Seed Yields of Four Moist-soil Plants on Noxubee National Wildlife Refuge

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Abstract: Emphasis on use of moist-soil management for waterfowl has increased in recent years. One component of this form of management which is not well documented are seed yields of many native plants produced. Seed yields of 4 moist-soil plant species were measured during the growing season of 1985 and 1986 on the Noxubee National Wildlife Refuge in Mississippi. Seed yields of 3 species, *Polygonum hydropiperoides* (Michaux), *Polygonum densiflorum* (Meissner), and *Rhyncospora corniculata* (Gray), were measured using a specially designed seed trap. The fourth species, *Ludwigia glandulosa* (Walter), was measured by clipping plants from 0.31-m^2 quadrats, then removing their capsules. Of the 4 species measured, *P. densiflorum* and *R. corniculata* appeared to be the best overall seed producers, producing an average of 430 kg/ha and 661 kg/ha in 1985, respectively, and 576 kg/ha and 1,091 kg/ha in 1986, respectively. *P. hydropiperoides* produced much less seed than *P. densiflorum,* with an average of 85 kg/ha in 1985 and 21 kg/ha in 1986. Possible waterfowl use of *L. glandulosa* seed was determined by observing birds feeding on 12 days in areas containing driftlines composed predominantly of its seed and by collecting 8 birds from the same areas and analyzing their proventriculi and gizzards. Though *L. glandulosa* was the highest seed producer studied, with an average of 946 kg/ha in 1985 and 907 kg/ha in 1986, it was not a selected waterfowl food.

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Exploiting the natural seed bank available in wetland habitats to meet food and cover needs of many species of wildlife, particularly waterfowl, has been recognized (Meeks 1969, Weller 1978, Fredrickson and Taylor 1982, Smith and

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Kadlec 1983, Pederson and van der Valk 1984). Previous researchers concerned with the management of wetlands realized that high quality habitat for waterfowl could be generated through water manipulation (Uhler 1956, Givens and Atkinson 1957). In recent years, interest in providing natural food for waterfowl through moist-soil management has increased. Much of the increased interest has evolved from moist-soil management practices employed at the Mingo National Wildlife Refuge in southeast Missouri (Fredrickson and Taylor 1982). Fredrickson and Taylor (1982) reported the advantages of natural wetland management (e.g., moist-soil plant management). They noted that natural management is more permanent, more pleasing aesthetically, and requires less cost and energy consumption than row crops. They also stated that native plants are more nutritionally complete than monocultures. For these reasons, moist-soil management has become a widely accepted and utilized tool of the waterfowl manager (Fredrickson and Taylor 1982).

Much research has been done to answer questions relating to moist-soil management such as influence of drawdown date and duration on plant species composition (Meeks 1969, Smith and Kadlec 1983), impacts of longterm water manipulation on plant succession, and effect of varying water regimes on invertebrate production (Meeks 1969, Fredrickson and Taylor 1982). One major component of this form of management, seed production of wetland plants, has received little attention.

Wetland researchers also have long recognized the need for additional information concerning quantities of potential foods provided by natural wetlands used by waterfowl. This need was first promoted by Martin and Uhler (1939). They noted that little is known about quantities of food produced in a marsh area. Low and Bellrose (1944) recognized the need for further information on the seed and vegetative yield of wetland plants. Griscom (1947) also expressed the need for additional research and improvements in techniques used in estimating the plant and animal crop on waterfowl winter range. Singleton (1951) studied production and use of waterfowl food plants on the east Texas Gulf Coast and determined pounds of food/acre for aquatic plant species. This need also was recognized by Arner et al. (1974) who studied the aquatic ecosystems of 2 national wildlife refuges in Mississippi where seed yields of 7 aquatic plant species were determined.

We estimated seed yields of 4 plant species: (1) swamp smartweed (*Polygonum hydropiperoides*), (2) stout smartweed (*P. densiflorum*), (3) beak rush (*Rhyncospora corniculata*), and (4) water primrose (*Ludwigia glandulosa*) in managed moist-soil areas of Noxubee National Wildlife Refuge. Three additional objectives included comparing seed yields among each of the plant species in the study, evaluating short term relationships of seed yield to edaphic characteristics, and determining if waterfowl preferentially selected *L. glandulosa* as a food source.

Methods

This study was conducted on Noxubee National Wildlife Refuge located in east-central Mississippi. We sampled an 80-ha complex of 9 interconnected moist-soil impoundments established in 1983 and known as Prisock Field. A 36-ha lake, located adjacent to the complex, functioned as a reservoir for inundation of the complex. Water was drawn down in the complex at varying times each year. In general, water was slowly removed from each impoundment beginning in May and was completed by late July or early August, then reflooded by mid-October with the inundation of all 9 impoundments completed by mid-November. We also sampled an area located along both sides of the main levee of Green Tree Reservoir (GTR) 3. These areas were naturally flooded and generally were not influenced by water manipulation.

Plant Species Selection

A survey was conducted of the study area to determine relative abundance and availability of plant species considered to be waterfowl foods. We selected the 4 species based on their frequency of occurrence within the study area and their importance to waterfowl (McAtee 1918, Martin and Uhler 1939, Bellrose and Anderson 1943, Singleton 1951). Only *P. densiflorum* and *R. corniculata* were abundant in the GTR-3 levee area. Although there appears to be no record of use of *L. glandulosa* by waterfowl, its vast abundance within a large portion of the moist-soil complex area in 1985 prompted its selection for study.

Seed Trap Sampling

Seed yields of 3 of the plant species selected (*P. hydropiperoides, P. densiflorum,* and *R. corniculata*) were measured using a specially designed seed trap. The trap design involved using a 8.5-cm diameter aluminum can, 6.5 cm in height. Holes were drilled in the base of the can to allow water drainage. A window screen with a mesh size of 24 squares/cm^2 was cut and placed in the bottom of cans to prevent seed loss through the holes. A plastic bird control netting with a 1.27-cm mesh size was then placed over the top of the trap and taped in place to prevent birds from eating seeds caught in the traps. Finally, to reduce deflection of seed, a tie wire was placed through the bird netting and the holes in the base of the can and then fastened to create a funnel shape in the netting. The aluminum cans were then taped to a wooden stake.

Sixty randomly selected sample plots were established within selected areas of the 3 species to be sampled using the seed trap method (e.g., 20 sample plots/plant species). Twelve seed traps were then randomly placed within each sample plot. Traps were staked into the ground in a manner that would ensure the top of the trap was a minimum of 30 cm below the seed bearing portion of the plants being sampled. Sample variances were evaluated (Steel and Torrie 1980) after the first sampling period (1985) to determine if a gain in precision could be achieved by increasing or decreasing sampling intensity or by altering the sample design during the second sampling period (1986).

Seeds were collected from traps at the end of the seed producing period for each of the species sampled (*P. densiflorum, P. hydropiperoides,* and *R. corniculata*). All seeds were separated from other materials in each trap. Numbers of seed/trap were counted and recorded. All samples were air dried at 21.1 C for at least 48 hours. Following drying, each sample was weighed on a closed electronic balance to the nearest 0.0001 g.

Quadrat Sampling

Although *Ludwigia glandulosa* tends to grow in dense, nearly monotipic stands which would normally be well-suited for seed trap sampling, it was not possible to sample it using the seed trap method because of its small sized seed. Seeds of each plant are produced in hundreds of capsules ranging in size from 4.5- to 8-mm long and 2.2- to 2.5-mm wide (Radford et al. 1981) which at maturity dehisce.

Samples of this species were collected prior to seed fall by clipping 5 randomly located, 0.31-m^2 quadrats/ha of *L. glandulosa* plants from each impoundment selected for sampling. Following collection, samples were air dried and the capsules were removed from all plants in each sample. Following capsule removal, each sample was again air dried at 21.1 C for at least 48 hours, and total weight of capsules in each sample was determined. Weights were recorded to the nearest 0.0001 g.

Waterfowl Use of *L. glandulosa*

In 1985, blinds were established along sites where driftlines of *L. glandulosa* seed occurred to determine potential use of its seed by waterfowl. Observations were made from blinds between 0500–1000 hours on 12 days between 18 December 1985 and 3 February 1986. Waterfowl were allowed to feed a minimum of 30 minutes before collection with a .22 caliber rifle or a 12 gauge shotgun. The proventriculi and gizzard were removed from each of the birds collected and contents were separated and air dried. Following drying, samples from each bird were analyzed under a magnifying glass to determine food items consumed.

Edaphic Data

Soil samples were collected from each of the sample plots for the 3 species measured with seed traps and from each of the impoundments where *L. glandulosa* were collected. Soil samples were tested at the Soil Testing Lab, Mississippi Cooperative Extension Service, Mississippi State University.

Statistical Analyses

Mean number and weight of seeds/ha and their standard errors were calculated from the sample data for each of the 3 species sampled with seed traps. Correlations between weight of seeds in grams and number of seeds/trap were assessed for each species. Analysis of variance (ANOVA) was conducted to test for significant differences in mean number of seeds among plant species, mean weight of seed among sample plots, and plots within study areas and between study areas where applicable. The least significant difference (lsd) test was used to detect differences among study area means for the 2 species sampled in both study areas, *P. densiflorum* and *R. corniculata.*

Sample variances among seed traps and among plots were evaluated after the 1985 sample season. A precision factor, as described by Steel and Torrie (1980), was calculated for each of the 3 seed trap species to determine if a gain in precision could be obtained by altering the sample design in 1986.

To determine kg of *L. glandulosa* seed/ha, weight of the seeds in each of 10 *L. glandulosa* capsules was determined to the nearest 0.0001 g. A ratio-estimator, as described by Schaeffer et al. (1979), was used to calculate a sample variance to determine precision of the sample of capsules. Average percent of seed/capsule was determined to calculate weight of seed/sample of capsules. Mean number of stems and capsules/sample was then determined. These values were used to estimate mean number of stems/ha, mean weight of seed in kg/ha, and their standard errors of the means. Correlations between number of stems/quadrat and weight of seeds/quadrat were performed.

F-values were calculated in the analysis and were used to test for significance among *L. glandulosa* quadrat means for each study year. Significant differences were tested for both mean number of stems and mean weight of seed in each of the above analyses for each year of the study. Adequacy of the sampling intensity ($P = 0.05$, $d = 0.02$) used for 0.31 m^2 quadrats in 1985 was determined (Gysel and Lyon 1980).

Five soil characteristics had enough variability to potentially affect seed yield (Dr. Eddie Funderburg, Extension agronomist, Miss. Coop. Ext. Serv., pers. commun.). Relationships between mean weight of seeds/trap and mean number of seeds/trap for each sample plot and the 5 soil characteristics (percent organic matter, phosphorous, potash, cation exchange capacity, and pH) were determined using Spearman's coefficient of rank correlation (SPSS-X, SPSS Inst. Inc. 1983).

Results

Seed Trap Data

Sample sizes varied due to unexpected losses of a portion of the sample sites in 1985 for *P. densiflorum* and *R. corniculata.* The sampling of 20 *P. hydropiperoides* plots was successful with 12 traps removed due to rodent damage. Eleven plots with 117 traps and 7 plots with 84 traps were collected for *P. densiflorum* and *R. corniculata,* respectively, during the 1985 sampling period (Table 1).

Using the results of the 1985 sample, we examined how great a gain in precision could be obtained by increasing number of sample plots to 30 using 8 traps/plot. We computed that precision could be increased by 45%, 166%, and 315% for *P. hydropiperoides, P. densiflorum* and *R. corniculata,* respectively.

Table 1. Mean seed numbers and weights for 3 species measured with seed traps on Noxubee National Wildlife Refuge, Mississippi, 1985–1986.

Year	Study[a] area	*N* plots	*N* traps	$\bar{x}$ *N* seed/ trap	SE of *N* seed/ trap	$\bar{x}$ wt. (g) seed/ trap	SE of wt. seed/ trap	$\bar{x}$ wt. (g) seed kg/ha	SE of $\bar{x}$ wt. seed kg/ha
P. hydropiperoides									
1985	Impound.	20	228	42.1	8.5	0.048	0.010	84.6	17.6
1986	Impound.	30	236	11.0	1.7	0.012	0.002	21.1	3.5
P. densiflorum									
1985	Impound.	8	96	147.3	36.8	0.278	0.057	489.9	100.5
	GTR-3	3	21	50.0	15.4	0.153	0.054	269.6	95.2
	Overall	11	117	120.8	29.8	0.244	0.046	430.0	81.1
1986	Impound.	15	120	209.3	21.4	0.423	0.027	745.4	47.6
	GTR-3	15	115	101.0	19.5	0.232	0.042	408.8	74.0
	Overall	30	235	155.2	17.4	0.327	0.030	576.2	52.9
R. corniculata									
1985	Impound.	3	35	60.7	11.2	0.325	0.047	572.7	82.8
	GTR-3	4	49	75.6	18.5	0.413	0.077	727.8	135.7
	Overall	7	84	69.2	11.2	0.375	0.048	660.8	84.6
1986	Impound.	15	115	135.8	49.7	0.684	0.069	1,205.3	121.6
	GTR-3	14	112	104.9	35.2	0.551	0.049	971.0	86.3
	Overall	29	227	120.9	45.4	0.619	0.044	1,090.7	77.5

[a]Impound. = 80-ha complex of 9 impoundments known as Prisock Field and GTR-3 = Green Tree Reservoir.

Subsequently, the sample design was changed to 30 plots with 8 traps/plot for the 1986 sample.

Of the 3 species sampled with traps in both years of the study, *P. hydropiperoides* produced the smallest amount of seed ($P = 0.01$), the lowest occurring in 1986 with an average of 21 kg/ha (SE = 4, $N = 30$). *P. densiflorum* was the intermediate producer with a high in 1986 averaging 576 kg/ha (SE = 53, $N = 30$). *R corniculata* was the largest seed producer with a 1986 average of 1,091 kg/ha (SE = 78, $N = 30$) (Table 1). Mean number of seeds/trap and mean weight of seeds/trap were strongly correlated for each of the 3 species sampled in both sample years ($P < 0.01$).

Results of the ANOVA indicate that differences in both mean number of seeds and mean weight of seeds varied ($P < 0.01$) among plots for all 3 species. The least significant difference test for sample areas indicated that differences in both mean number of seeds and mean weight of seeds were not as variable among sample areas as they were among sample plots (Table 2).

Quadrat Data

Seventy-nine 0.31-m^2 quadrats were sampled in 1985 for *L. glandulosa.* Using the 1985 results, we estimated needed sample sizes for 1986 with a designated accuracy of 20% times mean weight of seed/quadrat at $\alpha = 0.05$. Based on these

Table 2. Least significant differences (P = 0.05) for 2 species measured with seed traps on 2 study areas, Noxubee National Wildlife Refuge, Mississippi, 1985–1986.

Year	Dependent Variable	Area[a]	D.F.	Area (ha) $\bar{x}$	SE of $\bar{x}$	Mean Diff.	Sig.
P. densiflorum							
1985	*N* seed	Impoundments	9	147.3	11.5	97.4	N.S.
		GTR-3		50.0	42.1		
	wt. seed (g)	Impoundments	9	.2882	0.020	.1351	N.S.
		GTR-3		.1531	0.075		
1986	*N* seed	Impoundments	28	199.6	4.4	97.7	Sig.
		GTR-3		101.8	4.6		
	wt. seed (g)	Impoundments	28	.4284	0.008	.2049	Sig.
		GTR-3		.2235	0.008		
R. corniculata							
1985	*N* seed	Impoundments	5	60.7	10.5	14.9	N.S.
		GTR-3		75.6	7.8		
	wt. seed (g)	Impoundments	5	.3249	0.043	.0886	N.S.
		GTR-3		.4135	0.033		
1986	*N* seed	Impoundments	27	135.8	3.0	30.8	N.S.
		GTR-3		104.9	3.1		
	wt. seed (g)	Impoundments	27	.6838	0.162	.1347	N.S.
		GTR-3		.5491	0.164		

[a]Impoundments is an 80-ha complex of 9 impoundments known as Prisock Field and GTR-3 = Green Tree Reservoir.

Table 3. Mean stem numbers, mean seed weights and coefficients of determination for *Ludwigia glandulosa* on Noxubee National Wildlife Refuge, Mississippi, 1985–1986.

Impoundment No.	Year	*N* quad.	Stems/quadrat $\bar{x}$	Stems/quadrat SE	Wt. seed/quad. (g) $\bar{x}$	Wt. seed/quad. (g) SE	Wt. seed (kg/ha) $\bar{x}$	Wt. seed (kg/ha) SE	r^2
2	1985	28	12.5	1.5	7.3	0.5	790.7	53.8	0.11
3		13	11.2	1.9	8.0	0.6	858.1	64.6	0.35
5		26	12.2	2.4	10.8	1.0	1,164.3	107.6	0.01
6		12	12.1	3.5	8.7	0.7	932.0	75.3	0.14
Overall		79	12.1	1.4	8.8	0.4	946.2	43.1	0.01
2	1986	20	13.8	3.1	6.8	1.8	735.0	193.7	0.09
6		10	26.8	4.6	14.2	1.1	1,251.0	118.4	0.55
Overall		30	18.2	3.3	8.4	0.6	907.0	64.6	0.43

parameters, the sample size was calculated and reduced to 30 0.31-m^2 quadrats in 1986.

Results of the ratio-estimator analysis indicated that differences between quantity of *L. glandulosa* seed in each capsule were insignificant. Mean weight of capsules was divided by mean weight of seed/capsule to determine percentage seed weight; both the 1985 and 1986 samples equaled 82%. Results of the ratio-estimator analysis were used to calculate both mean weight of seeds/quadrat then mean weight of seeds/ha (Table 3). Overall average quantity of seed produced in 1985 was 946 kg/ha (SE = 43, N = 79), while for 1986 the overall

Table 4. Spearman's coefficients of rank correlation (r_s) and their significances (P), determined for 5 edaphic variables and 3 species measured with seed traps on Noxubee National Wildlife Refuge 1985–1986.

			Edaphic variables									
			% Organic matter		Phosphorus		Potassium		Cation exchange capacity		pH	
Year	Dep. var.	*N*	r_s	*P*	r_s	*P*	r_s	*P*	r_s	*P*	r_s	*P*
P. hydropiperoides												
1985	*N* seed	20	.49	.01	.56	.01	.37	.05	.32	.09	.08	.37
	wt. seed		.43	.03	.50	.01	.32	.09	.25	.14	.14	.28
1986	*N* seed	30	<−.01	.49	.04	.41	.26	.09	.09	.33	.42	.01
	wt. seed		<.01	.50	.04	.42	.26	.09	.09	.31	.47	.01
P. densiflorum												
1985	*N* seed	11	−.72	.01	−.08	.41	−.67	.01	−.05	.45	−.55	.04
	wt. seed		−.67	.01	−.24	.24	−.75	<.01	−.19	.29	−.49	.06
1986	*N* seed	30	.05	.38	.50	<.01	.25	.09	.43	.01	−.43	.01
	wt. seed		.06	.38	.54	<.01	.30	.06	.49	<.01	−.44	.01
R. corniculata												
1985	*N* seed	7	−.04	.47	.07	.44	.07	.44	.29	.27	−.40	.19
	wt. seed		−.18	.35	−.07	.44	.00	.50	.18	.35	−.57	.09
1986	*N* seed	29	.37	.02	.42	.01	.20	.15	.04	.41	.24	.11
	wt. seed		.32	.04	.40	.02	.14	.24	−.01	.50	.25	.10

average was 907 kg/ha (SE = 65, N = 30). Little correlation existed between number of stems/quadrat compared with weight of seeds/quadrat (Table 3).

Waterfowl Use

Eight ducks, 3 mallards (*Anas platyrhyncos*), 3 american wigeon (*A. americana*), and 2 ring-necked ducks (*Aythya collaris*) were collected to evaluate possible use of *L. glandulosa* in the moist-soil complex. Only 1 male american wigeon had ingested 1 *L. glandulosa* seed. *P. densiflorum* seed was present in 6 of the 8 birds sampled: 3 mallards and 3 ring-necked. *P. hydropiperoides* seed were consumed by 3 of the 8 birds collected: 2 mallards and 1 ring-necked.

Edaphic Data

Mean number of seed and mean weight of seed/plot indicate that none of the r_s values for each of the 5 soil variables tested were high enough to support a strong correlation between either of the 2 dependent variables ($P > 0.05$) (Table 4).

Discussion

Seed yields of the 4 plant species sampled varied annually. Seed yields of *P. hydropiperoides* and *L. glandulosa* both decreased from 1985 to 1986, while seed yields of *P. densiflorum* and *R. corniculata* increased. Specific environmental factors which most influence annual productivity of each of the species sampled were not identified. The soil factors which occurred with the most variability in the study appear to have no strong effect on seed yields of the 3 plant species tested.

In general, the seed trap designed for the study was effective and easy to use. Once traps are placed in the field, they require little or no attention until time of collection. Also, traps may be used for several seasons with little or no maintenance. Rodent damage to traps and/or seed samples that occurred during the study were insignificant, even in areas where traps were established on dry ground where they were susceptible to rodent depredation. The greatest weakness of the seed trap is that it cannot be used in areas that experience frequent flooding during the sampling season.

Management Implications

P. densiflorum and *R. corniculata* both appear to be good seed producers, are considered high quality natural waterfowl foods, provide good cover, and provide conditions which promote invertebrate production. Although *L. glandulosa* may have some value in promoting invertebrate production and providing cover in wetland areas, its seed appear to be a non-selected waterfowl food. Therefore, management techniques that would discourage the spread of *L. glandulosa* while encouraging the growth of moist-soil plants are recommended. Although *P. hydropiperoides* appears to be a poor seed producer, it may be a suitable substitute for invertebrate production. Management techniques which would control its spread in a specific area may be worthwhile to prevent it from inhibiting growth of species which are considered more important seed producers.

Fredrickson and Taylor (1982) pointed out that barnyard grasses, sedges, and smartweeds (*Polygonum*) respond well to shallow flooding (2–5 cm) after attaining a height of 10–15 cm. They also pointed out that complete submergence of seedlings for longer than 2–3 days can retard growth of millets, grasses, and smartweeds (*Polygonum*). This information may be valuable in both encouraging growth of desirable moist-soil species as well as controlling species which are considered undesirable. It is evident that water manipulation on a controlled area is a key component in managing species composition, but little information is available concerning enhancement and control of specific species. Continued research aimed at gaining more information on the impact of water manipulation on plant species composition and productivity will be an integral part of the successful future of moist-soil management.

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