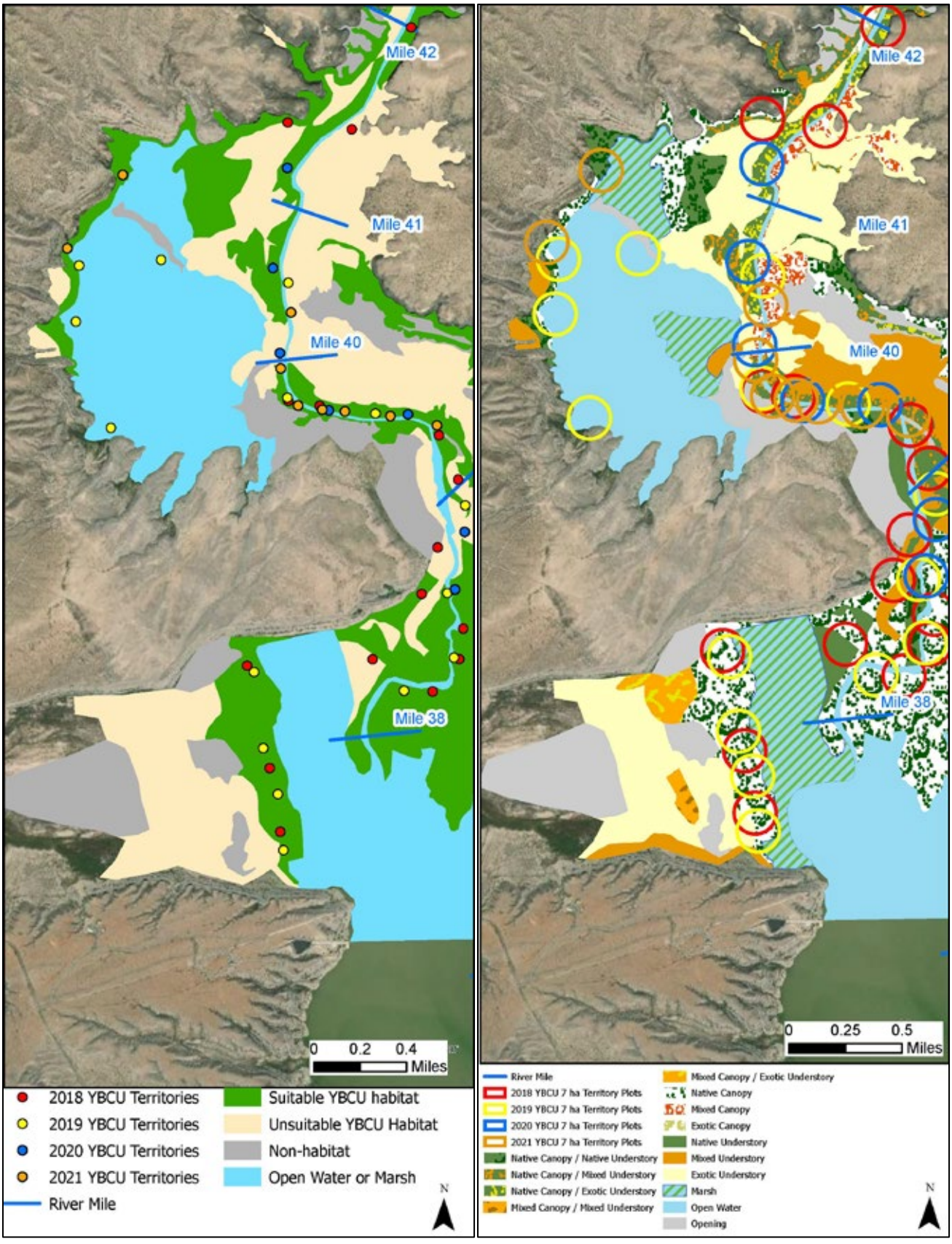
River Miles 42 to 47



River Miles 37 to 42 East



River Miles 37 to 42 West



PEER REVIEW DOCUMENTATION

PROJECT AND DOCUMENT INFORMATION

Project Name Western Yellow-billed Cuckoo Habitat Suitability WOID UC705

Document Western Yellow-billed Cuckoo Breeding Habitat Suitability 2021; Middle Rio Grande, New Mexico

Document Date May 2022

Team Leader Dave Moore

Document Author(s)/Preparer(s) Rebecca Siegle

Peer Reviewer Tori Barron

REVIEW REQUIREMENT

Part A: Document Does Not Require Peer Review

Explain _____

Part B: Document Requires Peer Review: SCOPE OF PEER REVIEW

Peer Review restricted to the following Items/Section(s):	Reviewer:
Entire document subject to review	Tori Barron

REVIEW CERTIFICATION

Peer Reviewer - I have reviewed the assigned Items/Section(s) noted for the above document and believe them to be in accordance with the project requirements, standards of the profession, and Reclamation policy.

Reviewer: Tori Barron Review Date: March 2022 Signature: TORI BARRON Digitally signed by TORI BARRON Date: 2022.05.20 15:24:55 -06'00'

I have discussed the above document and review requirements with the Peer Reviewer and believe that this review is completed, and that the document will meet the requirements of the project.

Team Leader: Dave Moore Date: May 2022 Signature: STANTON MOORE Digitally signed by STANTON MOORE Date: 2022.05.24 13:56:52 -06'00'