Plant Response to Moist-soil Management in Southeastern Arkansas

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Abstract: We examined plant response to moist-soil management in the delta region of Arkansas in 1985–87. We monitored 3 fields subjected to May, June, and July drawdowns and passive management (no summer irrigation). Total seed production varied from 253 to 1,288 kg/ha and vegetation mass ranged from 1,070 to 4,880 kg/ha. Seed production was more dependent on year and field effects than on drawdown date. Fall panicum (*Panicum dichotomiflorum*) was the most important seed producer and longpod sesbania (*Sesbania macrocarpa*) was the major problem species. Primrose willow species (*Ludwigia* spp.) became increasingly dominant in successive years. Drawdowns later than 1 June appeared to minimize sesbania problems.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 44:356–363

Management of seasonally-flooded impoundments (moist-soil fields) can cost-effectively produce high quality foods for waterfowl and other wildlife (Fredrickson and Taylor 1982). Private lands in eastern Arkansas hold great potential for meeting the needs of the region's high wintering waterfowl populations through moist-soil management because much of the area is flood-prone, regional rice-farming practices are conducive to moist-soil management, landowners value waterfowl highly for

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recreational and financial benefits, and >300,000 ha of set-aside areas are established each year, much of which could be managed for moist-soil plants. However, plant response to moist-soil management practices varies regionally (Knauer 1977) and results in Arkansas are uncertain.

Fredrickson and Taylor (1982) emphasized the importance of summer irrigation to maximize seed production or control nuisance species on moist-soil fields. Summer irrigation, however, may be beyond the financial or logistic capability of many landowners. Our purpose was to assess plant response and seed production on passively-managed (no summer irrigation) moist-soil fields in Arkansas' delta region. Resulting knowledge will facilitate implementation of moist-soil management in this important wintering area for North American waterfowl.

We thank the staff of Bayou Meto Wildlife Management Area (WMA), Arkansas Game and Fish Commission, for aid in maintaining study facilities and logistic support. Interns J. A. James and S. A. Lewis, Arkansas Tech University, helped with seed and plant collections, and G. E. Tucker, Arkansas Tech University, assisted with species identification. The North Carolina State University Department of Statistics conducted a portion of the analysis. L. H. Fredrickson, K. J. Reinecke, and M. R. Widner provided helpful comments on the manuscript. This research was funded in part by Federal Aid in Wildlife Restoration (Project W–64).

Methods

The Wrape Plantation is 243 ha of cleared bottomland on Bayou Meto WMA near Reydel, Arkansas. It is divided into 6 subimpoundments, 3 of which were used as study fields. Fields 2, 3, and 7 (37, 24, and 49 ha, respectively) were row-cropped from 1960–1984 and planted in milo from 1979–1984. Soils in all fields were Portland Clay—occasionally flooded (except 10% of field 7 was Perry Clay—occasionally flooded).

All 3 fields were flooded during winter 1984–1985 prior to our study. Drawdown dates of 1 May, 1 June, and 1 July were randomly assigned to fields in 1985 and then rotated among fields in 1986 and 1987 following a Latin-square design (Table 1). Soil exposure was complete within 2 weeks of drawdown and no additional water management was practiced until reflooding in November.

We established 2 permanent line transects in each field. Transect direction and length (from 274 to 609 m) were selected to follow the elevation gradient of fields. Transects were subdivided and marked into 30.5 m segments. Vegetation and seed production was sampled from 1-m^2 quadrats placed randomly in alternate segments along each transect (1 quadrat/segment). We placed 1–2 seed collection pans (5 × 51 × 5 cm, covered by 0.64-cm wire mesh) in each quadrat on 12 October 1985, 12 August 1986, and 6 August 1987. We collected seed pans and clipped all vegetation within quadrats at ground level from 20–30 October 1985–87. Samples were air dried at room temperature for >3 months. Seeds were removed from clipped vegetation and vegetation was sorted by species, and weighed on an electronic top-loading balance. Seeds removed from vegetation and seeds removed from seed pans

Table 1. Annual seed and vegetation production (kg/ha) in random plots on 3 moist-soil fields on Bayou Meto Wildlife Management Area, Arkansas, in 1985–87.

Field and year	*N* plots	Drawdown date	Preferred seed mass[a]	Total seed mass[b]	Vegetative mass[b]	Rainfall index[c]
Field 2						
1985	8	1 Jun	266	551	1070	−54.6
1986	9	1 Jul	55	253	1290	−66.5
1987	8	1 May[d]	183	491	1270	−10.7
Field 3						
1985	7	1 May[d]	607	658	4880	−99.8
1986	7	1 Jun[d]	155	417	2240	−99.6
1987	7	1 Jul[d]	221	692	1980	−17.3
Field 7						
1985	8	1 Jul	1192	1288	4000	−3.3
1986[e]	6	1 May[d]	376	498	3360	−155.4
1987	7	1 Jun[d]	606	674	4430	−6.1

[a] Only species that produce seeds considered as important waterfowl foods are included, i.e., members of *Cyperaceae*, *Gramineae*, and *Polygonaceae*.
[b] Cocklebur was excluded because it has little value to waterfowl.
[c] Departure from normal rainfall (mm) between drawndown date and seed harvest.
[d] Field was treated with 2,4-D to control growth of sesbania.
[e] No seed pan data was available due to flooding; seed mass remaining on plants were added to estimates of shattered seed derived from field 7 data in 1987.

were sorted by species and weighed separately. Seed pan data were extrapolated to a m^2 basis and added to the mass of seed removed from vegetation to estimate annual seed production (g/m^2). We calculated "total seed mass" by summing weights of all species except common cocklebur (*Xanthium strumarium*) because of its low value to waterfowl, and "preferred seed mass" by summing weights of species commonly considered important duck foods (members of *Cyperaceae*, *Gramineae*, or *Polygonaceae;* Martin et al. 1951, Fredrickson and Taylor 1982).

Unscheduled flooding of field 7 in 1986 invalidated all seed pan data and vegetation data of 6 quadrats. Three substitute quadrats were randomly selected from non-flooded areas to obtain additional vegetative mass data. Seed mass was estimated from seeds removed from vegetation in original and substitute quadrats and adjusted to account for seeds that had already dropped by using species-specific ratios, seed on vegetation-to-total seed, from field 7 data in 1987.

Rank stands of sesbania developed in some fields. Because the tall and robust growth form of sesbania can form a physical barrier to field access by ducks, problem areas were treated with 2,4-D between 23 July and 10 August (aerially applied at a rate of 1.16 liter/ha in aqueous solution).

We measured frequency and diversity of plant species along permanent transects by the point-intercept method. We identified each plant directly above, below, or touching a tape measure at 30.5-cm intervals along transects. All transect segments in 1985 and alternate segments in 1986–87 were analyzed. We calculated average Shannon-Weaver diversity indices (Shannon and Weaver 1949) for 2 transects in each field.

We analyzed data with 3 × 3 Latin-square ANOVA with sampling (N = 18 transects) and subsampling (N = 67 quadrats) and Duncan's Multiple Range tests. The deviation of observed rainfall from normal rainfall for the period between drawdown and seed collection for each field was calculated (U.S. Climatological data—Stuttgart, Ark., ESE station). This rainfall index was included as a covariate in some Latin-square analyses.

Plant names follow Scott and Wasser (1980) or Godfrey and Wooten (1981*a*, *b*). Additional information on plants encountered in Arkansas moist-soil fields is available from the senior author.

Results

Estimates of total seed production in different fields and years ranged from 253 to 1,288 kg/ha, and production of preferred species ranged from 55 to 1,192 kg/ha (Table 1). Total seed production, averaged over 3 years, was 432, 589, and 820 kg/ha for fields 2, 3, and 7, respectively. Vegetation production varied from 1,070 to 4,880 kg/ha.

Main effects of drawdown date, year, and field were not significant indicators of preferred seed or total seed production (ANOVA, $F < 7.0$, $P > 0.12$, df = 2, and $F < 3.9$, $P > 0.20$, df = 2, respectively); however, interactions among main effects were significant ($F = 14.61$, $P = 0.002$, df = 2) or nearly so ($F = 4.16$, $P = 0.058$).

When preferred seed production was analyzed with rainfall as a covariate, interaction and drawdown were not significant (ANCOVA, $F = 0.50$, $P = 0.50$, df = 1, and $F = 21.6$, $P = 0.15$, df = 2, respectively), field effects were significant ($F = 221.6$, $P = 0.047$, df = 2), and year effects nearly were significant ($F = 146.5$, $P = 0.058$, df = 2).

Variation Among Years

Total and preferred seed production were highest in 1985, significantly higher for preferred species ($P < 0.05$). Production of preferred seeds in 1986 showed similar decreases from 1985 in fields 2, 3, and 7 (−79%, −74%, and −68%, respectively), despite relative differences in rainfall indices between 1985 and 1986 among fields (Table 1). Production of preferred seed in 1987 increased an average of 112% from 1986 but remained 48% lower than in 1985. Total seed production declined only 18% from 1985 to 1987 but included less desirable species composition.

Variation Among Fields

Despite similar soils and close proximity of all fields, field 7 produced more seed of preferred species in all years ($P < 0.05$ for 2 of 3 years) and more total seed in 2 of 3 years ($P < 0.05$ for 1985). Additionally, seeds of preferred species comprised the highest proportion of total seed mass in field 7 each year (76%–92%). Field 2 produced the least amount of seeds of both categories in all years ($P > 0.05$).

Variation Among Drawdown Dates

Late drawdowns resulted in highest average production of both seed categories ($P > 0.05$), but averages were strongly influenced by extremely high estimates in field 7 in 1985. Generally, little variation in seed production could be attributed to drawdown date.

Interactions among drawdown date, year, and field effects were significant in analyses of total and preferred species vegetative mass (ANOVA, $F > 10.3$, $P < 0.006$, df = 2; ANCOVA, $F > 19.4$, $P < 0.002$, df = 1). Although no main effects were significant (ANOVA, $F < 4.7$, $P > 0.17$, df = 2; ANCOVA, $F < 2.44$, $P > 0.41$, df = 2), field effects appeared most important.

Species Composition

Many quality waterfowl foods were abundant in moist-soil fields (Table 2). Fall panicum was the dominant seed producer and most frequent species on transects in 1985 (Table 2, 3). Plants and seeds of primrose willow (*Ludwigia decurrens*) and floating primrose willow (*L. peploides*) became increasingly dominant in study fields through 1987. June drawdowns resulted in the highest diversity indices for preferred species within each field among years, and among fields in 2 of 3 years.

Dense stands of sesbania emerged in each field in years of early drawdowns and in subsequent years. Herbicide treatment to reduce adverse effects of sesbania (i.e., shading, competition, physical interference to duck access) effectively killed sesbania and apparently had minimal impact on desirable plants (Table 1). Smart-

Table 2. Relative rank of top 5 seed producing species (descending order by weight) in moist-soil fields on Bayou Meto Wildlife Management Area, Arkansas, 1985–1987.

Field	1985	1986	1987
2	white morningglory[a]	primrose willow	floating primrose willow
	fall panicum	common cocklebur	sprangletop
	sprangletop	floating primrose willow	fall panicum
	junglerice barnyardgrass	tooth-cup	prickly sida
	prickly sida	broadleaf signalgrass	hairy crabgrass
3	fall panicum	floating primrose willow	floating primrose willow
	junglerice barnyardgrass	fall panicum	fall panicum
	blunt spikerush	prickly sida	blunt spikerush
	prickly sida	blunt spikerush	prickly sida
	hairy crabgrass	flatsedge	horned beakrush
7	fall panicum	broadleaf signalgrass	fall panicum
	hairy crabgrass	prickly sida	broadleaf signalgrass
	broadleaf signalgrass	fall panicum	Pennsylvania smartweed
	tooth-cup	sesbania	floating primrose willow
	junglerice barnyardgrass	buttonweed	hairy crabgrass

[a] Scientific names: white morningglory (*Ipomoea lacunosa*), sprangletop (*Leptochloa uninerva*), junglerice barnyardgrass (*Echinochloa colonum*), tooth-cup (*Ammania coccinea*), prickly sida (*Sida spinosa*), broadleaf signalgrass (*Brachiaria platyphylla*), hairy crabgrass (*Digitaria sanguinalis*), blunt spikerush (*Eleocharis obtusa*), flatsedge (*Cyperus pseudovegatus*), horned beakrush (*Rhyncospora corniculata*), Pennsylvania smartweed (*Polygonum pennsylvanicum*), buttonweed (*Diodia* sp.).

Table 3. Species rank and frequency[a] derived from point-intercept vegetative transects in moist-soil fields on Bayou Meto Wildlife Management Area, Arkansas, 1985–87.

	Rank			Frequency		
Common name[b]	1985	1986	1987	1985	1986	1987
Fall panicum	1	2	2	55.2	23.8	26.3
White morningglory	2	4		14.7	10.4	
Broadleaf signalgrass	3	5	6	5.4	5.0	3.8
Junglerice barnyardgrass	4			4.9		
Sprangletop	5	10	8	4.0	1.8	3.6
Prickly Sida	6	8	7	3.1	3.4	3.6
Blunt spikerush	7	3	5	3.0	15.1	3.9
Hairy crabgrass	8	11	9	2.4	1.7	2.7
Tooth-cup	9	6		2.3	4.3	
Field bindweed	10	7	4	1.9	3.8	6.6
Floating primrose willow	11	1	1	1.3	24.3	37.3
Marshpepper smartweed		9			3.2	
Rush		12	12		1.1	1.1
Pennsylvania smartweed			3			7.1
Chufa flatsedge			10			1.2
Yerba de Tajo			11			1.1

[a] Average frequency from all transects in all 3 fields (species with frequencies >1.0 reported). Averaging all transects reduced effects of unequal lengths in different fields (points sampled; 1985 = 8,300, 1986 = 3,200, 1987 = 4,400).
[b] Scientific names (also see Table 2): field bindweed (*Convolvulus arvensis*), marshpepper smartweed (*Polygonum hydropiper*), rush (*Juncus* sp.), chufa flatsedge (*Cyperus esculentus*), Yerba de Tajo (*Eclipta alba*).

weeds (*Polygonum* spp.) wilted somewhat after treatment but plants recovered and produced good seed crops. Cocklebur presented only limited problems, notably in field 2 in 1986 (Table 2).

Discussion

Several authors have estimated seed production of certain species or selected plant stands in moist-soil fields (Singleton 1951, Olinde et al. 1985), but information on seed production of entire moist-soil fields is limited and variable. Taylor (1977), Knauer (1977), and Fredrickson and Taylor (1982) estimated seed production of intensively managed fields as 221, 666, and 1,629 kg/ha, respectively (variation was due partially to differences in successional stage). Davis et al. (1961) estimated annual seed production at 549 kg/ha for passive management of fallow rice fields. Total seed production from all fields in this study averaged 833 kg/ha for the first year and 613 kg/ha for all years. Even though our estimates of seed production were undoubtedly reduced by late seed pan distribution in 1985, rainfall deficits in 1985 and 1986, and possibly adverse effects of herbicide, our estimates are intermediate among previous studies and higher than the estimated 450 kg/ha production of moist-soil fields in the lower Mississippi Alluvial Valley (Reinecke et al. 1989). Declines in seed production over time, as we observed, have been reported by Olinde et al. (1985) and Reid et al. (1989).

Species composition in this study generally was similar to that reported from Missouri (Fredrickson and Taylor 1982), but several differences were apparent. Control of sesbania, rather than cocklebur, may present the greatest challenge for moist-soil managers in Arkansas. Floating primrose willow (*Ludwigia peploides*) dominated 2 of 3 fields within 3 years. Related species (*L. repens* and *L. palustris*) were abundant in some Missouri moist-soil fields after 7–8 years but were not as dominant as our species. Although *Ludwigia* species are used to some extent by waterfowl for food, provide good wood duck brood habitat (Beshears 1974), and to provide ample substrate for invertebrates, dominant stands are undesirable because they interfere with the growth of more preferred species.

We suggest that moist-soil managers in Arkansas employ drawdowns 1 June to 1 July because 1 May drawdowns apparently favored establishment of sesbania. Later drawdowns also may reduce seed loss to deterioration and depredating wildlife by reducing the interval between seed maturation and arrival of fall migrants. Managers should consider frequent rotation of moist-soil fields or frequent disturbance to reduce adverse changes in seed production and species composition and should recognize the possibility of additional expense for control measures if fields have histories of sesbania or cocklebur problems.

Moist-soil management is very compatible with current U.S. Department of Agriculture farm programs and rice farming practices in Arkansas. Rice fields, normally rotated out of rice production every 1–2 years, make excellent moist-soil fields because of level topography, presence of easily reparable contour levees, and proximity to water-pumping facilities. Alternating rice crops with moist-soil management on annual set-aside lands would maintain early succession of moist-soil fields.

Our results indicate that substantial crops of desirable waterfowl foods can be produced in Arkansas' delta region with passive moist-soil management. Moist-soil management also benefits other wildlife species and soil and water conservation. These benefits, the compatibility of moist-soil management with current farming practices, and the strong waterfowling tradition among landowners in eastern Arkansas, indicate moist-soil management has excellent potential for implementation on private lands in Arkansas and for meeting the needs of waterfowl and landowners in the region.

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