Scotton et al. Appendices

Appendix 1. Characteristics of the grasses used in simple and multiple regression analyses to explain the harvesting efficiency of hay-making and seed-stripping.

Trial		Pradet			Lusia	
Characteristic	1000-seeds weight (g)	Fertile stem height (cm)	Seed ripeness index [1]	1000-seed weight (g)	Fertile stem height (cm)	Seed ripeness index [1]
Agrostis capillaris (common bent)	0.0656	60.2	270	0.0708	40.8	270
Anthoxanthum alpinum (alpine vernal-grass)	-	-	-	0.4171	30.1	390
Anthoxanthum odoratum (sweet vernal-grass)	0.6141	53.8	365	-	-	-
Arrhenatherum elatius (false oat-grass)	3.3797	99.3	335	-	-	-
Avenella flexuosa (wavy hair-grass)	-	-	-	0.3875	47.0	340
Briza media (quaking grass)	-	-	-	0.7301	43.3	340
Dactylis glomerata subsp. *glomerata* (cock's-foot)	1.0077	98.0	360	-	-	-
Elymus repens (common couch)	1.6629	90.0	260	-	-	-
Festuca nigrescens (chewing's fescue)	-	-	-	0.7974	58.8	350
Festuca rubra subsp. *rubra* (ref fescue)	0.6075	62.5	370	-	-	-
Helictotrichon pubescens subsp. *pubescens* (downy oat-grass)	2.2091	70.2	370	2.7084	71.2	355
Holcus lanatus (Yorkshire-fog)	0.2963	59.7	295	-	-	-
Lolium perenne (perennial rye-grass)	2.1209	54.0	370	-	-	-
Poa trivialis subsp. *trivialis* (rough meadow-grass)	0.2002	58.0	390	-	-	-
Poa variegata (variegated meadow-grass)	-	-	-	0.3976	40.2	360
Trisetum flavescens subsp. *flavescens* (yellow oat-grass)	0.2708	73.2	345	-	-	-

[1] Seed ripeness index at harvesting date (0-400). Calculated by:
+ estimating the percentage of flowers in the five phenological stages: flowering, milky, dough, fully ripe and shed seed;
+ assigning the weights 0, 1, 2, 3 and 4 to the five stages;
+ multiplying the percentage of flowers in each phenological stage by its weight;
+ summing up the five products.

Appendix 2.

Data analysis (extended version)

We considered five response variables: the number of fertile stems harvested per m^2 (SSY and H), the number and weight of seeds harvested per m^2, and the number and weight of seeds harvested per fertile stem (SSY, H, and SS). In SS, we calculated the number or weight of seeds per fertile stem by dividing the number or weight of seeds per m^2 harvested in SS by the number of fertile stems found in SSY, because with seed-stripping only the seeds are harvested and not both seeds and stems as with haymaking.

To test the null hypothesis "there is no effect of harvesting method on the response variables" we used both univariate and multivariate methods. Univariate analysis of variance (ANOVA) was applied to the total amounts of harvested fertile stems and seed obtained by summing up all single species values (StatSoft Inc. 2006). To meet ANOVA assumptions, prior to the analyses the data on the number of seeds harvested per m^2 and number of seeds harvested per fertile stem at Pradet were $\log(x + 1)$ transformed. When performing ANOVA, subsampling error was taken into account according to Gomez and Gomez (1984). By ANOVA giving differences among treatments significant at $p< 0.05$, the means were compared with Tukey's studentized range test. GLM procedure (SAS, version 9.1, SAS Institute, Cary NC) was used in the analyses.

The adopted multivariate method was a linear constrained ordination technique, redundancy analysis (RDA), which, for simplicity, was applied only to the three "number" response variables in each trial. Prior to the analyses, we square-root transformed the original values, as they were of the "count" type (Leps and Šmilauer 2003). For each of the two trials (Pradet and Lusia), we then organised the transformed values in three primary data matrices "species x sampling units", one matrix for each response variable. The considered sampling units were the nine plots, three plots for each of the three treatments. The whole plots data were obtained by averaging the sub-plots values. The three matrices "harvesting methods × sampling units" used to constrain the ordination of the primary data matrices were constructed by coding the categorical explanatory variable "harvesting method" with three dummy variables, one for each harvesting method. According to the recommendations of Leps and Šmilauer (2003), we selected a linear instead of a unimodal constrained method, as the available explanatory variable was categorical and all datasets, submitted to a detrended correspondence analysis with detrending by segments, showed longest gradient shorter than 2. In each RDA, to remove the differences in response variables due to the samples belonging to different blocks, we used three dummy variables characterizing the block structure of the experimental design as covariables. A Monte Carlo permutation test (999 randomisations) was also performed to determine the accuracy of the relationship between the primary and constraining datasets. As recommended by Anderson and Ter Braak (2002), in the test we

chose the option of unrestricted permutations under the reduced model (blocks used as covariables and permutation of the residuals obtained after subtracting the effect of covariables). This option allows for a strong test without inflating the type I error rate. As test statistic, we used the F-ratio calculated on the basis of the sum of all canonical eigenvalues. All ordinations were performed with CANOCO (vers. 4.5, Microcomputer Power, Ithaca NY).

We discarded the other possible multivariate approach, multivariate analysis of variance, as, with the adopted experimental design (three replications and two or three treatments), it allowed only a few species to be used (at most two or four, depending on the considered response variable), in order to have a sufficient number of freedom degrees for the F's of the Wilks' lambda and Pillais' trace statistics.

To describe the species selectivity of the two harvesting methods, we created species-environment biplots obtained with the first two RDA canonical axes. In the plots, the three harvesting treatments were introduced as centroids, and species are shown according to the greater "species fit." Scaling of ordinations scores was focused on intersample distances, so that the distances between treatment points on the plot represent their real dissimilarities.

A simple regression analysis was performed to test the similarity of the species mixes to the standing seed yield.

In an effort to relate the harvesting efficiency of H and SS to specific plant traits, we considered the grass species, which have relatively homogeneous inflorescences. We performed simple and multiple regression analyses where, separately for H and SS, the harvesting efficiencies for the single species, expressed as the ratio between the number of seeds per fertile stem harvested with the method and that of SSY, were used as dependent (Y) variables and the following plant traits were used as explanatory (X) variables: 1,000-seed weight, inflorescence height above the ground, and a seed ripeness index, calculated as explained in the footnote of Appendix 1.

For all simple and multiple regression analyses we used the REG procedure (SAS, vers. 9.1, SAS Institute, Cary NC).

Additional References

Anderson, M.J. and C.J.F. Ter Braak. 2002. Permutation tests for multi-factorial analysis of variance. *Journal of Statistical Computation and Simulation* 73 (2):85–113.

Appendix 3. Number of fertile stems and seeds harvested with hay making (H) or seed stripper (SS) as compared to the standing seed yield (SSY) in an *Arrhenatherum elatius* meadow in the eastern Italian Alps.

Response variable	No. of fertile stems m^{-2}		No. of seeds m^{-2}			No. of seeds per fertile stem		
Treatment	SSY	H	SSY	H	SS	SSY	H	SS
Agrostis capillaris (common bent)	72.8	127	2029	1197.6	249	28	9.4	3.5
Anthoxanthum odoratum (sweet vernal-grass)	105	97	587	152	155	5.6	1.6	1.4
Arrhenatherum elatius (false oat-grass)	53	37	922	149	163	17	4	3
Artemisia vulgaris (mugwort)	0.4	0	1.6	0	4.3	3.9	.	3.2
Campanula patula subsp. *jahorinae* (Jahorina bellflower)	0.3	0.1	8.6	9.5	0	32	578	0
Cardaminopsis halleri	0.3	0	0	0	0	0	.	0
Carex leporina (oval sedge)	0	0.2	0	7.2	0	.	47	.
Centaurea nigrescens (black-rayed knapweed)	1.8	0	128	0	0	70	.	0
Clinopodium vulgare subsp. *vulgare* (wild basil)	0.6	0.2	111	5	0	186	30	.
Crepis biennis (rough hawk's-beard)	1	0.8	4.6	0.1	1.1	4.6	0.2	1
*Dactylis glomerata*subsp. *glomerata* (cock's-foot)	24	22	1036	546	260	43	25	10.6
Elymus repens (common couch)	5.5	2.3	0	0	18.6	0	0	3.2
Festuca rubra subsp. *rubra* (red fescue)	13	28	105	87	0	8.1	3.1	.
Galium album subsp. *album* (upright hedge-straw)	19	1.1	513	13	0	27	11	0
Helictotrichon pubescens subsp. *pubescens* (downy oat-grass)	313	296	1098	532	818	3.5	1.8	2.6
Holcus lanatus (Yorkshire-fog)	176	104	10534	3465	2418	60	33	12.2
Knautia arvensis (field scabious)	1.9	3.9	99	51	11	52	13	5.7
Lolium perenne (perennial rye-grass)	61	18.9	437	102	42	7.2	5.4	0.7
Plantago lanceolata (ribwort plantain)	7.4	3.3	301	70	10	40	21	1.2
Poa trivialis subsp. *trivialis* (rough meadow-grass)	3.5	4.9	170	99	0	48	20	.
Polygala comosa (longhaired milkwort)	0	0.3	0	0	0	.	0	.
Ranunculus acris subsp. *acris* (meadow buttercup)	6.3	0.8	161	47	2.3	26	57	0.4
Rhinanthus freynii (freyn's yellow-rattle)	0.1	0.4	0	7.6	0	0	19.2	0
Rumex acetosa (common sorrel)	13	3.8	481	75	175	37	20	13.9
*Salvia pratensis*subsp. *pratensis* (meadow clary)	0.7	0.3	66	21	0.1	91	71	0.1
Silene dioica (red campion)	0	0.2	0	1.8	0	.	11	.
Silene vulgaris subsp. *vulgaris* (bladder campion)	0.1	0.2	0	11.6	0	0	58	0
Tragopogon pratensis subsp. *orientalis* (Eastern goat's-beard)	0.2	1.3	22	3.1	0	119	2.5	0
Trisetum flavescens subsp. *flavescens* (yellow oat-grass)	96	74	2454	376	5	26	5.1	0.1
Veronica chamaedrys subsp. *chamaedrys* (germander speedwell)	1.3	0.1	2.3	0.5	0	1.8	5.6	0
Viola tricolor (wild pansy)	1.4	0.1	17	0	0	13	0	0
Other species	1.2	1.5	3.2	4.2	0	2.7	2.8	.

Appendix 4. Number of fertile stems and seeds harvested with hay-making (H) or seed stripper (SS) as compared to the standing seed yield (SSY) in a *Festuca nigrescens- Agrostis capillaris* meadow in the eastern Italian Alps.

Response variable	No. of fertile stems m^{-2}		No. of seeds m^{-2}			No. of seeds per fertile stem		
Treatment	SSY	H	SSY	H	SS	SSY	H	SS
Agrostis capillaris (common bent)	297	165	6650	2883	4847	22.38	17.48	16.31
Alchemila gr. *vulgaris* (rough lady's-mantle)	3	25	2	11	0.03	0.62	0.43	0.01
Anthoxanthum alpinum (alpine vernal-grass)	7	13	2	3	0.4	0.34	0.26	0.05
Avenella flexuosa (wavy hair-grass)	1	0	1	0	1	1.19	.	0.89
Briza media (quaking grass)	17	15	78	65	61	4.49	4.49	2.98
Carum carvi (caraway)	2	5	32	1	5	17.67	0.17	3.02
Centaurea nervosa subsp. *nervosa* (nervous knapweed)	0.1	1	0.1	1	0.3	1.00	0.62	1.68
Crocus albiflorus (white spring crocus)	0.2	8	0	9	0.03	0	1.15	0.17
*Dactylis glomerata*subsp. *glomerata* (cock's-foot)	1	0.1	0	0	2	0	0	1.79
Festuca nigrescens (chewing's fescue)	156	79	280	37	154	1.79	0.47	0.98
Helictotrichon pubescens subsp. *pubescens* (downy oat-grass)	5	5	1	1	1	0.28	0.25	0.18
Knautia longifolia (long-leaf scabious)	1	2	0	0.1	0.3	0	0.05	0.19
Leontodon hispidus (rough hawkbit)	0.04	0.4	0	0.1	0	0	0.27	0
Leucanthemum vulgare (marguerite)	8	17	5	106	0	0.65	6.27	0
Nardus stricta (mat-grass)	0.3	0	2	0	0	6.19	.	0
Phleum rhaeticum (rhaetic cat's -tail)	0.2	0.1	3	2	0.1	18.12	21.02	0.76
Phyteuma orbiculare (round-headed rampion)	5	7	39	119	81	7.08	17.86	14.87
Plantago lanceolata (ribwort plantain)	3	4	272	73	248	78.75	18.05	63.70
Poa alpina (alpine meadow-grass)	2	1	0	0	20	0	0	8.60
Poa variegata (variegated meadow-grass)	31	27	13	0.1	1	0.41	0.002	0.02
Ranunculus acris subsp. *acris* (meadow buttercup)	11	4	0.2	1	2	0.02	0.26	0.23
Rhinanthus freynii (Freyn's yellow-rattle)	78	32	102	14	170	1.30	0.42	2.17
Scabiosa velenovskyana (Velenovsky's scabious)	0.1	1	0	0.4	0.1	0	0.40	0.15
Stellaria graminea (lesser stitchwort)	0	0.2	0	0.6	0	.	2.50	.
Trifolium pratense subsp. *pratense* (red clover)	30	53	60	125	21	2.03	2.38	0.70
Trifolium repens (white clover)	4	4	115	75	54	26.2	16.9	12.3
Trisetum flavescens subsp. *flavescens* (yellow oat-grass)	0.4	0.1	0.3	0	0	0.71	0	0
Trollius europaeus (globe flower)	7	4	32	0.1	4	4.59	0.02	0.54
Other species	35	71	24	18	0	0	0	0