Woody Riparian Vegetation near Selected Streamgages in the Western United States

Data Series 708

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

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Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
meter (m)	1.094	yard (yd)
	Area	
square meter (m^2)	0.0002471	acre
square kilometer (km^2)	247.1	acre
square meter (m^2)	10.76	square foot (ft^2)
square kilometer (km^2)	0.3861	square mile (mi^2)

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By Gregor T. Auble,[1] Jonathan M. Friedman,[1] Patrick B. Shafroth,[1] Michael F. Merigliano,[2] and Michael L. Scott[1]

Abstract

We visited and recorded occupancy and areal cover of woody riparian species near 456 streamgages in the western United States during the growing seasons of 1996–2002. We made concomitant estimates of grazing intensity, channel stabilization and incision, gradient, sediment particle size, and nearby planting of Russian olive. The purpose of this publication is to describe the data set and make it available to other investigators in an electronic format.

Introduction

Much of the understanding of relationships between streamflow and riparian vegetation comes from observations of spatial and temporal patterns at one site, or from a relatively small set of sites in a restricted geographic area. Applying the results of these studies of restricted areas to new locations and properly generalizing the determinants of broad patterns can be challenging. One approach to identifying general patterns is to examine spatially extensive data sets of riparian vegetation with species-level resolution, consistent methods, and concomitant long-term hydrologic records; however, these data sets are rare. In order to develop this kind of data set we visited and recorded riparian vegetation associated with over 450 U.S. Geological Survey (USGS) streamgages across 17 states in the western United States. The purpose of this publication is to describe the data set and make it available to other investigators in an electronic format.

File Structures and Variable Definitions

Data are organized in six separate, comma delimited files (*.csv) with a header line containing variable names (table 1). These are archived with this report in downloadable, electronic form; however, merging and reshaping the data will likely be required for analysis. There are two fields common to multiple files. GAGE is the USGS streamgage identification number linked to USGS streamflow records (U.S. Geological Survey 2012). SPPCODE represents the taxonomic units and cover types that we recognized. We recorded cover and occupancy only for entries on this pre-defined list (table 2). The list does, however, define a mixed set of individual valid species, conflations or pooling of valid species, separate age classes for selected single valid species, and placeholders for conditions such as no species present or excluded areas such as roads and cropland.

Naturally occurring woody species >1.5 m tall that were not included in the standard list were pooled into the class of Other Large Woody (SPPCODE = OLW, table 2). In general, nomenclature follows U.S. Department of Agriculture (USDA), 2004. There were several conflations of species that were difficult to distinguish in the field. The largest groups were *Prunus* spp. (SPPCODE = PRUSPE, table 2) representing all plums and cherries and *Salix* spp. (SPPCODE = SALSPP, table 2) representing all willow except for the recognized *Salix amygdaloides*, *Salix bonplandiana*, *Salix exigua* (itself a conflation of several species), *Salix gooddingi*, and *Salix* x *rubens*. We distinguished only two types of *Tamarix*: *Tamarix aphylla* and *Tamarix ramosissima* with *T. ramosissima* including *T. chinensis* and hybrids. Cottonwood species (*Populus angustifolia*, *P. deltoides* ssp. *monolifera*, and *P. deltoides* ssp. *wislizeni*) were each subdivided into estimated age classes of ≤ 30 years and >30 years for both cover and occupancy. Age was estimated based on bark characteristics and size. These classes must be combined to calculate overall site cover or occupancy for the respective species.

Methods

Sites

This data set is based on site visits to 456 streamgages carried out during the growing seasons of 1996–2002 (fig. 1). We selected USGS streamgages within a 17-state region of

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Table 1. Data files and variable definitions. Information in this table is also contained in electronic fileVARIABLESandFILES.pdf.

File	Variable	Values	Description
Occupy.csv			
	GAGE	Gage number	USGS gage number without leading zeros
	SPPCODE	Character species code	Species code as defined in table 1 and file SppList.csv; SPPCODE of NONE indicates no woody species at site
	PRESENT	1	Present; no entries for species not present; 1 for SPPCODE of NONE indicates no woody species at site
Gages.csv			
	GAGE	Gage number	USGS gage number without leading zeros
	RIVER	River name	Character; may include embedded spaces
	LONG	Decimal degrees	Longitude in decimal degrees; from gage description NAD83
	LAT	Decimal degrees	Latitude in decimal degrees; from gage description NAD83
	ALTITUDE	Meters	Altitude; from gage description NGVD29
Indicators.csv			
	GAGE	Gage number	USGS gage number without leading zeros
	YYYY	Year	Year sampled
	MM	Month	Month (1–12) sampled
	LSTABLE	Decimal fraction	Fraction of left bank (looking downstream) with anthropogenic bank stabilization
	RSTABLE	Decimal fraction	Fraction of right bank (looking downstream) with anthropogenic bank stabilization
	FPSED	D_{50} in millimeters	Estimate of floodplain sediment size class, value of 99999 is bedrock
	GZHERB	Classification of 1-4	Classification of current herbaceous grazing indicators
		1	Seed heads of cool and warm season grass species intact
		2	Seed heads of cool season grasses present but scattered-visible feces less than 1 year old
		3	Most herbaceous species obviously grazed-but stubble heights obscure the ground
		4	All herbaceous species are grazed so close to the ground that feces become very prominent
	GZSHRUB	Classification of 1–2	Classification of current shrub grazing indicators
		1	Existing shrubs intact
		2	Existing shrubs show some recent use, leaves stripped off; some young twigs clipped
	GZPAST	Classification of 1–4	Classification of past use grazing indicators
		1	Shrubs show little to no browsing; Regeneration present on suitable sites
		2	Shrubs, especially those known to be palatable, show browse patterns; Shrub and tree regeneration present; Weedy annual or biennial species typically prominent
		3	Shrubs widely scattered, crowns reduced and shaped by browsing (flat-topped or umbrella-shaped); Weedy annual or biennial species typically present but may not be noticeable due to grazing
		4	Few to no shrubs where expected; other indicators of long and high grazing use present such as: Animal trails well-defined and shade-up areas have trampled appearance and bare soil; Bank trampling is well-distributed and not restricted to local areas; All herbaceous species are grazed so close to the ground that feces become very prominent; If winter-grazed, known invader and increaser species are prominent

Table 1. Data files and variable definitions. Information in this table is also contained in electronic file VARIABLESandFILES.pdf.—Continued

File	Variable	Values	Description
	EPLANT	1=Yes; 0=No	Was planted ELEANG observed within 5 km of site
	TPLANT	1=Yes; 0=No	Was planted TAMRAM observed within 5 km of site
	SALT	1=Yes; 0=No	Were indicators of high salinity observed; salt crusts or halophytes other than TAMRAM
	DOWN	1=Yes; 0=No	Has there been notable and obvious downcutting or channel narrowing in the last 150 years
Geometry.csv			
	GAGE	Gage number	USGS gage number without leading zeros
	SITEAREA	km^2	Total mapped study area
	CHANAREA	km^2	River channel area in mapped study area
	CHANLEN	km	Length of river channel in mapped study area
	VALLEN	km	Length of valley corresponding to mapped study area
	GRADFRAC	decimal fraction	River gradient as decimal fraction representing change in altitude/river length
	GRADCODE	Classification of 1-4	
		1	Normal estimation using topographic maps of larger area
		2	Estimation limited to mapped study site area
		3	Estimate is a maximum where gradient was very shallow
		4	zero gradient assigned when study site was actually linear reservoir section
CoverArea.csv			
	GAGE	Gage number	USGS gage number without leading zeros
	POLYNO	Polygon ID number	Polygon identification number
	POLYAREA	km^2	Polygon area; same for all SPPCODE rows for a given POLYNO
	SPPCODE	Character species code	Species code as defined in table 1; some codes are placeholders for excluded area or no species present
	COVER	Percent (1-100)	Percent cover of SPPCODE species; values are 1–100; species with covers of less than 1 percent in any polygon may occur in Occupy file but not in cover file; Total cover can exceed a total of 100 summed over all species in polygon
SppList.csv			
	SPPCODE	Character species code	Species code as defined in table 1; some codes are placeholders for excluded area or no species present
	TYPE	Classification of 1-5	
		1	Valid species
		2	Age class of single valid species
		3	Conflation of 2 or more valid species
		4	Species not on species list; OLW for Other Large Woody
		5	Other type: channel; bare ground; excluded polygon; no species
	SCINAME	Character species name	Species name and authority; no italics; Some entries are placeholders not species
	NOTES	Character	Common name and notes if any

Table 2. Codes used for vegetation species and cover mapping classes. This table is the contents of electronic file SppList.csv. Nomenclature follows USDA (2004).

[SPPCODE is acronym used for classes of vegetation and cover type. Values of TYPE are: 1=Valid species; 2=Age class of single valid species; 3=Conflation of two or more valid species; 4=Species not on species list and thus included as other large woody; 5=Other cover type, including channel, excluded polygon, bare or no woody species present. NOTES contains common name of species and clarifying text]

SPPCODE	TYPE	SCINAME	NOTES
ABICON	1	*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.	White fir
ABILAS	1	*Abies lasiocarpa* (Hook.) Nutt.	Subalpine fir
ACENEG	1	*Acer negundo* L.	Box elder
ALNINC	1	*Alnus incana* (L.) Moench	Gray alder; includes ssp. *rugosa* (Du Roi) Clausen and ssp. *tenuifolia* (Nutt.) Breitung
ALNOBL	1	*Alnus oblongifolia* Torr.	Arizona alder
ALNSIN	3	*Alnus viridis* (Vill.) Lam. & DC.	Green alder; includes *Alnus sinuata* (Regel) Rydb.
ARTTRI	1	*Artemisia tridentata* Nutt.	Big sagebrush
ATRCAN	1	*Atriplex canescens* (Pursh) Nutt.	Four-winged saltbush
B	5	bare; no woody species present	Pertains to either polygon or site as a whole depending on context
BACSAL	3	*Baccharis salicifolia* (Ruiz & Pavón) Pers.	Seep willow; includes *B. glutinosa* Pers. and *B. viminea* DC. but not *B. salicina* Torr. & Gray
BETOCC	1	*Betula occidentalis* Hook.	Water birch
C	5	channel polygon (polygon data only)	Same polygon number may include cover of actual species in some cases
CELOCC	1	*Celtis occidentalis* L.	Common hackberry
CELRET	1	*Celtis laevigata* Willd. var. *reticulata* (Torr.) L. Benson	Netleaf hackberry
CORSTO	1	*Cornus sericea* L.	Redosier dogwood; formerly *C. stolonifera*
E	5	excluded polygon (polygon data only)	Road; house; bridge; agricultural field; etc
ELAANG	1	*Elaeagnus angustifolia* L.	Russian-olive
ELACOM	1	*Elaeagnus commutata* Bernh. ex Rydb.	Silverberry
FORNEO	1	*Forestiera pubescens* Nutt. var. *pubescens*	New Mexico olive; synonymous with *F. neomexicana* Gray
FRAPEN	1	*Fraxinus pennsylvanica* Marsh.	Green ash
FRAVEL	1	*Fraxinus velutina* Torr.	Velvet ash
HYMMON	1	*Hymenoclea monogyra* Torr. & Gray ex Gray	Burrobrush
JUGMAJ	1	*Juglans microcarpa* Berl. and *J. major* (Torr.) Heller	Walnut
OLW	4	Other Large Woody spp. (> 1.5 m tall)	
PICSPE	1	*Picea* A. Dietr. spp.	Spruce
PINPON	1	*Pinus ponderosa* P. & C. Lawson	Ponderosa pine
PLAWRI	1	*Platanus wrightii* S. Wats.	Arizona sycamore; *P. racemosa* and *P. occidentalis* are OLW
POPANG1	2	*Populus angustifolia* James and hybrids <30 y old	Narrowleaf cottonwood
POPANG2	2	*Populus angustifolia* James and hybrids >30 y old	
POPDEL1	2	*Populus deltoides* Bartr. ex Marsh. ssp. *monilifera* (Ait.) Eckenwalder <30 y old	Plains cottonwood
POPDEL2	2	*Populus deltoides* Bartr. ex Marsh. ssp. *monilifera* (Ait.) Eckenwalder >30 y old	
POPFRE1	2	*Populus deltoides* Bartr. ex Marsh. ssp. *wislizeni* (S. Wats.) Eckenwalder <30 y old	Fremont cottonwood; formerly *P. fremontii*

Table 2. Codes used for vegetation species and cover mapping classes. This table is the contents of electronic file SppList.csv. Nomenclature follows USDA (2004).—Continued

[SPPCODE is acronym used for classes of vegetation and cover type. Values of TYPE are: 1=Valid species; 2=Age class of single valid species; 3=Conflation of two or more valid species; 4=Species not on species list and thus included as other large woody; 5=Other cover type, including channel, excluded polygon, bare or no woody species present. NOTES contains common name of species and clarifying text]

SPPCODE	TYPE	SCINAME	NOTES
POPFRE2	2	*Populus deltoides* Bartr. ex Marsh. ssp. *wislizeni* (S. Wats.) Eckenwalder >30 y old	
POPTRE	1	*Populus tremuloides* Michx.	Aspen
POPTRI1	2	*Populus balsamifera* L.< 30 y old	Balsam poplar; includes ssp. *balsamifera* and ssp. *trichocarpa* (Torr. & Gray ex Hook.) Brayshaw
POPTRI2	2	*Populus balsamifera* L.> 30 y old	
PROVEL	3	*Prosopis glandulosa* Torr. and *P. velutina* Woot.	Honey and velvet mesquite; *P. pubescens* is OLW
PRUSPE	3	*Prunus* L. spp.	Plums and cherries
PSEMEN	1	*Pseudotsuga menziesii* (Mirbel) Franco	Douglas fir
QUEGAM	1	*Quercus gambelii* Nutt.	Gambel oak
QUEMAC	1	*Quercus macrocarpa* Michx.	Bur oak
RHUTRI	3	*Rhus trilobata* Nutt. and *R. aromatica* Ait.	Skunkbrush
ROBNEO	1	*Robinia neomexicana* Gray	New Mexico locust
SALAMY	1	*Salix amygdaloide*s Anderss.	Peachleaf willow
SALBON	1	*Salix bonplandiana* Kunth	Bonpland willow
SALEXI	3	*Salix exigua* group (*S. exigua* Nutt.; *S. interior* Rowlee; *S. melanopsis* Nutt.; and *S. sessilifolia* Nutt.)	Sandbar willow
SALGOO	3	*Salix gooddingii* Ball and *S. nigra* Marsh.	Goodding's willow and black willow
SALRUB	1	*Salix* × *rubens* Schrank (pro sp.) [*alba* × *fragilis*]	Hybrid crack willow
SALSPP	3	*Salix* L. other (all *Salix* not listed above)	Willow other
SHEARG	1	*Shepherdia argentea* (Pursh) Nutt.	Buffaloberry
TAMAPH	1	*Tamarix aphylla* (L.) Karst.	Athel
TAMSPP	3	*Tamarix ramosissima* Ledeb.; *T. chinensis* Lour.; and their hybrids	Saltcedar
TESSER	1	*Pluchea sericea* (Nutt.) Coville	Arrow weed; formerly *Tessaria sericea*
THUPLI	1	*Thuja plicata* Donn ex D. Don	Western red cedar
ULMAME	1	*Ulmus americana* L.	American elm

the United States bounded on the east by the 100° W longitude line (the 100th meridian west), and on the west by the approximate crest of the Sierra Cascade Mountains. We further restricted the potential gages to those with daily discharge data for at least 20 of the years between 1965 and 1994. This set contained approximately 1,500 streamgages from which we carried out a weighted random selection of 500.

Streamgage locations are not randomly distributed across the landscape or within a river network. For example, they tend to be located to measure sources of water supply (for example, rivers draining mountains with snowpack in the western U.S.); to evaluate water management (for example, near reservoirs and diversions); and where rivers cross jurisdictional boundaries (for example, into or out of Canada). At a more local scale, specific gage locations tend to emphasize access (for example, bridges) and stable, well-behaved stage-discharge relationships (for example, at hydraulic controls). To counter the spatial clustering of gages, we constructed a Thessien polygon coverage attributing each gage by the area of landscape that was closer to it than to any other gage. We used these areas as weights in a random selection in which the probability of a gage being selected was proportional to the area of landscape closest to the gage—bigger areas associated with sparse gages having higher probabilities of selection. The set of 500 selected gages was further reduced to 476 that we actually visited based on access and the easily identified lack of a semi-natural site that could be associated with the gage. Finally, the 476 gages we visited were reduced to 456 included in this data set by dropping sites with substantial missing data (primarily in the daily hydrologic record), where we couldn't reasonably estimate the 30-year flood plain, or where no site could be found that represented a semi-natural vegetation response to the streamflow measured at the gage (for example, because of the arrangement of diversions or tributaries, or essentially complete urban or agricultural land use in the bottomland).

At the scale of a specific site, the goal was to select a location that fairly represented the naturally established vegetation near the gage, rather than sampling exactly at the gage itself in order to avoid spanning the type of breakpoints (for example, hydraulic control, canyon mouth) where gages are often located. We were striving to map flood plain associated with 0.5–3 km of stream with the length roughly proportional to the flood plain width. Sites in the data set had a median mapped river length of 1.2 km; a range of 0.14–6.4 km; and first and third quartiles of 0.9 and 1.8 km, respectively.

Mapping and Vegetation

All sites were visited during the growing seasons of 1996–2002 by one or more of a core team of six people (the authors and Michael D. Freehing, University of New Mexico). We trained together on multiple sites to increase consistency. At each site, we drew a map of the area estimated to have been inundated within the last 30 years (referred to as "flood plain") on an acetate overlay of a hard-copy aerial photograph. In cases where portions of the flood plain had been cleared of naturally established vegetation or isolated by levees or fill, we included these portions within the flood plain and then mapped them as excluded, anthropogenic polygons (SPPCODE = E, table 2). Where there had been an apparent reduction in flood plain width (resulting from arroyo cutting or flow regulation) within the last 150 years, we mapped the boundary of the flood plain before this reduction. The mapped flood plain generally contained all naturally established cottonwood at the site, but not all individuals of those woody species commonly occurring in both the flood plain and surrounding uplands (for example, green ash in central Kansas, or Englemann spruce in the Colorado mountains).

Within this mapped area we then defined a channel (SPPCODE = C, table 2) polygon representing the active channel following Hedman and Osterkamp (1982), delineated by the lowest extent of established (> 1-year old) perennial vegetation, and in some cases by an abrupt decrease in slope with increasing height away from the thalweg. Channel polygons did not contain cover of any woody species. The active channel was generally wider than the width of water in the channel in the aerial photograph or on the ground at the time of sampling. In cases where the active channel was too narrow to draw as a polygon we drew a single line along the channel, recorded the average active channel width on the data sheet, and later constructed a polygon by a geospatial buffering operation.

We divided the remainder of the flood plain area into polygons of relatively homogenous woody composition and attributed them with the percent cover of each of the taxonomic categories in the defined species list (table 2) including a category of Other Large Woody for naturally occurring woody species > 1.5 m tall that were not on the pre-defined species list (SPPCODE = OLW, table 2). Only cover values of greater than 1 percent were recorded. Polygons not containing woody species with cover greater than 1 percent were coded bare (SPPCODE = B, table 2). Total cover within a polygon (summed across all species in the polygon) could exceed 100 percent when there were overlapping layers of different species. Subsequent geospatial analysis quantified the area for each polygon supporting aggregations such as total percent cover by species for the site as a whole, for the non-channel portion of the site, and fraction of total woody cover for each species. Occupancy was recorded for all species listed in table 2 even if they did not exceed the 1 percent cover value that was necessary for inclusion in any polygon

Independent Variables

We also estimated several indicators of possible independent variables in the field. The fraction of the bank that was stabilized (for example, riprap or dikes) was estimated for each side of the river. We estimated the median sediment size (d_{50}) for the surface of the flood plain (the area between

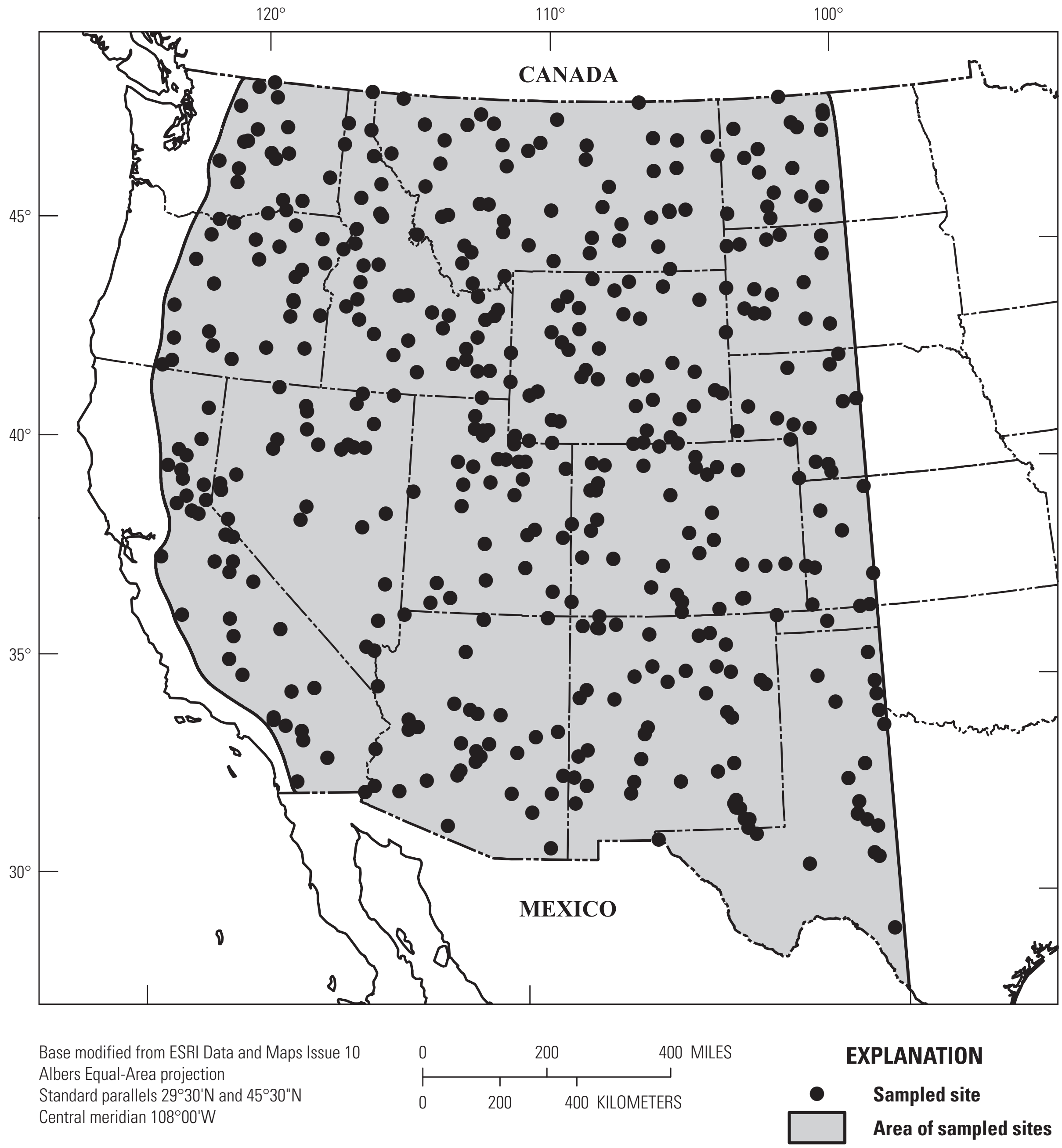

Figure 1. Locations of the 456 sampled sites.

the active channel and flood plain boundary). We recorded the presence of high-salinity indicators on the flood plain such as salt crusts or abundant halophytes—being careful to avoid using any species in table 2, such as saltcedar, as a halophytic indicator species. We recorded observations of planted Russian olive or saltcedar within 5 km of the site, without spending any time searching for them beyond traveling to and from the site.

We assigned categorical indicator values for three aspects of grazing (table 1): herbaceous current use (4 levels), shrub current use (2 levels), and past use (4 levels). Following the field sampling we extracted several geometric measurements for each site using a combination of the digitized overlay, 7.5-minute USGS topographic maps, and the aerial photography. These included length of channel, and valley width and length corresponding to the mapped study site. We also estimated river gradient by applying elevations from topography maps to channel lengths from the mapped study site or a larger section of river containing the mapped study site. Where the gradient was very shallow, generally upstream of a natural or anthropogenic hydraulic control, we either estimated a maximum gradient or assigned a value of 0 gradient.

Summary

We have used this data set to characterize the importance of non-native trees in the current western riparian forests and to characterize the distribution of selected riparian trees with respect to climatic variables (Friedman and others 2005). Parts of the data set have also been used in work focused on individual species (Guilbault and others 2012; Katz and Shafroth 2003; Nagler and others 2010, 2011) and in other distributional studies (Jarnevich and Reynolds 2010, Ringold and others 2008). We continue to examine the data set to evaluate the consistency of hypotheses generated from intensive studies with broad-scale patterns and encourage other investigators to use it for these or other purposes.

Acknowledgments

Tammy S. Fancher (USGS) digitized field maps and performed geospatial analysis. Peggy B. Anderson (Johnson Controls) coordinated logistics and equipment, compiled and proofed field data, and attributed field maps. Michael D. Freehling (University of New Mexico) sampled some of the field sites.

References Cited

Friedman, J.M., Auble, G.T., Shafroth P.B., Scott, M.L., Merigliano M.F., Freehling M.D., and Griffin E.R., 2005, Dominance of non-native riparian trees in western USA: Biological Invasions, v. 7, p. 747–751.

Guilbault, K.R., Brown C.S., Friedman J.M., and Shafroth, P.B., 2012. The influence of chilling requirement on the southern distribution limit of exotic Russian olive (*Elaeagnus angustifolia*) in western North America: Biological Invasions, v. 4, p. 1711-1724.

Hedman, E.R., and Osterkamp W.R., 1982, Streamflow characteristics related to channel geometry of streams in western United States: U.S. Geological Survey Water Supply Paper 2193, 17 p.

Jarnevich, C.S., and Reynolds L.V., 2010, Challenges of predicting the potential distribution of a slow-spreading invader—A habitat suitability map for Russian olive (*Elaeagnus angustifolia*) in the western United States: Biological Invasions, v. 13, p. 153–163.

Katz, G.L., and Shafroth P.B., 2003, Biology, ecology and management of *Elaeagnus angustifolia* L. (Russian olive) in western North America: Wetlands, v. 23, p. 763–777.

Nagler, P.L., Glenn E.P., Jarnevich C.S., and Shafroth P.B., 2010, Distribution and abundance of saltcedar and Russian olive in the western United States *in* Shafroth P.B., Brown C.A., and Merritt D.M., eds., Saltcedar and Russian olive control demonstration act science assessment: U.S. Geological Survey Scientific Investigations Report 2009–5247, p. 7–32.

Nagler, P.L., Glenn E.P., Jarnevich C.S., and Shafroth P.B., 2011. Distribution and abundance of saltcedar and Russian olive in the western United States: Critical Reviews in Plant Sciences, v. 30, p. 508–523.

Ringold, P.L., Magee T.K., and Peck D.V., 2008, Twelve invasive plant taxa in US western riparian ecosystems: Journal of the North American Benthological Society, v. 27, p. 949–966.

U.S. Department of Agriculture (USDA), 2004, The PLANTS Database, ver. 3.5 : Baton Rouge, La., U.S. Department of Agriculture, National Plant Data Center. Accessed on Jan. 08, 2004 at *http://plants.usda.gov*.

U.S. Geological Survey, 2012, Surface-water data for the Nation: U.S. Geological Survey, National Water Information System, available at *http://waterdata.usgs.gov/nwis/sw*.

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