

Supporting information to the paper

Rapinel, S. et al. Mapping grassland plant communities using a fuzzy approach to address floristic and spectral uncertainty. *Applied Vegetation Science*.

Appendix S1. Fuzzy accuracy assessment

The membership matrix for the validation dataset RM2 was labelled as the reference membership matrix \tilde{R}_n . The membership matrix CM2 derived from the fuzzy classification of remotely sensed data was labelled as classified membership matrix \tilde{C}_m . Within the fuzzy approach, \tilde{R}_n and \tilde{C}_m may be considered as a fuzzy set with the following membership function:

$$\mu_{\tilde{R}_n}: X \rightarrow [0,1]$$

$$\mu_{\tilde{C}_m}: X \rightarrow [0,1]$$

where $[0,1]$ denotes the interval of real numbers from 0 to 1 inclusive, $\mu_{\tilde{R}_n}(x)$ and $\mu_{\tilde{C}_m}(x)$ represent the gradual membership of the sample element x in classes n and m as indicated in the reference and classification data respectively.

\tilde{C}_m and \tilde{R}_n were crossed in order to derive an overall accuracy (OA) index and a fuzzy confusion matrix confusion matrix \tilde{M} :

$$\tilde{M}(m, n) = |\tilde{C}_m \cap \tilde{R}_n| = \sum_{x \in X} \mu_{\tilde{C}_m \cap \tilde{R}_n}(x)$$

where the “min” operator is introduced for the intersection operation as $\mu_{\tilde{C}_m \cap \tilde{R}_n}(x) = \min(\mu_{\tilde{C}_m}(x), \mu_{\tilde{R}_n}(x))$.

Binaghi et al. (1999) stated that “The conventional question of “how coincident are classification and reference data” must be reformulated as “how close are the grades in class assignments for classification and reference data”. In short, in the fuzzy case, the sum of the major diagonal was divided by the total degrees of membership found in the reference data, interpreting the OA as a measure of the total match between the reference and classification membership matrices. In order to assess the potential misclassifications, the producer’s accuracy (PA), related to errors of commission, and the user’s accuracy (UA), related to errors of omission, and were calculated by dividing the corresponding element of the major diagonal by the total grades of membership found in the reference and classification matrices in either the corresponding column or row. Finally, a fuzzy kappa was calculated using Cohen’s kappa coefficient to measure the agreement between the fuzzy sets proposed by (Dou et al. 2007):

$$K_{fuzzy} = \frac{P_0^F - P_e^F}{1 - P_e^F}$$

where P_0^F is the proportion of observed agreement in the fuzzy classification and P_e^F is the expectation of random agreement.

Table 1. Fuzzy error matrix for the map of the plant communities' derived from the remotely sensed imagery. The values represent the cardinality of the intersection set $\tilde{C}_m \cap \tilde{R}_n$

Reference data										Total grades	User's
Class data	\tilde{R}_1	\tilde{R}_2	\tilde{R}_3	\tilde{R}_4	\tilde{R}_5	\tilde{R}_6	\tilde{R}_7	\tilde{R}_8	\tilde{R}_9		Accuracy %
\tilde{C}_1	2.69	3.62	0.76	1.57	2.09	2.00	1.49	2.11	1.46	4.65	57
\tilde{C}_2	2.54	17.74	2.40	4.61	7.05	4.89	4.41	7.52	6.15	29.21	60
\tilde{C}_3	1.35	3.13	3.84	2.08	2.89	2.16	2.12	2.72	1.74	6.38	60
\tilde{C}_4	1.72	4.37	1.34	4.22	4.52	2.85	2.42	4.75	2.14	6.42	65
\tilde{C}_5	1.90	6.69	2.13	5.80	8.36	4.43	2.58	6.70	2.30	13.65	61
\tilde{C}_6	2.25	7.16	1.57	4.79	9.16	7.23	2.60	6.21	2.34	17.19	42
\tilde{C}_7	1.43	3.92	1.44	2.31	3.02	2.20	3.78	3.53	2.75	5.92	63
\tilde{C}_8	1.91	6.53	1.94	5.28	5.84	3.61	3.51	8.41	2.93	12.32	68
\tilde{C}_9	2.35	6.93	1.29	3.22	5.05	3.56	3.22	5.45	2.83	11.22	25
Total grades	4.41	25.36	6.77	9.66	12.40	11.45	5.77	12.28	6.92		
Producer's Accuracy %	60	69	56	43	67	63	65	68	40		
Median overall accuracy = 62%											
Median Kappa coefficient = 0.56											

Cited references:

- Binaghi, E., Brivio, P.A., Ghezzi, P., & Rampini, A. 1999. A fuzzy set-based accuracy assessment of soft classification. Pattern Recognition Letters 20: 935–948.
- Dou, W., Ren, Y., Wu, Q., Ruan, S., Chen, Y., Bloyet, D., & Constans, J.-M. 2007. Fuzzy kappa for the agreement measure of fuzzy classifications. Neurocomputing 70: 726–734.