Population Dynamics of Seeded Species on Northeast Washington Semiarid Sites, 1948-1983

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Abstract

Fifty-one graminoid and 10 forb taxa commonly used in range seedings were planted at 3 semiarid northeast Washington sites, spring and fall seasons, in monospecific stands, on 5.5 m by 1.3 m plots, 1948 to 1951. Population dynamics and clipped yields were observed at irregular intervals from 1952 to 1983. Ten graminoid, but no forb, taxa are recommended for range seeding. Grass species differ markedly in fitness for the sites, as demonstrated in success of passing through the environmental sieve, recruiting posterity, and long-term survival. Species interactions were site specific, demonstrating characteristic and complex demographic schedules at each site. Hard fescue was the most aggressive competitor, progressively replacing many of the others at all sites. Crested wheatgrass taxa provided the highest yields. Species mixtures which developed were unstable in the long term (30 years), and are not recommended in seeding practice.

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Exotic graminoid species have been introduced onto semiarid sites in the western United States over the past century to restore valuable perennial forage plants where climax species have been removed. Eventual ecological adjustment of these extrinsic populations into the habitats which they have been introduced is frequently in doubt, because accurate long-term records have rarely been kept. Consequently, information necessary for selection of proper species to be used in future seeding activities is inadequate.

More than 30 years of records are now available for 3 sites in northeast Washington. The primary objective of these trials was to bracket the environments with exotic forage taxa having differing site requirements, as a means of selecting the highest producing, longest lived, and most competitive for each location. Sixty-one species and varieties (or cultivars), were included.

Although modern concepts of population ecology were not included in the original design, results provide a rare, if less than ideal, perception of population dynamics. Plant population ecology terms and concepts of Silverton (1982) are followed in this discussion. It is our purpose to report here both species fitness and demographic trends.

Table 1. Site characteristics at three Northeast Washington species adaptation nurseries.

	Harrington	Republic	Riverside[1]
Annual precipitation (inches) (see Fig. 1)	12.26	16.04	22.19
slope	1% SW	0–1% SW	2% SW
elevation (feet)	2167	2610	2200
latitude	47° 25′	48° 39′	47° 58′
longitude	118° 15′	118° 44′	117° 26′
Legal Description	NE¼SE¼Sec16, T23N, R36E	SE¼NE¼Sec20, T37N, R33E	NE¼NE¼Sec3, T28N, R43E
Soil	Benge silt loam	Chesaw sandy loam	Bonner gravelly silt loam
Landform	Dry terrace, well drained	Outwash terrace, well drained	Dry Outwash terrace well drained
Parent material	Loess over outwash gravel	Glacial outwash & volcanic ash	Glacial outwash & volcanic ash
Habitat type	*Calcic Haploxerolls* *Artemisia tripartita* *Festuca idahoensis*	*Entic Haploxerolls* *Pinus ponderosa/* *Agropyron spicatum* and *P. ponderosa/* *Stipa comata*	*Typic Haplorthods* *Pinus ponderosa/* *Stipa comata* and *P. ponderosa/* *Agropyron spicatum*

[1]Climatological data from nearest weather station, at Deer Park, WA.

Hafenrichter et al. (1949) classified forages adapted to the Pacific Northwest into 10 major groups based on phenology, productivity, and utility of the species. Woolfolk and Harris (1951) listed forage taxa found to be best adapted to the nurseries discussed in this study and recommended proper seasons for seeding ranges typified by these sites. Evanko (1955) listed all taxa seeded in the three nurseries and rated them according to seedling establishment and survival through 1953, as well as recommended 8 taxa as superior. Earlier releases reported data on germination, phenology, and mortality, giving insight into success in passing the environmental sieve, recruitment, birth, and survival of taxa on these sites (Evanko 1952, 1954). Gates and Harris (1959) reported further on species adaptation at the 3 nurseries, including yields for 8 outstanding species and varieties. These were Nordan and commercial crested wheatgrass varieties (*Agropyron desertorum* Schult)[1], Fairway crested wheatgrass (*A. cristatum* [L.] Gaertn.), Whitmar variety bluebunch wheatgrass (*A. spicatum* [Pursh] Scribn. and Smith), tall wheatgrass (*A. elongatum* [Host] Beauv.), intermediate wheatgrass (*A. intermedium* [Host] Beauv.), hard fescue (*Festuca ovina* var. *duriuscula* [L.] Koch), and big bluegrass (*Poa ampla* Merr.).

Methods

Species adaptation trials were established on semiarid sites near Harrington, Republic, and Riverside in northeastern Washington (Table 1). Average annual precipitation data for the study period are given in Figure 1.

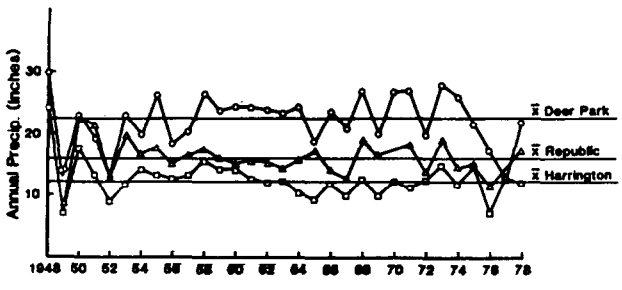

Fig. 1. *Average annual precipitation, 1948-1978, for 3 northeast Washington locations near forage nurseries (Deer Park is nearest climatological station to Riverside site).*

One plot of each species was seeded at each site in fall 1948, spring and fall 1949 and 1950, and spring 1951. Sites were prepared by plowing, harrowing and packing immediately prior to seeding. Three 5.5-m rows, 45 cm apart, with 45-cm alleys between rows in adjacent plots, were seeded using a vegetable seed drill. Competing weed species were removed twice each growing season for 2 years following seeding.

Evaluations were made annually following germination until 1953, and at irregular intervals since that time. Yields, vigor, and area dominance are reported here for 1959, 1968, and 1978. Planted species were clipped 2 cm above the crown, from a 1-m randomly selected section of the center row of the plot, air dried, weighed, and the result converted to kg/ha. If the center row lacked established plants of the designated taxa, the clipped subplot was established on one of the outside rows or a nearby area having a stand. Nondesignated taxa clippings were kept separate, dried, and weighed. Vigor was estimated on a scale of 1 to 5, with ratings of 3 or above considered satisfactory. Area dominance maps were prepared indicating parts of the sites controlled by specific taxa. Areas of species dominance were established subjectively on the basis of coverage and vigor. Confirming observations of aggressive invasion, but no yield or vigor observations, were made in August, 1983.

In the beginning, all sites were fenced to prevent livestock grazing use. Fences were maintained regularly during early years, but repairs became infrequent as administrative responsibility was transferred between Forest Service, Agricultural Research Service, and Washington State University.

Results and Discussion

A majority of the taxa seeded proved not to be fitted to the environments found on the test sites. They either failed to pass the environmental sieve, or to effectively recruit a viable population (Table 2).

Six short-lived taxa are recommended as suitable for short-term range plantings on these sites. They establish quickly and produce large quantities of good quality forage. These include timothy (*Phleum pratense* L.), mountain brome (*Bromus marginatus* Nees), reed fescue (*Festuca arundinacea* Schreb.), and orchardgrass (*Dactylis glomerata* L.) at the Harrington and Republic sites, and green needlegrass (*Stipa viridula* Trin.) at Riverside.

Forb seedings had failed by 1953, except for ladak, creeping, and Siberian alfalfa (*Medicago sativa* L.) varieties at Harrington. These had disappeared also by 1959. Legumes are desired in range grass plantings on semiarid soils for their nitrogen fixing ability. However, none were found adapted to long-term competition in these trials.

Ten seeded species or varieties demonstrated sufficient fitness to be recommended for semipermanent or permanent range seedings

[1]Scientific names follow USDA-Forest Service (1976) Northwest Plant Names. (See Dewey (1983) for proposed changes in *Agropyron taxonomy).*

Table 2. Taxa seeded in 1948-51, not recommended for long-term range seedings at three Northeast Washington sites.

Bluegrass, bulgous*	Rye, mountain
Bluegrass, Canada§ (2)	Ryegrass, perennial
Bluegrass, Canby	Timothy (2)
Bluegrass, Kentucky (2)	Wheatgrass, slender (4)
Brome, mountain	Wheatgrass, streambank (2)
Brome, smooth	Wheatgrass, western
Canarygrass, reed	Wildrye, blue
Fescue, Idaho (2)	Wildrye, Russian
Fescue, sheep	Alfalfa (3)
Fescue, tall	Burnet, small
Foxtail, creeping	Clover, alsike
Foxtail, meadow	Clover, strawberry
Needlegrass, green	Clover, white, ladino
Oatgrass, tall	Clover, yellow, sweet
Orchardgrass (3)	Trefoil, big, Granger
Redtop	Milkvetch, sicklepod
Ricegrass, Indian	

*For scientific names, variety names, or accession numbers, see Gates and Harris (1959), table 2.
§Numbers in parentheses indicate number of varieties or accessions in trials, when more than one.

on these, or similar sites (Tables 3 and 4). They include Nordan, standard, and Fairway crested wheatgrasses; tall, intermediate, and bluebunch (Whitmar) wheatgrasses; hard fescue and big bluegrass; and Siberian wheatgrass (*A. sibericum* Beauv.) and pubescent wheatgrass (*A. trachycaulum* C. Richt.) The latter 2 are added in this report to the 8 previously recommended by Gates and Harris (1959), based on 1968-78 evaluations.

The 10 recommended species and varieties appear to be long-lived. However the original seeded rows in none of the plots were clearly observable by 1983, and individual plants occurred at random where distinct rows had been earlier. This observation leads to questioning whether members of the original cohorts were still present, or replaced by newly recruited vegetative daughters and seedlings. The implication is that at least some individual plants of these species have longevity less than 30 years, and through recruitment of seedings or clones their populations may move about the site. On the other hand, seedings of commercial crested wheatgrass 30 years old have been observed on other sites in the west with rows clearly delineated, and essentially no recruitment between. The presence of new plants of the recommended species and varieties at these 3 sites, especially in competition with cheatgrass (*B. tectorum* L.) and other aggressive weeds, indicates close naturalization of these seeded perennial exotics to their new environments (Harris 1967).

Hard fescue was the most aggressive invader of all seeded taxa (Table 3). It controlled almost half of the area of the 3 sites after 30 years (1948-78). It became established after initial seeding at Riverside and Republic, but failed in early seedings at Harrington (Evanko 1955). However, once established there by later seedings, it progressively dominated Harrington, as well as the other sites.

Intermediate, pubescent, and crested wheatgrasses became well established by 1959, and spread aggressively into plots where competition was mild. Intermediate and pubescent spread by rhizomes as well as seeds. These 2 species are similar in appearance and ecologic site requirements, with pubescent being slightly more drought tolerant. Seeds of the 2 are frequently mixed in commercial lots. However, by 1978 these aggressive wheatgrasses had lost area dominance in competition with others, primarily hard fescue.

Bluebunch (Whitmar), Siberian, and tall wheatgrasses, and big bluegrass were the least aggressive of those listed in Table 3. They have proven useful in some situations, mostly as monospecific stands. Tall wheatgrass is ideally adapted to saline and alkaline subirrigated sites in this region where yields of 8 to 9 metric tons/hectare (7 short tons/acre) have been reported (Hafenrichter et al. 1949). Big bluegrass is slow to establish, and susceptible to uprooting during grazing.

Wheatgrasses were most successful in resisting the incursions of hard fescue at the Harrington site (Table 3 and Fig. 2, 5). Crested, intermediate, and pubescent wheatgrasses proved to be well

Table 3. Changes in percent of nursery site covered by major taxa on 3 successive dates.

	Harrington			Republic			Riverside		
Planted Taxa	1948/1951§	1968	1978	1948/1951§	1968	1978	1951§	1968	1978
	%								
Crested wheatgrasses (mixed)	11	24	21	8	14	3	8	4	0
Tall wheatgrass	4	0	0	4	0	0	4	1	2
Intermediate wheatgrass	6	13	12	4	9	9	4	8	20
Siberian wheatgrass	4	6	0	1	7	0	2	0	0
Pubescent wheatgrass	4	11	12	4	14	6	3	11	10
Bluebunch wheatgrass (Whitmar)	2	2	0	7	6	2	4	0	0
Hard fescue	10	29	34	4	24	56	5	25	50
Big bluegrass	0	6	6	2	3	0	4	0	0
Major invading species									
Cheatgrass	*	6	12	*	4	2	*	8	2
Duffuse knapweed	*	0	0	*	0	2	*	0	0
St. Johnswort	*	0	0	*	1	17	*	0	0
Spanish clover	*	0	0	*	0	0	*	50	11
Major invading native species									
Bluebunch wheatgrass	*	0	0	*	T	3	*	0	0
Silky lupine	*	†	†	*	†	†	*	†	†
Sandberg bluegrass	*	0	0	*	4	0	*	0	0
Canda bluegrass	*	0	0	*	0	0	*	4	2
Bottlebrush squirreltail	*	0	0	*	0	0	*	1	0
Needle-and-thread	*	0	0	*	10	0	*	0	0
% of site covered by above taxa	41	97	91	34	89	100	36	93	97

§Percent of original seeded site.
*Not reported.
†Scattered throughout site, without area dominance.

Table 4. Yields of ten best adapted grasses at three northeast Washington sites, 1959, 1968 and 1978.

Location and species	Standing Crop Yield (kg/ha) 1959		1968		1978		Average Yield by species location	
Harrington								
Fairway crested wheatgrass	AB*	2477(5)§	A	1219(5)	AB	1861(5)	A	1852
Commercial crested wheatgrass	AB	2464(6)	A	1308(6)	AB	1971(6)	A	1915
Nordan crested wheatgrass	A	3311(4)	A	1337(4)	AB	1643(4)	A	2097
Tall wheatgrass	B	1320(1)	A	1078(1)	B	000(1)	B	799
Intermediate wheatgrass	B	1563(9)	A	939(9)	AB	1392(9)	AB	1298
Siberian wheatgrass	B	1848(5)	A	873(5)	AB	1033(5)	AB	1252
Whitmar bluebunch wheatgrass	B	1500(3)	A	476(3)	AB	394(3)	B	798
Pubescent wheatgrass	B	1499(4)	A	898(4)	AB	1591(4)	AB	1330
Hard fescue	B	1705(4)	A	798(4)	A	2389(4)	AB	1597
Big bluegrass	AB	2642(2)	A	1381(2)	AB	2065(2)	A	2029
Republic								
Fairway crested wheatgrass	CD	976(6)	CDE	679(6)	A	1822(6)	BC	1159
Commercial crested wheatgrass	B	1942(7)	AB	1515(7)	B	752(7)	AB	1403
Nordan crested wheatgrass	A	2766(2)	A	1637(2)	B	776(2)	A	1726
Tall wheatgrass	E	138(7)	DE	115(7)	B	000(7)	E	84
Intermediate wheatgrass	CD	1105(8)	BCD	877(8)	AB	889(8)	BCD	957
Siberian wheatgrass	DE	518(2)	E	000(2)	B	184(2)	E	234
Whitmar bluebunch wheatgrass	BC	1690(7)	ABC	1147(7)	AB	862(7)	AB	1233
Pubescent wheatgrass	BCD	1208(7)	CDE	729(7)	B	758(7)	BCD	898
Hard fescue	DE	555(7)	DE	363(7)	AB	975(7)	CDE	631
Big bluegrass	BCD	1276(4)	CDE	392(4)	B	000(4)	DE	556
Riverside								
Fairway crested wheatgrass	AB	932(5)	CD	129(5)	C	000(5)	CD	354
Commercial crested wheatgrass	AB	924(4)	ABC	445(4)	B	896(4)	BC	755
Nordan crested wheatgrass	AB	1129(5)	CD	118(5)	BC	768(5)	BC	671
Tall wheatgrass	ABC	632(5)	AB	559(5)	BC	507(5)	BC	566
Intermediate wheatgrass	A	1397(6)	ABC	474(6)	B	1172(6)	B	1014
Siberian wheatgrass	AB	795(4)	CD	76(4)	C	000(4)	CD	290
Whitmar bluebunch wheatgrass	AB	989(4)	A	712(4)	A	3040(4)	A	1580
Pubescent wheatgrass	ABC	708(5)	CD	272(5)	B	1014(5)	BC	664
Hard fescue	BC	595(5)	CD	120(5)	BC	678(5)	CD	464
Big bluegrass	C	000(6)	D	000(6)	C	000(6)	D	0
Average yield by year	A	1288	B	988	C	677		

*Duncan's multiple range. Yields with the same letter are not significantly different at the 5% level.
§Figures in parentheses are numbers of plots represented in yield means.

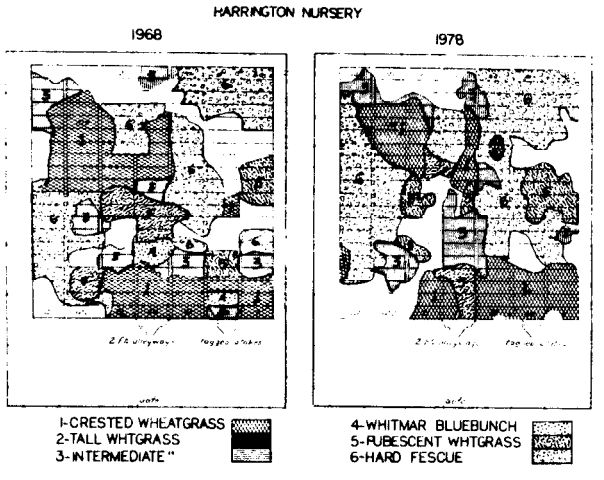

Fig. 2. *Population dominance areas at Harrington site, 1968 and 1978.*

adapted to that site and in the period between 1968 and 1978 lost only small areas to competition, although areas of dominance shifted within its boundaries. The unshaded parts (Fig. 2) were dominated primarily by cheatgrass and a mixture of seeded and native plants. Cheatgrass is well adapted to invade plots abandoned by unsuccessful taxa, or to vigorously compete with seedlings of all perennials (Harris 1967). Observations in 1983 revealed that hard fescue seedlings scattered over the site in 1968 and 1978 were actually the forerunners of an invading population of that taxa.

In 1968 at the Republic site all of the more aggressive taxa were invading nearby plot areas as well as adjacent native plant stands. Hard fescue had increased from 4% coverage in 1951 to 24% in 1968 (Table 3, Fig. 3 and 5). Crested, intermediate, Whitmar and pubescent wheatgrasses had likewise expanded coverage from their original seeded plots all across the site. Big bluegrass, smooth brome (*Bromus inermus* Leys), and western wheatgrass (*A. smithii* Rydb.) were evident in small amounts, located in the unshaded areas of Figure 3. St. Johnswort (*Hypericum perforatum* L.), was invading all seeded populations except hard fescue. Needle-and-thread (*Stipa comata* Trin. and Rupr.), a native perennial grass common to secondary seres in this area, had become established in peripheral areas, along with Sandberg bluegrass (*Poa secunda* Presl.) a unbiguitous native understory species. Cheatgrass was scattered throughout the site, and in control of 4% of the area.

By 1978, hard fescue had expanded its control to more than half (56%) of the Republic site, displacing crested, intermediate, Whitmar, and pubescent wheatgrasses, as well as cheatgrass, needle-and-thread, smooth brome, and western wheatgrass populations

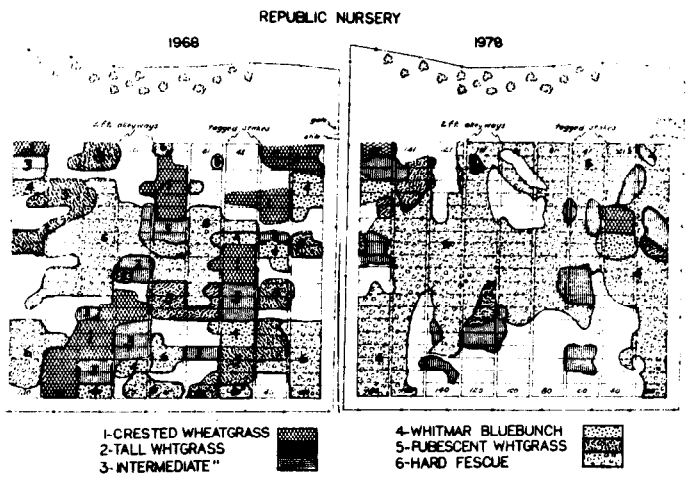

Fig. 3. *Population dominance areas at Republic site, 1968 and 1978.*

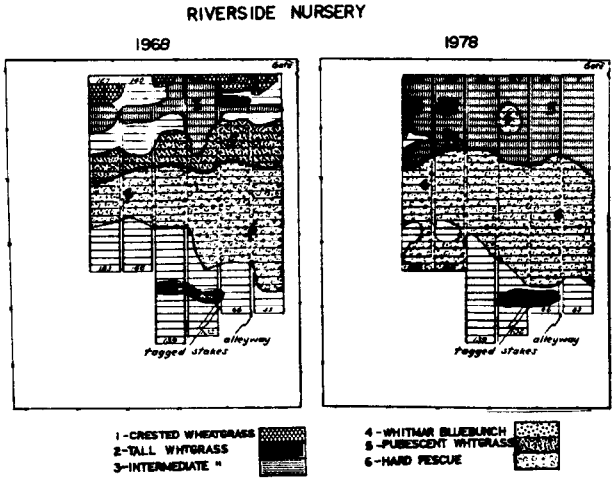

Fig. 4. *Population dominance areas at Riverside site, 1968 and 1978.*

from all or parts of areas dominated 10 years earlier (Fig. 3). St. Johnswort had substantially increased its presence, and diffuse knapweed (*Centauria diffusa* Lam.), another exotic perennial weed, had appeared on the site. Both noxious weeds demonstrated the capacity to thoroughly invade all but hard fescue populations. Hard fescue and these weeds had continued to further expand across the site when observed in 1983.

Fewer seeded taxa were fitted to the Riverside site than at Harrington or Republic (Fig. 4). At this site the taxa were arranged in plots so that as additions were made in successive seasons, the same taxa were planted in an adjacent row in the next column. Thus all the crested wheatgrass was planted across the top row of plots in Figure 4, and so on throughout the list of taxa. This gave the 1968 map a definite horizontal bias.

In 1968, 25% of the site was dominated by hard fescue. Pubescent, intermediate, and crested wheatgrass populations had expanded moderately since first planted. Tall wheatgrass, green needlegrass (*Stipa viridula* Trin.) and Idaho fescue (*F. idahoensis* Elmer) were present only on part of the plots where they were originally planted and are not considered to be well fitted to the site. Canada bluegrass (*P. compressa* L.) a native perennial, had invaded several plots where seeded taxa had failed. Spanish clover (*Lotus purshianus* [Benth] C. & C.) a native annual forb, competed vigorously and displaced cheatgrass in part. Bottlebrush squirreltail [*Sitanion hystrix* (Nutt.) S.G. Sm.] a native seral grass, invaded a small area on one side of the site. Most of the more than 50 taxa originally planted here were evaluated as maintaining satisfactory stands in 1953 (Evanko 1955).

By 1978 hard fescue controlled half of the entire Riverside site by invading and displacing stands of Spanish clover, Canada bluegrass, bottle-brush squirreltail, and cheatgrass. Intermediate wheatgrass had reduced crested wheatgrass and pubescent wheatgrass as dominants, and covered 20% of the site. However, 1983 observations found these 2 latter taxa still present and functioning as significant co-dominants with intermediate wheatgrass in areas mapped as intermediate in 1978 (Fig. 4). Also, as at the other sites, hard fescue continued to expand its area of dominance. Individual pioneer plants of hard fescue were scattered throughout the site, and their presence indicated continued expansion of this taxa when observed in 1983.

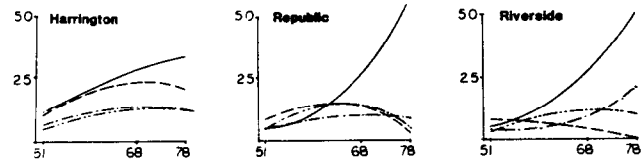

Fig. 5. *Diagrams of 27 year changes in percent area dominance, 1951, '68, and '78, at three nursery sites (Hard fescue, solid line; crested wheatgrass, dashed; intermediate wheatgrass, dot-dash; pubescent wheatgrass, dot-dot-dash). See Table 3 and Figures 2, 3, and 4.*

Differences in population dynamics of the major seeded species are clearly evident in Figure 5. Again, it is obvious that hard fescue is more competitive in Republic and Riverside habitats than at Harrington. At Republic and Riverside, hard fescue dominance has increased at an accelerated rate to occupy 50% and more of these sites by 1978. In the future it might be expected that hard fescue curves in Figure 5 will flex and begin to level off as they

Table 5. Average yields by site and taxa, combined plots and years, 1968 and 1978 (kg/ha).

Taxa	Harrington		Republic		Riverside		Average	
				Kg/ha				
Commercial wheatgrass	A	1915	AB	1403	BC	755	A	1431
Nordan wheatgrass	A	2097	A	1726	BC	671	A	1382
Whitmar wheatgrass	B	790	AB	1233	A	1580	AB	1237
Fairway wheatgrass	A	1852	BC	1159	CD	354	ABC	1124
Intermediate wheatgrass	AB	1298	BCD	957	B	1014	ABCD	1105
Pubescent wheatgrass	AB	1330	BCD	898	BC	664	BCD	933
Hard fescue	AB	1597	CDE	631	CD	464	CDE	821
Big bluegrass	A	2029	DE	556	D	00	EF	524
Tall wheatgrass	B	800	E	84	BC	566	F	324
Average	A	1288	B	988	C	677		

[1]Yields with the same letters are not significantly different at .05 probability as determined by Duncan's multiple range.

approach 100% nursery area coverage. This is typical of logistic population development, and follows the classical sine curve. Of the 3 major competing wheatgrases, intermediate was more resistant to replacement, trailed by pubescent and crested wheatgrasses. Native and exotic species previously invading these sites have also receded before the recruitment pressure of hard fescue.

At Harrington site, hard fescue has been measureably less aggressive, and the wheatgrasses relatively more competitive. There has also been more competition exerted by other seeded native and exotic taxa (particularly by cheatgrass) for plot areas abandoned by unfit taxa. Total area dominated by taxa listed in Table 3 dropped from 97% in 1968 to 91% in 1978, including 6% increase in cheatgrass over this period. Superior soil texture and depth at Harrington site (Table 1) appear to reduce the differences in recruitment and survival ability between hard fescue and competing taxa. The flex point in the sine curve has apparently been passed for hard fescue at this site and maximum coverage will presumably level off below 50%.

Standing crop yield data for selected years are presented in Table 4. These yields were produced under conditions of intense interspecific or intraspecific competition (presumably for soil moisture and nutrients). By 1959, and thereafter, all of the bare soil spaces opened by site preparation and plot weeding activities had been reinvaded to full site capacity, under prevailing conditions, by aggressive seeded perennials, or annuals and perennials from adjacent borders. Thus, yield performance of a particular seeded taxa is inextricably confounded with differing intensities of competition imposed by an unknown variety of neighbors.

Examination of yield data in Table 4 in connection with site coverage data in Table 3 reveals that a few taxa show significant ($P>.05$) yields on sites where their site coverage is zero. Note, for example, big bluegrass yields and site coverage at Harrington and Republic in 1978. Yields in these examples, and a few others, were clipped from spots too small to be mapped out separately in the site coverage matrix at the scale used.

Average yields were greatest at Harrington and least at Riverside (Table 5). This was true for all taxa except Whitmar bluebunch wheatgrass, which reversed the general trend. The Harrington site received the least precipitation, but has the finest textured and deepest solum (Table 1 and Fig. 1) as noted above. Conversely, the Riverside site received the highest average annual precipitation but has the coarsest textured and shallowest soil. Inasmuch as competition for soil moisture and nutrients is known to be limiting on these sites, it may be assumed that differences in soil characteristics (primarily texture and underlying drainage structures) more than compensated for the increased precipitation received at Riverside, as expressed in standing crop yield.

Commercial and Nordan wheatgrass populations were highest producers overall, and tall wheatgrass the lowest (Table 5), although variability within taxa reduced statistical significance of differences noted. All recommended taxa yielded sufficient amounts to justify use in range seedings as one or more of the test sites, particularly in monospecific stands.

Conclusions

Grass species used in seeding semiarid ranges of northeast Washington differ significantly in ability to establish through the environmental sieve, recruit posterity, and survive in the long-term. Crested, desert, Whitmar bluebunch, intermediate, pubescent, Siberian and tall wheatgrass, big bluegrass, and hard fescue are recommended as sufficiently fitted to sites where tested to be useful in long-term range seedings if proper steps are taken in establishment. The other 51 taxa planted were much less successful, and are not recommended except in situations of predetermined site suitability.

Species interactions are highly site-specific. Each site demonstrated a different and complex schedule of dynamics. Hard fescue appears to be capable of fully dominating Republic and Riverside sites, but less so at Harrington. Crested wheatgrasses were highest standing crop producers, but all recommended taxa yielded sufficient amounts to be useful.

Among the 10 recommended, correct taxa selection may depend on individual species characteristics other than reported here. Hard fescue proved to have some outstanding demographic qualities, but palatability for livestock is low, as is yield. It is best suited for erosion control, ground cover, and to close sites to serious noxious weed invasion. The crested wheatgrasses are most valuable for early spring forage before becoming tough and unpalatable in early summer. Intermediate, tall, and Whitmar wheatgrasses extend the green forage season into mid-summer, but intermediate is the only highly palatable one of the 3.

Species mixtures in range seedings are unstable particularly in the longer-term. Hard fescue will eventually dominate most species complexes on sites reported here. It is suggested that monospecific populations of suitable species, selected to fit seasonal or other requirements, and fenced out separately, may be more economical to establish, and simpler to manage in grazing systems than species mixtures.

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