Weed Technology 2015 29:587–595

Distribution of Arable Weed Populations along Eastern Arkansas Mississippi Delta Roadsides: Occurrence, Distribution, and Favored Growth Habitats

Nicholas E. Korres, Jason K. Norsworthy, Muthukumar V. Bagavathiannan, and Andy Mauromoustakos*

A survey was conducted in 2012 across 13 counties in the eastern Arkansas–Mississippi Delta area on 489 randomly selected road sites to assess the distribution of the most commonly occurring arable weeds. Among the 36 species recorded, Palmer amaranth, johnsongrass, large crabgrass, barnyardgrass, prickly sida, and broadleaf signalgrass were the top six weed species, occurring at 313, 294, 261, 238, 176, and 136 sites, respectively. Barnyardgrass, johnsongrass, and Palmer amaranth were present at 34, 32, and 31% of all sampling occasions (site by roadside topographical characteristic). Habitat preferences varied between weed species. Palmer amaranth, large crabgrass, and johnsongrass exhibited a preference for disturbed habitats as well as field shoulders. Conversely, barnyardgrass, yellow nutsedge, hemp sesbania, and giant ragweed exhibit a preference for moist environments similar to these found in roadside ditches. Herbicide use on roadsides is subject to many environmental regulations and public concerns that, in combination with the evolution of herbicide resistance, necessitate an effective plan for managing agronomically important weed species on eastern Arkansas–Mississippi Delta roadsides.
Nomenclature: Barnyardgrass, *Echinochloa crus-galli* (L.) Beauv.; broadleaf signalgrass, *Urochloa platyphylla* (Nash) R. D Webster; giant ragweed, *Ambrosia trifida* L.; hemp sesbania, *Sesbania herbacea* (P. Mill.) McVaugh; johnsongrass, *Sorghum halepense* (L.) Pers.; large crabgrass, *Digitaria sanguinalis* (L.) Scop.; Palmer amaranth, *Amaranthus palmeri* S. Wats.; prickly sida, *Sida spinosa* L.; yellow nutsedge *Cyperus esculentus* L.
Key words: Data filtering, eastern Arkansas, land use, Mississippi Delta, roadside topography, road type, weed distribution, weed survey.

En 2012, se realizó un estudio observacional a lo largo de 13 condados en el este del área del Delta Arkansas-Mississippi en 489 sitios de carreteras, seleccionados aleatoriamente para evaluar la distribución de las malezas más comúnmente encontradas en áreas agrícolas arables. Entre las 36 especies detectadas, *Amaranthus palmeri*, *Sorghum halepense*, *Digitaria sanguinalis*, *Sida spinosa*, y *Urochloa platyphylla* fueron las seis especies de malezas más frecuentes encontrándose en 313, 294, 261, 238, 176, y 136 sitios, respectivamente. *Echinochloa crus-galli*, *S. halepense*, y *A. Palmeri* estuvieron presentes en 34, 32, y 31% de todas las condiciones de muestreo (sitio por característica topográfica de la carretera). Las preferencias de hábitat variaron entre las especies de malezas. *A. palmeri*, *D. sanguinalis*, y *S. halepense* exhibieron una preferencia por hábitats perturbados y los bordes de los campos. En cambio, *E. crus-galli*, *Cyperus esculentus*, *Sesbania herbacea*, y *Ambrosia trifida* exhibieron una preferencia por ambientes húmedos similares a los encontrados en los drenajes de las carreteras. El uso de herbicidas en los bordes de carreteras se encuentra bajo muchas regulaciones ambientales y preocupaciones del público que, en combinación con la evolución de resistencia a herbicidas, necesita un plan efectivo para el manejo de especies agronómicamente importantes en los bordes de carreteras en el este del área del Delta Arkansas-Mississippi.

Surveying weed distributions within a particular geographic area can be useful for identifying weed species spatial shifts, streamlining educational programs conducted by local extension agents, and directing future weed science research efforts (Rankin et al. 2005). At present, surveys of weed distributions are needed as herbicide-resistant weed populations continue to evolve. For example, glyphosate-resistant weed species such as Palmer amaranth, johnsongrass, giant ragweed, and goosegrass [*Eleusine indica* (L.) Gaertn.] have a profound effect on crop yields in the midsouth United States (Green and Owen 2011; Heap 2014; Osunsami 2009; Reddy and Norsworthy 2010; Riar et al. 2011; Shaner 2000).

Weeds can be spread from one location to another by pollen, seed, or by vegetative structures such as

DOI: 10.1614/WT-D-14-00130.1
* First and second authors: Postdoctoral Research Associate and Professor, Department of Crop, Soil, and Environmental Sciences, University of Arkansas, 1366 W. Altheimer Drive, Fayetteville, AR 72704; third author: Assistant Professor, Department of Soil and Crop Sciences, Texas A&M University, TX 77843; fourth author: Professor, Agricultural Statistics Laboratory, University of Arkansas, Fayetteville, AR 72701. Corresponding author's E-mail: korres@uark.edu or nkorres@yahoo.co.uk

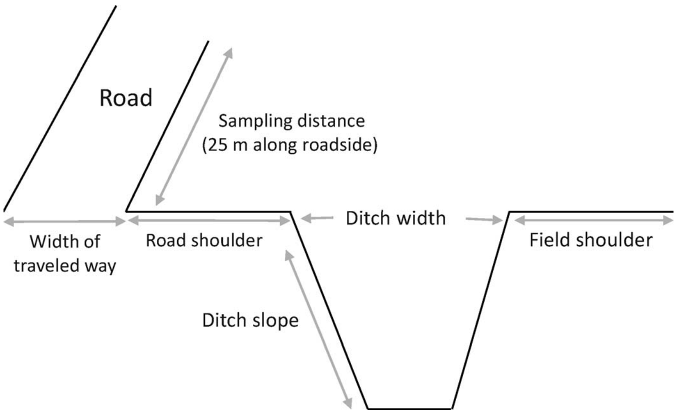

Figure 1. Schematic representation of the sampling points for each of the surveyed sites along eastern Arkansas–Mississippi Delta area.

tubers or rhizomes through various agents such as vehicles, equipment, or other human activities; animals; or natural events such as tornados, floods, or heavy rains (Burkeet al. 2007; Christen and Matlack 2009; Ward et al. 2013). Seed dispersal has greatly contributed to widespread dispersal of herbicide-resistant weeds throughout the Mississippi Delta region (Bagavathiannan et al. 2013). To control, even partially, spatial weed infestation and potential herbicide resistance, it is important to understand the dominant routes, mechanisms, and rates of weed spread across landscapes.

Roadsides are thought to both facilitate weed establishment and act as corridors assisting weed dispersal into neighboring habitats (Birdsall et al. 2012; Christen and Matlack 2006, 2009; Overton et al. 2002). The opportunity to understand and consequently prevent weed dispersal over long distances can be supported if key factors and attributes that facilitate weed movement and establishment are well-understood (Angelstam et al. 2005).

The aim of this paper is to assess the prevalence of agronomically important weeds in roadsides across eastern Arkansas counties along the Mississippi Delta because roadsides are corridors for seed dispersal, and agronomic weeds on roadsides are likely an extension of those in fields.

Materials and Methods

In the fall of 2012, 489 sampling sites in eastern Arkansas along the borders of the Mississippi River were randomly selected on a map, ensuring they covered a wide majority of road types and were at least 5 km apart from each other. Densities of agronomically important weeds were recorded for each road topographical characteristic at each site, including road shoulder (i.e., the area between the edge of the road surface and the ditch), open-cut ditch (i.e., ditch), and back slope (i.e., field shoulder) as defined by Bugg et al. (1997) and MDEP (2010). A diagram of road topographical characteristics at each site is presented in Figure 1.

Parameters recorded at each sampling site, in addition to weed densities, included the amount of surface incline or decline as described by Brouwer et al. (1985) (i.e., ditch slope), the width of the ditch, vegetation cover as described by Qiang (2005) at the roadside edge, whether or not the roadside was mown, and land use adjacent to the sampling site (i.e., nearby land use) (Table 1).

Table 1. List of explanatory and response (i.e., weed density) variables used in the weed roadside survey conducted in eastern Arkansas counties along the Mississippi Delta during 2012.

Type of road[a]	Width category (m)	Slope category	Mowing	Vegetation cover (%)	Nearby land use[a]	Weed density (plants 25 m^{-1})
Dirt	1 = < 1m	0 = Horizontal	1 = Yes	0 = 0	Soybean	0 = not present
Gravel	2 = 1–5 m	1 = Very flat	2 = No	1 = > 0–10	Cotton	1 = < 5 plants
Paved	3 = 5–10 m	2 = Flat		2 = > 11–20	Rice	2 = 6–25 plants
State highway	4 = > 10 m	3 = Moderate		3 = > 21–30	Corn	3 = 26–50 plants
		4 = Steep		4 = > 31–40	Grain sorghum	4 = 51–100 plants
		5 = Very steep		5 = > 41–50	Winter wheat	5 = > 100 plants
				6 = > 51–60	Pasture	
				7 = > 61–70	Natural area	
				8 = > 71–80	Residential area	
				9 = > 81–90		
				10 = > 91–100		

[a] After data filtering (see Materials and Methods).

https://doi.org/10.1614/WT-D-14-00130.1 Published online by Cambridge University Press

Table 2. Number of sampling sites per county across eastern Arkansas–Mississippi Delta area during 2012.

County	District	No. of sampling sites	County	District	No. of sampling sites
Mississippi	10	104	Arkansas	2	23
Chicot	2	86	Ashley	2	6
Crittenden	1	70	Poinsett	10	5
Phillips	1	68	Monroe	1	1
Desha	2	64	Drew	2	1
Lee	1	32	Jefferson	2	1
St. Francis	1	28			

Survey Area. The Mississippi Delta in eastern Arkansas is situated at 35.800 N and 91.200 W along the borders of Arkansas, Mississippi, Louisiana, and Tennessee. According to the Arkansas State Highway and Transportation Department, the area consists of three districts (Districts 1, 2, and 10) that include the counties of Crittenden, Lee, Monroe, Phillips, and St. Francis; Arkansas, Ashley, Chicot, Desha, Drew, and Jefferson; and Mississippi and Poinsett, respectively (Table 2).

It is a typical human-dominated area in which natural ecosystems can be found within an artificial matrix made of cultivated fields and rural settlements. The fertile and flat soils of the alluvial plains offer excellent conditions for agriculture that are reflected by the intensive use of the land for arable farming dominated by crops such as soybean [*Glycine max* (L.) Merr.], cotton (*Gossypium hirsutum* L.), rice (*Oryza sativa* L.), and corn (*Zea mays* L.) (Dadney et al. 2001; Myles and Reinschmiedt 1992; Saunders 1992; USDA 2014).

All spatial data at each location were recorded in latitude and longitude using an eTrex® Legend Cx, Garmin GPS system, (Garmin International, Inc., Olathe, Kansas A) and these were used to map the sampling sites across the survey area (Figure 2). Mississippi, Chicot, Crittenden, Phillips, Desha, Lee, and St. Francis were the counties in which most samples were collected, followed by Arkansas, Ashley, Poinsett, Monroe, Drew, and Jefferson (Table 2).

Weed Census. Survey personnel walked 25 m along the side of the road and visually recorded each weed species present in the ditch, road, and field shoulder. The distance of a sampling site from the road edge was dictated by each site's unique topography and was variable among sites (Figure 3).

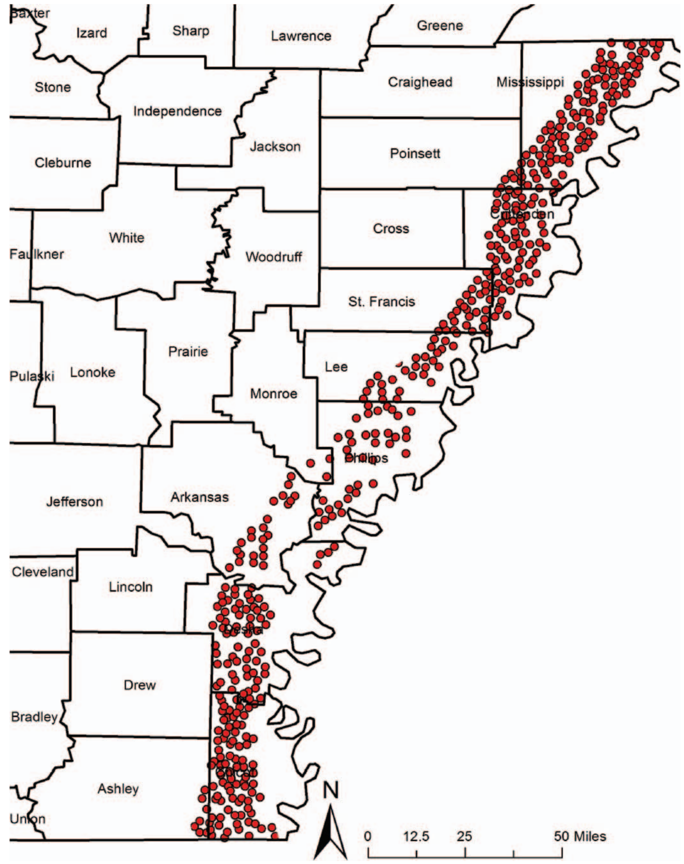

Figure 2. Distribution of sampling sites in the eastern Arkansas–Mississippi Delta survey area. (Color for this figure is available in the online version of this paper.)

The starting point for each sampling site was randomly selected. Such systematic sampling is regarded as analogous to simple random sampling when the population sampled is in random order (McNaught et al. 2008). Unknown weeds were collected for identification at the lab. Densities of weed species were clustered into several classes ranging from 0 (not present) to 5 (> 100 plants) (Table 1). Data were used to evaluate species abundance (i.e., frequency of occurrence expressed as a percentage of overall occurrence in the entire survey) or dominance (i.e., frequency of occurrence expressed as a percentage of occurrence among survey sites) within the entire sampling area (Table 3). The quantification of habitat availability (i.e., accessibility and occurrence of physical and biological components of habitat) (Krausman 1999) usually consists of a priori or a posteriori measures of the abundance in an area used by an organism. Thus, the term "availability" and

https://doi.org/10.1614/WT-D-14-00130.1 Published online by Cambridge University Press

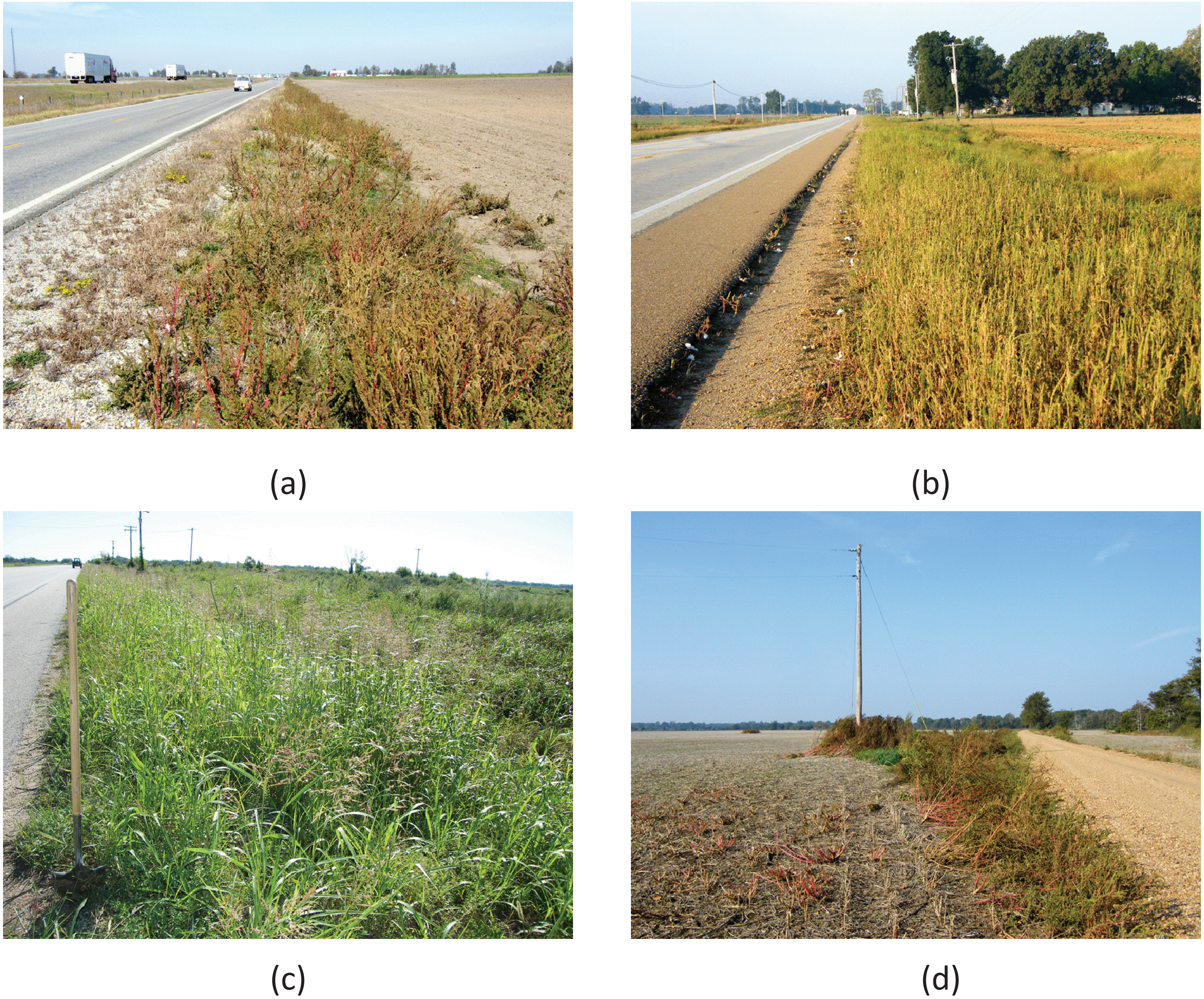

Figure 3. Road types (Photos a, b, c: paved; Photo d: gravel) and their topographical characteristics. The absence of an unpaved area between the road shoulder and the paved main road body (width of travelled way) in photo a compared to photos b and c is noticeable. Differences in weed flora, even within the same road type are present in photos a, b, and c.

"abundance" can be used interchangeably although "abundance" is commonly measured (Hall et al. 1997). Hence, in situations where the accessibility has been determined, then analyses to determine habitat preference by comparing "use" vs. "availability" are useful and operational (Hall et al. 1997). The "availability" of weeds for each of the roadside topographical characteristics (i.e., roadside shoulder, ditch, and field shoulder) across the survey area is presented in Table 3; therefore, the evaluation of weed habitat preference was possible (Figure 5).

Data Analysis. Because of variability among sampling sites, hypothesis testing with the collected data was not possible. We collected observational data that provided a baseline of weed infestations along eastern Arkansas roadsides in 2012. Species occurrence at and within sampling sites, as well as species distribution across surveyed counties, provided a qualitative comparison among survey sites among and across counties after raw data were processed and filtered (i.e., cleansed and sometimes consolidated or excluded by collapsing explanatory variable[s] level[s] to fewer larger groups and then

Table 3. Percentage occurrence of recorded weed species for all counties in eastern Arkansas–Mississippi Delta surveyed during 2012.

Latin name	Common name	Weed density expressed as percentage occurrence: 0	1	2	3	4	5	Overall occurrence[a]	Site occurrence[a]
		No. of weed plants: 0	< 5	6–25	26–50	51–100	> 100	%	%
Abutilon theophrasti	Velvetleaf	99.7 (1,463)	0.1 (2)	0 (0)	0.1 (2)	0 (0)	0 (0)	0.3 (4)	0.4 (2)
Acalypta ostryifolia	Hophornbeam Copperleaf	99.9 (1,465)	0 (0)	0 (0)	0.07 (1)	0 (0)	0.07 (1)	0.1 (2)	0.2 (1)
Amaranthus palmeri	Palmer amaranth	69.3 (1,017)	4.8 (71)	8.6 (126)	6.8 (100)	5.1 (74)	5.4 (79)	30.7 (450)	64 (313)
Amaranthus retroflexus L.	Redroot pigweed	99.6 (1,461)	0 (0)	0.1 (2)	0 (0)	0.07 (1)	0.2 (3)	0.4 (6)	0.6 (3)
Amaranthus rudis Sauer	Common waterhemp	97.3 (1,427)	0.7 (10)	1.3 (19)	0.3 (5)	0.2 (3)	0.2 (3)	2.7 (37)	4.3 (21)
Ambrosia trifida	Giant ragweed	95.4 (1,399)	1.09 (16)	1.8 (26)	0.9 (14)	0.2 (3)	0.6 (9)	4.6 (68)	4.1 (20)
Brunnichia ovata	Redvine	92.1 (1,351)	0.5 (7)	2.1 (31)	2.4 (36)	1.4 (21)	1.4 (21)	7.9 (116)	14.1 (69)
Chamaesyce maculata (L.) Small	Spotted spurge	98.6 (1,447)	0.1 (2)	0.5 (8)	0.2 (3)	0.3 (5)	0.1 (2	1.4 (20)	2.9 (14)
Commelina spp	Dayflowers	98.8 (1,450)	0.3 (4)	0.3 (4)	0.5 (7)	0 (0)	0.1 (2)	1.2 (17)	0.8 (4)
Conyza canadensis (L.) Cronq.	Horseweed	94.9 (1,393)	1.5 (22)	2.6 (38)	0.6 (9)	0.3 (4)	0.07 (1)	5.0(74)	8 (39)
Cyperus esculentus	Yellow nutsedge	87.5 (1,283)	1.8 (26)	4.9 (72)	3.3 (49)	1.5 (22)	1. (15)	12.5 (184)	18.8 (92)
Digitaria sanguinalis	Large crabgrass	73.1 (1,073)	2.9 (42)	8.9 (131)	6.5 (96)	4.5 (66)	4.0 (59)	26.8 (394)	53.4 (261)
Echinochloa crus-galli	Barnyardgrass	66.5 (975)	4.3 (63)	12.3 (181)	7.5 (110)	4.2 (61)	5.2 (77)	33.5 (492)	48.7 (238)
Eclipta prostrata	Eclipta	99.3 (1,457)	0.07 (1)	0.3 (5)	0.2 (2)	0.07 (1)	0.07 (1)	0.7 (10)	0.4 (2)
Eleusine indica	Goosegrass	92.7 (1,360)	0.9 (13)	3.8 (56)	1.8 (27)	0.7 (10)	0.07 (1)	7.3 (107)	15.3 (75)
Euphorbia spp.	Spurges	89.9 (1,319)	0.7 (10)	3.2 (47)	3.1 (45)	1.6 (24)	1.5 (22)	10.1 (148)	23.5 (115)
Galeopsis tetrahit L.	Common hempnettle	98.6 (1,447)	0.2 (3)	0.9 (13)	0.2 (3)	0 (0)	0.07 (1)	1.4 (20)	2 (10)
Heteranthera limosa (Sw.) Willd.	Ducksalad	99.6 (1,461)	0 (0)	0 (0)	0 (0)	0 (0)	0.4 (6)	0.4 (6)	0.2 (1)
Ipomoea spp.	Morningglory	84.7 (1,242)	1.6(24)	6.7 (98)	3.1 (45)	1.9 (28)	2.0 (30)	15.3 (225)	27.4 (134)
Lamium purpureum L.	Purple deadnettle	99.1 (1,453)	0 (0)	0.2 (3)	0.5 (7)	0.2 (3)	0.07 (1)	0.9 (14)	2 (10)
Mollugo verticillata L.	Carpetweed	98.8 (1,450)	0.3 (4)	0.3 (4)	0.3 (4)	0.07 (1)	0.3 (4)	1.1 (17)	2 (10)
Oryza sativa L.	Red rice	99.7 (1,462)	0.1 (2)	0 (0)	0.07 (1)	0.07 (1)	0.07 (1)	0.3 (5)	0.6 (3)
Panicum dichotomiflorum	Fall panicum	85.7 (1,257)	1.9 (29)	6.5 (96)	3.2 (47)	1.8 (27)	0.7 (11)	14.3 (210)	26.6 (130)
Polygonum pensylvanicum	Pennsylvania smartweed	96.9 (1,422)	0.3 (5)	0.6 (9)	0.7 (10)	0.7 (10)	0.7 (11)	3.1 (45)	1.4 (7)
Portulaca oleracea L.	Common purslane	98.9 (1,451)	0.07 (1)	0.4 (6)	0.5 (7)	0.07 (1)	0.07 (1)	1.1 (15)	2.7 (13)
Rumex crispus L.	Curly dock	99.6 (1,461)	0.1 (2)	0.1 (2)	0.07 (1)	0.07 (1)	0 (0)	0.5 (6)	0.6 (3)
Senna obtusifolia	Sicklepod	99.6 (1,461)	0.07 (1)	0.2 (3)	0.1 (2)	0 (0)	0 (0)	0.41 (6)	0.4 (2)
Sesbania herbacea	Hemp sesbania	90.4 (1,326)	3.7 (55)	3.6 (53)	1.0 (15)	0.7 (11)	0.5 (7)	9.6 (141)	11.5 (56)
Setaria parviflora	Knotroot foxtail	83.9 (1,232)	2.2 (33)	6.3 (93)	3.9 (58)	2.2 (32)	1.3 (19)	16.0 (235)	26.6 (130)
Sida spinosa	Prickly sida	79.7 (1,170)	1.6 (23)	7.2 (106)	6.1 (90)	2.8 (41)	2.5 (37)	20.2 (297)	36 (176)
Solanum carolinense	Carolina horsenettle	94.9 (1,393)	0.6 (9)	2.9 (42)	1.4 (20)	0.1 (2)	0.07 (1)	5.0 (74)	10.4 (51)
Sorghum halepense	Johnsongrass	68.4 (1,004)	7.2 (105)	9.3 (137)	6.2 (91)	3.9 (57)	5.0 (73)	31.6 (463)	60.1 (294)
Taraxacum officinale G. H. Weber ex. Wiggers	Dandelion	99.9 (1,466)	0 (0)	0 (0)	0.07 (1)	0 (0)	0 (0)	0.07 (1)	0.2 (1)
Tribulus terrestris L.	Puncturevine	98.2 (1,440)	0.1 (2)	0.8 (12)	0.5 (8)	0.3 (4)	0.07 (1)	1.8 (27)	4.5 (22)
Urtica dioica L.	Stinging nettle	98.8 (1,449)	0 (0)	0.5 (8)	0.3 (5)	0.3 (5)	0 (0)	1.2 (18)	2 (10)
Urochloa platyphylla	Broadleaf signalgrass	83.8 (1,229)	1.98 (29)	5.8 (85)	3.5 (52)	3.1(46)	1.7 (26)	16.2 (238)	27.8 (136)

[a] Overall weed occurrence is expressed as % occurrence of sampling occasions (occurrence in road shoulder, RS; field shoulder, FS; and ditch, D) for each sampling site (489 sampling sites) whereas site occurrence is based on percent weed occurrence along sampling sites (489 sampling sites) only. The number in parentheses indicate the number of sampling occasions recorded for individual weed species across surveyed sites.

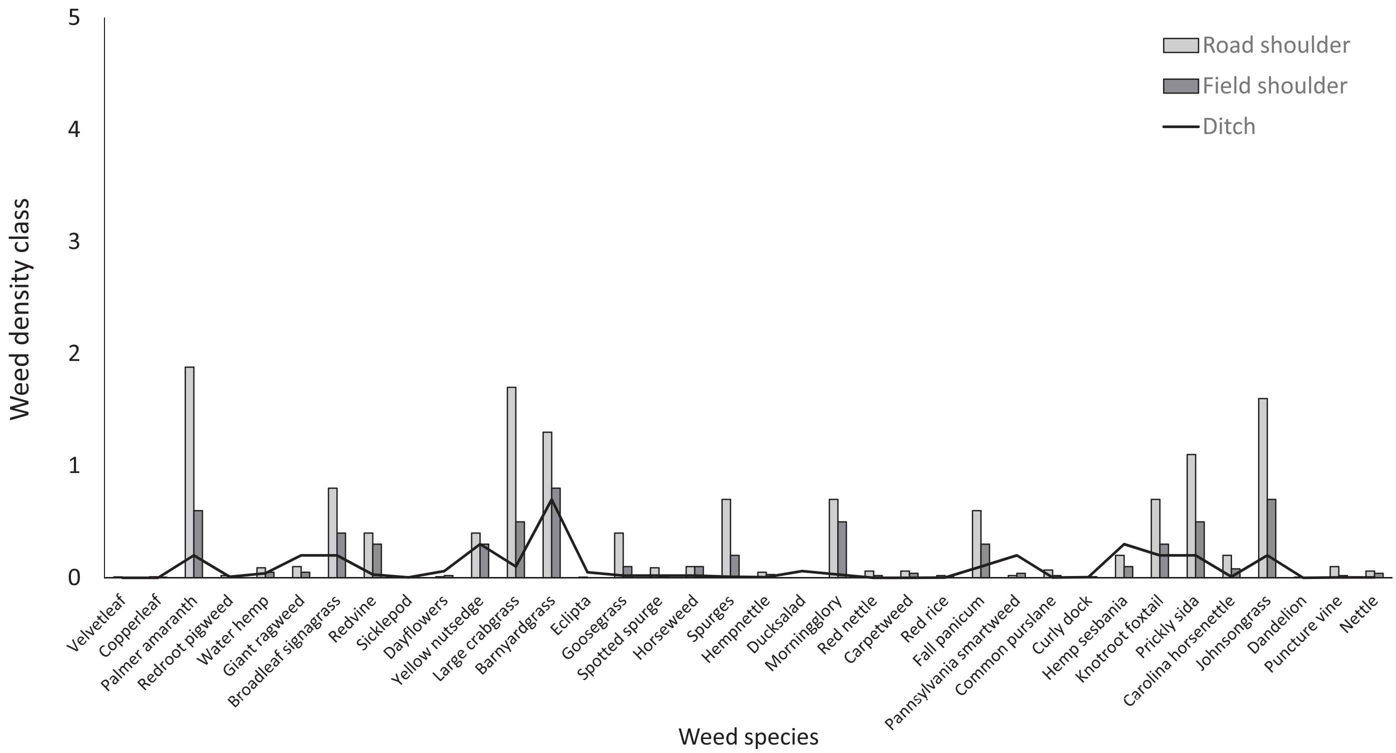

Figure 4. Average weed density class (by species) for three locations along roadsides in the eastern Arkansas–Mississippi Delta survey area during 2012. Data illustrate weed species preferences for different roadside topographical characteristics (D, ditch; FS, field shoulder; RS, road shoulder).

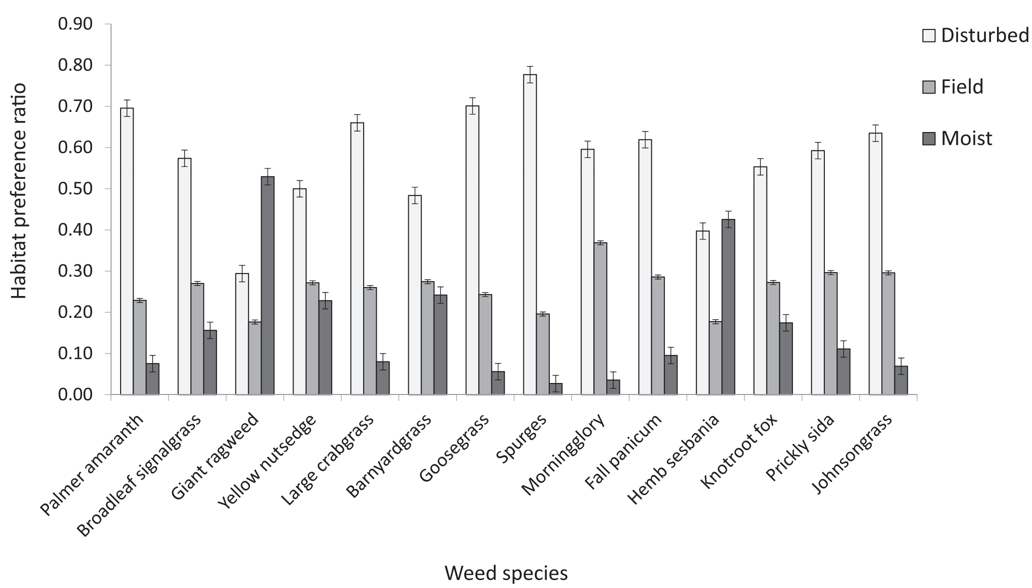

Figure 5. Habitat preference of selected weed species with distinguished growth habitats along roadsides in the eastern Arkansas–Mississippi Delta survey during 2012. Roadside shoulder is denoted as disturbed habitat, whereas ditch habitat is denoted as moist habitat. Vertical bars represent standard error of mean at the 0.05 significance level.

https://doi.org/10.1614/WT-D-14-00130.1 Published online by Cambridge University Press

filtered based on presence or absence) using JMP PRO version 11.2.0 Statistical Discovery package from SAS (SAS 2013). The habitat preference of weed species was determined as the proportion of habitat use over the habitat availability because it denotes the selection of a habitat component over another when both are equally available (Hall et al. 1997). A two-tailed *t* test was performed for habitat preference at the 0.05 significance level.

This survey includes 52,812 records, each one containing several discrete and continuous variables (Table 1) that total more than one million input items. Nominal logistic regression was used to identify the most important roadside parameters (i.e., road type, land use, road topography characteristics, vegetation cover of the dominant grasses excluding the weeds recorded, and mowing) affecting weed infestations along eastern Arkansas roadsides along the Mississippi Delta using JMP PRO version 11.2.0. Results of these analyses are presented in a companion paper (Korres et al. 2015).

Results and Discussion

Weed Species Occurrence and Distribution. The most abundant weed species recorded were Palmer amaranth, johnsongrass, large crabgrass, barnyardgrass, prickly sida, broadleaf signalgrass, morningglories (*Ipomoea* spp.), fall panicum (*Panicum dichotomiflorum* Michx.), knotroot foxtail [*Setaria parviflora* (Poir.) Kerguélen], spurges (*Euphorbia* spp.), and yellow nutsedge. All weed species recorded are listed in Table 3.

Barnyardgrass, johnsongrass, large crabgrass, broadleaf signalgrass, knotroot foxtail, and fall panicum were the most dominant and abundant grass weed species recorded in all counties; whereas Palmer amaranth, prickly sida, and morningglories were the most dominant and abundant broadleaf weed species. Yellow nutsedge and spurges were also among the most abundant and dominant recorded species. Not surprisingly, all species mentioned above were ranked as the most problematic weeds in the Mississippi Delta region by previous agronomic surveys (Bryson and Hanks 2006; Rankins et al. 2005; Riar et al. 2013a,b). An effective weed management strategy needs to be attained for the entire Mississippi Delta area to restrain the wide distribution and abundance of the most agronomically important weed species (i.e., Palmer amaranth, johnsongrass, barnyardgrass) in all counties surveyed. Spread of these species could affect costs of control to various degrees across a range of spatial scales, particularly in regard to biotypes that are herbicide-resistant. Although horsenettle (Solanum carolinense L.), Pennsylvania smartweed (Polygonum pensylvanicum L.), goosegrass, redvine [*Brunnichia ovata* (Watt.) Shinners], and giant ragweed were less abundant compared to the species mentioned previously, their presence was noticeable in most surveyed counties.

Occurrence of weeds such as hophornbeam copperleaf (*Acalypha ostryifolia* Riddell), velvetleaf (*Abutilon theophrasti* Medik.), sicklepod [*Senna obtusifolia* (L.) H. S. Irwin and Barneby], and eclipta (*Eclipta prostrata* L.) was infrequent, with infestations occurring at different sites from county to county. It has been stated that species with low population numbers that occur at few locations are at greater risk from stochastic environmental events, as well as intentional habitat destruction or even due to the loss of genetic diversity (US EPA 1999).

Road Topography. There was a noticeable variation among the species preferences for road topography. Palmer amaranth, large crabgrass, johnsongrass, and spurges preferred disturbed habitats such as road shoulders, similar to reports by others (Best et al. 1980; Maddox et al. undated; Ward et al. 2013). Road shoulders usually are compacted by vehicles and scraped by heavy maintenance machinery while herbicides or mowing are used to control naturally occurring weed flora. Mowing can create microsites for recruitment of various weeds. Thus, the typical vegetation on a road shoulder is usually composed of tough, drought-resistant plants (Anonymous 2000) such as Palmer amaranth, large crabgrass, johnsongrass, and spurges (Best et al. 1980; Ehleringer 1983; Turner et al. 2012).

The roadside ditch is a moist environment fed by rainwater running off the relatively impermeable road surface, the outer road, and the adjoining land beyond the roadside (Juneau and Tarasoff 2013; McNabb and Batterson 1991). Ditch vegetation therefore is usually dominated by moisture-demanding plants such as giant ragweed, yellow nutsedge, barnyardgrass, and hemp sesbania, which exhibit a strong preference for moist habitats (Bassett and Crompton 1982; Israel et al. 2012)

https://doi.org/10.1614/WT-D-14-00130.1 Published online by Cambridge University Press

(Figures 4 and 5). Fall panicum, large crabgrass, Palmer amaranth, and broadleaf signalgrass conversely show a neutral preference for these areas, allowing them to grow in a wide range of habitats as shown in Figures 4 and 5 (Burke et al. 2002; Newman 2003; USDA, NRCS 2003; Ward et al. 2013). In the current survey, morningglory species were found on road and field shoulders (Figures 4 and 5) because these species prefer to be near structures such as guardrails and road signs that provide support for a climbing growth habit (Price and Wilcut 2007). Ditches therefore are an inhospitable environment for morningglory species. Figure 5 summarizes weed habitat preferences (i.e., disturbed or road shoulder, field margins or field shoulder, and moist or ditch) based on the results presented in Figure 3.

The occurrence of the most agronomically important weed species along the eastern Arkansas Mississippi Delta area and their habitat preferences have been summarized following this survey. Palmer amaranth, morningglories, prickly sida, barnyardgrass, johnsongrass, large crabgrass, yellow nutsedge, and spurges were the most abundant and dominant weed species recorded. Some of these species (Palmer amaranth, morningglories, johnsongrass, prickly sida, and spurges) showed a preference for growth in disturbed habitats similar to those found in road and/or field shoulders. Others, such as barnyardgrass, yellow nutsedge, and giant ragweed, showed a preference for moist habitats such as those found in roadside ditches. A companion paper (Korres et al. 2015) discusses roadside characteristics that affect weed occurrence in the counties surveyed herein. This information can be an invaluable source for developing effective weed management programs for eastern Arkansas roadsides.

Acknowledgments

The improvements made to this paper by Associate Editor Jim Brosnan and two anonymous reviewers are greatly appreciated. The assistance of Vaughn Skinner, Jr. on map development is deeply valued.

Literature Cited

Angelstam P, Kopylova E, Korn H, Lazdinis M, Sayer JA, Teplyakov V, Tornblom J (2005) Changing forest values in Europe. Pages 59–74 *in* Sayer JA, Maginnis S, eds. Forests in Landscapes: Ecosystem Approaches to Sustainability. London, UK: Earthscan

Anonymous (2000) National Highways Verges. National Treasures. Delft, Netherlands: Ministerie vanVerkaar en Waterstaat. 47 p

Bagavathiannan MV, Norsworthy JK, Scott RC, Barber TL (2013) The spread of herbicide-resistant weeds: what should growers know? Agriculture and Natural Resources, FSA 2171. Fayetteville, AR: University of Arkansas Cooperative Extension Service. 7 p

Bassett JI, Crompton CW (1982) The biology of Canadian weeds. *Ambrosia trifida*. Can J Plant Sci 62:1003–1010

Best KF, Bowes GG, Thomas AG, Maw MG (1980) The biology of Canadian weeds. *Euphorbia esula*. Can J Plant Sci 60:651–663

Birdsall JL, McCaughey W, Runyon JB (2012) Roads impact the distribution of noxious weeds more than restoration treatments in a lodgepole pine forest in Montana, USA. Restor Ecol 20:517–523

Brouwer C, Goffean A, Heibloem M (1985) Irrigation Water Management: Training Manual No. 1. Introduction to irrigation. Food and Agriculture Organization (FAO) of the United Nations. Natural Resources Management and Environment Department Rome, Italy. 53–60 p

Bryson CT, Hanks JE (2006) Weed Populations in Conventional and Conservation Tillage Management Cotton and Soybean Systems. Mississippi Agricultural and Forestry Experiment Station. Research Report. Vol. 23, No. 18. MS: Mississippi State University. 1–6 p

Bugg RL, Brown CS, Anderson JH (1997) Restoring native perennial grasses to rural roadsides in the Sacramento Valley of California: establishment and evaluation. Restor Ecol 5:214–228

Burke IC, Holland JB, Burton JD, York AC, Wilcut JW (2007) Johnsongrass (*Sorghum halepense*) pollen expresses ACCase target-site resistance. Weed Technol 21:384–388

Burke IC, Thomas WE, Spears JF, Wilcut JW (2002) Influence of environmental factors on broadleaf signalgrass (*Brachiaria platyphylla*) germination. Weed Sci 51:683–689

Christen D, Matlack G (2006) The role of roadsides in plant invasions: a demographic approach. Conserv Biol 20: 385–391

Christen DC, Matlack GR (2009) The habitat and conduit functions of roads in the spread of three invasive plant species. Biol Invasions 11:453–465

Dadney SM, Rebich RA, Pote JW (2001) The Mississippi Delta MSEA Program. Pages 1094–1110 *in* Stott DE, Mohtar RH, Steinhardtb GC, eds. Sustaining the Global Farm. Selected papers from the 10th International Soil Conservation Organization Meeting, May 24–29, 1999, Purdue University and the USDA–ARS National Soil Erosion Research Laboratory West Lafayette, IN: Pubs: International Soil Conservation Organization in cooperation with United States Department of Agriculture Agricultural Research Service National Soil Erosion Research Laboratory and Purdue University

Ehleringer J (1983) Ecophysiology of *Amaranthus palmeri*, a Sonoran desert summer annual. Oecologia 57:107–112

Green JM, Owen MDK (2011) Herbicide-resistant crops: utilities and limitations for herbicide-resistant weed management. J Agric Food Chem 59:5819–5829

Hall LS, Krausman PR, Morrison ML (1997) The habitat concept and a plea for standard terminology. Wildl Soc Bull 25(1):173–182

Heap I (2014) The International Survey of Herbicide Resistant Weeds. http://www.weedscience.org. Accessed September 14, 2014

Israel TD, Rhodes GN, Jr, Via JD, Muller B (2012). Knotroot Foxtail. Pasture Weed Factsheet. Knoxville, TN: University Tennessee Extension. 1–2 p

Juneau KJ, Tarasoff CS (2013) The seasonality of survival and subsequent growth of common reed (*Phragmites australis*) rhizome fragments. Invasive Plant Sci Manag 6:79–86

Korres NE, Norsworthy JK, Bagavathiannan MV, Mauromoustakos A (2015) Distribution of arable weed populations along eastern Arkansas–Mississippi Delta roadsides: factors affecting weed occurrence. Weed Technol 29:596–604

Krausman PR (1999) Some basic principles of habitat use. Pages 85–90 *in* Launchbaugh KL, Mosley JC, Sanders KO, eds. Grazing Behavior of Livestock and Wildlife. Pacific Northwest Range Short Course, March 23–24, 1999, University of Idaho Moscow, Station Bulletin 70, Moscow, Idaho, University of Idaho

Maddox V, Bryd JB, Westbrooks R (undated). Large Crabgrass [*Digitaria sanquinalis* (L.) Scop.]. Row crop. Extension Service: Mississippi State University. 1–2 p

[MDEP] Maine Department of Environmental Protection (2010) Gravel Road Maintenance Manual. A Guide for Landowners on Camp and Other Gravel Roads. Kennebec County Soil and Water Conservation District and Maine Department of Environmental Protection and Water Quality. www.maine.gov/dep/land/watershed/camp/road/gravel_road_manual.pdf. Accessed December 15, 2014

McNabb C, Batterson T (1991) Occurrence of the common reed, *Phragmites australis*, along roadsides in lower Michigan. Mich Academician 23:211–220

McNaught I, Thackway R, Brown L, Persons M (2008) A Field Manual for Surveying and Mapping Nationally Significant Weeds. 2nd edn. Canberra, Australia: Bureau of Rural Sciences. 1–29 p

Myles A, Reinschmiedt L, (1992) Delta economy. The agricultural base. Pages 256–279 *in* Gosby AG, Brackin MW, Mason TD, McCulloch ER, eds, Social and Economic Portrait of the Mississippi Delta. Mississippi State University, Mississippi: Social Science Research Center. Mississippi Agricultural and Forestry Experimental Station. Mississippi State University

Newman SD (2003) Fall panicgrass. *Panicum dichotomiflorum*. USDA, NRCS. The PLANTS Database. Baton Rouge, Louisiana: National Plant Data Center. http://plants.usda.gov/plantguide/pdf/pg_padi.pdf. Accessed March 8, 2015

Osunsami S (2009). Killer Pigweeds Threaten Crops in the South. http://abcnews.go.com/WN/pig-weed-threatens-agriculture-industry-overtaking-fields-crops/story?id=8766404. Accessed August 5, 2014

Overton JM, Smale MC, Whaley KJ, Fitzgerald NB, McGlone H (2002) A Methodology for Assessing the Biodiversity of Road Networks: A Case Study in New Zealand. Transfund New Zealand Research Report 421. Wellington, New Zealand: Transfund. 80 p

Price AJ, Wilcut JW (2007) Response of ivyleaf morningglory (*Ipomoea hederacea*) to neighboring plants and objects. Weed Technol 21:922–927

Qiang S (2005) Multivariate analysis, description and ecological interpretation of weed vegetation in the summer crop fields of Anhui province, China. J Integr Plant Biol 47:1193–1210

Rankins A, Jr, Byrd JD, Jr, Mask DB, Barnett JW, Gerard PD (2005) Survey of soybean weeds in Mississippi. Weed Technol 19:492–498

Reddy KN, Norsworthy JK (2010) Glyphosate resistant crop production systems: impact on weed species shifts. Pages 165–184 *in* Nandula VK, ed. (2010). Glyphosate Resistance in Crops and Weeds: History, Development and Management, Singapore: J. Wiley

Riar DS, Norsworthy JK, Johnson DB, Scott RC, Bagavathiannan M (2011) Glyphosate resistance in johnsongrass (*Sorghum halepense*) biotype from Arkansas. Weed Sci 59:299–304

Riar DS, Norworthy JK, Steckel LE, Stephenson DO, Eubank TW, Scott RC (2013a) Assessment of weed management practices and problem weeds in the midsouth United States—soybean: a consultant's perspective. Weed Technol 27:612–622

Riar DS, Norsworthy JK, Steckel LE, Stephenson DO, Bond JA (2013b) Consultant perspectives on weed management needs in midsouthern United States cotton: a following-up survey. Weed Technol 27:778–787

SAS (2013) SAS Institute Inc. JMP® 11 Specialized Model. Cary, NC: SAS Institute Inc

Saunders J (1992) Demography of Delta. Pages 45–64 *in* Gosby AG, Brackin MW, Mason TD, McCulloch ER eds. Social and Economic Portrait of the Mississippi Delta. Mississippi State University, Mississippi Social Science Research Center. Mississippi Agricultural and Forestry Experimental Station. Mississippi State University

Shaner DL (2000) The impact of glyphosate-resistant crops on the use of other herbicides and resistance management. Pest Manag Sci 56:320–326

Turner FA, Jordan KS, Van Acker RC (2012) Review: The recruitment biology and ecology of large and small crabgrass in turfgrass: implications for management in the context of a cosmetic pesticide ban. Can J Plant Sci 92:829–845

[USDA] U.S. Department of Agriculture (2014) 2012 Census of Agriculture. Summary and State Data. Vol. 1. Geographic Area Series. Part 51. AC-12-A-51. United States Department of Agriculture, National Agricultural Statistics Service. 586 p

[USDA, NRCS] U.S. Department of Agriculture, Natural Resources Conservation Service (2003) The PLANTS Database. National Plant Data Center, Baton Rouge, Louisiana. http://plants.usda.gov. Accessed March 9, 2015

[US EPA] U.S. Environmental Protection Agency (1999) Considering Ecological Processes in Environmental Impact Assessments. July 1999. Washington, DC: Office of Federal Activities. 90 p

Ward SM, Webster TM, Steckel LE (2013) Palmer amaranth (*Amaranthus palmeri*): a review. Weed Technol 27:12–27

Received October 2, 2014, and approved February 28, 2015.