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Managing Water in the West

Photographic Monitoring of Defoliation by the Tamarisk Beetle

Middle Rio Grande from Belen to Elephant Butte Reservoir, New Mexico

U.S. Department of the Interior
Bureau of Reclamation
Fisheries and Wildlife Resources Group
Denver, Colorado

April 2017

Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

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.

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Executive Summary

Bureau of Reclamation personnel conducted photographic monitoring of riparian vegetation within occupied Southwestern Willow Flycatcher (*Empidonax traillii extimus;* SWFL) habitat along the Middle Rio Grande, New Mexico in 2015 and 2016. Photographic monitoring was conducted in an effort to quantify the effects of potential defoliation by the introduced tamarisk beetle (*Diorhabda* spp.). Monitoring consisted of photographs taken at fixed locations within the riparian corridor 1) facing upward into the vegetation overstory (hemispherical photography) and 2) facing inward at the vegetation community (landscape photography). Monitoring was conducted at 26 hemispherical photo stations and 13 landscape photo stations across 3 study sites occupied by SWFLs between Belen, NM and the Elephant Butte Reservoir. Photographs were taken between May and August in both years of the study, in order to correspond with tamarisk beetle activity and the Southwestern Willow Flycatcher breeding season.

The tamarisk beetle was not detected at any of the photo stations in 2015 and, thus, 2015 photography provided baseline data on vegetation structure and canopy closure prior to beetle-induced tamarisk (*Tamarix* spp.) defoliation. Defoliation by the tamarisk beetle was recorded at one hemispherical and three landscape photography stations located in one study site in 2016. Landscape photography revealed notable declines in tamarisk foliage health after the arrival of the tamarisk beetle. Additionally, hemispherical photography suggested a decline in canopy cover associated with tamarisk beetle defoliation, but not to a level outside of the natural range of variation for the study area. Continued photographic monitoring is recommended as the severity and extent of defoliation by the tamarisk beetle is expected to increase in coming years.

Introduction

Tamarisk (*Tamarix* spp.; aka salt cedar) is a large woody shrub that was introduced to the United States in the early 1800s for erosion control and horticulture. The species spread rapidly in the 1900s, expanding from 4,000 hectares (ha) in 1920 to more than 500,000 ha by 1970, and is now a dominant plant throughout riparian areas in the southwestern United States (U.S.) (Neill 1985, Gay and Fritschen 1979). Tamarisk is highly drought- and salt-tolerant, and the species' rapid expansion in the early 20th century is attributed primarily to the alteration of natural, dynamic river flows following construction of large dams and water diversion projects in the western U.S. (Di Tomaso 1998, Everitt 1998). The subsequent drying and salinization of riparian ecosystems, in addition to other disturbances such as grazing, reduced recruitment of native vegetation and created conditions favorable for rapid colonization by tamarisk (Di Tomaso 1998). Tamarisk has a deep tap root, reaches four to eight meters in height, and frequently expands into dense monotypic stands to the exclusion of native vegetation.

The decline of native riparian vegetation and the corresponding loss of biodiversity resulting from tamarisk invasion are two of the factors that prompted the initiation of efforts to eradicate the species (Di Tomaso 1998, Shafroth et al. 2005). Additionally, tamarisk was reported to cause streamflow depletion, increased soil salinization, increased fire severity, and degradation of wildlife habitat (Johnson 1987, Di Tomasso 1998, Shafroth et al. 2005). However, traditional methods to remove tamarisk, such as herbicides, fire, or mechanical treatment, were only marginally successful and often negatively impacted the riparian ecosystem (Shafroth et al. 2005, Harms and Hiebert 2006).

The search for an economical and effective method of controlling and eradicating tamarisk eventually led to the initiation of a biological control program. The tamarisk beetle (*Diorhabda* spp.) defoliates tamarisk, eliminating the plant's ability to photosynthesize, repeatedly over multiple growing seasons. This repeated defoliation eventually leads to plant mortality. The U.S. Department of Agriculture approved the release of the exotic tamarisk beetle in 2001, after laboratory and field testing concluded that the beetle would only defoliate tamarisk and that dispersal would be limited by beetle diapause and day length to only 1-2 kilometers (km) per year (yr^{-1}) (DeLoach and Tracy 1997, Tracy and Robins 2009). After an initial caged release, the tamarisk beetle was introduced in multiple watersheds throughout the southwestern United States.

Adult tamarisk beetles emerge from diapause in the spring and immediately begin feeding and mating. Females lay 10 to 20 eggs per day on tamarisk foliage, with total production ranging from 300 to 500 eggs per female. Eggs hatch in approximately seven days, and then go through three instar larval stages of approximately four to seven days each. Upon completion of the third instar stage, the larvae drop to the ground where they enter a 7 to 10 day pupal stage and then emerge as adult beetles. Adults live two to four weeks and typically produce two to five generations per year. All larval and adult stages feed on tamarisk foliage. Adults drop to the ground and burrow into the soil or leaf litter in autumn, enter diapause, and overwinter there (DeLoach et al. 2003; Lewis et al. 2003).

The tamarisk beetle was indeed highly successful at defoliating tamarisk and had limited impact on non-target plant species (Moran et al. 2009). However, the tamarisk beetle spread through riparian systems far more rapidly than predicted, resulting in defoliation of large expanses of tamarisk

(Dudley and Bean 2012). While this was effective for tamarisk control, there were unforeseen ecological consequences. The pre-release projections of tamarisk beetle dispersal rates led to the belief that native vegetation would replace tamarisk as the beetle slowly defoliated one area and moved along the riparian corridor. Instead, in many instances altered hydrology prevents the immediate re-establishment of native vegetation, or the tamarisk beetle simply defoliates tamarisk much more quickly than native vegetation can regenerate (Paxton et al. 2011). This rapid defoliation of tamarisk without replacement by native vegetation has particularly impacted riparian breeding birds, which are left with drastically reduced or absent nesting habitat, particularly in areas characterized by monotypic tamarisk stands.

The Southwestern Willow Flycatcher (*Empidonax traillii extimus;* SWFL) is one of the most notable avian species to be negatively impacted by tamarisk beetle defoliation, and concern for the species' welfare has led to the cessation of tamarisk beetle releases in many areas (Hultine et al. 2010; Dudley and Bean 2012). The Southwestern Willow Flycatcher (aka SWFL) is a State- and Federally-listed endangered subspecies of the Willow Flycatcher (*Empidonax traillii*). It is an insectivorous, Neotropical migrant that nests in dense riparian vegetation in the southwestern United States. Southwestern Willow Flycatchers commonly nest in tamarisk, and some SWFL breeding habitat is composed predominately or exclusively of tamarisk. SWFLs typically arrive on their breeding grounds between early May and early June; between late July and mid-August they depart for wintering areas in Mexico, Central America, and northern South America (Sogge et al. 1997, USFWS 2002). The SWFL's brief breeding season coincides with the peak of tamarisk defoliation by the tamarisk beetle.

In October 2005, the United States Fish and Wildlife Service (USFWS) designated Critical Habitat for the SWFL along the Middle Rio Grande between the Isleta Pueblo and Elephant Butte Reservoir (USFWS 2005). The designation was updated in January of 2013 to include the Sevilleta and Bosque del Apache National Wildlife Refuges and a portion of the Elephant Butte Reservoir conservation pool. No critical habitat was designated downstream of Elephant Butte Dam (USFWS 2013), although the SWFL does breed there. The Rio Grande currently supports one of the largest breeding populations of Southwestern Willow Flycatchers in the United States.

Although the tamarisk beetle was not released on the Rio Grande in New Mexico, it was released on the Rio Grande in Texas, the Pecos River in New Mexico, as well as on the San Juan River in Colorado. It is likely tamarisk beetles dispersing from these locations that are now being detected along the Rio Grande in New Mexico. In 2016 the beetle was detected throughout the river corridor from north of Albuquerque, NM to Texas, following several years of intermittent tamarisk beetle detections along the Rio Grande in New Mexico. Currently, all four tamarisk beetle sub-species have colonized New Mexico, although only one sub-species was purposely released in the state (Fig. 1). However, although the beetle was detected at sample locations throughout the Rio Grande in 2016, the population still consisted of multiple, disconnected patches and was not found in all tamarisk continuously throughout the Rio Grande.

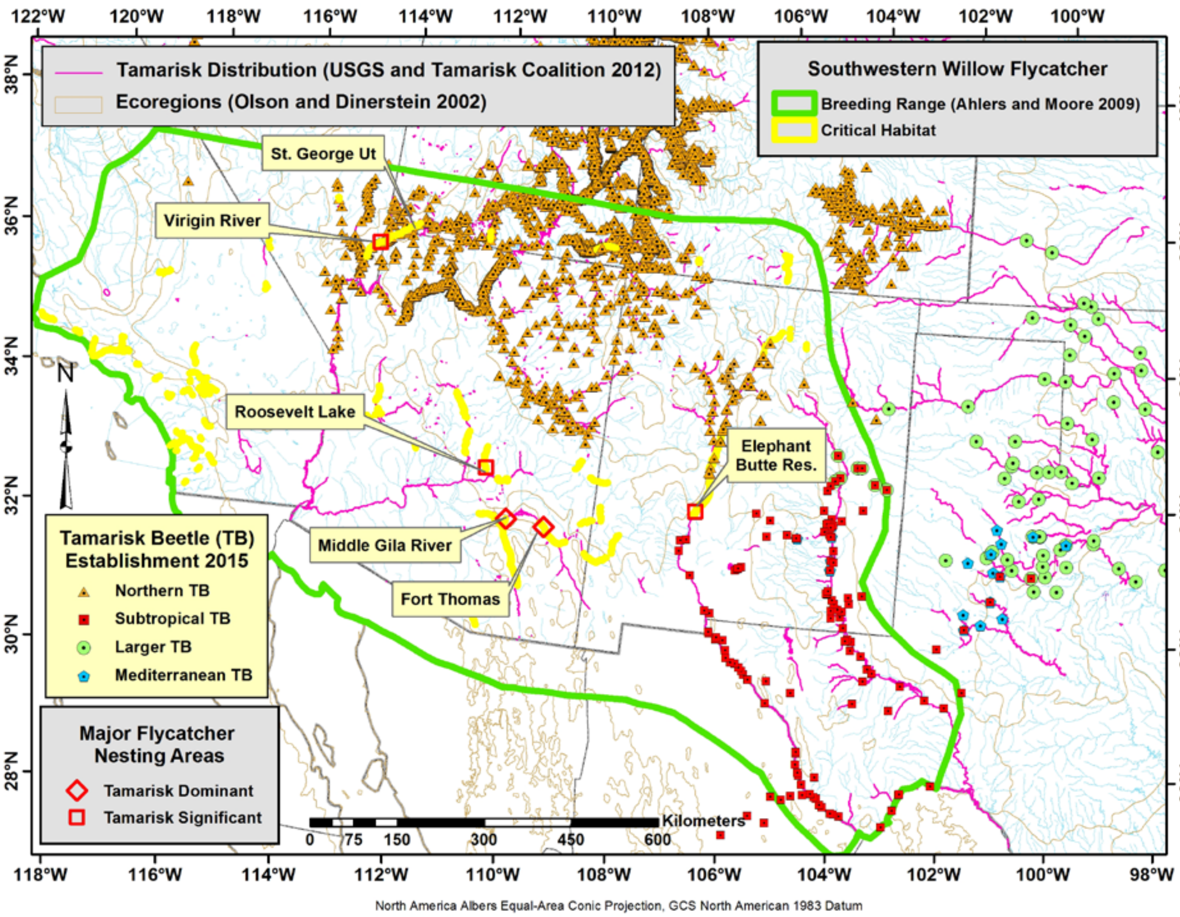

Figure 1. Distribution of the tamarisk beetle by species in 2015 (Tracy 2017).

Reclamation began a photographic monitoring study of the impacts of the tamarisk beetle on Southwestern Willow Flycatcher habitat in 2015. The objectives of the study were to monitor and quantify defoliation by the tamarisk beetle over time, and the effects of that defoliation on canopy closure and vegetation composition in SWFL breeding habitat.

Methods

Study Area

Eighteen hemispherical photography stations and 10 landscape photography stations were established at 2 occupied SWFL study sites in the Middle Rio Grande in 2015, one site in the Belen Reach (BL-10) and one site in the San Marcial Reach (DL-12; Figs. 2 and 3). In 2016, eight additional hemispherical photography stations and three landscape photography stations were added at a third study site, located in the San Marcial Reach (LFCC-5B; Fig. 4). The photo stations in BL-10 were located within the active floodplain of the Rio Grande, and the stations in DL-12 and LFCC-5B were located west of the Low Flow Conveyance Channel (LFCC) and LFCC Outfall. All sites included in this study have consistently supported breeding Southwestern Willow Flycatcher territories throughout many years of SWFL occupancy monitoring (Moore and Ahlers in press).

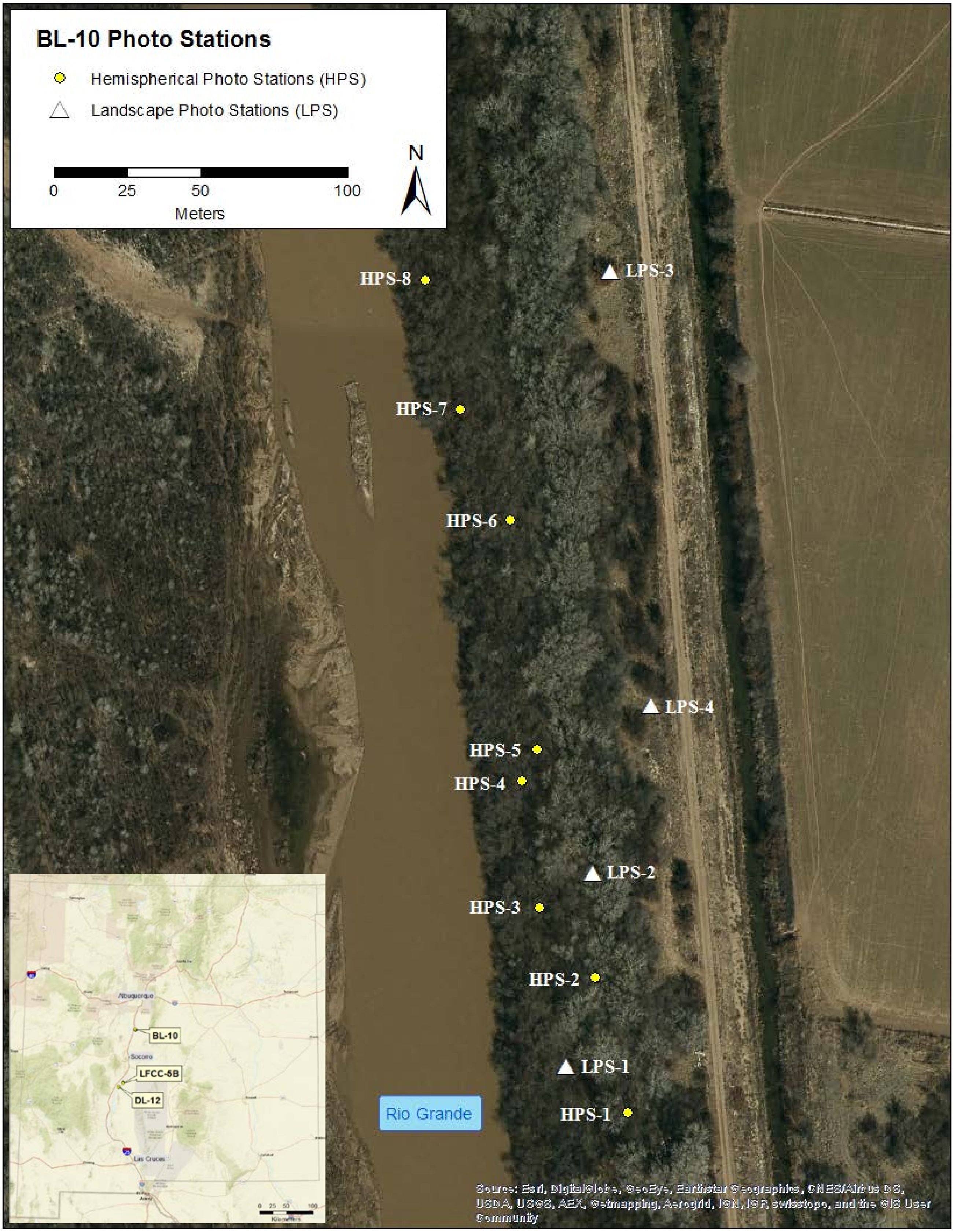

Figure 2. Hemispherical and landscape photography stations in site BL-10.

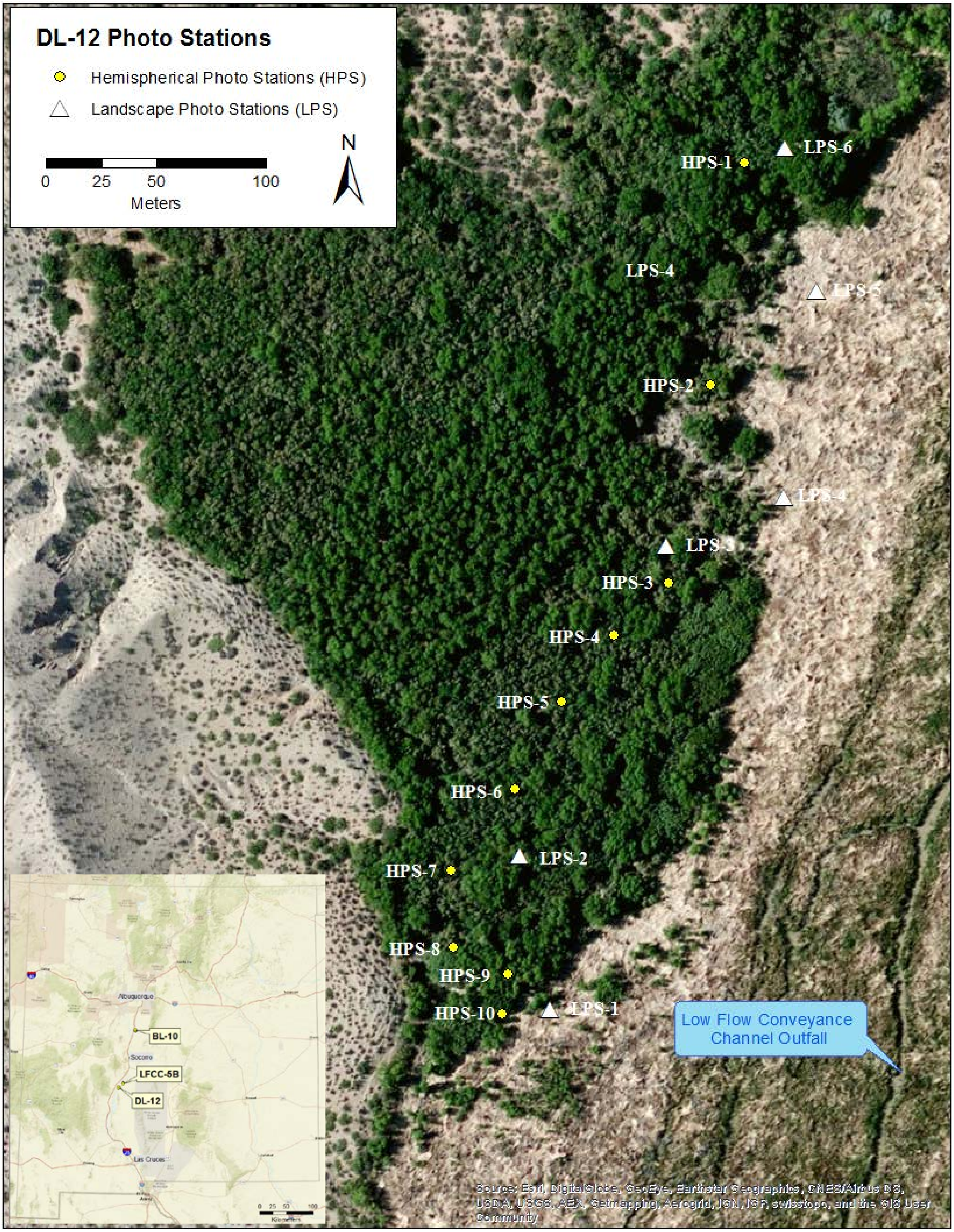

Figure 3. Hemispherical and landscape photography stations in site DL-12.

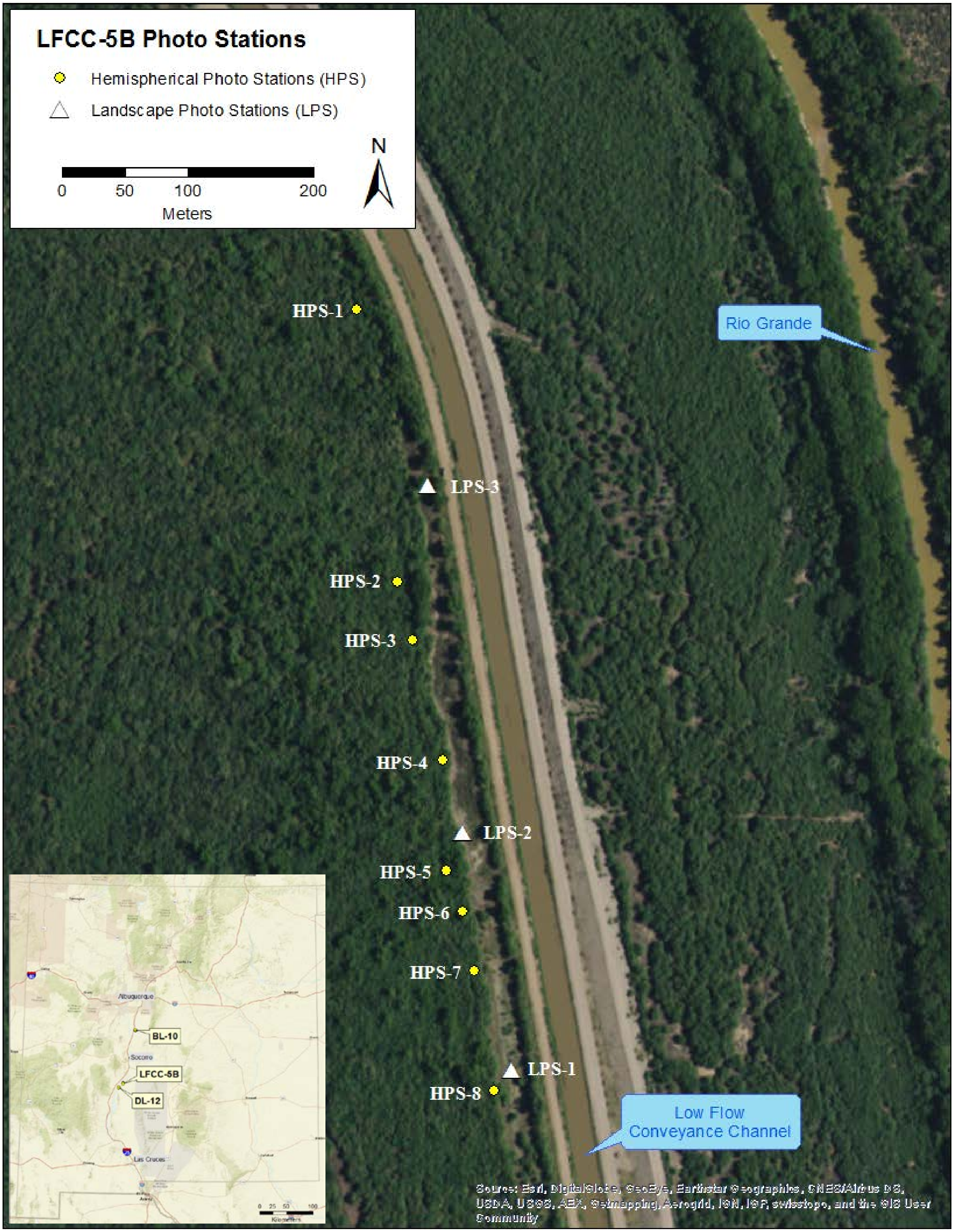

Figure 4. Hemispherical and landscape photography stations in site LFCC-5B.

Hemispherical Photography

Hemispherical photographs were taken with a digital camera fitted with a Sigma EX DC 4.5 millimeter (mm) circular fisheye lens aimed upwards towards the vegetation canopy. A circular fisheye lens is a type of wide-angle camera lens that produces an image with a 180 degree angle of view that is projected as circle within the image frame. Photographs were taken from a fixed point marked by a T-post. All hemispherical photography stations were established directly below a 2014 SWFL nest, or within an active SWFL territory (Attachment 1A).

HemiView software (v.2.1; Delta-T Devices 1999) was used to classify each pixel of the hemispherical images as sky or foliage. This binary classification was repeated three times for each image, with the data analyst blind to the associated numerical result, to ensure repeatability of results. All photographs were taken before sunrise, after sunset, or on a cloudy day to eliminate glare caused by the reflection of the sun on foliage that would impede the ability of the HemiView software to distinguish between sky and illuminated foliage.

HemiView quantifies visible sky on a scale from zero to one. Percent canopy closure was calculated from this value by subtracting the amount of visible sky from 1 and multiplying by 100. Canopy cover was then graphically compared among photo stations, survey sites, and years. However, two years of data and one station impacted by defoliation were considered to be insufficient to perform a robust statistical analysis of between-year change in canopy.

Vegetation species composition was visually estimated within a five meter radius of every hemispherical photo station on the last visit in July 2016. Vegetation species composition was estimated as species-specific percentages that were required to sum to 100 percent. This vegetation species composition estimation was added to our sampling to allow the examination of the impacts of tamarisk beetle defoliation within the context of variation in vegetation community composition, as well as to document changes in vegetation community composition over time.

Landscape Photography

Landscape photographs were taken with a digital Canon A620 Powershot camera aimed inwards towards the vegetation community. Photographs were taken in a standardized compass direction at each point to ensure the repeatability of photographs. Photographs were taken from a fixed point marked by a T-post. Landscape photography stations were established in close proximity to the hemispherical photo stations, and within or on the edge of SWFL breeding territories (Attachment 1B). The purpose of the landscape photography was to document changes in vegetation community composition, in association with beetle-induced die-back of tamarisk, as well as to document spatial and temporal variation in defoliation.

Photographs were taken twice annually at each landscape and hemispherical photography station between May and July 2015 and 2016. Photographs were taken at the LFCC-5B stations, which were added in 2016, once in mid-June and once in late July 2016. Photo sampling was timed to coincide with the SWFL breeding season and the period of tamarisk beetle activity. It was determined that May was still early in the season for both SWFL and beetle activity, and henceforth sampling will occur once per month in June and July. Two photographs were taken per year in order to ultimately enable a comparison of the potential impacts of defoliation by the tamarisk beetle within and among years.

Results

Hemispherical Photography

Tamarisk beetle presence or defoliation was not observed at any hemispherical photo stations in 2015, and was detected at only one station (BL-10, station 7) in 2016. Therefore, the majority of data that was collected in both years will provide baseline data for comparison in future years. Median site-wide canopy closure was highest at LFCC-5B (97.6%; n = 8), when summarized across all sampling points and dates (Fig. 5). Median canopy closure in BL-10 (91.7%; n = 8) was similar to DL-12 (93.6%; n = 10) but considerably higher variation in canopy closure was observed in BL-10 when compared to the other two study sites.

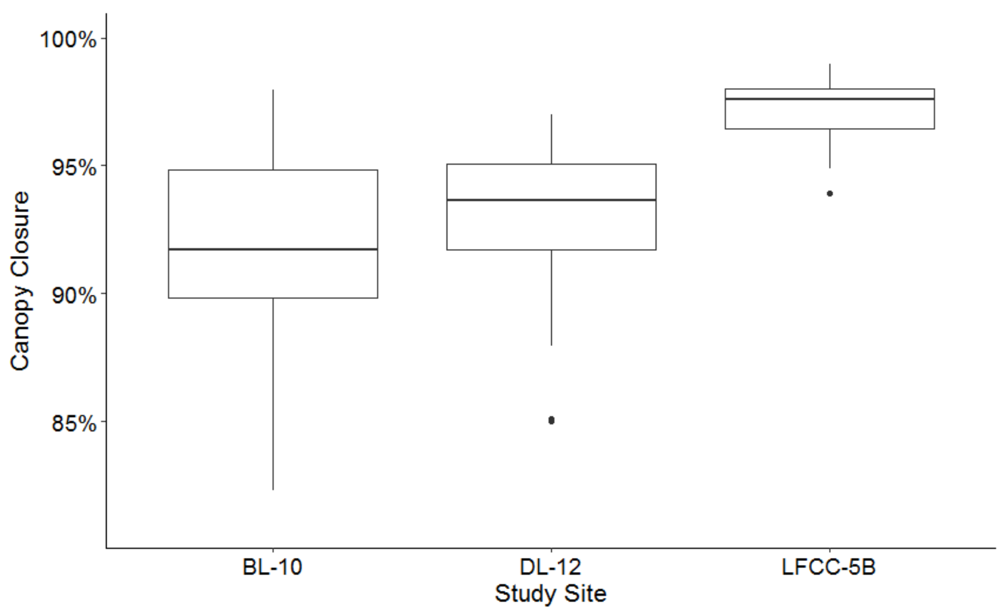

Figure 5. Canopy closure by study site (2015-2016).

Vegetation composition was estimated at each photo station once, in July 2016. The percent of the vegetation community composed of tamarisk was more than twice as high in DL-12 and LFCC-5B than in BL-10 (Fig. 6). The median percent of total vegetation within 5 meters of each hemispherical photo station composed of tamarisk was 95 percent at DL-12 and 97.5 percent at LFCC-5B, compared to 40 percent at BL-10. The majority (*Mdn* = 50%, range = 15% – 88%) of the remaining portion of the vegetation community in BL-10 was composed of Russian olive (*Elaeagnus angustifolia*).

Results

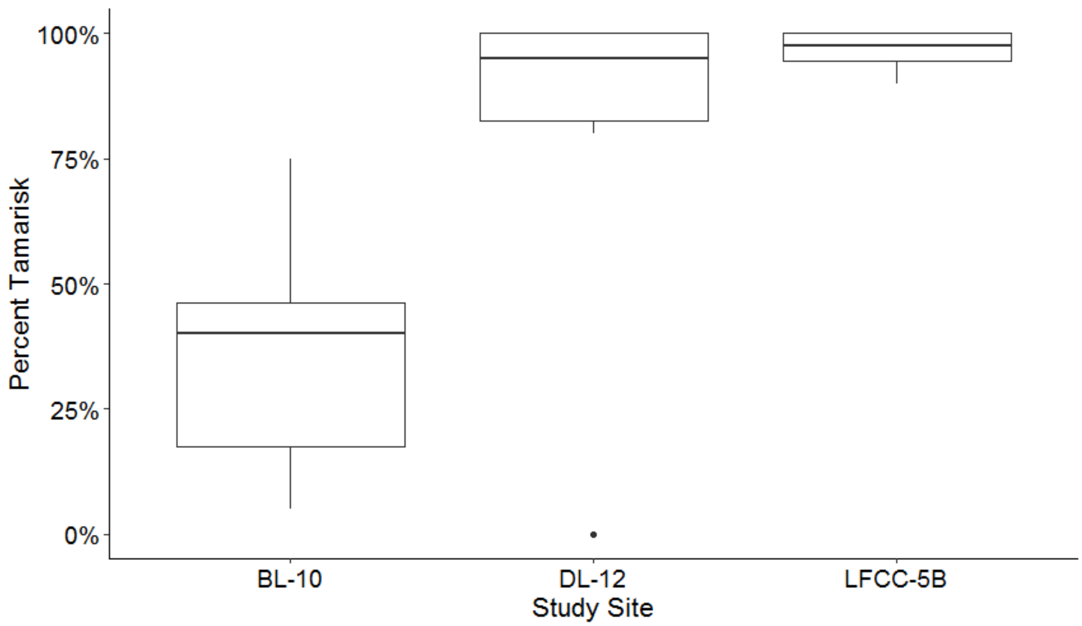

Figure 6. Percent of vegetation community within 5 meter radius of survey point composed of tamarisk (July 2016).

Hemispherical photos were taken at the BL-10 photo stations on 14 May and 22 June 2015 and on 8 June and 30 July 2016 (Table 1). Canopy cover was greatest at all photo stations on June 22, indicating the approximate peak of the growing season (Fig. 7). Indeed, canopy cover at most points followed a general pattern of increasing from May through June and then declining again at the end of July, suggesting a unimodal seasonal pattern of variation in vegetation leaf-out and progression towards senescence. Tamarisk beetle presence and defoliation was only observed at point 7, and not until the 30 July 2016 sampling occasion (Fig. 8). Although visible tamarisk foliage death and defoliation was recorded on that sampling date, the canopy cover calculated at point seven was not outside the normal range of variation for canopy cover at BL-10 (Figs. 7 and 8).

Table 1. Annual photographic sampling dates by study site.

	2015		2016	
Survey Site	**Sample 1**	**Sample 2**	**Sample 1**	**Sample 2**
BL-10	14 May	22 June	8 June	30 July
DL-12	11 May	7 July	9 July	29 July
LFCC-5B	N/A	N/A	15 June	27 July

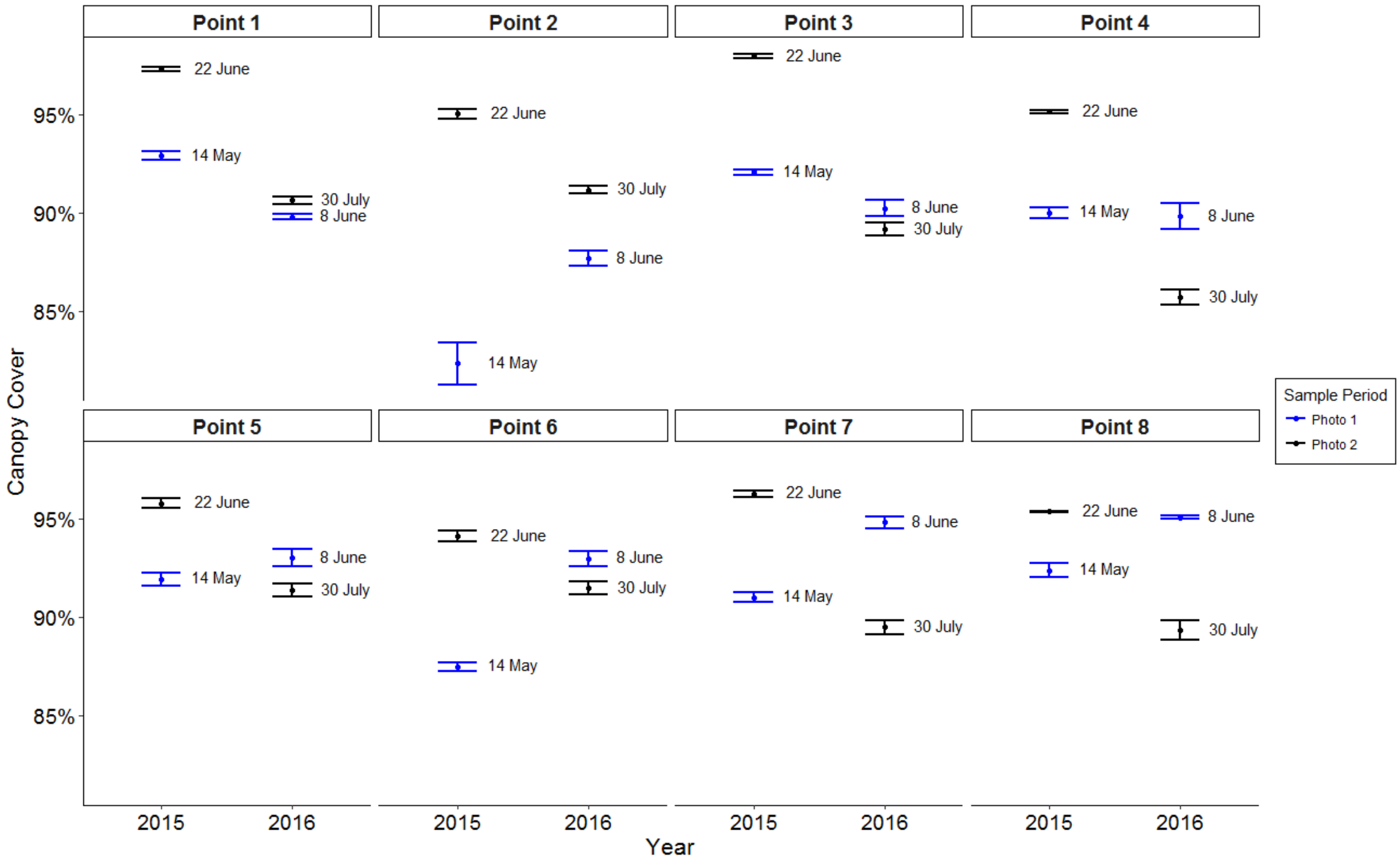

Figure 7. Canopy cover at BL-10 hemispherical photo stations by sampling occasion.
Blue points indicate the first sampling occasion of the study year and black points indicate the second sampling occasion of the year. Error bars represent standard error of canopy cover calculated from three repeat classifications of each hemispherical photo.

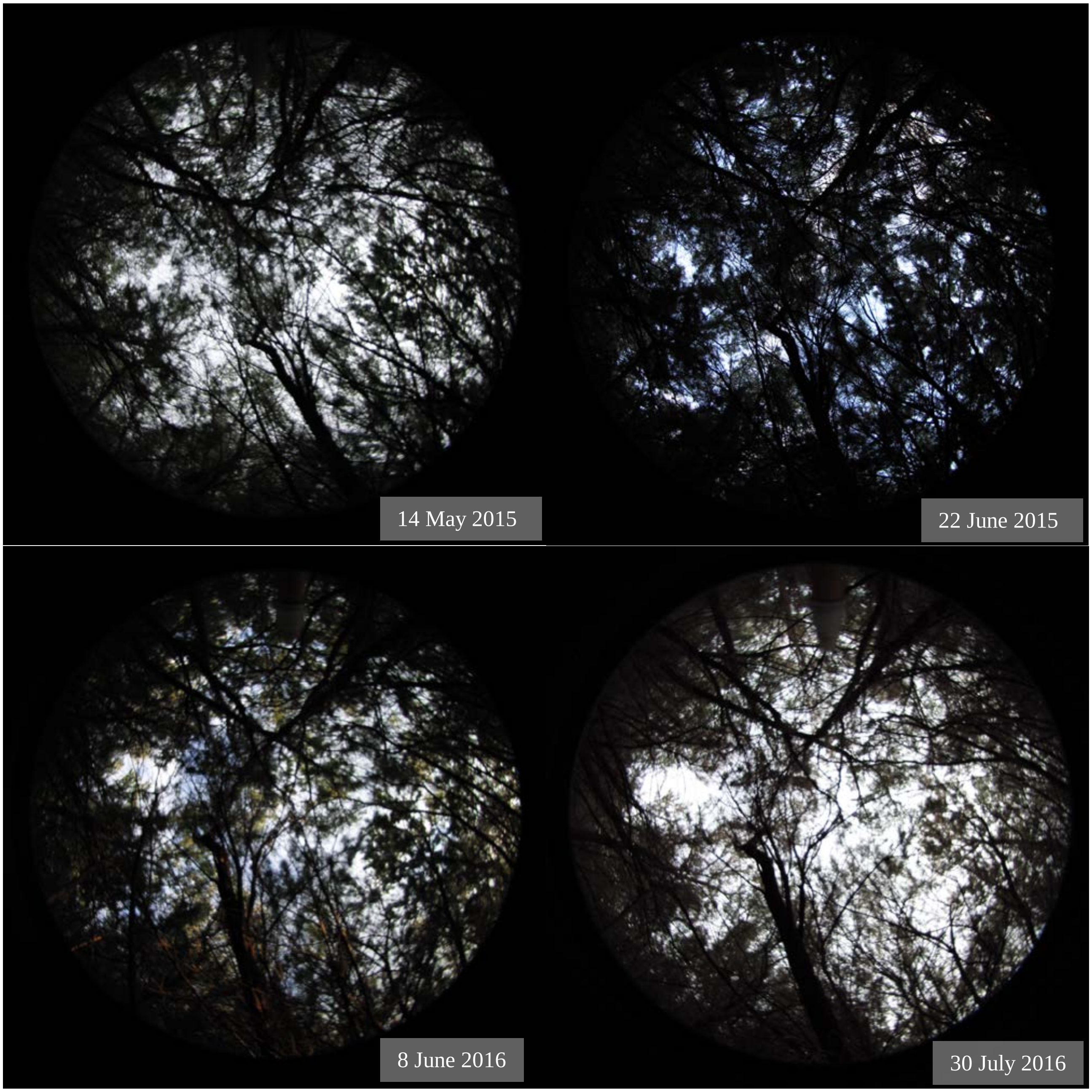

Figure 8. Hemispherical photography at BL-10 station 7.
Tamarisk beetle defoliation was observed on the 30 July 2016 sampling occasion.

Hemispherical photos were taken at the DL-12 photo stations on 11 May and 7 July 2015 and 9 July and 29 July 2016 (Table 1). Tamarisk beetle defoliation was not observed at any of the DL-12 photo stations during this time period. Canopy cover was greatest at 70 percent of points on 7 July, again suggesting a seasonal peak in leaf-out in late June to early July (Fig. 9). However, this pattern was not as pronounced as that observed in BL-10. Moreover, canopy cover on 29 July was higher, rather than lower, than canopy cover in June at 70 percent of photo stations. Canopy cover at all photo stations ranged between approximately 85 and 98 percent, as was observed in BL-10.

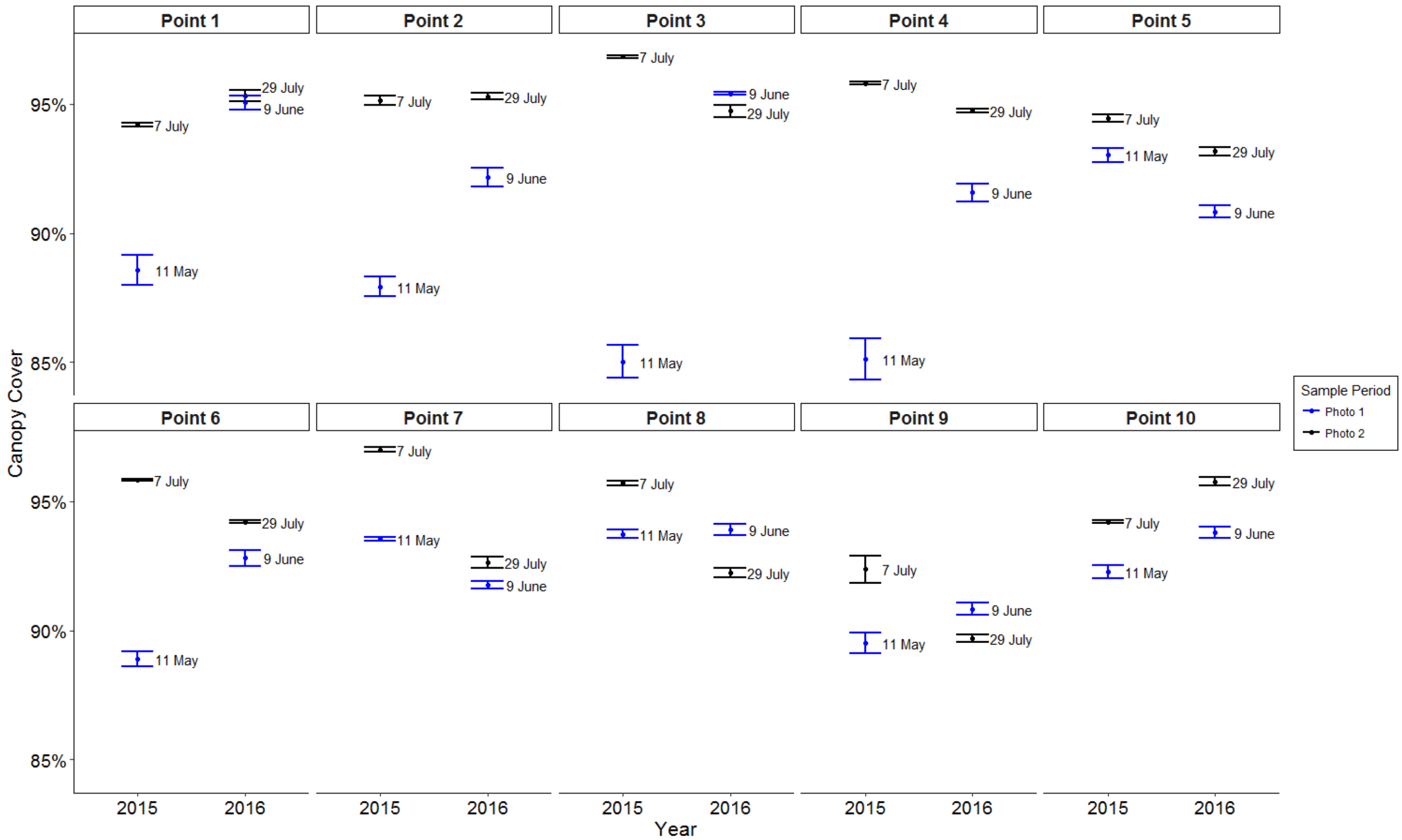

Figure 9. Canopy cover at DL-12 hemispherical photo stations by sampling occasion.
Blue points indicate the first sampling occasion of the study year and black points indicate the second sampling occasion of the year. Error bars represent standard error of canopy cover calculated from three repeat classifications of each hemispherical photo.

Hemispherical photos were taken at the LFCC-5B photo stations on 15 June and 27 July 2016 (Table 1). Tamarisk beetle defoliation was not observed at any of the LFCC-5B photo stations during this time period. Canopy cover declined in late July compared to mid-June at seven of eight (87.5%) photo stations (Fig. 10). Overall, canopy cover was higher at this study site than at the other two, ranging from approximately 94 to 99 percent with minimum canopy cover not below 96 percent at most photo stations.

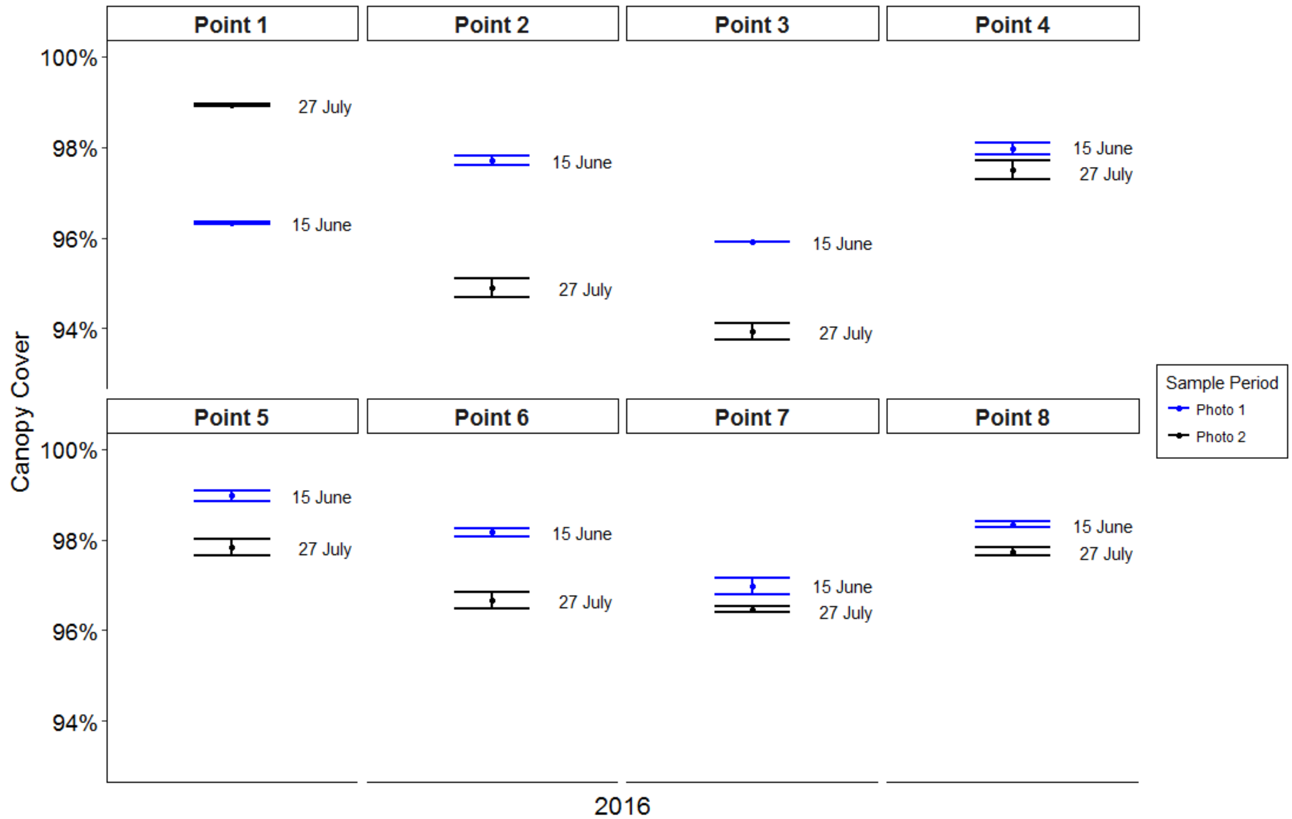

Figure 10. Canopy cover at LFCC-5B hemispherical photo stations by sampling occasion.
Blue points indicate the first sampling occasion of the study year and black points indicate the second sampling occasion of the year. Error bars represent standard error of canopy cover calculated from three repeat classifications of each hemispherical photo.

Landscape Photography

All landscape photographs were taken on the same dates as the hemispherical photographs in each study site (Table 1). Tamarisk beetle presence or defoliation was not recorded at any of the landscape photo stations in DL-12 (*n* = 6) or LFCC-5B (*n* = 3) in 2015 or 2016. Tamarisk browning and defoliation by the tamarisk beetle were recorded at three of four landscape photo stations in BL-10 on the second sampling occasion (30 July) of 2016 (Fig. 11).

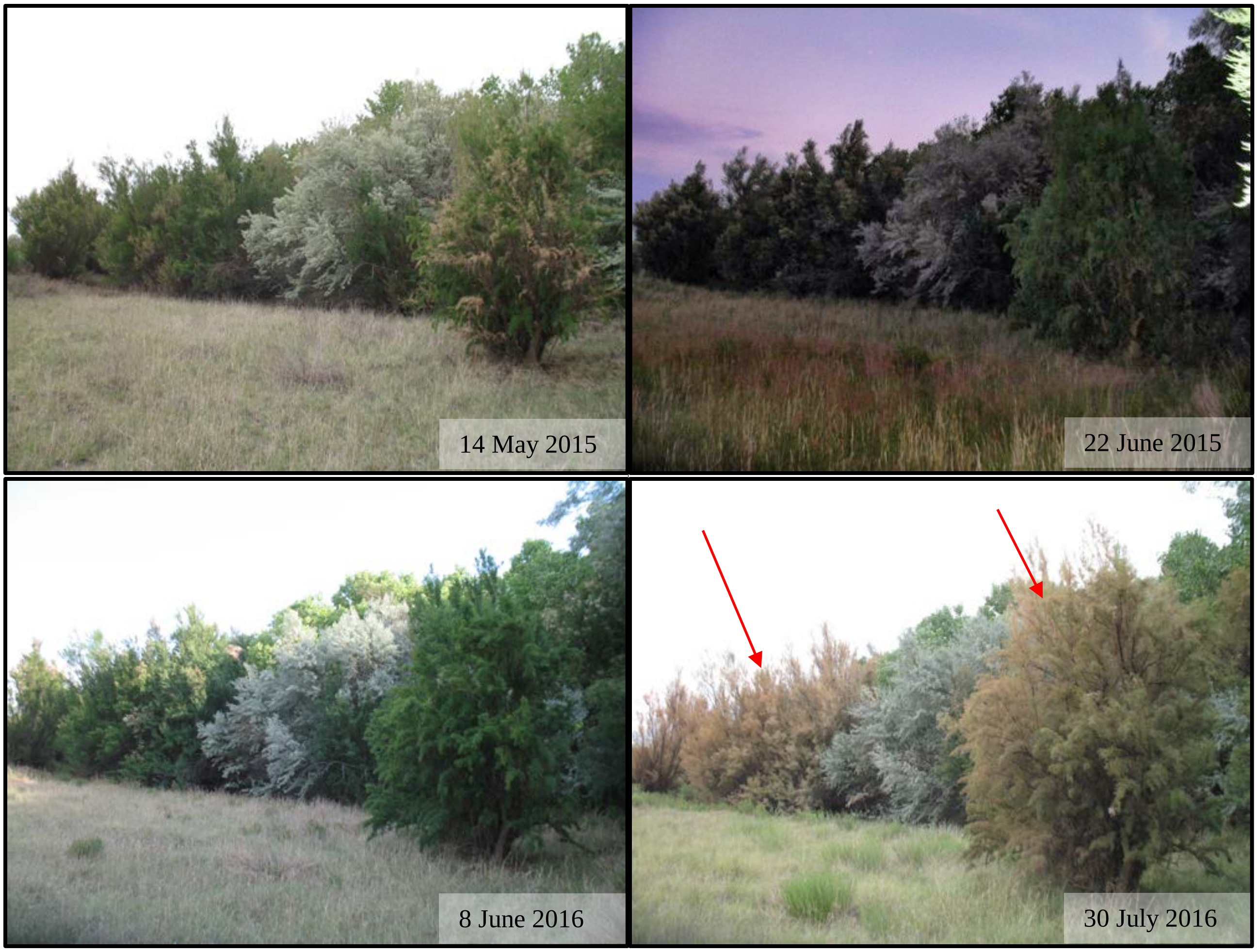

Figure 11. BL-10 landscape photo station #3, one of three stations at which tamarisk beetle defoliation was observed. Arrows indicate tamarisk exhibiting signs of browning and defoliation by the tamarisk beetle.

Discussion

Tamarisk has become an important component of riparian bird habitat as drought and changes in hydrology have prompted the increased abundance of invasive vegetation and the loss of native vegetation in many riparian areas of the southwestern U.S. Indeed, 70 percent of SWFL nests located within the receded pool of the Elephant Butte Reservoir, which supports the majority of the Middle Rio Grande population, were constructed in tamarisk in 2016 (Fig. 12). This is compared to 70 percent of nests constructed in native willow 14 years ago. Moreover, approximately two thirds of SWFL breeding territories in Elephant Butte Reservoir were either dominated by exotic vegetation (primarily tamarisk) or a mix of native and exotic vegetation (Fig. 13). The high use of tamarisk by breeding SWFLs raises many questions about how defoliation of SWFL habitat by the tamarisk beetle will ultimately influence the recovery of this endangered species, and makes early and continuous monitoring of these impacts an important aspect of population management.

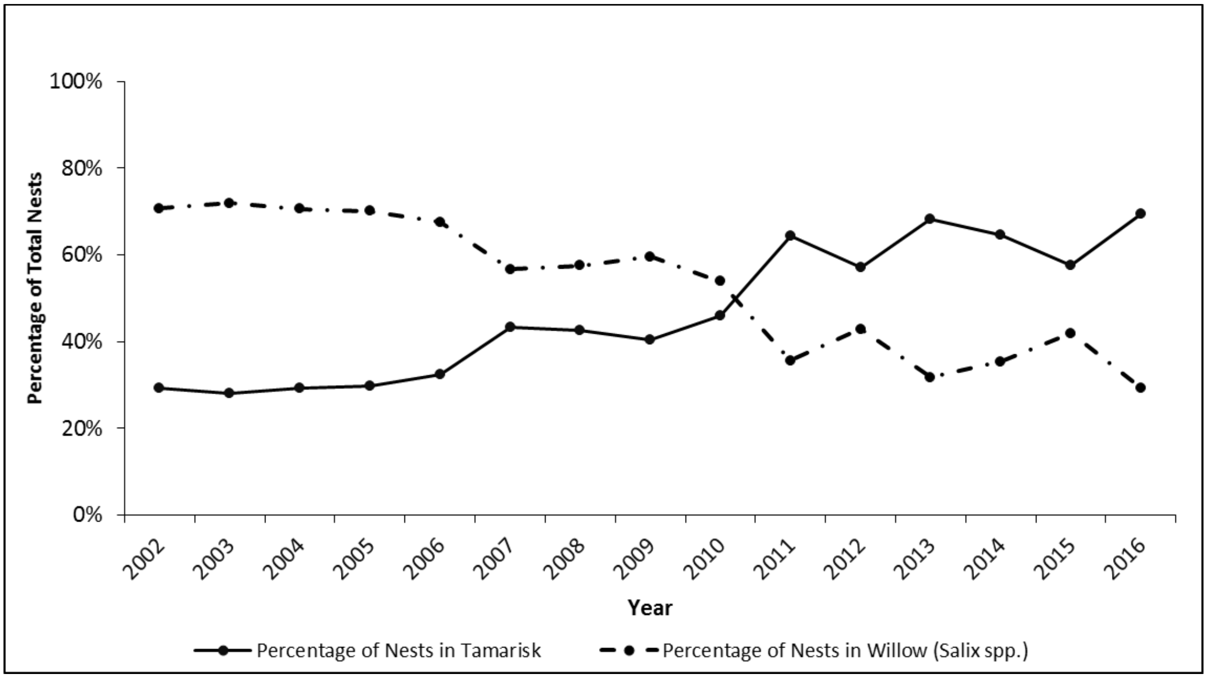

Figure 12. Percentage of Southwestern Willow Flycatcher nests constructed in native willow vs. invasive tamarisk. (n = 2602, range = 65-270 nests per year)

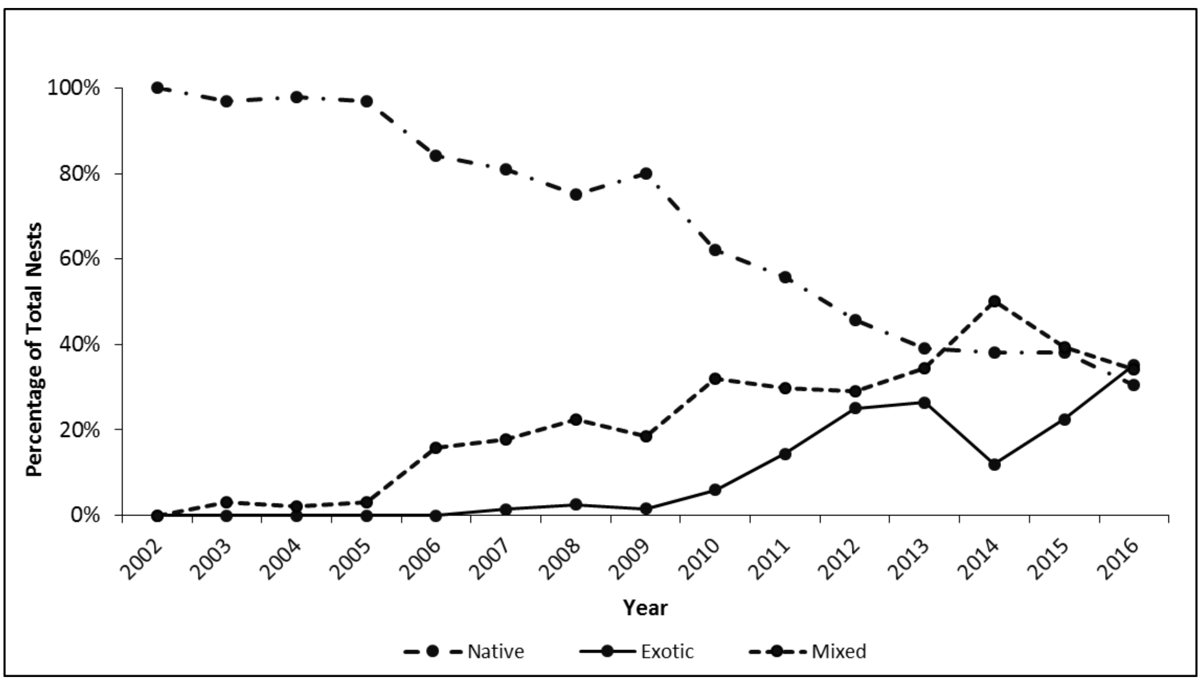

Figure 13. Percentage of Southwestern Willow Flycatcher nests constructed in territories dominated by native vs. exotic vs. mixed native and exotic vegetation.
(n = 2602, range = 65-270 nests per year)

The tamarisk beetle was documented throughout the entire Rio Grande riparian corridor in 2016 (Johnson pers.comm.; Tamarisk Coalition 2016). The subtropical and northern species of the tamarisk beetle were both found on the Middle Rio Grande, with the two populations converging in the vicinity of San Marcial. The northern tamarisk beetle is known to produce three generations in a single season, and the subtropical species produces four to five generations annually (Johnson pers.comm.). However, the beetle was still found in disconnected sub-populations rather than continuously throughout the riparian corridor. Indeed, the tamarisk beetle was not detected at any of the established photo stations in 2015 and only in part of one study site (BL-10) in 2016. Therefore, the majority of the data collected at the hemispherical and landscape photography stations in these two years will provide baseline data on canopy cover and vegetation community composition with which to evaluate the extent of changes in future years.

The 2015 and 2016 data suggested an overall pattern of percent canopy cover reaching a seasonal maximum in approximately late June to early July. This apparent peak of the growing season corresponds with the peak of the Southwestern Willow Flycatcher breeding season on the Rio Grande—at that point in the summer most paired SWFLs have active nests. At most locations canopy cover declined after that mid-summer peak. Additionally, percent canopy cover at all sites was typically in the range of 85 to 98 percent throughout the growing season.

Canopy cover at the one hemispherical photo station impacted by tamarisk beetle defoliation in 2016 remained within the normal range of variation for the study area, although it must be cautioned that no inference can be made from a single data point. Nevertheless, it is important to note that hemispherical photography cannot distinguish between live and dead foliage, a difference that is likely meaningful to a breeding bird. Additionally, tamarisk beetle defoliation did not begin at this site until at least mid-June 2016 and the vegetation had been impacted for less than two months at the time of the final 2016 photo survey. The tamarisk beetle controls tamarisk by repeatedly defoliating the plant over multiple growing seasons, eventually causing it to lose woody mass and vegetation (Dudley 2005). Given this, the impacts of tamarisk beetle defoliation on canopy cover may not be immediate. For example, canopy cover at photo stations impacted by multiple years of defoliation may eventually decline to a value below the 85 to 98 percent natural range of variation in canopy cover currently observed in the study area. Dense canopy cover is a critical component of Southwestern Willow Flycatcher breeding habitat (Stoleson and Finch 2003) and even small decreases in canopy cover can have a strong negative influence on SWFL habitat suitability, nest success, and productivity (Paxton et al. 2011).

Additionally, the timing of tamarisk beetle defoliation in future years will likely be an important factor determining the impact that defoliation has on breeding SWFLs. Severe browning and defoliation was not observed in occupied SWFL territories on the Middle Rio Grande until relatively late in the SWFL breeding season (mid- to late July) in 2016 (pers. obs.). However, in many parts of the SWFL's breeding range defoliation occurs in early summer, when birds are still in early stages of the breeding cycle. This creates an ecological trap in which a bird settles in apparently suitable, foliated vegetation only to have that vegetation defoliated shortly after they begin nesting (Paxton et al. 2011). Ultimately, the timing of defoliation on the Middle Rio Grande will be an important determinant of SWFL nest success and productivity

Conclusions

In the summer of 2016 the tamarisk beetle was documented throughout the Rio Grande. Although Reclamation biologists only documented tamarisk beetle defoliation in a small number of occupied SWFL breeding territories late in the breeding season, the tamarisk beetle population is expected to increase and spread in coming years. Ultimately, the timing, severity, and extent of tamarisk beetle defoliation will determine the level of impact on breeding willow flycatchers. Photographic monitoring of changes in canopy cover and vegetation composition in SWFL habitat will provide an important tool to assess the possible need for more active management of the riparian ecosystem. If changes in SWFL productivity and nest success raise concerns about the species' recovery, such modifications on management strategies may be deemed necessary. For example, efforts to mitigate the impact of tamarisk defoliation on the Virgin River watershed SWFL population led to the development of a collaborative riparian restoration plan (Dudley and Bean 2012). Additionally, overbank flooding of the riparian area during the winter is known to kill tamarisk beetle populations, which are in diapause in the soil at that time. Continued monitoring of beetle-induced changes in riparian vegetation and associated changes in SWFL demographic parameters will provide important data regarding the need, or lack thereof, of these or other management strategies.

Recommendations

- Continuation of landscape and hemispherical photography at established sampling locations to monitor impacts of the tamarisk beetle on riparian vegetation.
- Take hemispherical photographs once during the non-growing (winter) season in alternating years to determine changes in tamarisk foliage density versus woody mass. Winter measurements of canopy cover, after abscission has occurred for this deciduous shrub, when compared to the preceding summer measurements will enable a calculation of the amount of summer canopy cover comprised of foliage versus woody material - a distinction likely to be important for a breeding bird.
- Expand monitoring to include additional study areas with high Southwestern Willow Flycatcher and tamarisk densities.

Attachment 1: Photo Station Locations

Attachment 1A: Hemispherical Photography Station Locations

Station Number	Location (UTM NAD 83 Zone 13N)	Distance to Closest 2015/2016 SWFL Pair (m)
BL-10		
HPS-1	338241, 3824809	79
HPS-2	338230, 3824855	31
HPS-3	338211, 3824879	12
HPS-4	338205, 3824922	13
HPS-5	338210, 3824933	15
HPS-6	338201, 3825011	19
HPS-7	338184, 3825049	6
HPS-8	338172, 3825093	16
DL-12		
HPS-1	306804, 3717696	17
HPS-2	306789, 3717595	9
HPS-3	306770, 3717505	6
HPS-4	306745, 3717505	6
HPS-5	306721, 3717451	9
HPS-6	306700, 3717411	3
HPS-7	306671, 3717374	14
HPS-8	306672, 3717339	9
HPS-9	306697, 3717327	10
HPS-10	306694, 3717309	9
LFCC-5B		
HPS-1	314963, 3725319	7
HPS-2	314996, 3725102	6
HPS-3	315008, 3725056	52
HPS-4	315032, 3724960	39
HPS-5	315035, 3724872	11
HPS-6	315048, 3724840	13
HPS-7	315057, 3724793	15
HPS-8	315073, 3724697	15

Attachment 1B: Landscape Photography Station Locations

Station Number	Location (UTM NAD 83 Zone 13N)	Bearing (degrees)	Distance to Closest 2015/2016 SWFL Pair (m)
BL-10			
LPS-1	338220, 3824825	20	60
LPS-2	338229, 3824891	260	10
LPS-3	338235, 3825096	170	48
LPS-4	338249, 3824948	180	40
DL-12			
LPS-1	306716, 3717311	220	18
LPS-2	306702, 3717381	350	13
LPS-3	306769, 3717522	195	17
LPS-4	306822, 3717544	210 & 300	28
LPS-5	306837, 3717638	340 & 250	28
LPS-6	306823, 3717703	270	4
LFCC-5B			
LPS-1	315087, 3724714	215	27
LPS-2	315048, 3724903	130	23
LPS-3	315020, 3725179	175	30

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PEER REVIEW DOCUMENTATION

PROJECT AND DOCUMENT INFORMATION

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Document Photographic Monitoring of Defoliation by the Tamarisk Beetle: Middle Rio Grande from Belen to Elephant Butte Reservoir, NM

Document Date April 2017

Team Leader Darrell Ahlers, 86-68290, Wildlife Biologist

Document Author(s)/Preparer(s) K. Dillon and D. Ahlers

Peer Reviewer S. Dave Moore, 86-68290, Wildlife Biologist

Peer Reviewer ______

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:
Complete Document Subject to Review	S. Dave Moore

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: S. Dave Moore Review Date: April 3, 2017 Signature: SDM

Reviewer: ______ Review Date: ______ Signature: ______

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: Darrell Ahlers Date: 4/4/2017 Signature: Darrell Ahlers