Seed Germination and Storability Studies of 69 Plant Taxa Native to the Willamette Valley Wet Prairie

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Abstract

Seeds of 69 taxa native to the Willamette Valley, Oregon were subjected to four germination treatments: two under ambient late winter into summer environmental conditions (untreated (fresh) seed or dry and frozen seed) and two in controlled environment chambers (some seed was cold stratifed at 5°C then placed in a 10°C/20°C chamber, other seed was placed in 10°C/20°C chamber then moved to a 5°C/15°C chamber). At least 93% of the taxa tested can tolerate desiccation and frozen storage.

One third of the taxa had a maximum mean germination above 80% in at least one of the four germination treatments, 55% of the taxa had a maximum mean germination rate between 10% and 80%, and only 12 % of the taxa had less than 10% germination. A total of 88% of the taxa had their highest germination in one or both of the two treatments, fresh and cold stratification.

Keywords

seed germination, seed storage, cold stratification, native species, wetlands, Willamette valley

Introduction

Restoring degraded Willamette Valley wet prairie habitat is a goal central to a large number of public agencies and private organizations united under the banner of the West Eugene Wetlands Project. Ecological restoration is a complex task requiring specific information about many factors ranging from seed germination characteristics of individual species to the subtle web of ecological relationships among the many species that comprise a community, and their relationship to the abiotic environment.

This is a study of seed germination and storability of 69 species native to the Willamette Valley wet prairie habitat (Guerrant and Raven 1995, hereafter G&R). This work was designed to provide baseline data on which wet prairie species germinate readily under more or less natural conditions, and those which may need more highly controlled conditions. This project also provides information on which species are amenable to long term storage.

Materials and Methods

Seeds were collected during 1992 and 1993 by E. Alverson of The Nature Conservancy. They were stored in paper bags at ambient, indoor conditions at the Berry Botanic Garden (BBG) until used. Seeds (including single seeded fruits, e.g. Asteraceae) were hand cleaned and counted. Only apparently good seeds were used.

Seeds were subjected to four germination treatments. Two were conducted under ambient late winter into summer environmental conditions (on untreated or Fresh seed (F), or Dried at 15% RH under ambient indoor temperatures and then frozen seed (D)) and the other two in controlled environment chambers. One, Cold Stratification (CS) involved refrigerating imbibed seed at 5°C for six weeks then placing them into a chamber set at 10°C/20°C (8/16 hrs, dark/light) for six weeks. The other, Warm to Cold (WC), placed the seeds first in the warmer chamber for six weeks then moved them to a colder chamber (5°C/15°C) for six weeks.

For each cold frame treatment (F and D), five replicates of 50 seeds each (with some exceptions, see G&R) were placed in 4 inch pulp pots in a mixture of sand, pumice and sifted peat (1:1:1). Seeds were planted at a depth of two to three times their height. In the case of smaller seeds (e.g. *Downingia elegans*), seeds were sprinkled on the surface of the soil and lightly covered with sand. The pots were sunk into a sand bed in a cold frame in a randomized block design (G&R) and protected from sun and rain as necessary. Seeds were watered as necessary and seedlings counted weekly.

Five replicates of 50 seeds each for the controlled environment treatments (CS and WC) were stored in paper bags at ambient indoor conditions until being placed and moistened on Kimpac™ germination paper in plastic petri dishes 60 mm x 15 mm in diameter. Plates were assigned random positions within the germination chambers and repositioned weekly. Seeds in the two chambers were surveyed weekly for germination (appearance of the radicle), and moistened as needed. Captan™ was used to treat fungal infection. Seeds that were obviously decaying were removed.

Results

Germination was > 80% in 33% of the taxa (23/69), between 10% and 80% in 55% (38/69) taxa, and <10% in the remaining 12% (8/69).

The proportion of seed that germinated in each of the four treatments is presented in Table 1, along with the results of the ANOVA. Due to insufficient seed, only two treatments (F and D) were conducted on *Asclepias fascicularis* and *Eryngium petiolatum*.

Losses to fungal decay were typically less than 2% and none were above 5% except for *Eriophyllum lanatum* (46% in CS, and 52% in WC), *Haplopappus racemosus* (19%, and 23%), *Wyethya angustifolia* (45%, and 48%), and in WC only for *Aster hallii* (11%), *Perideridia gairdneri* (22%) and *P. oregana* (12%). Many apparently good achenes of these Asteraceae were later discovered to be empty.

In one case (*Eryngium petiolatum*) there were not enough seeds to have replicate treatments so no statistical tests are possible. Of the remaining 68 taxa, there were significant treatment effects at the $p < 0.05$ level in 59 taxa (87%) tested, of which 48 taxa (71%) were significant at the $p = 0.001$ level. The amount of the variation among treatments that is explained by the treatments is generally quite high, with 33 taxa having a Multiple R^2 value over 0.8 (i.e. treatments explained over 80% of the variation in the differences observed).

Lack of statistical tests notwithstanding, 100% of the eleven *Eryngium* seeds in the D treatment germinated, so the taxon can tolerate frozen storage. Because there was no germination in either the F or D treatment for two taxa (*Eleocharis palustris* and *Sisyrinchium cusickii*), no conclusions about their storability can be drawn. There was a significant reduction in the germination proportion of the seeds subjected to the D treatment,

Table 1. Mean proportion of germinated seed with standard deviations, and results of statistical tests, by taxon and treatment. N=5 for all cases except for *Eryngium*, where N=1. DE&D refers to the maximum germination found by Drake, Ewing and Dunn (1998) for taxa also studied here. The results of the ANOVA are expressed in two parameters: The Multiple R^2 value, which can vary between 0 and 1, expresses the proportion of the variation in the data that is explained by the treatments (the higher the value, the greater amount of the variation that is explained by the treatments); and the p-value, which is the probability of obtaining the data by chance (the lower the 'p-value', the less likely the result can be attributed to chance). The standard of significance used throughout table is $p<0.05$. The pst-hoc column refers to the results of the ANOVA in combination with the post-hoc Scheffe test (where the symbol "~" indicates a value approaching significance $0.05<p<0.10$)): X= no statistical comparision possible; N=ANOVA not significant; A=ANOVA significant, but no pairwise post-hoc comparision results significant ;W= one treatment significantly better than all others; L= one treatment significantly worse than all others; CW=CS and WC both better than F and D (after ripening?); FD= F and D both better than CS and WC (age fast, induced dormancy, soil factor?); and, O= Other, do not fit into any of the above categories.

Taxon	Family	Fresh	Dry+Freeze	Cold Strat.	Warm Cold	ANOVA R^2	ANOVA p-value	pst-hoc	DE&D
Achillea millefolium	Asteraceae	0.016±0.017	0.000±0.000	0.012±0.027	0.024±0.026	0.182	0.345	N	
Allium amplectens	Liliaceae	0.680±0.133	0.676±0.097	0.666±0.142	0.004±0.009	0.899	<0.001	L	
Alopecurus geniculatus	Poaceae	0.028±0.023	0.028±0.023	0.855±0.063	0.960±0.024	0.994	<0.001	W,CW	
Asclepias fasicularis	Asclepiadaceae	0.173±0.101	0.040±0.089	-----	------	0.379	0.058	N	
Aster hallii	Asteraceae	0.048±0.011	0.064±0.033	0.140±0.063	0.140±0.063	0.494	0.011	A	
Beckmannia syzigachne	Poaceae	0.268±0.098	0.232±0.084	0.406±0.157	0.723±0.067	0.804	<0.001	W	
Bidens frondosa	Asteraceae	0.180±0.196	0.016±0.036	0.776±0.195	0.060±0.080	0.847	<0.001	W	
Boisduvalia densiflora	Onagraceae	0.680±0.152	0.696±0.166	0.976±0.017	0.948±0.023	0.717	<0.001	CW	
Brodiaea hyacinthina	Liliaceae	0.568±0.191	0560±0.102	0.024±0.036	0.000±0.000	0.888	<0.001	FD	
Camassia leichtlinii	Liliaceae	0.956±0.022	0.908±0.039	0.976±0.009	0.772±0.069	0.823	<0.001	L	
Camassia quamash	Liliaceae	0.480±0.057	0.464±0.022	0.900±0.040	0.024±0.017	0.989	<0.001	W,L	85%
Carex aurea	Cyperaceae	0.656±0.048	0.696±0.135	0.032±0.030	0.000±0.000	0.962	<0.001	FD	
Carex densa	Cyperaceae	0.060±0.098	0.093±0.072	0.507±0.136	0.040±0.043	0.840	<0.001	W	
Carex leporina	Cyperaceae	0.088±0.077	0.064±0.043	0.120±0.087	0.108±0.077	0.096	0.645	N	
Carex tumulicola	Cyperaceae	0.020±0.035	0.032±0.033	0.400±0.170	0.192±0.100	0.741	<0.001	W	
Carex unilateralis	Cyperaceae	0.036±0.041	0.168±0.073	0.241±0.101	0.140±0.093	0.513	0.008	O	
Centunculus minimus	Primulaceae	0.106±0.026	0.020±0.014	0.067±0.048	0.004±0.009	0.472	0.015	O	
Danthonia californica	Poaceae	0.072±0.077	0.080±0.024	0.867±0.073	0.576±0.073	0.971	<0.001	W,CW	
Deschampsia cespitosa	Poaceae	0.724±0.041	0.692±0.077	0.840±0.040	0.864±0.089	0.612	<0.001	O,~CW	
Dodecatheon pulchellum	Primulaceae	0.484±0.122	0.592±0.095	0.224±0.118	0.000±0.000	0.875	<0.001	L,FD	44%
Downingia elegans	Campanulaceae	0.928±0.064	0.904±0.068	0.744±0.104	0.924±0.084	0.520	0.007	O,~L	
Eleocharis palustris	Cyperaceae	0.000±0.000	0.000±0.000	0.028±0.023	0.000±0.000	0.586	0.002	W	
Epilobium paniculatum	Onagraceae	0.156±0.100	0.168±0.023	0.815±0.044	0.793±0.069	0.967	<0.001	CW	
Eriophyllum lanatum	Asteraceae	0.192±0.102	0.161±0.067	0.243±0.108	0.267±0.061	0.224	0.243	N	31%
Eryngium petiolatum	Apiaceae	0.909	1.000	----------	----------	----	----	X	
Festuca rubra	Poaceae	0.680±0.068	0.852±0.078	0.904±0.067	0.899±0.020	0.727	<0.001	L	
Gentiana sceptrum	Gentianaceae	0.100±0.100	0.200±0.282	0.000±0.000	0.000±0.000	0.277	0.149	N	
Geranium oreganum	Gerianiaceae	0.933±0.082	0.893±0.101	0.360±0.138	0.053±0.087	0.940	<0.001	L,FD	
Geum macrophyllum	Rosaceae	0.852±0.050	0.644±0.128	0.964±0.038	0.968±0.011	0.808	<0.001	L	
Glyceria occidentalis	Poaceae	0.060±0.040	.0140±0.068	0.464±0.088	0.904±0.048	0.972	<0.001	W,CW	

(Table 1. continued)

Taxon	Family	Fresh	Dry+Freeze	Cold Strat.	Warm Cold	ANOVA R^2	ANOVA p-value	pst-hoc	DE&D
Grindelia integrifolia	Asteraceae	0.512±0.168	0.524±0.159	0.000±0.000	0.008±0.011	0.860	<0.001	FD	
Haplopappus racemosa	Asteraceae	0.200±0.086	0.180±0.053	0.487±0.087	0.116±0.043	0.830	<0.001	W	
Heracleum lanatum	Apiaceae	0.088±0.033	0.064±0.022	0.000±0.000	0.000±0.000	0.826	<0.001	FD	
Hordeum brachyantherum	Poaceae	0.972±0.033	0.984±0.030	0.984±0.009	0.925±0.017	0.561	0.004	O,~L	
Horkelia congesta	Rosaceae	0.210±0.139	0.230±0.175	0.105±0.042	0.000±0.000	0.449	0.020	O	
Juncus tenuis	Juncaceae	0.032±0.039	0.004±0.009	0.052±0.106	0.792±0.060	0.971	<0.001	W	
Lasthenia glaberrima	Asteraceae	0.044±0.022	0.048±0.027	0.431±0.108	0.960±0.047	0.979	<0.001	W,CW	
Lomatium nudicaule	Apiaceae	0.700±0.275	0.860±0.130	0.500±0.075	0.060±0.051	0.817	<0.001	L	
Lomatium utriculatum	Apiaceae	0.696±0.098	0.756±0.062	0.833±0.059	0.780±0.078	0.345	0.073	N	59%
Lotus formosissimus	Fabaceae	0.048±0.039	0.032±0.050	0.012±0.011	0.004±0.009	0.259	0.177	N	
Lotus pinnatus	Fabaceae	0.072±0.030	0.052±0.058	0.004±0.009	0.000±0.000	0.524	0.007	O	
Lotus purshianus	Fabaceae	0.384±0.038	0.164±0.043	0.112±0.036	0.075±0.037	0.922	<0.001	W	
Lupinus polyphyllus	Fabaceae	0.216±0.038	0.620±0.066	0.088±0.033	0.104±0.026	0.968	<0.001	W,FD	
Luzula campestris	Juncaceae	0.310±0.089	0.540±0.305	0.330±0.168	0.883±0.101	0.655	0.001	O,~W	58%
Madia elegans	Asteraceae	0.484±0.055	0.464±0.033	0.826±0.060	0.731±0.124	0.841	<0.001	CW	
Madia sativa	Asteraceae	0.548±0.176	0.556±0.164	0.952±0.039	0.948±0.030	0.767	<0.001	CW	
Microseris laciniata	Asteraceae	0.472±0.091	0.402±0.151	0.240±0.076	0.660±0.114	0.695	<0.001	O	
Microsteris gracilils	Polemoniaceae	0.232±0.112	0.064±0.079	0.931±0.047	0.812±0.059	0.965	<0.001	L,CW	
Myosotis laxa	Boraginaceae	0.668±0.526	0.588±0.336	0.948±0.033	0.972±0.022	0.267	0.164	N	
Navarretia intertexta	Polemoniaceae	0.036±0.033	0.020±0.024	0.839±0.111	0.232±0.106	0.956	<0.001	W,CW	
Orthocarpus bracteosus	Scrophulariaceae	0.000±0.000	0.004±0.009	0.568±0.087	0.008±0.018	0.974	<0.001	W	
Orthocarpus hispidus	Scrophulariaceae	0.004±0.009	0.004±0.009	0.135±0.100	0.000±0.000	0.620	0.001	W	
Panicum occidentale	Poaceae	0.012±0.018	0.064±0.026	0.044±0.050	0.012±0.018	0.393	0.042	A	
Perideridia gairdneri	Apiaceae	0.252±0.027	0.352±0.104	0.104±0.033	0.000±0.000	0.878	<0.001	FD,~L	
Perideridia oregana	Apiaceae	0.916±0.048	0.808±0.179	0.404±0.065	0.208±0.046	0.911	<0.001	FD,~L	
Plectritis congesta	Valerianaceae	0.176±0.043	0.192±0.098	0.470±0.125	0.540±0.110	0.770	<0.001	CW	
Potentilla gracilis	Rosaceae	0.196±0.048	0.171±0.051	0.416±0.105	0.020±0.014	0.861	<0.001	W,L	21%
Prunella vulgaris var. *lanceolata*	Lamiaceae	0.712±0.262	0.608±0.221	0.952±0.034	1.000±0.000	0.528	0.006	O	17%
Ranunculus occidentalis	Ranunculaceae	0.211±0.059	0.177±0.089	0.866±0.057	0.907±0.027	0.974	<0.001	CW	52%
Ranunculus orthorhynchus	Ranunculaceae	0.340±0.104	0.232±0.039	0.146±0.069	0.132±0.050	0.637	0.001	O	
Rorippa curvisiliqua	Brassicaceae	0.008±0.018	0.044±0.064	0.024±0.033	0.024±0.026	0.117	0.563	N	
Rumex salicifolius	Polygonaceae	0.596±0.086	0.640±0.121	0.736±0.072	0.766±0.063	0.432	0.025	A	
Saxifraga oregana	Saxifragaceae	0.020±0.035	0.016±0.036	0.434±0.232	0.024±0.022	0.739	<0.001	W	
Sidalcea cusickii	Malvaceae	0.104±0.052	0.348±0.084	0.232±0.050	0.156±0.055	0.732	<0.001	O,~W	
Sisyrinchium hitchcockii	Iridiaceae	0.000±0.000	0.000±0.000	0.064±0.030	0.016±0.017	0.748	<0.001	W	
Trichostema oblongum	Lamiaceae	0.812±0.199	0.504±0.379	0.000±0.000	0.000±0.000	0.766	<0.001	FD	
Veronica americana	Scrophulariaceae	0.224±0.055	0.252±0.190	0.968±0.033	0.928±0.078	0.932	<0.001	CW	
Wyethia angustifolia	Asteraceae	0.420±0.055	0.451±0.099	0.160±0.063	0.012±0.011	0.908	<0.001	L,FD	
Zigadenus venenosus	Liliaceae	0.252±0.141	0.236±0.059	0.331±0.055	0.000±0.000	0.742	<0.001	L	72%

relative to the F treatment in only 3 taxa (*Geum macrophyllym*, *Lotus purshianus*, and *Microsteris gracilis*). In the other 63 cases, there were not statistically significant differences between the F and D germination rates, indicating a strong majority of species are able to survive being stored dry and frozen. A significant increase in germination proportion of D seed relative to F seed was found in three taxa (*Festuca rubra*, *Lupinus polyphyllus*, and *Sidalcea cusickii*).

Cold stratification (CS) yielded statistically better germination than all other treatments for 19% of the taxa (13/68): *Bidens frondosa*, *Camassia quamash*, *Carex densa*, *Carex tumulicola*, *Danthonia californica*, *Eleocharis palustris*, *Haplopappus racemosus*, *Navarretia intertexta*, *Orthocarpus bracteosus*, *Orthocarpus hispidus*, *Potentilla gracilis*, *Saxifraga oregana* and *Sisyrinchium hitchcockii*. Fresh (F) seed of *Lotus purshianus* germinated better than the other treatments and the D treatment was best for *Lupinus polyphyllus*. Warm stratification followed by colder conditions (WC) provided the greatest germination in 5 taxa (*Alopecurus geniculatus*, *Beckmannia syzigachne*, *Glyceria occidentalis*, *Juncus tenuis*, and *Lasthenia glaberrima*).

The F treatment yielded the lowest germination of the four treatments in *Festuca rubra*, while the D treatment was poorest in *Geum macrophyllum* and *Microsteris gracilis*. In no case was the CS treatment inferior to all others, while the WC treatment was the poorest in 9 (*Allium amplectens*, *Camassia leichtlinii*, *Camassia quamash*, *Dodecatheon pulchellum*, *Geranium oreganum*, *Lomatium nudicaule*, *Potentilla gracilis*, *Wyethia angustifolia*, and *Zigadenus venenosus*.

Cold Stratification (CS) and the Warm to Cold (WC) treatments were both statistically different than the Fresh and Dry treatments in 24 cases. The CS and WC treatments were jointly superior in 13: *Alopecurus geniculatus*, *Boisduvalia densiflora*, *Danthonia californica*, *Epilobium paniculatum*, *Glyceria occidentale*, *Lasthenia glaberrima*, *Madia elegans*, *Madia sativa*, *Microsteris gracilis*, *Navarretia intertexta*, *Plectritis congesta*, *Ranunculus occidentale*, and *Veronica americana*. The CS and WC treatments were inferior in 11: *Brodiaea hyacinthina*, *Carex aurea*, *Dodecatheon pulchellum*, *Geranium oreganum*, *Grindelia integrifolia*, *Heracleum lanatum*, *Lupinus polyphyllus*, *Perideridia gairdneri*, *Perideridia oregana*, *Trichostema oblongum*, and *Wyethia angustifolia*.

In some cases a taxon may fall into more than one category. Twelve taxa did not fit into any of the above categories, although five of them only marginally missed. They are: *Carex unilateralis*, *Centunculus minimus*, *Deschampsia cespitosa*, *Downingia elegans*, *Hordeum brachyantherum*, *Horkelia congesta*, *Lotus pinnatus*, *Luzula campestris*, *Microseris laciniata*, *Prunella vulgaris* var. *lanceolata*, *Ranunculus orthorhynchus*, and *Sidalcea cusickii*. In these taxa, there were some significant treatment effects, but not so pronounced as to have one treatment significantly better or worse than all others.

Discussion and Conclusions

We will focus the discussion on those aspects having particular relevance to potential restoration work.

Storability: Most Species Appear to Tolerate Drying and Frozen Storage

At least 93% (64/69) of the species examined can withstand drying and frozen storage without apparent ill effects. There was a significant reduction in germination proportion in Dry seed relative to Fresh seed in three species (*Geum macrophyllum*, *Lotus purshianus*, and *Microsteris gracilis*), indicating that they might not be well suited to dry storage. Nevertheless, the germination in these did not drop to 0%, so drying and freezing are not necessarily lethal.

The fact that most of these species can be stored also means that standard agricultural techniques can potentially be used to bulk up the numbers available for use in restoration. However, if they are grown off site to increase sample sizes, care must be taken to maintain the genetic integrity of the samples (Guerrant 1997). Possible deleterious effects associated with bulking up a sample in an agricultural setting include but are not limited to:

1. Loss of genetic diversity due to random drift and increased homozygosity (with attendant inbreeding depression) resulting from small initial sample sizes,
2. Genetic contamination from cross pollination in an agricultural

setting by members of the same species being grown too close together or by interspecific crossing with sexually compatible members of the same genus grown nearby (Ellstrand 1992, Ellstrand and Elam 1993), and

3. Introducing new diseases or pathogens acquired in an agricultural setting.

Germination Characteristics: Highly Variable Among Treatments and Taxa.

Maximum germination proportion varied widely among treatments ranging from a low of about 2% (*Achillea millefolium*) to a high of 100% (*Prunella vulgaris* var. *lanceolata*). This pattern can be compared with the results of a massive study of germination characteristics of 403 taxa found in the Sheffield region of Great Britain (Grime et al. 1981) and a more recent study of 35 species native to the Puget Trough, in WA state (Drake et al. 1998). The comparisons are not perfect, and should be viewed skeptically because the treatments and procedures used were not the same. Grime et al. (1981) found a relatively even distribution of germination among three broad ranges: 32% of the species had a germination rate of over 80%, 29% between 10% and 80%, while 39% had less than 10% germination. In a study of 35 taxa, Drake et al. (1998) found 6% had a germination rate higher than 80%, 57% with germination between 10% and 80%, and 37% with less than 10% germination. Relative to Grime et al., we found the Willamette Valley taxa had a similar proportion with high germination (33% of our taxa had greater than 80% germination), an overabundance with an intermediate germination rate (55% in our study had a germination between 10% and 80% germination), and relatively few poor germinators (12% with a germination less than 10%).

One take-home message is that it may not be reasonable to expect that all species will have a high germination rate. Our results are not necessarily discouraging because even medium or low germination rates may be acceptable in a restoration project if sufficient seed is available. These studies should be viewed as providing minimum estimates, because not all ungerminated seed is dead. For example, some species may have delayed germination, a possibility we did not examine systematically.

Comparison of Treatments

The results of the ANOVAs showed that the treatments tried here do significantly affect germination in 87% (59/68) of the taxa studied. Cold stratification was clearly superior to all other treatments in 13 taxa, the Warm to Cold (WC) treatment superior in an additional 5, and the Fresh (F) or Dry (D) treatments superior in only one taxon each. At the other extreme, the Cold Stratification (CS) treatment was not worse than all others for any taxa, while WC was clearly inferior for 9 taxa. The F treatment was a worst in 1 taxon (*Festuca*), but even then, 68% of the seeds germinated. The D treatment was clearly the poorest in two taxa (*Geum* and *Microsteris*), suggesting that these may not store well. Further work, however, is called for because the reduced germination may indicate induced dormancy.

There are two groups of 11 taxa each where both the CS and WC treatments did either significantly better or significantly worse than the F and D treatments. Although we cannot definitively explain these results, there are some interesting possibilities to consider. In the species where both CS and WC did better than both the F and D treatments, it is possible that we are seeing the effect of 'afterripening' (Baskin and Baskin 1998). Due to logistical constraints, the CS and WC treatments were conducted significantly later in time than the D and F treatments. The other group of taxa—where the WC and CS treatments did significantly poorer than the D treatments—are more problematical to explain. Given the delayed application of the CS and WC treatments and other differences between the two groups, we can think of three possible explanations. One is that survivorship had declined in the samples before the CS and WC treatments were applied. Another is that the seeds had developed some sort of 'induced dormancy' in the elapsed time. A third is that there could be some factor in the soil itself that was available in the F and D treatments but not in the CS and WC treatments (done in petri dishes), which stimulated the seeds to germinate.

In practical restoration work, it is easiest simply to sow fresh or dried seed into the field and subject them to ambient conditions of temperature and moisture. Therefore, we will view the

data from the perspective that where possible it is preferable not to have to resort to more difficult measures, such as the WC treatment. Overall, the F treatment yielded either the highest germination, or was statistically indistinguishable from the treatment that yielded the highest rate in 51% (35/68) of the taxa. Cold Stratified (CS) seed had the highest germination or was indistinguishable from the highest in 63% (43/68) of the taxa. Considering the two treatments together, a total of 88% (60/68) of the taxa had their highest germination in one or both of the treatments, F and CS.

The WC treatment was superior to all others in only 5 taxa, and in 4 of these the second place treatment was dramatically lower (*Beckmannia*, *Glyceria*, *Juncus*, and *Lasthenia*). Even though the WC treatment was best for *Alopecurus* (96% germination), the CS treatment was still relatively high (86%).

In summary, seeds of the vast majority of 69 species examined appear able to tolerate frozen storage and to germinate relatively easily. These results bode well for possible restoration of degraded wet prairie habitat in the Willamette Valley of Oregon.

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