

Electronic Supplementary Material (ESM)

**Appendix S1.** Grass variety data (means and standard deviations), including seed and seedling trait data, seedlot viability, and life stage transition probabilities.

**Do key dimensions of seed and seedling functional trait variation capture variation in recruitment probability?**

Julie E. Larson<sup>1\*†</sup>, Roger L. Sheley<sup>2</sup>, Stuart P. Hardegree<sup>3</sup>, Paul S. Doescher<sup>4</sup>, Jeremy J. James<sup>5</sup>

<sup>1</sup> Environmental Sciences Graduate Program, Oregon State University, Corvallis, OR 97330, USA

<sup>2</sup> United States Department of Agriculture-Agricultural Research Service, Burns, OR 97720, USA

<sup>3</sup> United States Department of Agriculture-Agricultural Research Service, Boise, ID 83712, USA

<sup>4</sup> College of Forestry, Oregon State University, Corvallis, OR 97330, USA

<sup>5</sup> Sierra Foothills Research and Extension Center, University of California Division of Agriculture and Natural Resources, Browns Valley, CA 95918, USA

\* Corresponding author

†Current address: School of Earth and Environmental Sciences, Chapman University, Orange, CA 92866, USA.

Email: jlarson@chapman.edu

Phone: (714)744-5614

*Submitted to Oecologia*

**Table S1** Seedling trait means and standard deviations for each grass variety. Standard deviations were not available for RGR plasticity (see Table 2 of the manuscript for calculation). Standard errors are given for RGR and RER. Data has not been transformed. Trait abbreviations, units and definitions are given in Table 2 of the manuscript.

| Species                        | Variety         | LDMC | LDMC (S.D.) | SLA   | SLA (S.D.) | SRL   | SRL (S.D.) | RMR  | RMR (S.D.) | RMi   | RMi (S.D.) | RGR   | RGR (S.E.) | RER   | RER (S.E.) | RGR Plasticity |
|--------------------------------|-----------------|------|-------------|-------|------------|-------|------------|------|------------|-------|------------|-------|------------|-------|------------|----------------|
| <i>Achnatherum lemmonii</i>    | n/a             | 33.0 | 0.91        | 112.9 | 3.4        | 90.3  | 19.3       | 0.24 | 0.06       | 12.18 | 3.39       | 0.061 | 0.019      | 0.027 | 0.027      | -0.683         |
| <i>Agropyron cristatum</i>     | Kirk            | 28.6 | 1.39        | 153.8 | 12.3       | 87.6  | 35.7       | 0.29 | 0.13       | 5.24  | 1.05       | 0.101 | 0.033      | 0.049 | 0.034      | -0.265         |
| <i>Agropyron cristatum</i>     | Fairway         | 25.5 | 1.59        | 215.8 | 14.6       | 96.5  | 33.8       | 0.34 | 0.04       | 6.88  | 1.64       | 0.112 | 0.024      | 0.078 | 0.019      | -0.208         |
| <i>Agropyron desertorum</i>    | Hycrest         | 25.3 | 3.18        | 177.0 | 39.0       | 81.5  | 13.7       | 0.39 | 0.02       | 6.51  | 4.59       | 0.076 | 0.020      | 0.057 | 0.026      | 0.237          |
| <i>Agropyron desertorum</i>    | Hycrest II      | 27.9 | 1.93        | 152.0 | 5.4        | 89.9  | 15.2       | 0.27 | 0.04       | 5.68  | 1.04       | 0.098 | 0.019      | 0.068 | 0.018      | -0.071         |
| <i>Agropyron desertorum</i>    | Nordan          | 27.6 | 0.57        | 154.5 | 9.4        | 97.3  | 19.7       | 0.27 | 0.09       | 5.74  | 3.04       | 0.104 | 0.019      | 0.078 | 0.011      | 0.044          |
| <i>Agropyron fragile</i>       | Vavilov II      | 26.0 | 1.16        | 171.7 | 16.3       | 73.4  | 16.3       | 0.37 | 0.07       | 6.02  | 0.80       | 0.112 | 0.009      | 0.078 | 0.021      | -0.111         |
| <i>Agropyron fragile</i>       | Vavilov         | 29.2 | 1.27        | 160.8 | 17.6       | 70.8  | 36.2       | 0.34 | 0.10       | 6.02  | 1.67       | 0.078 | 0.019      | 0.029 | 0.027      | 0.258          |
| <i>Agropyron fragile</i>       | P27             | 30.3 | .           | 133.2 | .          | 95.2  | .          | 0.39 | .          | 7.09  | 0.91       | 0.094 | .          | 0.084 | .          | 0.079          |
| <i>Bromus inermis</i>          | Manchar         | 25.4 | 1.84        | 223.7 | 21.3       | 97.9  | 17.4       | 0.41 | 0.05       | 7.52  | 2.18       | 0.101 | 0.020      | 0.083 | 0.030      | -0.230         |
| <i>Bromus inermis</i>          | Lincoln         | 27.6 | 1.24        | 161.6 | 7.4        | 46.1  | 3.0        | 0.47 | 0.04       | 7.00  | 0.93       | 0.120 | 0.011      | 0.079 | 0.010      | -0.425         |
| <i>Bromus japonicus</i>        | n/a             | 23.4 | 2.09        | 219.8 | 27.9       | 62.3  | 17.0       | 0.38 | 0.06       | 2.88  | 0.55       | 0.118 | 0.011      | 0.087 | 0.013      | -0.102         |
| <i>Bromus riparius</i>         | Cache           | 25.2 | 0.28        | 181.3 | 13.6       | 68.5  | 27.2       | 0.34 | 0.17       | 10.88 | 6.24       | 0.087 | 0.021      | 0.041 | 0.007      | -0.114         |
| <i>Bromus riparius</i>         | Regar           | 26.3 | 2.37        | 175.1 | 19.8       | 83.4  | 21.4       | 0.32 | 0.20       | 14.33 | 5.69       | 0.071 | 0.013      | 0.022 | 0.031      | 0.143          |
| <i>Bromus tectorum</i>         | n/a             | 23.3 | 1.35        | 211.7 | 42.2       | 131.4 | 9.9        | 0.29 | 0.00       | 3.01  | 0.13       | 0.113 | 0.008      | 0.105 | 0.007      | 0.196          |
| <i>Elymus elymoides</i>        | Antelope Creek  | 31.3 | 1.97        | 141.9 | 3.4        | 78.8  | 19.3       | 0.30 | 0.03       | 8.44  | 2.45       | 0.079 | 0.027      | 0.043 | 0.022      | -0.122         |
| <i>Elymus elymoides</i>        | Toe Jam Creek   | 32.6 | 1.60        | 116.0 | 11.7       | 57.4  | 19.0       | 0.37 | 0.10       | 6.50  | 2.82       | 0.083 | 0.014      | 0.044 | 0.032      | -0.409         |
| <i>Elymus elymoides</i>        | Fish Creek      | 31.2 | 2.33        | 150.9 | 6.4        | 84.7  | 35.2       | 0.33 | 0.14       | 4.97  | 2.83       | 0.088 | 0.019      | 0.048 | 0.025      | -0.262         |
| <i>Elymus elymoides</i>        | Rattlesnake     | 30.7 | 0.75        | 151.9 | 15.0       | 46.9  | 10.2       | 0.46 | 0.19       | 6.00  | 0.81       | 0.092 | 0.012      | 0.064 | 0.017      | -0.165         |
| <i>Elymus lanceolatus</i>      | Bannock         | 30.7 | 3.44        | 115.7 | 23.9       | 96.9  | 24.5       | 0.35 | 0.01       | 9.28  | 7.67       | 0.062 | 0.026      | 0.057 | 0.019      | 0.198          |
| <i>Elymus lanceolatus</i>      | Critana         | 25.8 | 3.33        | 162.8 | 26.2       | 117.5 | 20.6       | 0.28 | 0.06       | 4.48  | 4.11       | 0.095 | 0.035      | 0.068 | 0.056      | -0.085         |
| <i>Elymus multisetus</i>       | Boardman        | 26.1 | 1.55        | 162.4 | 7.7        | 67.1  | 9.4        | 0.30 | 0.00       | 5.03  | 0.09       | 0.098 | 0.039      | 0.072 | 0.034      | -0.238         |
| <i>Elymus trachycaulus</i>     | First Strike    | 26.3 | 1.64        | 176.8 | 13.7       | 119.6 | 34.9       | 0.28 | 0.07       | 6.51  | 2.49       | 0.105 | 0.023      | 0.063 | 0.020      | -0.276         |
| <i>Elymus trachycaulus</i>     | Pryor           | 27.3 | 0.98        | 198.6 | 12.1       | 94.6  | 7.8        | 0.32 | 0.04       | 6.49  | 1.38       | 0.091 | 0.012      | 0.051 | 0.012      | -0.303         |
| <i>Elymus wawawaiensis</i>     | Secar           | 28.2 | 1.75        | 181.7 | 0.3        | 66.3  | 0.5        | 0.32 | 0.08       | 4.08  | 0.60       | 0.094 | 0.013      | 0.078 | 0.027      | -0.095         |
| <i>Eremopyrum triticeum</i>    | n/a             | 23.4 | .           | 244.1 | .          | 91.4  | .          | 0.32 | .          | 3.23  | .          | 0.087 | .          | 0.064 | .          | 0.308          |
| <i>Festuca idahoensis</i>      | Joseph          | 31.5 | 4.06        | 123.6 | 15.9       | 100.4 | 19.5       | 0.42 | 0.05       | 1.99  | 0.25       | 0.072 | 0.024      | 0.049 | 0.037      | 0.253          |
| <i>Festuca ovina</i>           | Covar           | 28.3 | 0.74        | 127.4 | 20.4       | 136.7 | 17.7       | 0.37 | 0.11       | 3.04  | 0.38       | 0.046 | 0.034      | 0.043 | 0.031      | 0.384          |
| <i>Hesperostipa comata</i>     | n/a             | 39.1 | 1.87        | 95.4  | 13.8       | 132.1 | 57.1       | 0.23 | 0.08       | 10.85 | 3.29       | 0.053 | 0.016      | 0.035 | 0.018      | 0.367          |
| <i>Koeleria macrantha</i>      | n/a             | 29.7 | 0.84        | 146.8 | 16.5       | 123.3 | 54.4       | 0.40 | 0.17       | 1.54  | 0.49       | 0.074 | 0.032      | 0.055 | 0.035      | 0.326          |
| <i>Leymus cinereus</i>         | Trailhead       | 26.8 | 2.23        | 179.1 | 19.3       | 55.8  | 12.6       | 0.45 | 0.07       | 8.52  | 4.81       | 0.057 | 0.014      | 0.042 | 0.018      | 0.406          |
| <i>Lolium multiflorum</i>      | n/a             | 25.6 | 1.39        | 131.6 | 23.2       | 97.5  | 23.6       | 0.31 | 0.08       | 5.39  | 1.81       | 0.125 | 0.017      | 0.088 | 0.016      | 0.036          |
| <i>Pascopyrum smithii</i>      | Recovery        | 27.4 | 3.05        | 139.7 | 12.5       | 74.7  | 30.1       | 0.32 | 0.11       | 9.15  | 1.48       | 0.051 | 0.010      | 0.028 | 0.024      | 0.317          |
| <i>Pascopyrum smithii</i>      | Rodan           | 27.4 | 2.67        | 149.5 | 5.0        | 80.0  | 17.5       | 0.31 | 0.16       | 9.40  | 1.93       | 0.067 | 0.010      | 0.030 | 0.031      | -0.056         |
| <i>Poa secunda</i>             | Sherman         | 28.9 | 5.53        | 140.5 | 32.7       | 115.7 | .          | 0.28 | .          | 1.64  | 0.44       | 0.119 | .          | 0.066 | .          | 0.164          |
| <i>Poa secunda</i>             | Opportunity     | 29.1 | 1.76        | 139.3 | 8.2        | 94.4  | 42.8       | 0.33 | 0.08       | 1.77  | 0.68       | 0.103 | 0.029      | 0.042 | 0.050      | -0.076         |
| <i>Poa secunda</i>             | Mountain Home   | 29.2 | 0.64        | 179.1 | 16.4       | 78.4  | 7.7        | 0.58 | 0.09       | 1.42  | 0.29       | 0.081 | 0.029      | 0.068 | 0.040      | 0.130          |
| <i>Poa secunda</i>             | Reliable        | 32.6 | 3.74        | 150.7 | 7.4        | 82.0  | 21.2       | 0.48 | 0.07       | 3.02  | 0.98       | 0.095 | 0.035      | 0.070 | 0.033      | 0.129          |
| <i>Psathyrostachys juncea</i>  | Bozoisky-Select | 30.5 | 2.70        | 141.2 | 13.5       | 84.4  | 28.9       | 0.34 | 0.00       | 6.69  | 1.91       | 0.089 | 0.010      | 0.045 | 0.027      | -0.305         |
| <i>Psathyrostachys juncea</i>  | Bozoisky II     | 29.4 | 1.40        | 136.5 | 11.9       | 75.8  | 31.6       | 0.37 | 0.07       | 6.91  | 0.82       | 0.082 | 0.013      | 0.052 | 0.023      | -0.174         |
| <i>Psathyrostachys juncea</i>  | Vinall          | 29.3 | 3.75        | 138.1 | 17.2       | 38.7  | 6.7        | 0.54 | 0.07       | 9.84  | 5.08       | 0.039 | 0.032      | 0.010 | 0.030      | 0.572          |
| <i>Pseudoroegneria spicata</i> | P7 (G6)         | 32.1 | 1.00        | 164.9 | 16.9       | 98.9  | 44.4       | 0.31 | 0.11       | 5.63  | 1.81       | 0.094 | 0.018      | 0.065 | 0.027      | -0.018         |
| <i>Pseudoroegneria spicata</i> | Goldar          | 28.6 | 1.28        | 179.2 | 16.8       | 101.9 | 65.0       | 0.40 | 0.11       | 4.78  | 0.55       | 0.092 | 0.042      | 0.091 | 0.027      | 0.082          |
| <i>Pseudoroegneria spicata</i> | Anatone         | 31.6 | 2.93        | 158.9 | 20.5       | 62.8  | 12.9       | 0.39 | 0.10       | 5.72  | 1.74       | 0.088 | 0.024      | 0.060 | 0.031      | -0.131         |
| <i>Pseudoroegneria spicata</i> | T 1561          | 32.1 | 0.96        | 133.6 | 3.2        | 60.8  | 13.0       | 0.31 | 0.12       | 6.97  | 2.21       | 0.078 | 0.030      | 0.025 | 0.036      | -0.026         |
| <i>Thinopyrum intermedium</i>  | Rush            | 26.5 | 1.85        | 190.3 | 6.1        | 95.7  | 19.0       | 0.31 | 0.06       | 10.05 | 1.81       | 0.052 | 0.013      | 0.048 | 0.013      | 0.349          |
| <i>Thinopyrum ponticum</i>     | Alkar           | 25.6 | 2.10        | 147.8 | 13.4       | 82.2  | 12.8       | 0.24 | 0.06       | 9.21  | 2.67       | 0.062 | 0.022      | 0.018 | 0.023      | -0.021         |
| <b>Trait mean</b>              |                 | 28.5 |             | 159.6 |            | 86.5  |            | 0.35 |            | 6.29  |            | 0.086 |            | 0.056 |            | 0.00           |
| <b>Trait S.E.</b>              |                 | 0.44 |             | 4.54  |            | 3.30  |            | 0.01 |            | 0.43  |            | 0.00  |            | 0.00  |            | 0.04           |

**Table S2** Seed trait means and standard deviations. Standard deviations were not generated for hydrothermal time parameters: rate sum, hydrothermal time, base temperature, and base water potential. Substitutions used for missing data in analyses are italicized: <sup>a</sup>value is substituted by values of a different seedlot of the same species and variety also measured during the hydrothermal experiment, but not included in other experiments; <sup>b</sup>value is substituted by the average for all other varieties of the same species in the analysis, except for *Achnatherum lemmonii*, which was substituted by closely related *Heterostipa comata* (previously of the same genus, *Stipa*); <sup>c</sup>value is substituted by column average. Data has not been transformed. Trait abbreviations, units, and definitions are given in Table 2 of the manuscript.

| Species                        | Variety         | Seed mass | Seed mass (S.D) | CTD                | CTD (S.D.) | Rate sum           | Hydrothermal time (Θ <sub>HT</sub> ) | Base temperature (T <sub>b</sub> ) | Base water potential (Ψ <sub>b</sub> ) |
|--------------------------------|-----------------|-----------|-----------------|--------------------|------------|--------------------|--------------------------------------|------------------------------------|--|
| <i>Achnatherum lemmonii</i>    | n/a             | 5.87      | 0.21            | 15.26 <sup>b</sup> | .          | 12.52 <sup>c</sup> | 132.35 <sup>c</sup>                  | 5.29 <sup>c</sup>                  | -2.53 <sup>c</sup>                     |
| <i>Agropyron cristatum</i>     | Kirk            | 2.30      | 0.09            | 12.73              | 1.10       | 10.23              | 128.14                               | 3.27                               | -2.36                                  |
| <i>Agropyron cristatum</i>     | Fairway         | 1.17      | 0.05            | 14.95              | 1.63       | 16.24              | 107.85                               | 3.42                               | -3.19                                  |
| <i>Agropyron desertorum</i>    | Hycrest         | 2.84      | 0.11            | 13.81              | 1.93       | 10.42              | 83.65                                | 4.63                               | -2.02                                  |
| <i>Agropyron desertorum</i>    | Hycrest II      | 2.87      | 0.05            | 12.04              | 0.60       | 15.33              | 120.24                               | 3.15                               | -3.20                                  |
| <i>Agropyron desertorum</i>    | Nordan          | 2.26      | 0.06            | 14.01              | 3.29       | 9.60               | 224.13                               | 2.96                               | -3.59                                  |
| <i>Agropyron fragile</i>       | Vavilov II      | 2.84      | 0.04            | 12.83              | 1.55       | 12.73              | 152.69                               | 2.65                               | -3.11                                  |
| <i>Agropyron fragile</i>       | Vavilov         | 2.62      | 0.02            | 14.94              | 3.08       | 17.16              | 137.42                               | 2.05                               | -3.41                                  |
| <i>Agropyron fragile</i>       | P27             | 2.60      | 0.21            | 12.78              | 1.21       | 14.03              | 151.71                               | 3.27                               | -3.74                                  |
| <i>Bromus inermis</i>          | Manchar         | 3.32      | 0.07            | 12.93              | 2.65       | 8.86               | 116.71                               | 4.89                               | -2.49                                  |
| <i>Bromus inermis</i>          | Lincoln         | 2.55      | 0.11            | 11.41              | 1.48       | 9.51               | 139.51                               | 3.61                               | -2.52                                  |
| <i>Bromus japonicus</i>        | n/a             | 2.18      | 0.06            | 12.20              | 0.71       | 14.82              | 69.69                                | 1.39                               | -1.42                                  |
| <i>Bromus riparius</i>         | Cache           | 5.53      | 0.18            | 12.21              | 0.96       | 14.16              | 109.75                               | 2.40                               | -2.42                                  |
| <i>Bromus riparius</i>         | Regar           | 4.93      | 0.11            | 11.89              | 0.98       | 16.27              | 97.05                                | 2.29                               | -2.42                                  |
| <i>Bromus tectorum</i>         | n/a             | 2.32      | 0.00            | 11.94              | 1.38       | 28.76              | 49.59                                | 2.69                               | -2.33                                  |
| <i>Elymus elymoides</i>        | Antelope Creek  | 3.02      | 0.13            | 12.40              | 1.01       | 17.58              | 125.11                               | 2.71                               | -3.53                                  |
| <i>Elymus elymoides</i>        | Toe Jam Creek   | 2.31      | 0.07            | 14.31              | 2.66       | 11.28 <sup>a</sup> | 97.20 <sup>a</sup>                   | 3.07 <sup>a</sup>                  | -1.93 <sup>a</sup>                     |
| <i>Elymus elymoides</i>        | Fish Creek      | 2.23      | 0.08            | 14.27              | 1.24       | 9.23               | 296.85                               | 2.28                               | -4.08                                  |
| <i>Elymus elymoides</i>        | Rattlesnake     | 2.00      | 0.06            | 14.20              | 2.32       | 12.39              | 144.99                               | 2.32                               | -2.74                                  |
| <i>Elymus lanceolatus</i>      | Bannock         | 2.95      | 0.16            | 12.62              | 0.81       | 11.71              | 118.08                               | 2.66                               | -2.26                                  |
| <i>Elymus lanceolatus</i>      | Critana         | 2.99      | 0.01            | 13.75              | 1.65       | 13.37              | 111.93                               | 2.47                               | -2.36                                  |
| <i>Elymus multisetus</i>       | Boardman        | 2.51      | 0.14            | 17.68              | 2.73       | 18.27              | 137.27                               | 2.63                               | -3.95                                  |
| <i>Elymus trachycaulus</i>     | First Strike    | 3.92      | 0.13            | 12.40              | 1.79       | 7.87 <sup>b</sup>  | 98.69 <sup>b</sup>                   | 2.34 <sup>b</sup>                  | -1.25 <sup>b</sup>                     |
| <i>Elymus trachycaulus</i>     | Pryor           | 3.56      | 0.11            | 13.90              | 1.37       | 7.87               | 98.69                                | 2.34                               | -1.25                                  |
| <i>Elymus wawawaiensis</i>     | Secar           | 2.13      | 0.10            | 14.63              | 2.32       | 12.87              | 132.80                               | 2.12                               | -2.54                                  |
| <i>Eremopyrum triticeum</i>    | n/a             | 1.18      | 0.08            | 12.82              | .          | 19.16              | 94.25                                | 0.46                               | -2.11                                  |
| <i>Festuca idahoensis</i>      | Joseph          | 1.05      | 0.07            | 13.37              | 1.42       | 9.30               | 125.44                               | 2.86                               | -1.98                                  |
| <i>Festuca ovina</i>           | Covar           | 0.70      | 0.02            | 12.69              | 1.86       | 9.12               | 110.78                               | 3.00                               | -1.77                                  |
| <i>Hesperostipa comata</i>     | n/a             | 4.75      | 0.21            | 15.26              | 1.38       | 12.52 <sup>c</sup> | 132.35 <sup>c</sup>                  | 5.29                               | -2.53 <sup>c</sup>                     |
| <i>Koeleria macrantha</i>      | n/a             | 0.28      | 0.01            | 13.91              | 2.43       | 9.13               | 82.70                                | 2.89                               | -1.32                                  |
| <i>Leymus cinereus</i>         | Trailhead       | 2.85      | 0.15            | 14.11              | 1.37       | 8.06               | 134.86                               | 4.22                               | -2.32                                  |
| <i>Lolium multiflorum</i>      | n/a             | 3.20      | 0.11            | 10.81              | 0.93       | 12.22              | 159.14                               | 2.56                               | -3.07                                  |
| <i>Pascopyrum smithii</i>      | Recovery        | 4.71      | 0.14            | 15.09              | 2.60       | 6.91               | 126.37                               | 2.94                               | -1.53                                  |
| <i>Pascopyrum smithii</i>      | Rodan           | 4.08      | 0.22            | 16.87              | 1.98       | 4.28               | 169.05                               | 5.77                               | -2.10                                  |
| <i>Poa secunda</i>             | Sherman         | 0.42      | 0.02            | 13.28              | 1.14       | 8.66               | 250.28                               | 1.40                               | -2.86                                  |
| <i>Poa secunda</i>             | Opportunity     | 0.44      | 0.02            | 13.84              | 2.80       | 9.12               | 129.45                               | 2.54                               | -1.91                                  |
| <i>Poa secunda</i>             | Mountain Home   | 0.46      | 0.02            | 18.13              | 0.22       | 9.09               | 91.62                                | 2.27                               | -1.32                                  |
| <i>Poa secunda</i>             | Reliable        | 0.46      | 0.01            | 15.08 <sup>b</sup> | .          | 9.34               | 98.80                                | 1.99                               | -1.39                                  |
| <i>Psathyrostachys juncea</i>  | Bozoisky-Select | 3.18      | 0.05            | 12.60              | 1.69       | 11.71              | 171.72                               | 2.03                               | -2.92                                  |
| <i>Psathyrostachys juncea</i>  | Bozoisky II     | 3.78      | 0.07            | 12.96              | 1.89       | 12.51              | 188.29                               | 1.90                               | -3.33                                  |
| <i>Psathyrostachys juncea</i>  | Vinall          | 2.50      | 0.10            | 13.81              | 1.84       | 12.11 <sup>b</sup> | 180.01 <sup>b</sup>                  | 1.97 <sup>b</sup>                  | -3.13 <sup>b</sup>                     |
| <i>Pseudoroegneria spicata</i> | P7 (G6)         | 4.22      | 0.11            | 13.85              | 0.01       | 14.26              | 109.85                               | 1.37                               | -2.09                                  |
| <i>Pseudoroegneria spicata</i> | Goldar          | 4.77      | 0.05            | 14.29              | 1.95       | 14.48              | 100.95                               | 1.25                               | -1.93                                  |
| <i>Pseudoroegneria spicata</i> | Anatone         | 2.96      | 0.07            | 13.86              | 1.55       | 12.88              | 152.56                               | 0.69                               | -2.36                                  |
| <i>Pseudoroegneria spicata</i> | T 1561          | 3.38      | 0.17            | 12.68              | 0.91       | 18.08              | 91.57                                | 1.60                               | -2.28                                  |
| <i>Thinopyrum intermedium</i>  | Rush            | 5.27      | 0.08            | 12.41              | 0.41       | 14.06              | 199.86                               | 2.36                               | -4.22                                  |
| <i>Thinopyrum ponticum</i>     | Alkar           | 5.73      | 0.27            | 15.05              | 3.49       | 10.24              | 114.32                               | 3.21                               | -2.1                                   |

**Table S3** Life stage transition probability means and standard deviations under the low water treatment. Data has not been transformed. Life stage transition units and definitions are given in Table 2 of the manuscript. Viability: TZ, tetrazolium test of viability; G, germination test of viability.

| Species                        | Variety         | Viability   | Germination | Germination (S.D.) | Emergence | Emergence (S.D.) | Seedling Survival | Seedling Survival (S.D.) | Cumulative Survival | Cumulative Survival (S.D.) |
|--------------------------------|-----------------|-------------|-------------|--------------------|-----------|------------------|-------------------|--------------------------|---------------------|----------------------------|
| <i>Achnatherum lemmonii</i>    | n/a             | 89% (TZ)    | 0.82        | 0.06               | 0.02      | 0.02             | 0.91              | 0.10                     | 0.02                | 0.01                       |
| <i>Agropyron cristatum</i>     | Kirk            | 94% (TZ)    | 0.36        | 0.09               | 0.47      | 0.09             | 0.83              | 0.03                     | 0.14                | 0.03                       |
| <i>Agropyron cristatum</i>     | Fairway         | 96% (TZ)    | 0.47        | 0.05               | 0.58      | 0.11             | 0.89              | 0.11                     | 0.24                | 0.02                       |
| <i>Agropyron desertorum</i>    | Hycrest         | 96% (TZ)    | 0.34        | 0.16               | 0.22      | 0.08             | 0.85              | 0.13                     | 0.07                | 0.03                       |
| <i>Agropyron desertorum</i>    | Hycrest II      | 100% (TZ)   | 0.69        | 0.07               | 0.59      | 0.10             | 0.93              | 0.06                     | 0.38                | 0.07                       |
| <i>Agropyron desertorum</i>    | Nordan          | 78% (TZ)    | 0.42        | 0.03               | 0.47      | 0.03             | 0.85              | 0.00                     | 0.17                | 0.01                       |
| <i>Agropyron fragile</i>       | Vavilov II      | 90% (G)     | 0.54        | 0.08               | 0.33      | 0.02             | 0.90              | 0.02                     | 0.16                | 0.01                       |
| <i>Agropyron fragile</i>       | Vavilov         | 96% (TZ)    | 0.44        | 0.11               | 0.54      | 0.07             | 0.86              | 0.05                     | 0.21                | 0.03                       |
| <i>Agropyron fragile</i>       | P27             | 93% (TZ)    | 0.24        | 0.10               | 0.45      | 0.20             | 0.81              | 0.16                     | 0.09                | 0.06                       |
| <i>Bromus inermis</i>          | Manchar         | 97% (TZ)    | 0.85        | 0.05               | 0.43      | 0.14             | 0.86              | 0.06                     | 0.32                | 0.12                       |
| <i>Bromus inermis</i>          | Lincoln         | 90% (G)     | 0.53        | 0.08               | 0.54      | 0.27             | 0.81              | 0.14                     | 0.24                | 0.15                       |
| <i>Bromus japonicus</i>        | n/a             | 94% (TZ)    | 0.47        | 0.14               | 0.11      | 0.04             | 0.72              | 0.10                     | 0.04                | 0.02                       |
| <i>Bromus riparius</i>         | Cache           | 95% (TZ)    | 0.94        | 0.07               | 0.31      | 0.12             | 0.84              | 0.09                     | 0.24                | 0.08                       |
| <i>Bromus riparius</i>         | Regar           | 68% (TZ)    | 0.79        | 0.05               | 0.33      | 0.03             | 0.88              | 0.13                     | 0.22                | 0.02                       |
| <i>Bromus tectorum</i>         | n/a             | 96% (G)     | 0.35        | 0.08               | 0.18      | 0.03             | 0.93              | 0.13                     | 0.06                | 0.01                       |
| <i>Elymus elymoides</i>        | Antelope Creek  | 94% (G)     | 0.88        | 0.07               | 0.04      | 0.02             | 0.92              | 0.07                     | 0.03                | 0.01                       |
| <i>Elymus elymoides</i>        | Toe Jam Creek   | 96% (TZ)    | 0.65        | 0.05               | 0.09      | 0.01             | 0.73              | 0.13                     | 0.04                | 0.01                       |
| <i>Elymus elymoides</i>        | Fish Creek      | 95% (TZ)    | 0.87        | 0.18               | 0.14      | 0.02             | 0.75              | 0.09                     | 0.09                | 0.02                       |
| <i>Elymus elymoides</i>        | Rattlesnake     | 98% (TZ)    | 0.72        | 0.11               | 0.14      | 0.06             | 0.74              | 0.14                     | 0.08                | 0.04                       |
| <i>Elymus lanceolatus</i>      | Bannock         | 93% (TZ)    | 0.80        | 0.02               | 0.47      | 0.07             | 0.76              | 0.12                     | 0.28                | 0.08                       |
| <i>Elymus lanceolatus</i>      | Critana         | 94% (TZ)    | 0.88        | 0.08               | 0.47      | 0.12             | 0.85              | 0.14                     | 0.35                | 0.09                       |
| <i>Elymus multisetus</i>       | Boardman        | 92% (TZ)    | 0.33        | 0.11               | 0.24      | 0.12             | 0.84              | 0.07                     | 0.07                | 0.04                       |
| <i>Elymus trachycaulus</i>     | First Strike    | 93% (TZ)    | 0.98        | 0.00               | 0.09      | 0.05             | 0.78              | 0.09                     | 0.07                | 0.04                       |
| <i>Elymus trachycaulus</i>     | Pryor           | 92% (TZ)    | 0.60        | 0.08               | 0.64      | 0.21             | 0.82              | 0.18                     | 0.33                | 0.17                       |
| <i>Elymus wawawaiensis</i>     | Secar           | 93% (TZ)    | 0.60        | 0.07               | 0.15      | 0.06             | 0.66              | 0.19                     | 0.06                | 0.04                       |
| <i>Eremopyrum triticeum</i>    | n/a             | 89% (TZ)    | 0.22        |                    | 0.43      |                  | 0.91              |                          | 0.08                |                            |
| <i>Festuca idahoensis</i>      | Joseph          | 97% (TZ)    | 1.00        | 0.03               | 0.34      | 0.07             | 0.80              | 0.05                     | 0.27                | 0.07                       |
| <i>Festuca ovina</i>           | Covar           | 96% (TZ)    | 0.78        | 0.13               | 0.38      | 0.03             | 0.85              | 0.07                     | 0.25                | 0.04                       |
| <i>Hesperostipa comata</i>     | n/a             | 97% (TZ)    | 0.49        | 0.17               | 0.37      | 0.07             | 0.86              | 0.04                     | 0.16                | 0.03                       |
| <i>Koeleria macrantha</i>      | n/a             | 93% (G)     | 0.83        | 0.12               | 0.22      | 0.15             | 0.82              | 0.19                     | 0.14                | 0.10                       |
| <i>Leymus cinereus</i>         | Trailhead       | 96% (G)     | 0.91        | 0.02               | 0.24      | 0.08             | 0.77              | 0.05                     | 0.17                | 0.05                       |
| <i>Lolium multiflorum</i>      | n/a             | 97% (TZ)    | 0.24        | 0.13               | 0.33      | 0.15             | 0.80              | 0.21                     | 0.06                | 0.04                       |
| <i>Pascopyrum smithii</i>      | Recovery        | 92% (TZ)    | 0.96        | 0.10               | 0.10      | 0.05             | 0.83              | 0.05                     | 0.08                | 0.03                       |
| <i>Pascopyrum smithii</i>      | Rodan           | 90% (G)     | 0.68        | 0.05               | 0.07      | 0.04             | 0.79              | 0.04                     | 0.04                | 0.03                       |
| <i>Poa secunda</i>             | Sherman         | 86% (TZ)    | 0.52        | 0.15               | 0.07      | 0.01             | 0.51              | 0.22                     | 0.02                | 0.00                       |
| <i>Poa secunda</i>             | Opportunity     | 86% (TZ)    | 0.89        | 0.02               | 0.46      | 0.08             | 0.65              | 0.12                     | 0.27                | 0.09                       |
| <i>Poa secunda</i>             | Mountain Home   | 95% (TZ)    | 0.43        | 0.03               | 0.09      | 0.06             | 0.42              | 0.16                     | 0.01                | 0.01                       |
| <i>Poa secunda</i>             | Reliable        | 95% (G)     | 0.20        | 0.02               | 0.16      | 0.04             | 0.43              | 0.27                     | 0.01                | 0.01                       |
| <i>Psathyrostachys juncea</i>  | Bozoisky-Select | 97% (TZ)    | 0.99        | 0.03               | 0.47      | 0.15             | 0.69              | 0.03                     | 0.32                | 0.10                       |
| <i>Psathyrostachys juncea</i>  | Bozoisky II     | 96% (TZ)    | 0.88        | 0.00               | 0.33      | 0.07             | 0.91              | 0.12                     | 0.26                | 0.02                       |
| <i>Psathyrostachys juncea</i>  | Vinall          | 70% (TZ)    | 0.17        | 0.02               | 0.63      | 0.13             | 0.74              | 0.12                     | 0.08                | 0.02                       |
| <i>Pseudoroegneria spicata</i> | P7 (G6)         | 90% (G)     | 0.77        | 0.06               | 0.25      | 0.05             | 0.87              | 0.06                     | 0.17                | 0.02                       |
| <i>Pseudoroegneria spicata</i> | Goldar          | 95% (G)     | 0.73        | 0.05               | 0.16      | 0.07             | 0.76              | 0.09                     | 0.09                | 0.04                       |
| <i>Pseudoroegneria spicata</i> | Anatone         | 89% (TZ)    | 0.77        | 0.06               | 0.36      | 0.15             | 0.86              | 0.05                     | 0.23                | 0.10                       |
| <i>Pseudoroegneria spicata</i> | T 1561          | 91% (TZ)    | 0.93        | 0.04               | 0.24      | 0.12             | 0.90              | 0.03                     | 0.20                | 0.09                       |
| <i>Thinopyrum intermedium</i>  | Rush            | 90% (TZ)    | 0.93        | 0.04               | 0.10      | 0.03             | 0.93              | 0.03                     | 0.09                | 0.03                       |
| <i>Thinopyrum ponticum</i>     | Alkar           | 93% (TZ)    | 0.88        | 0.13               | 0.07      | 0.03             | 0.76              | 0.04                     | 0.05                | 0.03                       |
|                                |                 | <b>Mean</b> | 0.65        |                    | 0.30      |                  | 0.80              |                          | 0.15                |                            |
|                                |                 | <b>S.E.</b> | 0.04        |                    | 0.03      |                  | 0.02              |                          | 0.02                |                            |

**Table S4** Life stage transition probability means and standard deviations under the high water treatment. Data has not been transformed. Life stage transition units and definitions are given in Table 2 of the manuscript. Viability: TZ, tetrazolium test of viability; G, germination test of viability.

| Species                        | Variety         | Viability   | Germination | Germination (S.D.) | Emergence | Emergence (S.D.) | Seedling Survival | Seedling Survival (S.D.) | Cumulative Survival | Cumulative Survival (S.D.) |
|--------------------------------|-----------------|-------------|-------------|--------------------|-----------|------------------|-------------------|--------------------------|---------------------|----------------------------|
| <i>Achnatherum lemmonii</i>    | n/a             | 89% (TZ)    | 0.74        | 0.06               | 0.06      | 0.03             | 0.56              | 0.32                     | 0.02                | 0.01                       |
| <i>Agropyron cristatum</i>     | Kirk            | 94% (TZ)    | 0.31        | 0.07               | 0.50      | 0.21             | 0.85              | 0.03                     | 0.13                | 0.06                       |
| <i>Agropyron cristatum</i>     | Fairway         | 96% (TZ)    | 0.54        | 0.06               | 0.49      | 0.15             | 0.93              | 0.10                     | 0.25                | 0.10                       |
| <i>Agropyron desertorum</i>    | Hycrest         | 96% (TZ)    | 0.23        | 0.04               | 0.36      | 0.14             | 0.86              | 0.08                     | 0.07                | 0.02                       |
| <i>Agropyron desertorum</i>    | Hycrest II      | 100% (TZ)   | 0.73        | 0.04               | 0.50      | 0.11             | 0.94              | 0.02                     | 0.35                | 0.08                       |
| <i>Agropyron desertorum</i>    | Nordan          | 78% (TZ)    | 0.38        | 0.13               | 0.69      | 0.19             | 0.86              | 0.10                     | 0.23                | 0.09                       |
| <i>Agropyron fragile</i>       | Vavilov II      | 90% (G)     | 0.57        | 0.12               | 0.39      | 0.02             | 0.93              | 0.07                     | 0.21                | 0.01                       |
| <i>Agropyron fragile</i>       | Vavilov         | 96% (TZ)    | 0.42        | 0.27               | 0.45      | 0.13             | 0.94              | 0.03                     | 0.18                | 0.05                       |
| <i>Agropyron fragile</i>       | P27             | 93% (TZ)    | 0.32        | 0.22               | 0.23      | 0.04             | 0.87              | 0.05                     | 0.06                | 0.01                       |
| <i>Bromus inermis</i>          | Manchar         | 97% (TZ)    | 0.84        | 0.08               | 0.33      | 0.01             | 0.60              | 0.23                     | 0.17                | 0.06                       |
| <i>Bromus inermis</i>          | Lincoln         | 90% (G)     | 0.48        | 0.03               | 0.74      | 0.23             | 0.85              | 0.07                     | 0.31                | 0.12                       |
| <i>Bromus japonicus</i>        | n/a             | 94% (TZ)    | 0.29        | 0.24               | 0.15      | 0.07             | 0.79              | 0.12                     | 0.03                | 0.02                       |
| <i>Bromus riparius</i>         | Cache           | 95% (TZ)    | 0.89        | 0.06               | 0.37      | 0.05             | 0.92              | 0.07                     | 0.30                | 0.05                       |
| <i>Bromus riparius</i>         | Regar           | 68% (TZ)    | 0.73        | 0.02               | 0.36      | 0.15             | 0.83              | 0.11                     | 0.22                | 0.12                       |
| <i>Bromus tectorum</i>         | n/a             | 96% (G)     | 0.45        | 0.28               | 0.09      | 0.03             | 0.90              | 0.09                     | 0.04                | 0.01                       |
| <i>Elymus elymoides</i>        | Antelope Creek  | 94% (G)     | 0.79        | 0.04               | 0.06      | 0.02             | 0.87              | 0.08                     | 0.04                | 0.01                       |
| <i>Elymus elymoides</i>        | Toe Jam Creek   | 96% (TZ)    | 0.50        | 0.14               | 0.15      | 0.01             | 0.88              | 0.15                     | 0.07                | 0.01                       |
| <i>Elymus elymoides</i>        | Fish Creek      | 95% (TZ)    | 0.90        | 0.05               | 0.18      | 0.04             | 0.89              | 0.13                     | 0.15                | 0.04                       |
| <i>Elymus elymoides</i>        | Rattlesnake     | 98% (TZ)    | 0.49        | 0.12               | 0.31      | 0.12             | 0.82              | 0.11                     | 0.13                | 0.06                       |
| <i>Elymus lanceolatus</i>      | Bannock         | 93% (TZ)    | 0.85        | 0.08               | 0.49      | 0.06             | 0.92              | 0.06                     | 0.38                | 0.03                       |
| <i>Elymus lanceolatus</i>      | Critana         | 94% (TZ)    | 0.94        | 0.05               | 0.40      | 0.14             | 0.90              | 0.03                     | 0.34                | 0.11                       |
| <i>Elymus multisetus</i>       | Boardman        | 92% (TZ)    | 0.21        | 0.09               | 0.57      | 0.15             | 0.87              | 0.04                     | 0.11                | 0.02                       |
| <i>Elymus trachycaulus</i>     | First Strike    | 93% (TZ)    | 0.97        | 0.04               | 0.31      | 0.13             | 0.92              | 0.08                     | 0.27                | 0.10                       |
| <i>Elymus trachycaulus</i>     | Pryor           | 92% (TZ)    | 0.58        | 0.03               | 0.77      | 0.25             | 0.88              | 0.10                     | 0.38                | 0.12                       |
| <i>Elymus wawawaiensis</i>     | Secar           | 93% (TZ)    | 0.49        | 0.08               | 0.25      | 0.06             | 0.85              | 0.09                     | 0.11                | 0.03                       |
| <i>Eremopyrum triticeum</i>    | n/a             | 89% (TZ)    | 0.16        |                    | 0.63      |                  | 0.92              |                          | 0.09                |                            |
| <i>Festuca idahoensis</i>      | Joseph          | 97% (TZ)    | 0.90        | 0.07               | 0.35      | 0.18             | 0.76              | 0.09                     | 0.25                | 0.14                       |
| <i>Festuca ovina</i>           | Covar           | 96% (TZ)    | 0.74        | 0.09               | 0.27      | 0.23             | 0.76              | 0.03                     | 0.15                | 0.12                       |
| <i>Hesperostipa comata</i>     | n/a             | 97% (TZ)    | 0.54        | 0.06               | 0.40      | 0.16             | 0.87              | 0.06                     | 0.19                | 0.06                       |
| <i>Koeleria macrantha</i>      | n/a             | 93% (G)     | 0.85        | 0.02               | 0.31      | 0.13             | 0.68              | 0.20                     | 0.19                | 0.13                       |
| <i>Leymus cinereus</i>         | Trailhead       | 96% (G)     | 0.91        | 0.06               | 0.15      | 0.10             | 0.81              | 0.10                     | 0.10                | 0.05                       |
| <i>Lolium multiflorum</i>      | n/a             | 97% (TZ)    | 0.35        | 0.01               | 0.12      | 0.02             | 0.92              | 0.09                     | 0.04                | 0.01                       |
| <i>Pascopyrum smithii</i>      | Recovery        | 92% (TZ)    | 0.89        | 0.07               | 0.10      | 0.04             | 0.79              | 0.05                     | 0.07                | 0.03                       |
| <i>Pascopyrum smithii</i>      | Rodan           | 90% (G)     | 0.75        | 0.05               | 0.17      | 0.11             | 0.81              | 0.07                     | 0.11                | 0.07                       |
| <i>Poa secunda</i>             | Sherman         | 86% (TZ)    | 0.44        | 0.06               | 0.12      | 0.06             | 0.49              | 0.16                     | 0.03                | 0.02                       |
| <i>Poa secunda</i>             | Opportunity     | 86% (TZ)    | 0.79        | 0.03               | 0.61      | 0.10             | 0.75              | 0.09                     | 0.36                | 0.08                       |
| <i>Poa secunda</i>             | Mountain Home   | 95% (TZ)    | 0.45        | 0.13               | 0.10      | 0.03             | 0.55              | 0.15                     | 0.03                | 0.02                       |
| <i>Poa secunda</i>             | Reliable        | 95% (G)     | 0.23        | 0.03               | 0.21      | 0.11             | 0.54              | 0.19                     | 0.02                | 0.00                       |
| <i>Psathyrostachys juncea</i>  | Bozoisky-Select | 97% (TZ)    | 0.97        | 0.07               | 0.28      | 0.10             | 0.86              | 0.08                     | 0.23                | 0.10                       |
| <i>Psathyrostachys juncea</i>  | Bozoisky II     | 96% (TZ)    | 0.98        | 0.06               | 0.42      | 0.08             | 0.87              | 0.09                     | 0.36                | 0.10                       |
| <i>Psathyrostachys juncea</i>  | Vinall          | 70% (TZ)    | 0.12        | 0.10               | 0.80      | 0.21             | 0.85              | 0.07                     | 0.08                | 0.02                       |
| <i>Pseudoroegneria spicata</i> | P7 (G6)         | 90% (G)     | 0.77        | 0.11               | 0.32      | 0.08             | 0.79              | 0.09                     | 0.19                | 0.03                       |
| <i>Pseudoroegneria spicata</i> | Goldar          | 95% (G)     | 0.67        | 0.12               | 0.25      | 0.02             | 0.85              | 0.05                     | 0.14                | 0.02                       |
| <i>Pseudoroegneria spicata</i> | Anatone         | 89% (TZ)    | 0.81        | 0.04               | 0.25      | 0.02             | 0.88              | 0.08                     | 0.18                | 0.03                       |
| <i>Pseudoroegneria spicata</i> | T 1561          | 91% (TZ)    | 0.91        | 0.07               | 0.35      | 0.02             | 0.74              | 0.15                     | 0.23                | 0.05                       |
| <i>Thinopyrum intermedium</i>  | Rush            | 90% (TZ)    | 0.92        | 0.09               | 0.21      | 0.12             | 0.93              | 0.12                     | 0.19                | 0.12                       |
| <i>Thinopyrum ponticum</i>     | Alkar           | 93% (TZ)    | 0.92        | 0.05               | 0.18      | 0.02             | 0.96              | 0.04                     | 0.16                | 0.02                       |
|                                |                 | <b>Mean</b> | 0.63        |                    | 0.34      |                  | 0.83              |                          | 0.17                |                            |
|                                |                 | <b>S.E.</b> | 0.04        |                    | 0.03      |                  | 0.02              |                          | 0.02                |                            |