Prepared in Cooperation with the U.S. Fish and Wildlife Service

CHANNEL RESPONSE TO LOW-ELEVATION DESERT FIRE:

The King Valley Fire of 2005

By Robert H. Webb, Peter G. Griffiths, Cynthia S.A. Wallace, and Diane E. Boyer

Report Series Data–DS 275

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
Dirk E. Kempthorne, Secretary

U.S. Geological Survey
Mark D. Myers, Director

U.S. Geological Survey, Tucson, Arizona 2007

For product and ordering information:
World Wide Web: http://www.usgs.gov/pubprod
Telephone: 1-888-ASK-USGS

For more information on the USGS—the Federal source for science about the Earth,
its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone: 1-888-ASK-USGS

Suggested citation:
Webb, R.H., Griffiths, P.G., Wallace, C.S.A., and Boyer, D.E., 2007, Channel response to low-elevation desert fire: the King Valley Fire of 2005: U.S. Geological Survey Data Report DS 275, 47 p.

Contents

Figures

Tables

Conversion Factors

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square meter (m^2)	0.0002471	acre
hectare (ha)	2.471	acre
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)

Vertical coordinate information is referenced to the "North American Vertical Datum of 1988 (NAVD 88), Geoid 03".

Horizontal coordinate information is referenced to the "World Geodetic System of 1984 (WGS 84)".

Altitude, as used in this report, refers to distance above the vertical datum.

CHANNEL RESPONSE TO LOW-ELEVATION DESERT FIRE: The King Valley Fire of 2005

By Robert H. Webb, Peter G. Griffiths, Cynthia S.A. Wallace, and Diane E. Boyer

Abstract

In late September to early October 2005, a fire swept north from the Yuma Proving Grounds and into the Kofa National Wildlife Refuge (NWR), traveling mainly along desert wash systems and low-relief alluvial fans. This fire burned 9,975 ha, moving through xeroriparian systems in washes as well as low-elevation desert ecosystems in King Valley, a major area of designated wilderness in the southern part of the Kofa NWR. Using satellite imagery, we determined that 9,255 ha of the Kofa NWR in King Valley burned. The fine-fuel loading for the fire was mostly a native forb (*Plantago insularis*), and the desert environment that was burned was mostly low-cover creosote bush (*Larrea tridentata*) scrub with scattered palo verde (*Cercidium microphyllum*). The wash environments had significant tree cover, including ironwood (*Olneya tesota*), blue palo verde (*Cercidium floridum*), desert willow (*Chilopsis linearis*), and/or smoke tree (*Psorothamnus spinos*a). This report presents monitoring data collected in June 2006 and January-February 2007 on the effects of this fire on channel morphology in King Valley.

Introduction

In late September to early October 2005, a fire swept north from the Yuma Proving Grounds and into the Kofa National Wildlife Refuge (NWR), traveling mainly along desert wash systems and low-relief alluvial fans in King Valley, a designated wilderness area. According to the fire management crew, this fire burned a total of about 11,700 hectares (fig. 1), approximately 10,500 ha of which was in the designated wilderness area of the Kofa NWR. The fire moved through xeroriparian systems in washes with significant tree cover, as well as through low-elevation desert ecosystems that had mostly xerophytic shrubs and desert trees. The fine fuel that sustained this fire was primarily native forbs that had dried following the extremely wet winter of 2004-2005.

Following this fire, which may well have been unprecedented in King Valley, the U.S. Fish and Wildlife Service became concerned about the possible soil loss and channel erosion caused by rainfall on the burned watershed. Severe drought in the winter of 2005-2006 resulted in limited surface runoff during that season. However, decreased winter precipitation also limited regrowth of perennial cover, thereby maximizing the potential for initial surface runoff and erosion during future periods of increased rainfall. Beginning in June 2006, the authors began a monitoring program designed to compare channel morphology in areas draining the burned landscape with unburned sites upstream in King Valley. This report presents the data collected during two surveys – June 2006 and January-February 2007 – in the Kofa National Wildlife Refuge.

Purpose and Scope

The purpose of this study was to establish a monitoring program for evaluation of short- and long-term soil erosion and channel change on selected burned and unburned parts of the King Valley watershed. To minimize expenses, we used a combination of repeat photography, surveying, and sediment sampling to provide baseline data and initiate long-term monitoring of the effects of this fire.

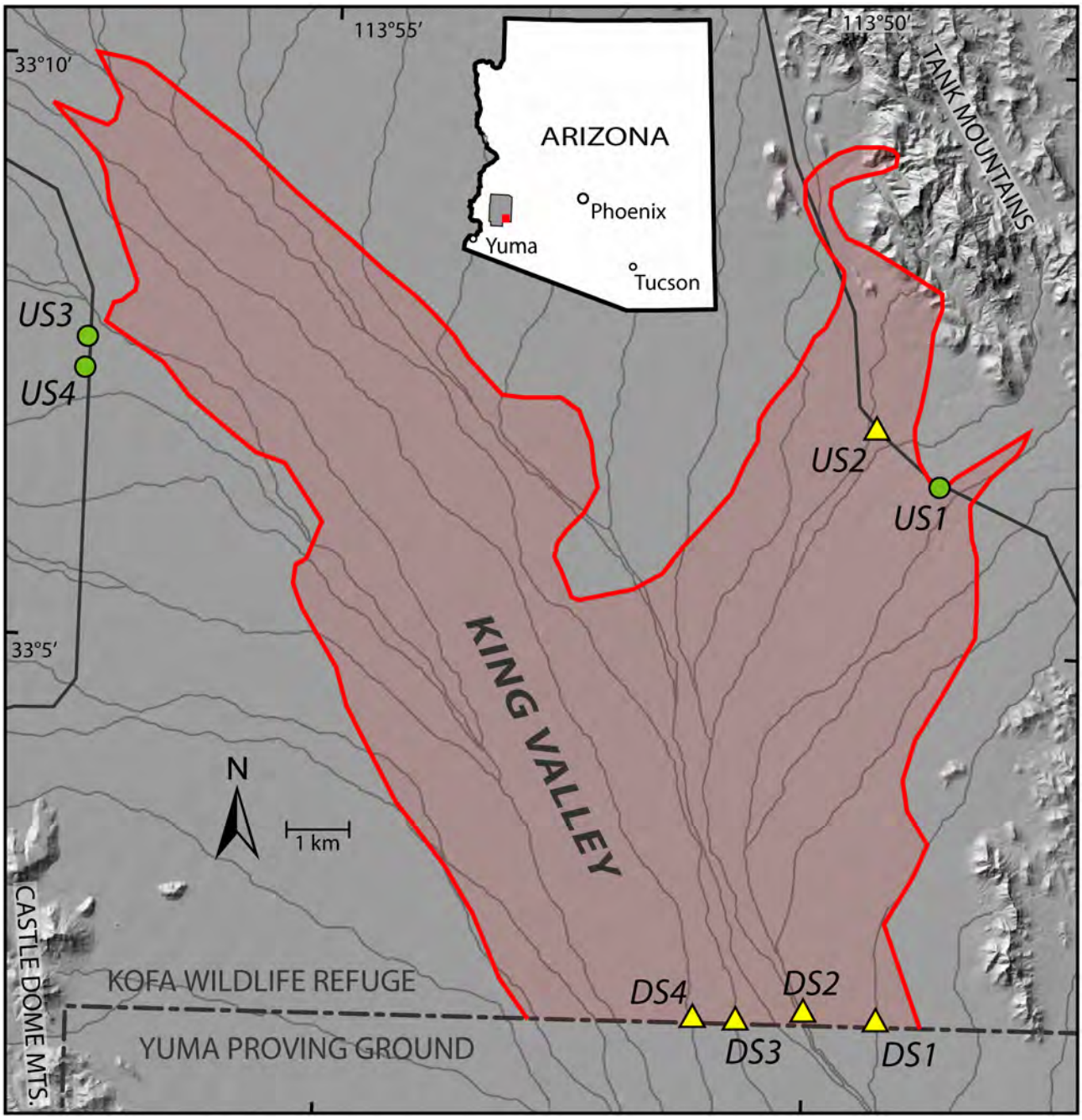

Figure 1. Map of King Valley burn area within the Kofa National Wildlife Refuge (NWR). The red line surrounds the fire perimeter established roughly by the fire crew at the time the fire was extinguished. Channel-response monitoring sites at unburned and burned sites are marked with green circles and yellow triangles, respectively. Only the largest channels are displayed. The map extent is indicated in red on the inset map within the boundaries of the Kofa NWR.

Acknowledgments

We thank Todd Esque for incorporating our research project into the larger-scale study of the recovery of King Valley following the 2005 fire. Lindsay Smythe provided funding through the U.S. Fish and Wildlife Service as well as logistical support and assistance in the field. We acknowledge the assistance of the Yuma Proving Ground, particularly Valerie Morrell, for providing access to the study sites. This study was funded by the U.S. Fish and Wildlife Service.

Background

King Valley is a large, low-relief area of coalescing alluvial fans and distributary-flow washes in western Arizona (fig. 1). The vegetation in interfluve areas, away from active washes, is mostly creosote bush (*Larrea tridentata*) scrub with other xerophytic shrubs and scattered palo verde (*Cercidium microphyllum*). The washes were lined with a large number of trees and had high tree cover contributed mostly by ironwood (*Olneya tesota*), palo verde, blue palo verde (*Cercidium floridum*), desert willow (*Chilopsis linearis*), and/or smoke tree (*Psorothamnus spinosa*). The climate in the area, as determined from a single rainfall gage at the Kofa Mine at the north end of King Valley (fig. 2a; 12 km north of the burn area), indicates a mean annual precipitation of 163 mm (1952-2006, many missing years) with an annual maximum of 402 mm in 1983 and a minimum of 42 mm in 1956. Rainfall is biseasonal with high variability (fig. 2b).

On September 29, 2005, a fire that started on the Yuma Proving Ground (YPG) south of Kofa NWR swept northwards, guided by southerly winds. The fine fuel that sustained this fire was primarily the dried *Plantago insularis*, which allowed the fire to spread between the scattered shrubs and trees. The fire was fought with a combination of ground crews and aircraft, was contained on October 6th, and was declared extinguished on October 12th. The area burned was generally between 200 and 300 m elevation on low slopes.

The area of the King Valley fire is visible on Moderate Resolution Imaging Spectroradiometer (MODIS) Normalized Difference Vegetation Index (NDVI) satellite images (fig. 3a). These grayscale images display the maximum "greenness" at each pixel location over a 16-day period, with the lightest shade being the most green and the darkest shade being the least green. Early in the year, the King Valley is visible as a bright NW-trending swath, which darkens over the course of the year. The burned area is clearly evident in a difference image calculated from the September 14 (immediately pre-fire) and November 1 (post-fire) images (fig. 3b). Based on this imagery, the total area changed as a result of the fire is 9,975 ha, of which 9,255 ha is in the Kofa NWR. Following a relatively dry winter, monitoring of channel response began in early summer of 2006.

Methods

In both the burned and unburned areas of King Valley, we selected wash sites for monitoring channel morphology. The washes draining unburned areas are on the eastern and western flanks of King Valley (sites US1, US3, and US4; fig. 1), are accessible by road, and provide representative conditions for pre-fire fluvial geomorphology. We measured three washes down slope within the burned area, at the Kofa NWR –YPG border (sites DS1, DS3, and DS4; fig. 1), which we reached with the permission and cooperation of YPG staff. Two additional burned wash sites – one along the Kofa NWR – YPG border (site DS2, fig. 1) and one on the eastern flank of King Valley (site US2, fig. 1) – were chosen for photographic monitoring alone. The washes were selected for maximum impact from removal of upland vegetation cover by fire as well as alteration of channel roughness by surface runoff. Because the distributary flow system through King Valley blurs the connectivity of channels, it is uncertain whether continuous washes were selected in the burned/unburned comparisons. The initial work was conducted on June 28-29, 2006, and the sites were revisited on January 31-February 1, 2007.

We established permanent repeat-photography camera stations at each selected wash, using a large-format film camera and a digital camera to capture conditions both upstream and downstream from the channel cross sections. We established ten camera stations and marked the locations with rebar stakes. From many of these stations we took images from multiple angles, for a total of 22 unique views of burned and unburned washes. This photography provides a much larger perspective on the question of channel change and flooding than can be obtained from measured cross sections alone.

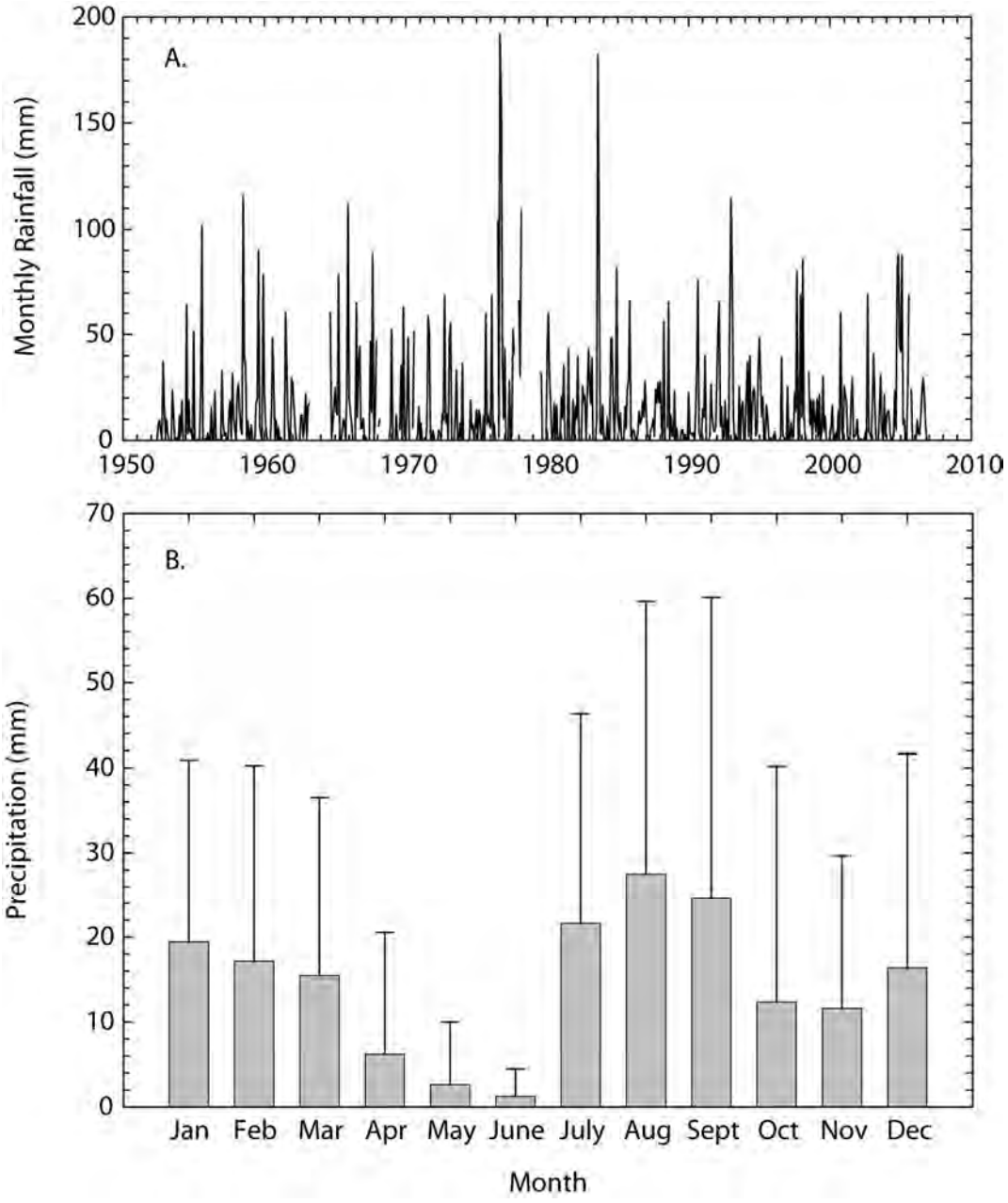

Figure 2. Precipitation at the King of Arizona Mine, northern King Valley, Arizona. A. Time series of monthly precipitation, 1952-2006. B. Mean monthly precipitation (error bars are 1 standard deviation). Data from *http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?az4702*. The winter of 2004-2005 was extremely wet in southwestern Arizona, with a total of 362 mm of precipitation falling from October through April. Ephemeral plants grew in extremely dense stands in an otherwise sparsely vegetated landscape. Following a relatively dry summer, the ephemeral plants dried, leaving a large amount of fine fuel on the landscape. Post-fire examination indicated that most of the annual vegetation was native plantago (*Plantago insularis*) with lesser amounts of non-native Mediterranean grass (*Schismus* sp.) between shrubs and trees and substantial mustard (*Sisymbrium* sp.) within *Larrea* clumps.

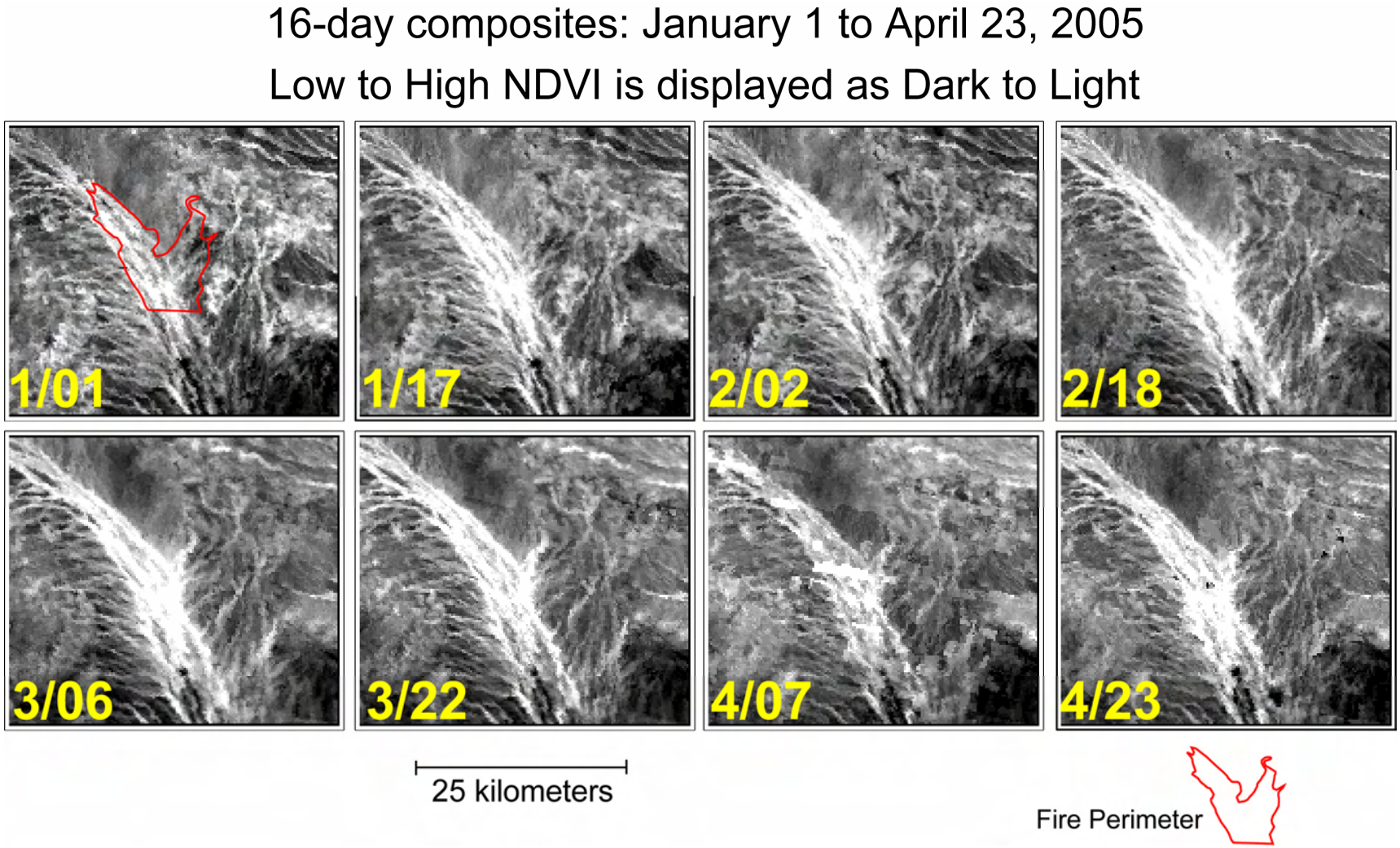

Figure 3a. MODIS-EVI composite images (250 m by 250 m pixels) for January 1 to April 23, 2005 showing King Valley and the extent of the September 29 through October 6 fire within the Kofa NWR. Each composite represents the maximum greenness value for each pixel for the 16 day period beginning with the date shown in yellow. The fire perimeter was roughly drawn by fire crews immediately after the event.

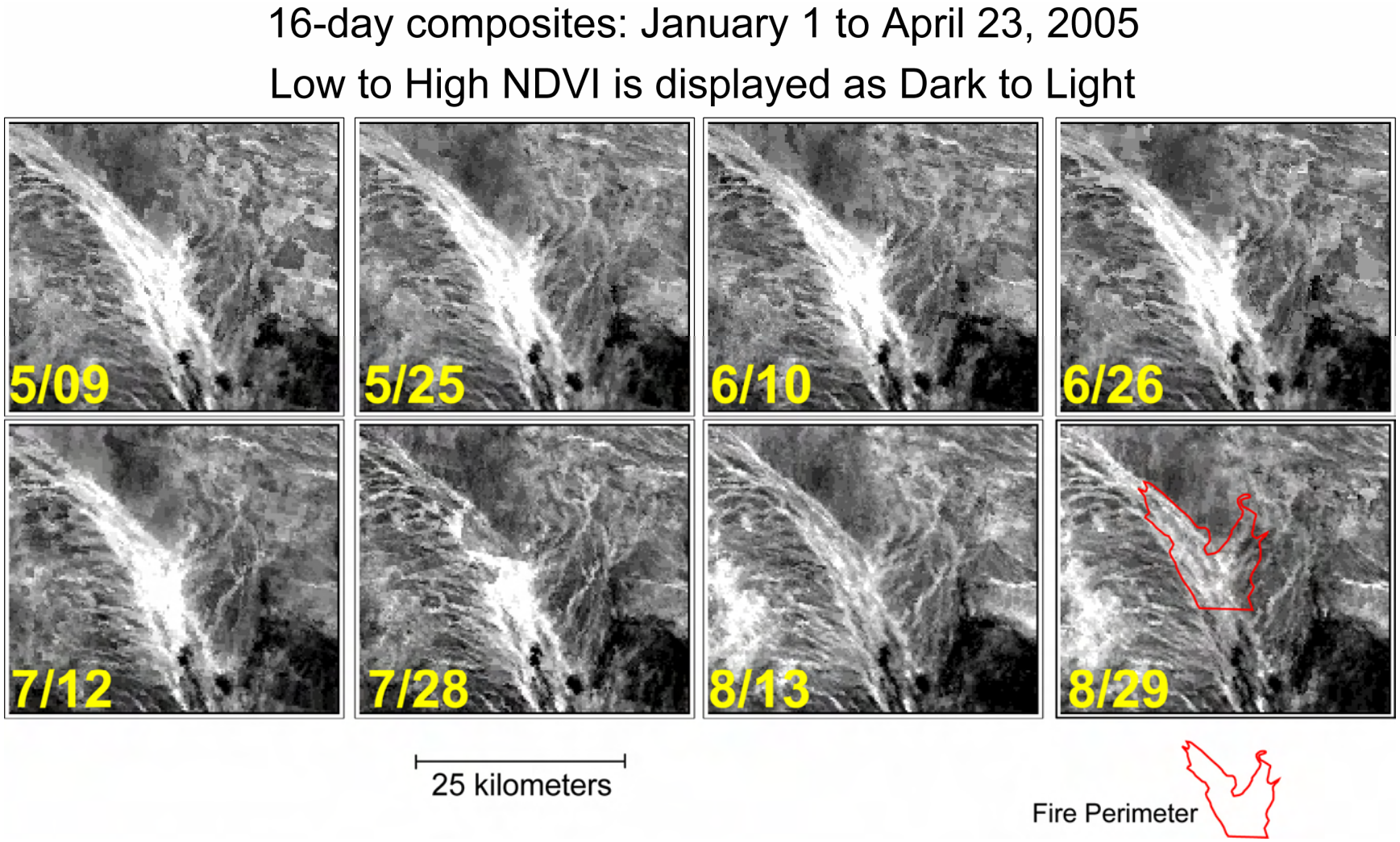

Figure 3a. (continued) MODIS-EVI composite images for May 9 to August 29, 2005 showing King Valley and the extent of the September 29 through October 6 fire within the Kofa NWR. Each composite represents the maximum greenness value for each pixel for the 16 day period beginning with the date shown in yellow. The pixel resolution is 250 m.

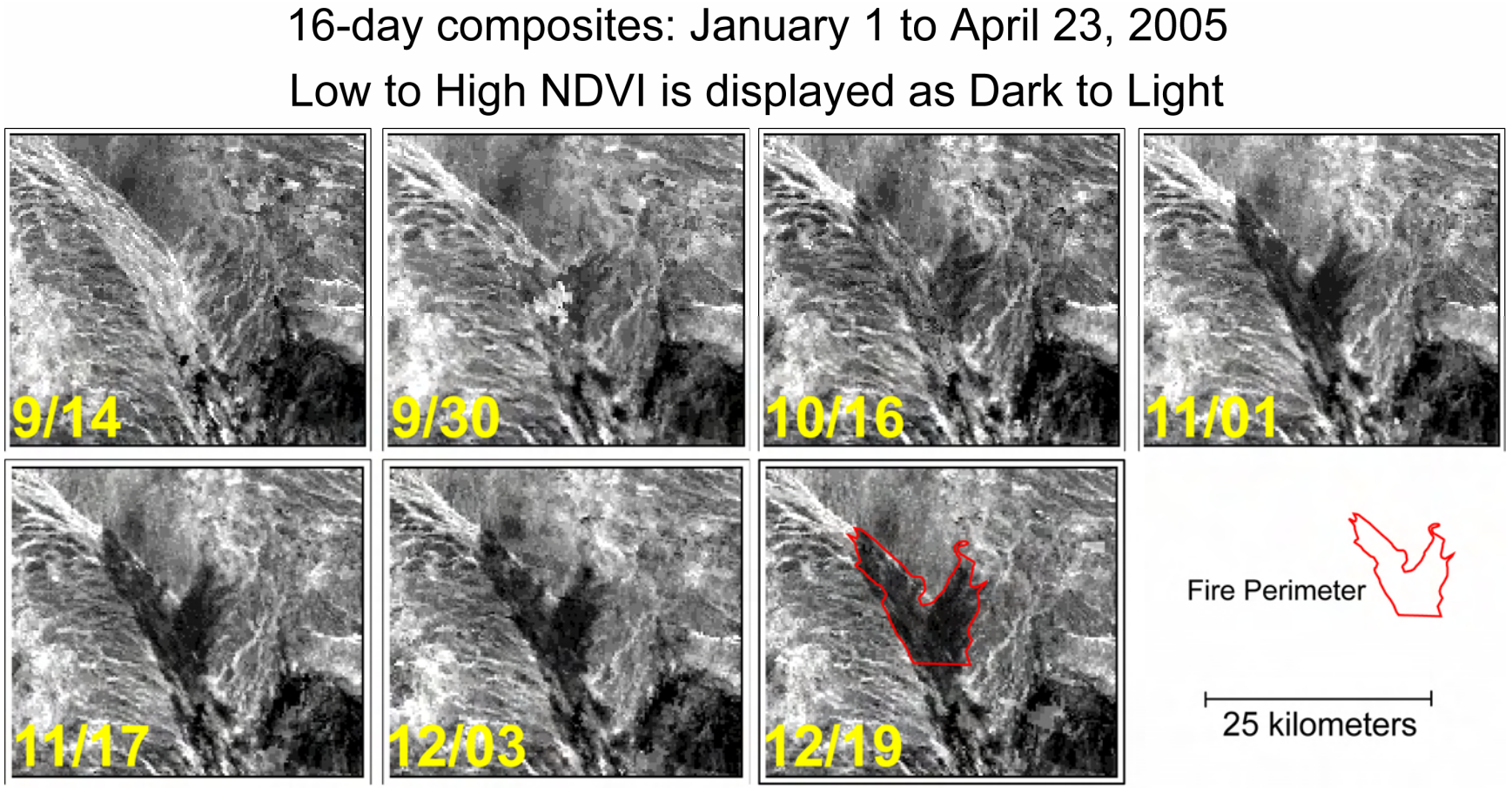

Figure 3a. (continued) MODIS-EVI composite images for September 14 to December 19, 2005 showing King Valley and the extent of the September 29 through October 6 fire within the Kofa NWR. Each composite represents the maximum greenness value for each pixel for the 16 day period beginning with the date shown in yellow. The pixel resolution is 250 m.

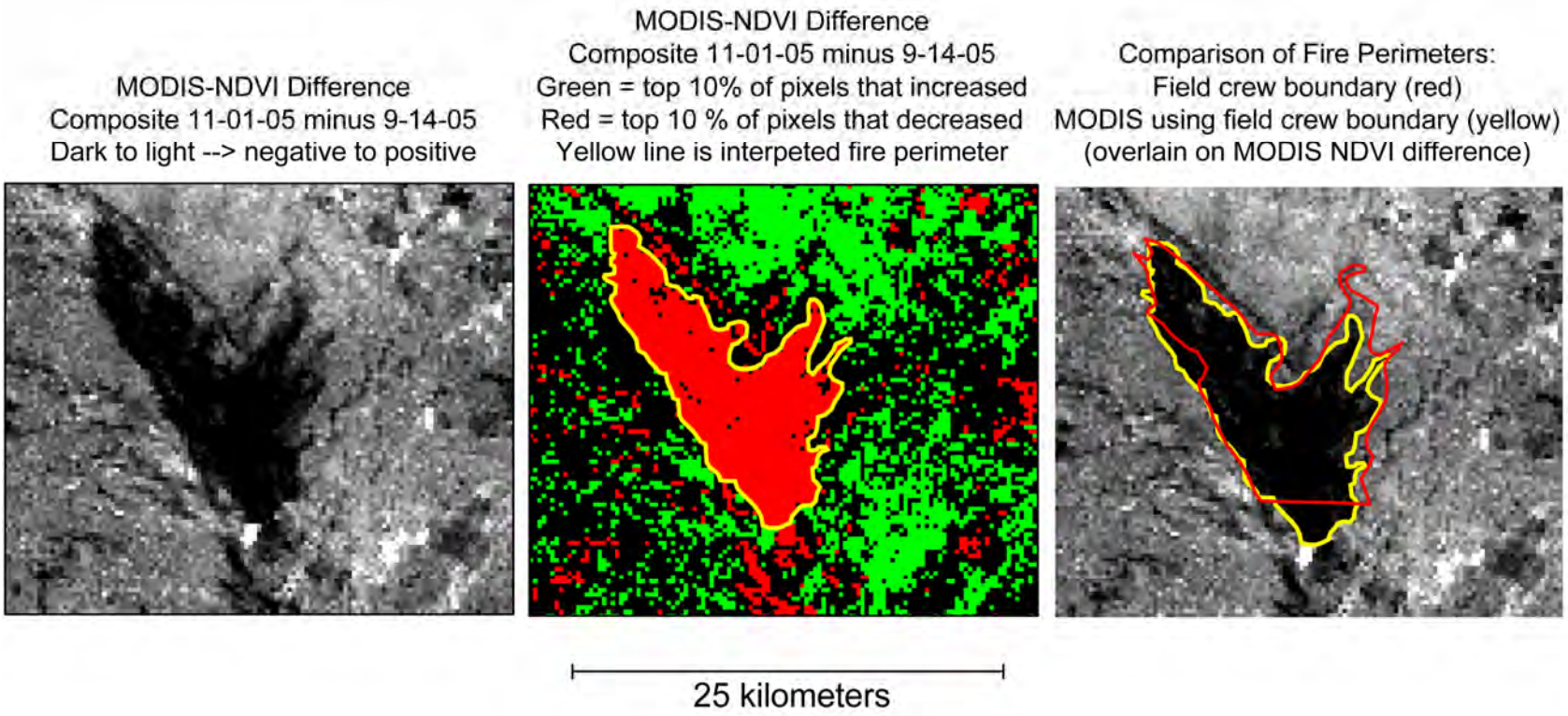

Figure 3b. Image difference and change detection image for the King Fire. Left image shows the difference between a post-fire and pre-fire composite image; the area burned shows up as a contiguous dark region. The center image is created by calculating the global statistics for the area of the image and identifying the most-changed pixels. In this case, a threshold of 10% was chosen, with red highlighting the 10% most decreased and green the 10% most increased pixels between the image dates. The yellow line in the center image is an interpreted fire boundary based on the change image but guided by field information. The image on the right is the difference image with the field-defined fire boundary within the Kofa NWR shown in red and the image-interpreted fire boundary shown in yellow.

We installed monitoring cross sections at three washes for each treatment (burned and unburned) for a total of six sites. Three cross sections spaced at approximately twice the channel width were established at each wash, except at site DS1 where only one cross-section was required owing to the small size of the channel. The endpoints of each cross-section were marked with rebar stakes, one of which – typically the northern or western end of the middle cross-section – was selected as the permanent instrument station. Cross sections were surveyed using a total station from above existing high-water marks at intervals spaced to reflect channel morphology, particularly those features expected to be affected by fire-induced flooding, such as low floodplain terraces. Data from the June 2006 survey of DS3 were corrupted in translation from the total station. They are unusable for comparison with the February 2007 data and are not included in this report.

The locations of all cross-section end points and photo stations were recorded using a hand-held GPS receiver and post-processed to horizontal and vertical precisions (99%) of < 2 m and < 5 m, respectively. UTM coordinates of cross-section end points were then adjusted within their individual range of error to fit their established survey locations and all survey coordinates converted to UTM values (Zone 12). Cross-section data points were projected onto a straight line between end points and plotted horizontally as the distance from the channel right end point and vertically in reference to the relative instrument station elevation of 100 m.

To detect potential changes in bed particle size, we collected sediment samples from each surveyed wash site as well as photographic monitoring site US2, which is a burned area. At each site, we collected three samples from randomly selected sites in the bed of the wash. Each sample was 2.5 to 3.0 kg in weight to ensure that the larger particles in the wash were adequately represented. In a laboratory, we sieved these samples to determine an average particle-size distribution using the following procedure: (1) we passed the entire sample through 64, 32, 16, and 8 mm sieves, weighing the particles retained on each sieve and expressing these as a weight percent of the entire sample; (2) we split the remaining sample to a size of 800-1200 g; (3) we sieved the sample split using a standard sieve set of 4, 2, 1, 0.5, 0.25, 0.125, and 0.063 mm sieves; and (4) we then calculated the weight percent of particles retained on each sieve, calculated with respect to the entire sample weight.

MONITORING DATA

Burned Sites

Table 1. Metadata for burned monitoring sites in King Valley.

Site	North Latitude[1] (degrees)	West Longitude[1] (degrees)	Elevation (m)	Surveyed Cross-sections	Photographic Stake Number	First Survey	Second Survey
DS1	33.031041	113.820954	206	1	4799	06/27/06	01/31/07
DS2	33.032514	113.833325	207	0	4900	06/27/06	01/31/07
DS3	33.029804	113.844831	208	3	4901	06/27/06[2]	01/31/07
DS4	33.030362	113.852141	207	3	4902	06/27/06	01/31/07
US2	33.116272	113.823357	272	0	4905	06/28/06	02/01/07

[1]Geographic coordinates given are for the location of the photographic station at each site. (Horizontal datum WGS84; vertical datum NAVD83)

[2]Data from first survey at DS3 were corrupted and unusable.

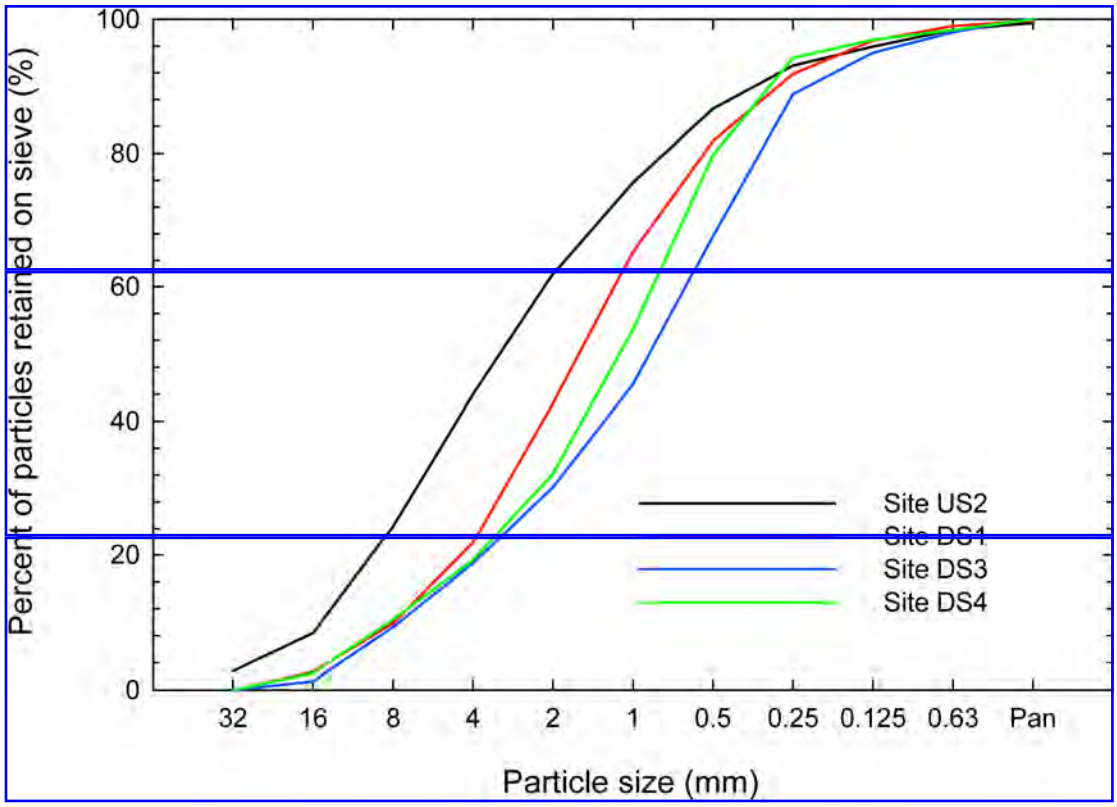

Figure 4. Graph showing particle-size distributions of channel sediments in burned areas of King Valley.

Table 2. Metadata for photographs of burned monitoring sites in King Valley.

Site	Latitude (degrees)	Longitude (degrees)	Elevation (m)	Stake Number	Photographer	Camera Height (m)	View Direction (degrees)	Date-Time of Original	Date-Time of Match
King Valley burned site DS1	33.032514	113.833325	206	4799a	Boyer	1.26	35	06/27/2006 8:12A	01/31/2007 10:00A
King Valley burned site DS1	33.032514	113.833325	206	4799b	Boyer	1.26	355	06/27/2006 8:22A	01/31/2007 10:12A
King Valley burned site DS1	33.032514	113.833325	206	4799c	Boyer	1.26	310	06/27/2006 8:34A	01/31/2007 10:24A
King Valley burned site DS1	33.032514	113.833325	206	4799d	Boyer	1.26	270	06/27/2006 8:43A	01/31/2007 10:33A
King Valley burned site DS1	33.032514	113.833325	206	4799e	Boyer	1.26	230	06/27/2006 8:57A	01/31/2007 10:41A
King Valley burned site DS1	33.032514	113.833325	206	4799f	Boyer	1.26	170	06/27/2006 9:05A	01/31/2007 10:49A
King Valley burned site DS2	33.03104	113.82095	207	4900a	Boyer	1.22	5	06/27/2006 9:44A	01/31/2007 11:31A
King Valley burned site DS2	33.03104	113.82095	207	4900b	Boyer	1.22	210	06/27/2006 9:56A	01/31/2007 11:45A
King Valley burned site DS2	33.03104	113.82095	207	4900c	Boyer	1.22	170	06/27/2006 10:04A	01/31/2007 11:55A
King Valley burned site DS2	33.03104	113.82095	207	4900d	Boyer	1.22	100	06/27/2006 10:24A	01/31/2007 12:05P
King Valley burned site DS3	33.03036	113.85214	208	4901a	Boyer	1.15	0	06/27/2006 11:40A	01/31/2007 1:08P
King Valley burned site DS3	33.03036	113.85214	208	4901b	Boyer	1.15	170	06/27/2006 11:50A	01/31/2007 1:20P
King Valley burned site DS4	33.02980	113.84483	207	4902a	Boyer	1.25	0	06/27/2006 12:58P	01/31/2007 3:05P
King Valley burned site DS4	33.02980	113.84483	207	4902b	Boyer	1.25	160	06/27/2006 1:09P	01/31/2007 3:13P
King Valley burned site US2	33.11627	113.82336	272	4905a	Boyer	1.35	165	06/28/2006 10:00A	02/01/2007 12:43P
King Valley burned site US2	33.11627	113.82336	272	4905b	Boyer	1.35	5	06/28/2006 10:06A	02/01/2007 12:55P

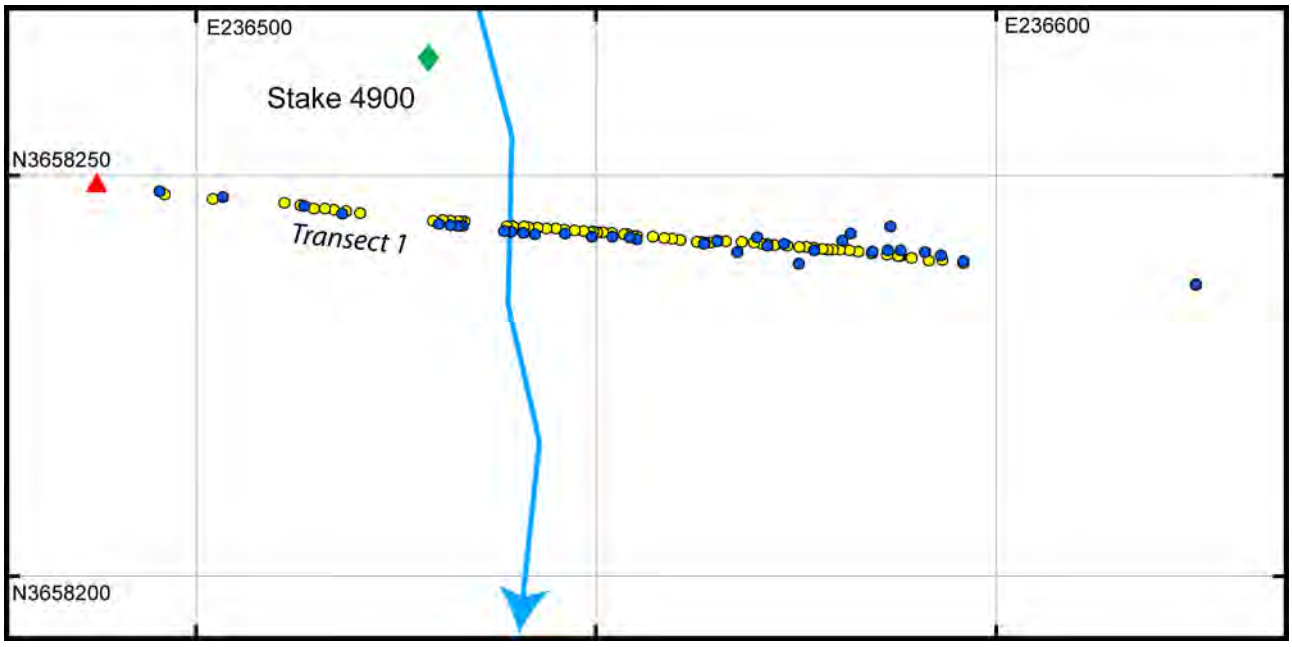

Figure 5. Map showing site DS1 and the location of the monitoring photograph (Stake 4900, marked by green diamond) and monitoring cross section. The red triangle indicates the instrument station. Circles indicate the cross-section data points collected, light yellow for June 2006 and dark blue for February 2007. The channel location and flow direction is indicated by the blue arrow.

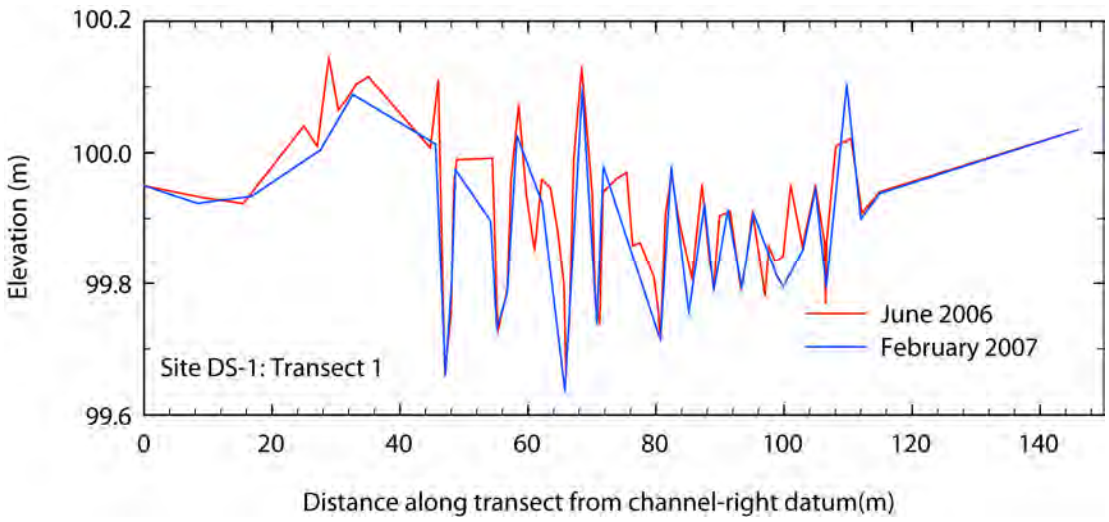

Figure 6. Graph showing transect 1 at site DS1 looking upstream, measured in June 2006 and February 2007

A.

B.

Figure 7. Photographs showing burned site DS1 on the Yuma Proving Grounds – Kofa National Wildlife Refuge boundary. A. June 27, 2006. B. January 31, 2007 (Stake 4900a). The view is north. The plants that were burned are *Larrea tridentata* and *Lycium andersonii* (foreground) and *Cercidium microphyllum* and *Olneya tesota* (background). The channel has filled slightly, possibly from eolian transport but more likely from local runoff.

A.

B.

Figure 8. Photographs showing burned site DS1 on the Yuma Proving Grounds – Kofa National Wildlife Refuge boundary. A. June 27, 2006. B. January 31, 2007 (Stake 4900b). The view is south-southwest. The plants that were burned are mostly *Larrea tridentata* and *Lycium andersonii*.

A.

B.

Figure 9. Photographs showing burned site DS1 on the Yuma Proving Grounds – Kofa National Wildlife Refuge boundary. A. June 27, 2006. B. January 31, 2007 (Stake 4900c). The view is south-southeast. The plants that were burned are *Larrea tridentata, Ambrosia dumosa,* and *Lycium andersonii* (foreground) and *Cercidium microphyllum* and *Olneya tesota* (background).

A.

B.

Figure 10. Photographs showing burned site DS1 on the Yuma Proving Grounds – Kofa National Wildlife Refuge boundary. A. June 27, 2006. B. January 31, 2007 (Stake 4900d). The view is east-northeast. The plants that were burned are mostly *Larrea tridentata* (foreground).

A.

B.

Figure 11. Photographs showing burned site DS2 on the Yuma Proving Grounds – Kofa National Wildlife Refuge boundary. A. June 27, 2006. B. January 31, 2007 (Stake 4799a). The view is east-northeast. The plants that were burned are *Larrea tridentata* and *Lycium andersonii* (foreground) and *Cercidium microphyllum* and *Olneya tesota* (background).

A.

B.

Figure 12. Photographs showing burned site DS2 on the Yuma Proving Grounds – Kofa National Wildlife Refuge boundary. A. June 27, 2006. B. January 31, 2007 (Stake 4799b). The view is north. The plants that were burned are *Larrea tridentata* and *Lycium andersonii* (foreground) and *Cercidium microphyllum* and *Olneya tesota* (background).

A.

B.

Figure 13. Photographs showing burned site DS2 on the Yuma Proving Grounds – Kofa National Wildlife Refuge boundary. A. June 27, 2006. B. January 31, 2007 (Stake 4799c). The view is northwest. The plants that were burned are *Larrea tridentata* and *Lycium andersonii* (foreground) and *Cercidium microphyllum* and *Olneya tesota* (background).

A.

B.

Figure 14. Photographs showing burned site DS2 on the Yuma Proving Grounds – Kofa National Wildlife Refuge boundary. A. June 27, 2006. B. January 31, 2007 (Stake 4799d). The view is west-northwest. The plants that were burned are *Larrea tridentata* and *Lycium andersonii* (foreground) and *Cercidium microphyllum* and *Olneya tesota* (background).

A.

B.

Figure 15. Photographs showing burned site DS2 on the Yuma Proving Grounds – Kofa National Wildlife Refuge boundary. A. June 27, 2006. B. January 31, 2007 (Stake 4799e). The view is southwest. The plants that were burned are *Larrea tridentata* and *Lycium andersonii* (foreground) and *Cercidium microphyllum* and *Olneya tesota* (background).

A.

B.

Figure 16. Photographs showing burned site DS2 on the Yuma Proving Grounds – Kofa National Wildlife Refuge boundary. A. June 27, 2006. B. January 31, 2007 (Stake 4799f). The view is east. The plants that were burned are *Larrea tridentata* and *Lycium andersonii* (foreground) and *Cercidium microphyllum* and *Olneya tesota* (background).

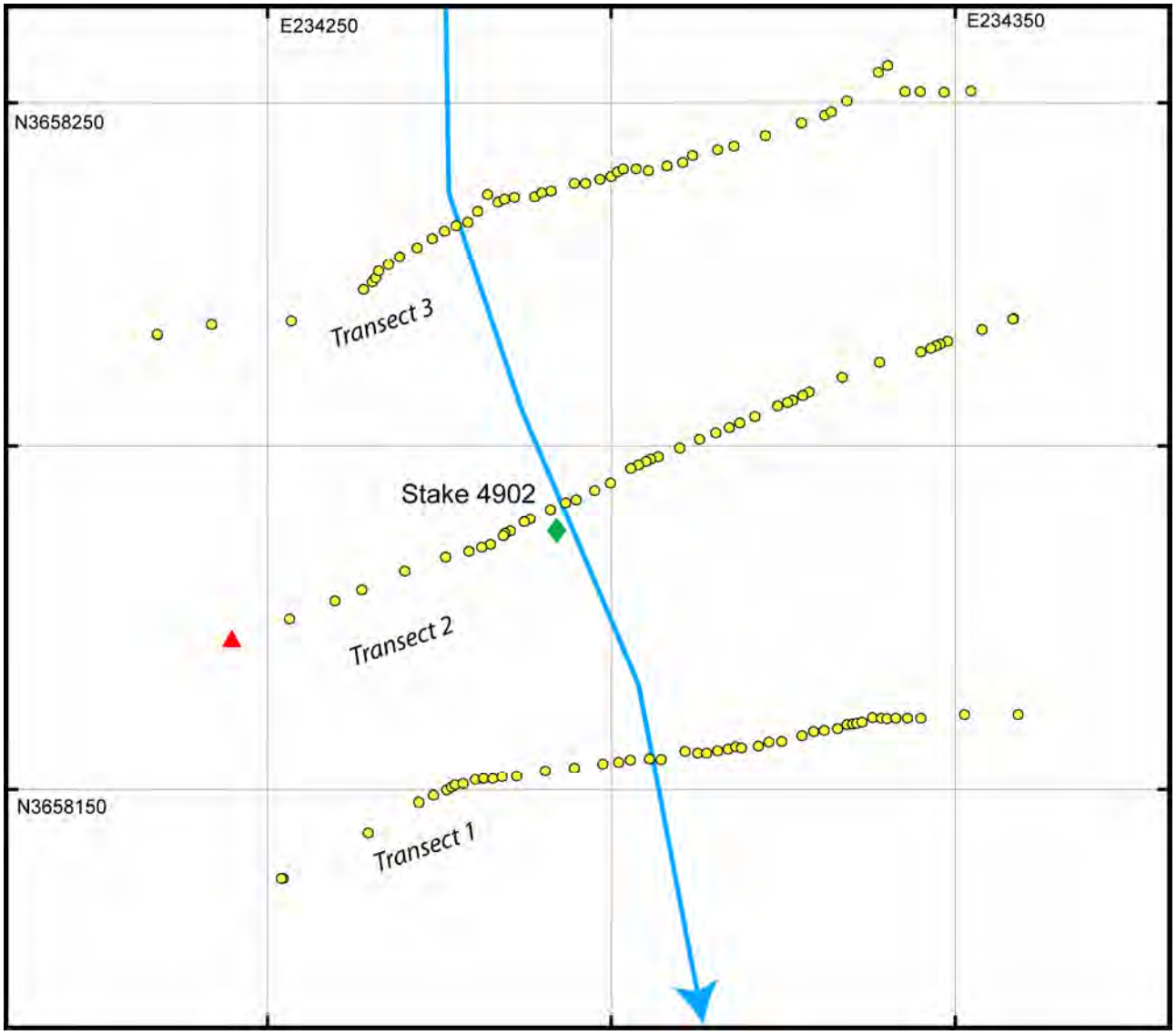

Figure 17. Map showing site DS3 and the location of the monitoring photograph (Stake 4902, marked by green diamond) and monitoring cross section. The red triangle indicates the instrument station. Yellow circles indicate the cross-section data points collected in February 2007 (data collected for June 2006 is not included). The channel location and flow direction is indicated by the blue arrow.

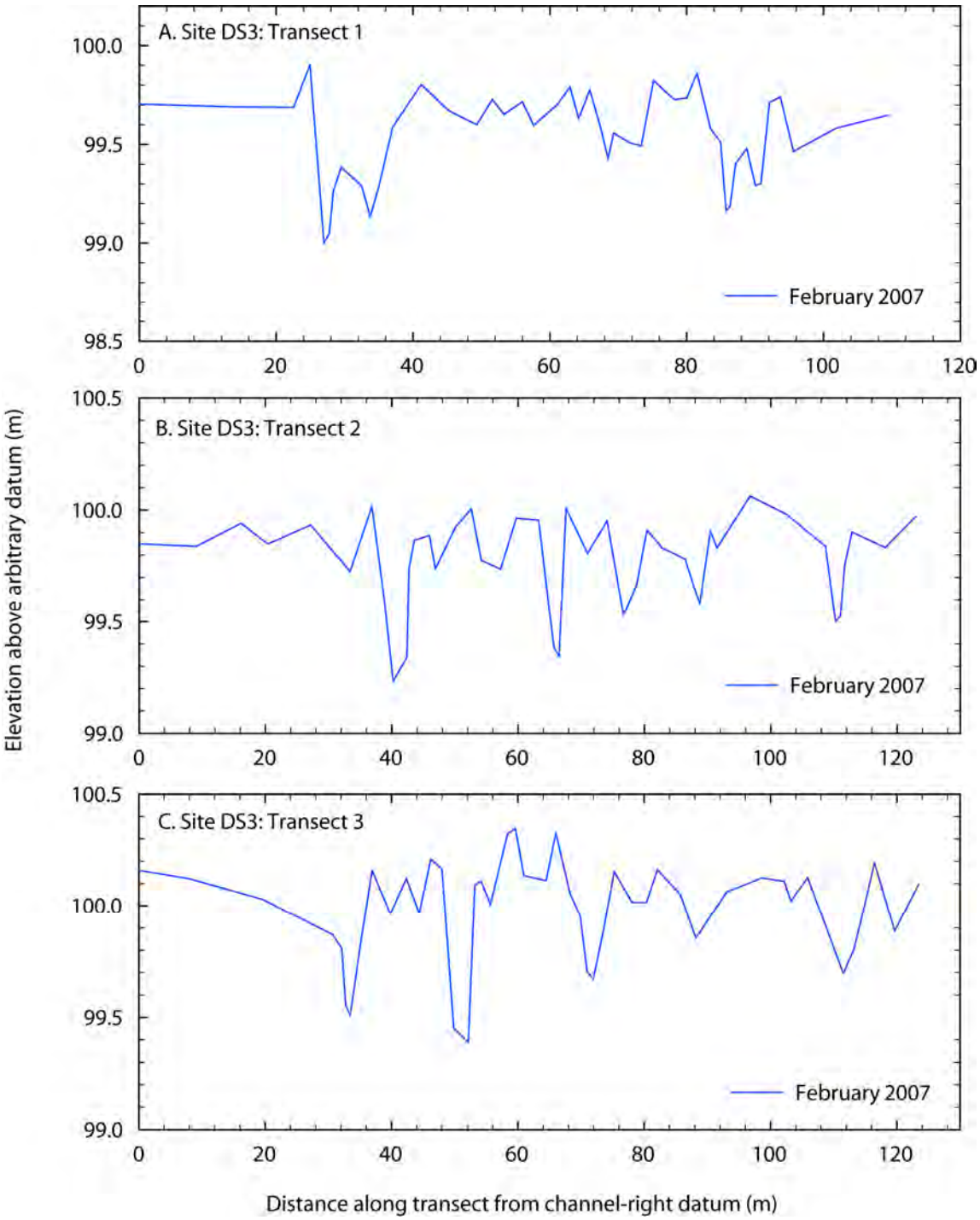

Figure 18. Graph showing channel cross sections at site DS3, looking upstream, measured in January 2007.

A.

B.

Figure 19. Photographs showing burned site DS3 on the Yuma Proving Grounds – Kofa National Wildlife Refuge boundary. A. June 27, 2006. B. January 31, 2007 (Stake 4901a). The view is north. The plants that were burned are *Larrea tridentata* and *Lycium andersonii* (foreground) and *Cercidium microphyllum* (background).

A.

B.

Figure 20. Photographs showing burned site DS3 on the Yuma Proving Grounds – Kofa National Wildlife Refuge boundary. A. June 27, 2006. B. January 31, 2007 (Stake 4901b). The view is south. The plants that were burned are *Larrea tridentata* and *Lycium andersonii* (background) and *Cercidium microphyllum* (foreground).

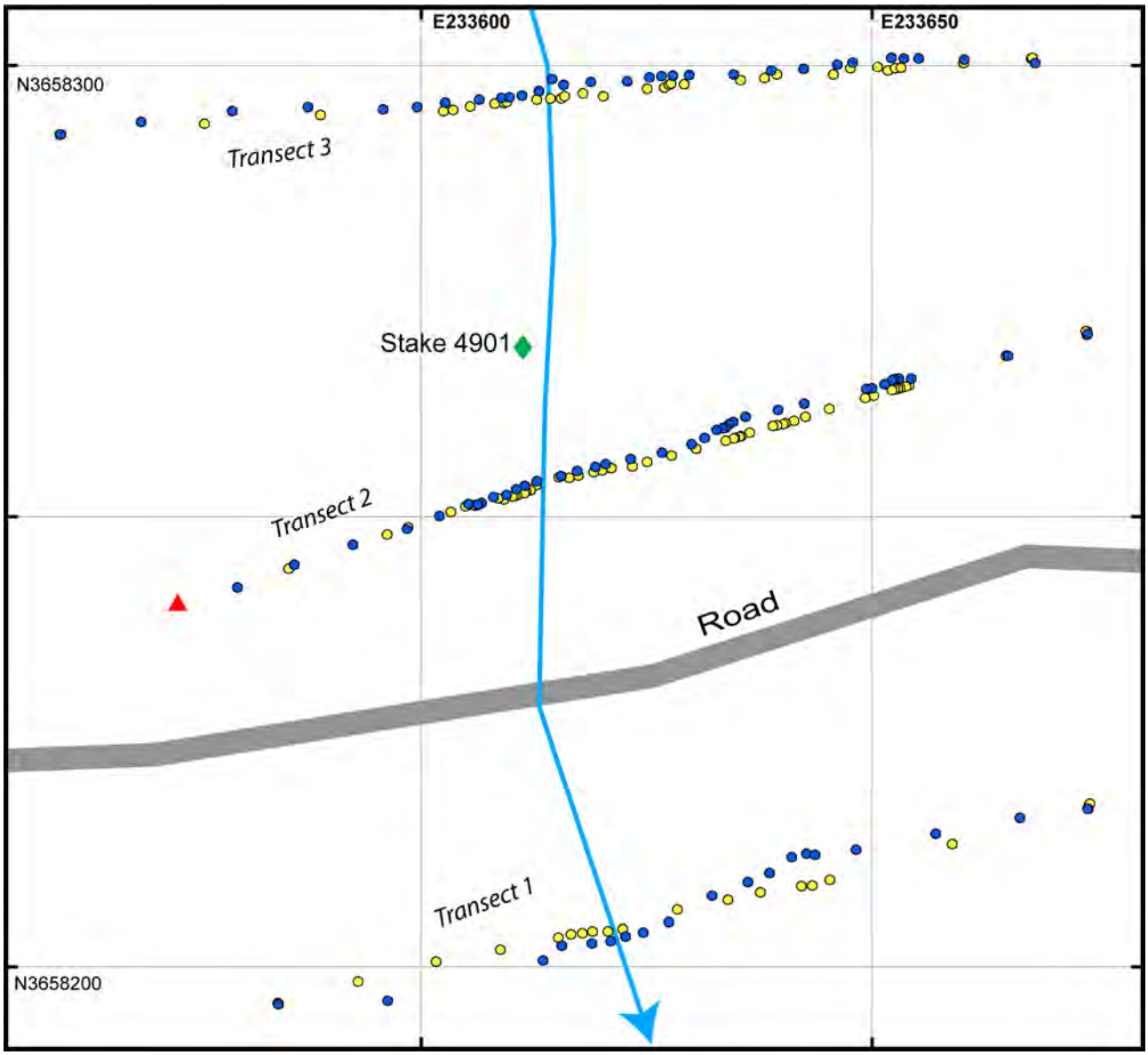

Figure 21. Map showing site DS4 and the location of the monitoring photograph (Stake 4901, marked by green diamond) and monitoring cross section. The red triangle indicates the instrument station. Circles indicate the cross-section data points collected, light yellow for June 2006 and dark blue for February 2007. The channel location and flow direction is indicated by the blue arrow.

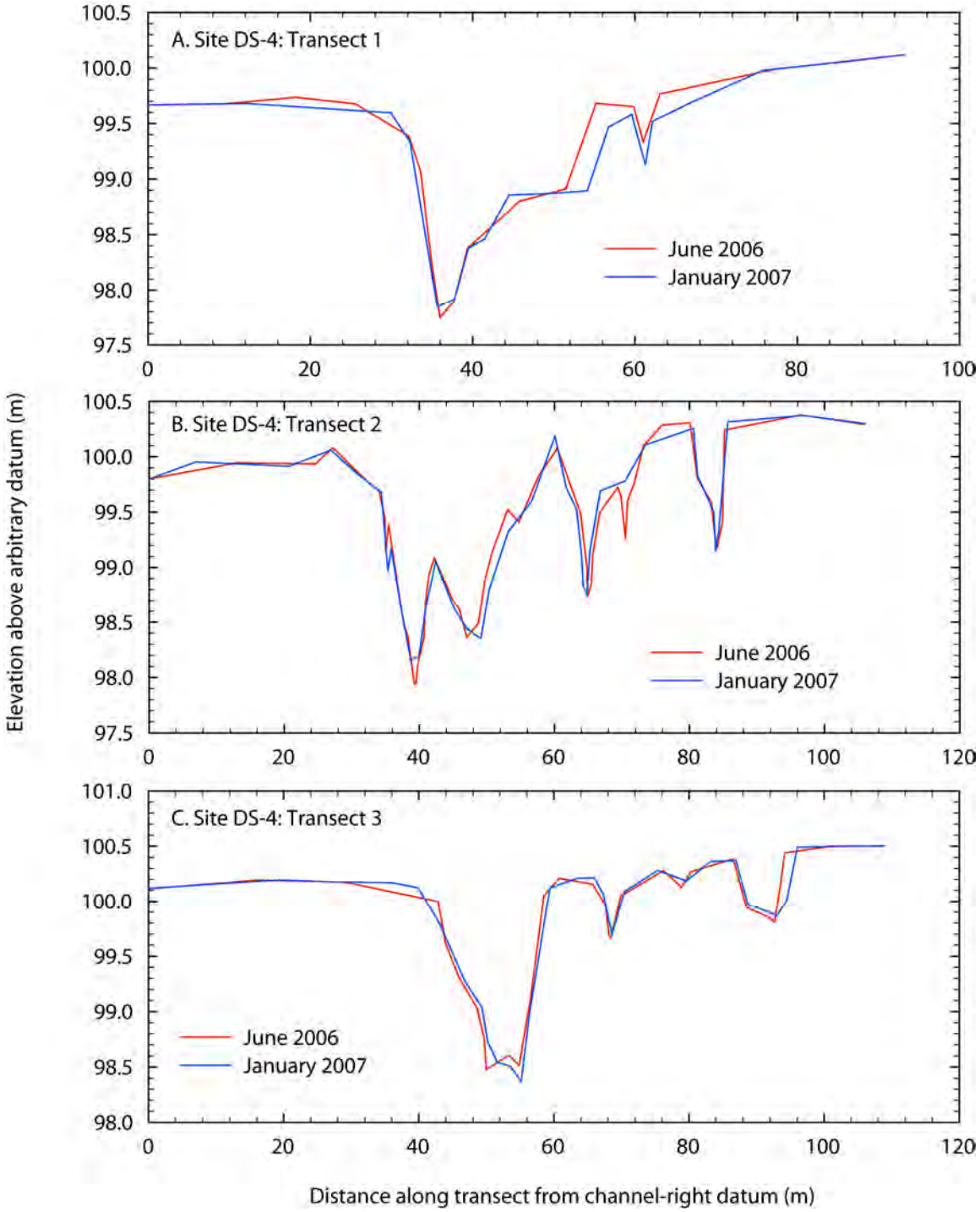

Figure 22. Graph showing channel cross sections at site DS4, measured in June 2006 and January 2007.

A.

B.

Figure 23. Photographs showing burned site DS4 on the Yuma Proving Grounds – Kofa National Wildlife Refuge boundary. A. June 27, 2006. B. January 31, 2007 (Stake 4902a). The view is north. The plants that were burned are *Cercidium microphyllum* and *Olneya tesota* (foreground).

A.

B.

Figure 24. Photographs showing burned site DS4 on the Yuma Proving Grounds – Kofa National Wildlife Refuge boundary. A. June 27, 2006. B. January 31, 2007 (Stake 4902b). The view is south. The plants that were burned are *Larrea tridentata* and *Lycium andersonii* (foreground) and *Cercidium microphyllum* and *Olneya tesota* (background).

A.

B.

Figure 25. Photographs showing burned site US2 on the Kofa National Wildlife Refuge in King Valley (for location, see fig. 1). A. June 28, 2006. B. February 1, 2007 (Stake 4905a). The view is south-southeast. The plants in the view are *Larrea tridentata, Ambrosia dumosa,* and *Encelia farinosa* (foreground) and *Cercidium microphyllum* and *Olneya tesota* (background).

A.

B.

Figure 26. Photographs showing burned site US2 on the Kofa National Wildlife Refuge in King Valley (for location, see fig. 1). A. June 28, 2006. B. February 1, 2007 (Stake 4905b). The view is north. The plants in the view are *Larrea tridentata* and *Lycium andersonii* (foreground) and *Cercidium microphyllum* and *Olneya tesota* (background).

Unburned Sites

Table 3. Metadata for unburned monitoring sites in King Valley.

Site	North Latitude[1] (degrees)	West Longitude[1] (degrees)	Elevation (m)	Surveyed Cross-sections	Photographic Stake Number	First Survey	Second Survey
US1	33.108413	113.812432	279	3	4904	06/28/06	02/01/07
US3	33.126805	113.958428	305	3	4908, 4909	06/28/06	02/01/07
US4	33.122130	113.958690	305	3	4906, 4907	06/28/06	02/01/07

[1] Geographic coordinates given are for the location of the first photographic station at each site.

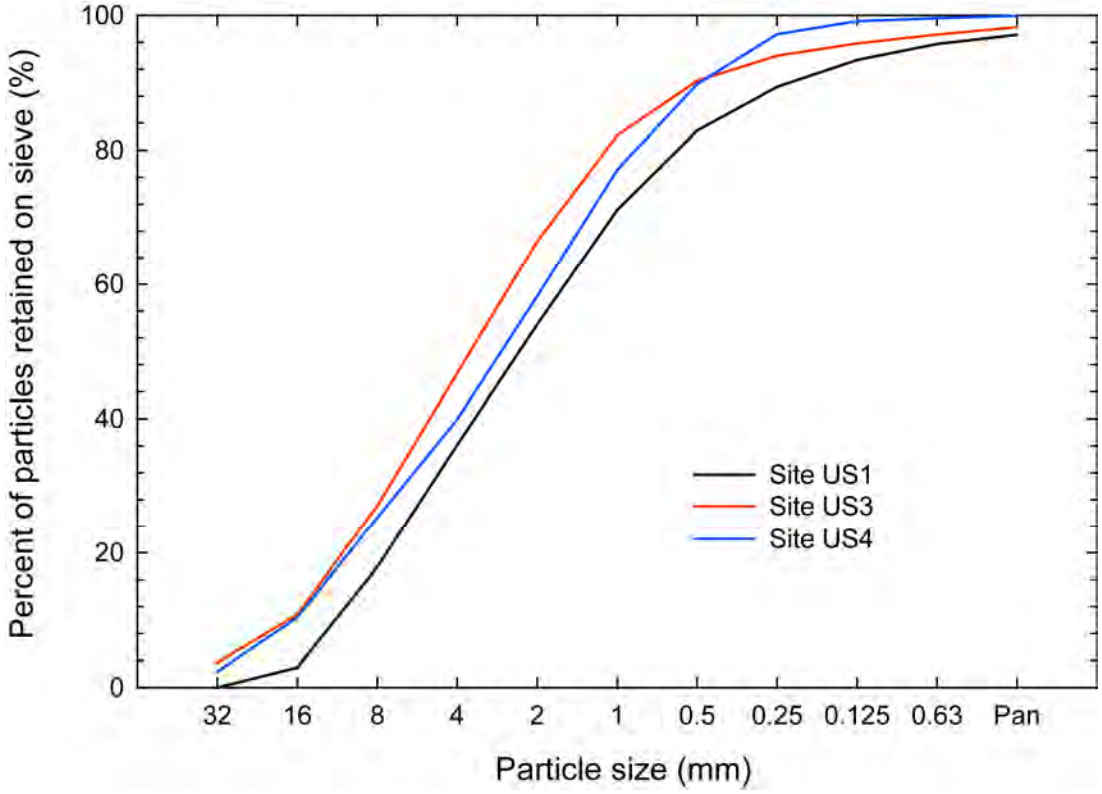

Figure 27. Graph showing particle-size distributions for channel sediments in unburned parts of King Valley.

Table 4. Metadata for photographs of unburned monitoring sites in King Valley.

Site	Latitude (degrees)	Longitude (degrees)	Elevation (m)	Stake Number	Photographer	Camera Height (m)	View Direction	Date-Time of Original	Date-Time of Match
King Valley unburned site US1	33.10841	113.81243	279	4904a	Boyer	1.20	220	06/28/2006 9:05A	02/01/2007 11:43A
King Valley unburned site US1	33.10841	113.81243	279	4904b	Boyer	1.20	50	06/28/2006 9:17A	02/01/2007 11:56A
King Valley unburned site US3	33.12681	113.95843	305	4908	Boyer	1.17	320	06/28/2006 2:07P	02/01/2007 4:39P
King Valley unburned site US3	33.12687	113.95856	305	4909	Boyer	1.22	115	06/28/2006 2:21P	02/01/2007 4:55P
King Valley unburned site US4	33.12213	113.95869	305	4906	Boyer	1.21	70	06/28/2006 1:06P	02/01/2007 3:50P
King Valley unburned site US4	33.12209	113.95850	305	4907	Boyer	1.17	260	06/28/2006 1:21P	02/01/2007 4:55P

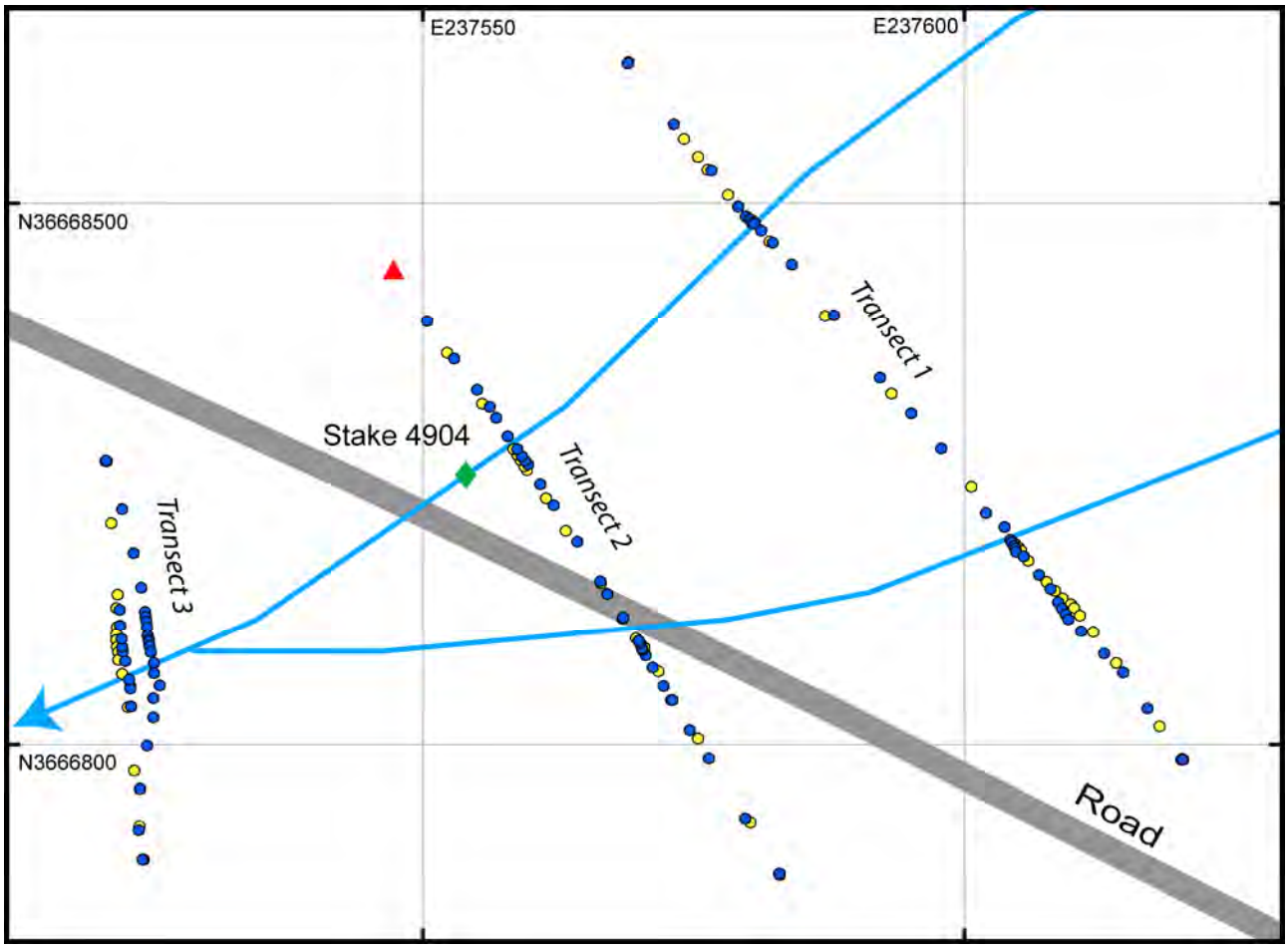

Figure 28. Map showing site US1 and the location of the monitoring photograph (Stake 4904, marked by green diamond) and monitoring cross section. The red triangle indicates the instrument station. Circles indicate the cross-section data points collected, light yellow for June 2006 and dark blue for February 2007. The channel location and flow direction is indicated by the blue arrow.

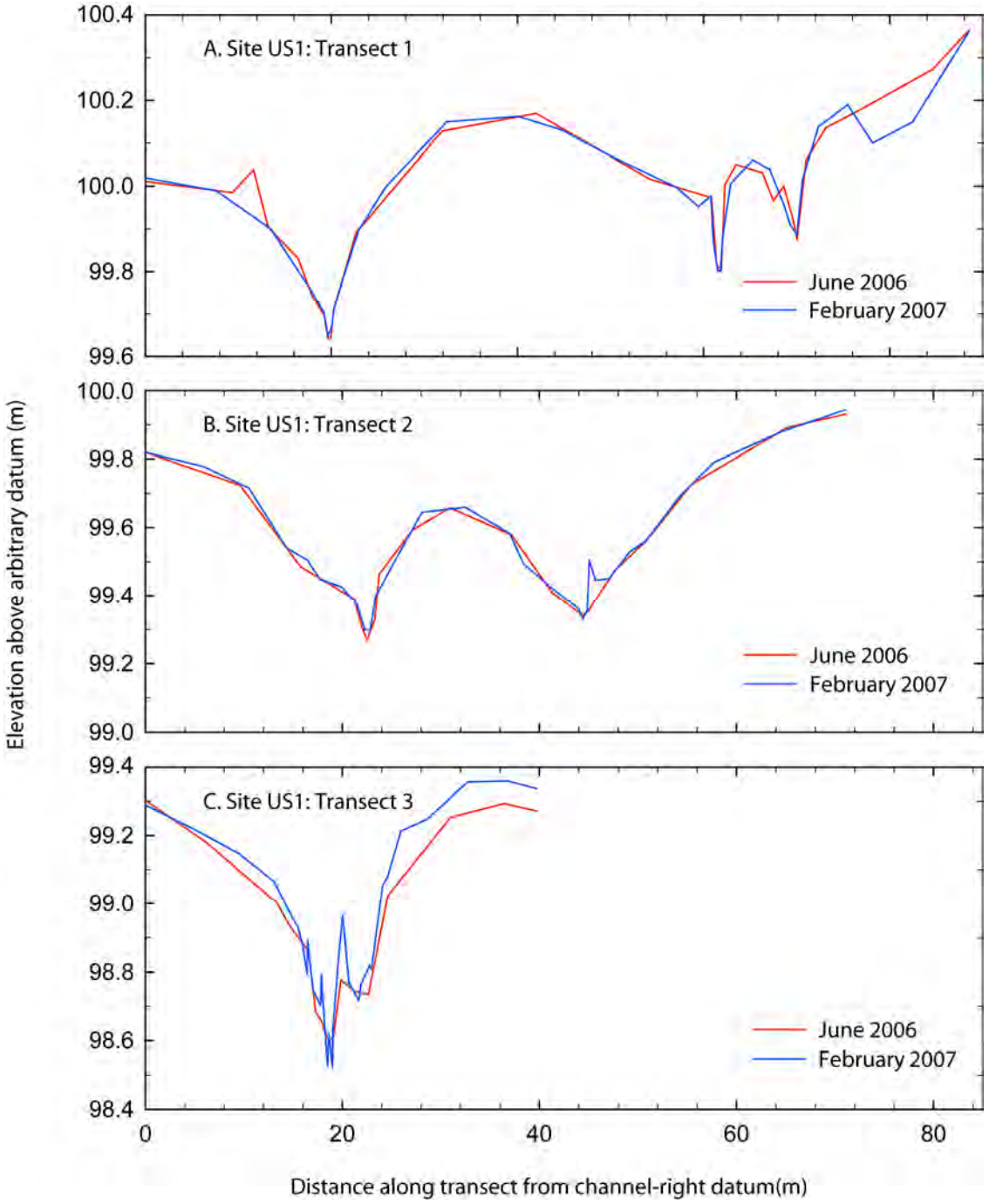

Figure 29. Graph showing channel cross sections at site US1, looking upstream, measured in June 2006 and February 2007.

A.

B.

Figure 30. Photographs showing unburned site US1 on the Kofa National Wildlife Refuge in King Valley. A. June 28, 2006. B. February 1, 2007 (Stake 4904a). The view is southwest. The plants in the view are *Larrea tridentata, Ambrosia dumosa,* and *Encelia farinosa* (foreground) and *Cercidium microphyllum* and *Olneya tesota* (background).

A.

B.

Figure 31. Photographs showing unburned site US1 on the Kofa National Wildlife Refuge in King Valley. A. June 28, 2006. B. February 1, 2007 (Stake 4904b). The view is northeast. The plants in the view are *Larrea tridentata, Ambrosia dumosa,* and *Encelia farinosa* (foreground) and *Cercidium microphyllum* (background).

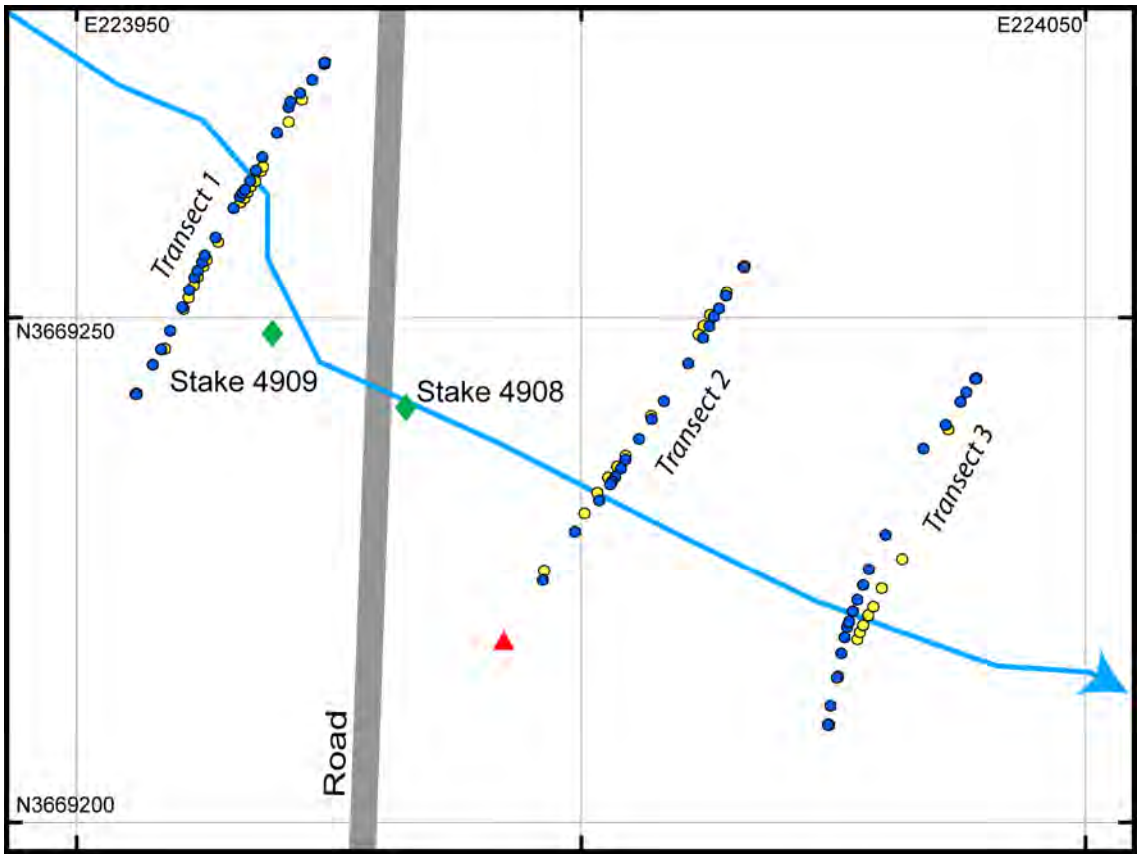

Figure 32. Map showing site US3 and the location of the monitoring photographs (Stake 4908 and 4909, marked by green diamonds) and monitoring cross section. The red triangle indicates the instrument station. Circles indicate the cross-section data points collected, light yellow for June 2006 and dark blue for February 2007. The channel location and flow direction is indicated by the blue arrow.

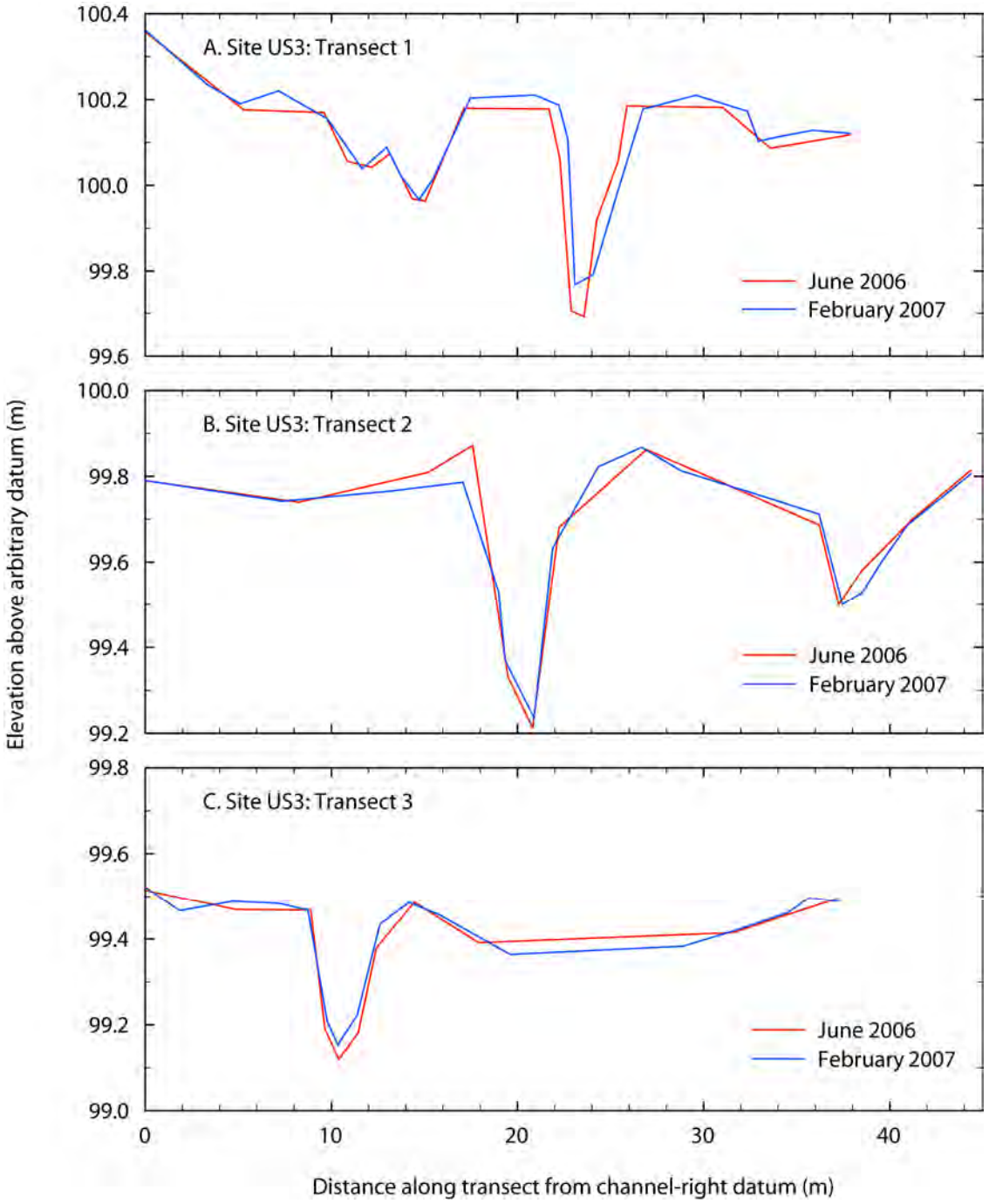

Figure 33. Graph showing channel cross sections at site US3, looking upstream, measured in June 2006 and February 2007.

A.

B.

Figure 34. Photographs showing unburned site US3 on the Kofa National Wildlife Refuge in King Valley. A. June 28, 2006. B. February 1, 2007 (Stake 4908). The view is northwest. The plants in the view are *Larrea tridentata, Ambrosia dumosa,* and *Encelia farinosa* (foreground) and *Cercidium microphyllum* and *Acacia gregii* (background).

A.

B.

Figure 35. Photographs showing unburned site US3 on the Kofa National Wildlife Refuge in King Valley. A. June 28, 2006. B. February 1, 2007 (Stake 4909). The view is southeast. The plants in the view are *Larrea tridentata, Ambrosia dumosa,* and *Encelia farinosa* (foreground) and *Cercidium microphyllum* (background).

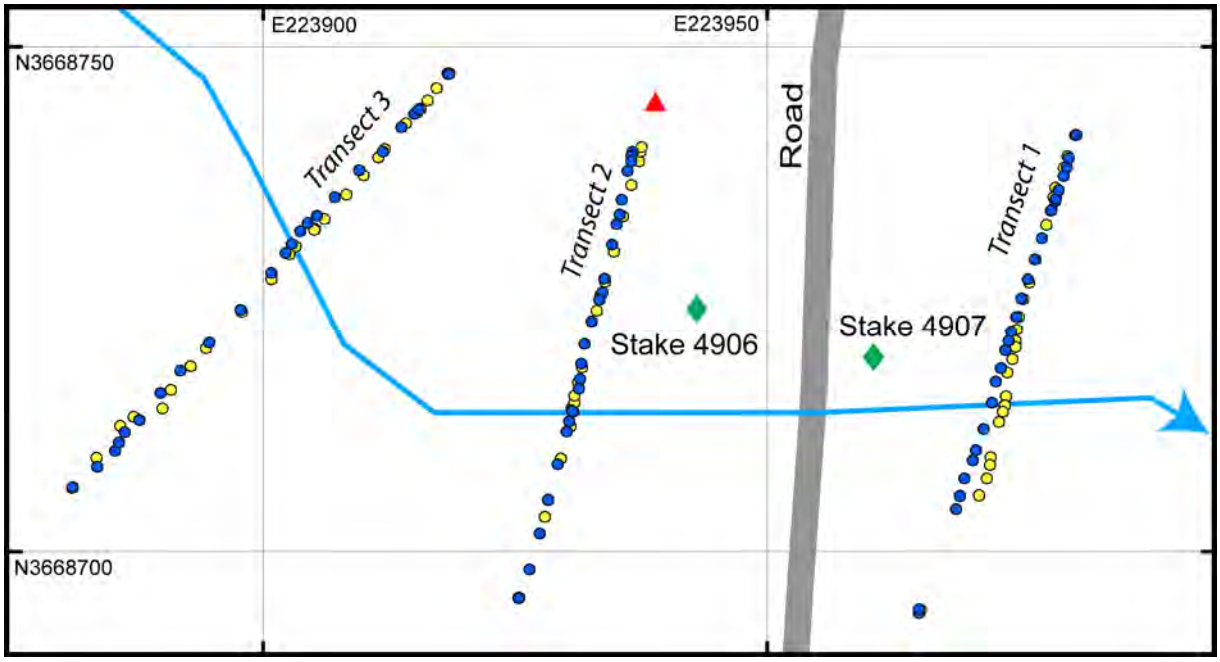

Figure 36. Map showing site US4 and the location of the monitoring photographs (Stakes 4906 and 4907, marked by green diamonds) and monitoring cross section. The red triangle indicates the instrument station. Circles indicate the cross-section data points collected, light yellow for June 2006 and dark blue for February 2007. The channel location and flow direction is indicated by the blue arrow.

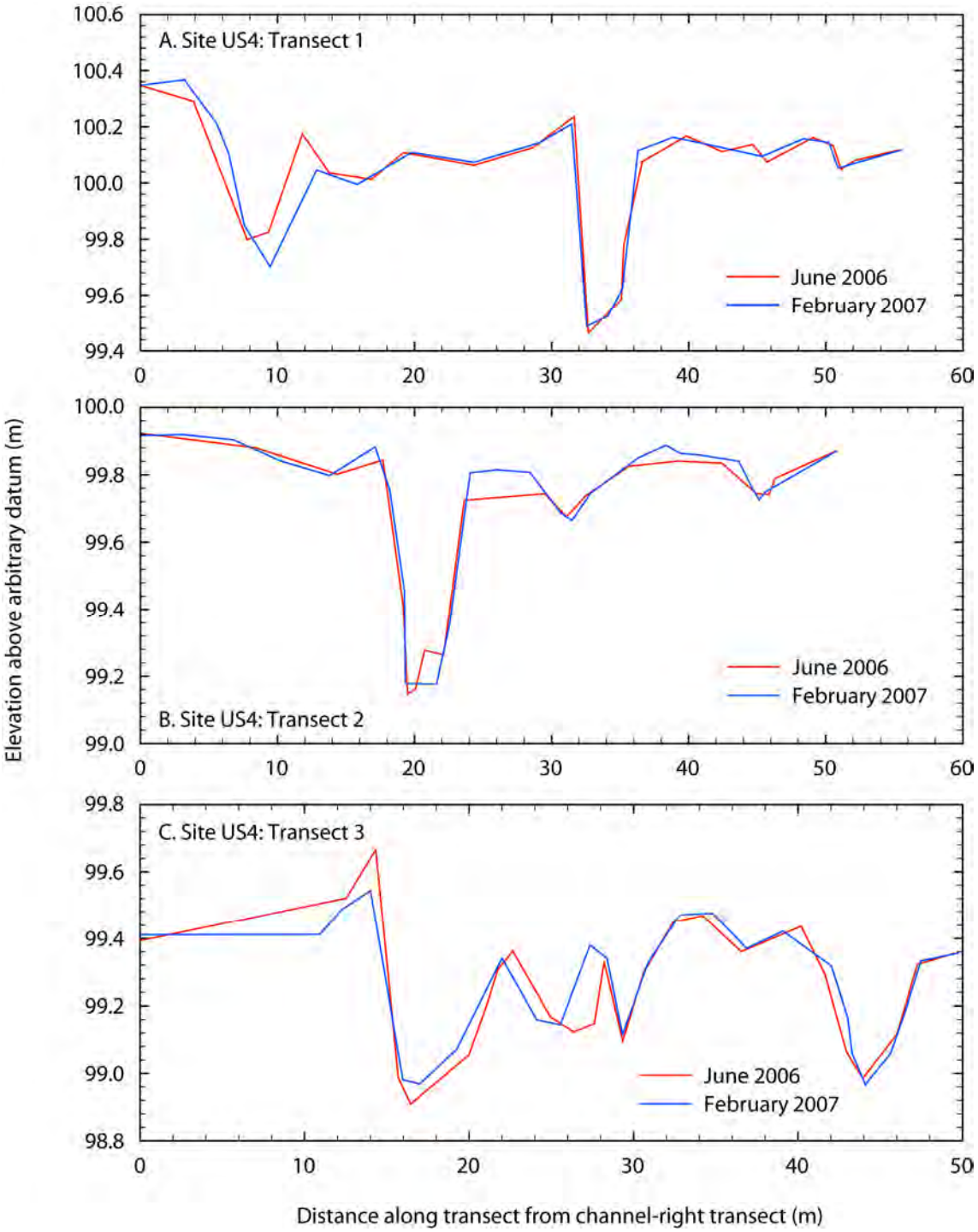

Figure 37. Graph showing channel cross sections at site US4, looking upstream, measured in June 2006 and February 2007.

A.

B.

Figure 38. Photographs showing unburned site US4 on the Kofa National Wildlife Refuge in King Valley. A. June 28, 2006. B. February 1, 2007 (Stake 4906). The view is east-northeast. The plants in the view are *Larrea tridentata* (foreground) and *Cercidium microphyllum* and *Olneya tesota* (background).

A.

B.

Figure 39. Photographs showing unburned site US4 on the Kofa National Wildlife Refuge in King Valley. A. June 28, 2006. B. February 1, 2007 (Stake 4907). The view is west-southwest. The plants in the view are *Larrea tridentata* and *Lycium andersonii* (foreground) and *Cercidium microphyllum* and *Olneya tesota* (background).