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CLUSTER ANALYSIS IN POLLEN DATA OF HOLOCENE VEGETATION IN NORTHERN IRELAND: 12,000 TO 1,000 YEARS BP
I. NUMERICAL METHOD

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ABSTRACT - *Cluster analysis in pollen data of Holocene vegetation in Northern Ireland:12,000 to 1,000 years BP. I. Numerical method* - Il Quaternario, 5(1), 1992, p. 77-84 - Palynological data from 9 spectra developed from peat cores taken in Northern Irish raised bogs are an ideal data set for the evaluation of cluster analysis applied to pollen data sets. The cores are from a geographically restricted area; samples from each core are taken at intervals of 20÷40 mm; 9 radiocarbon dates are on average available for each core; analyses were carried out by 4 palynologists operating within the same laboratory. Data subjected to clustering have been corrected using Andersen's (1970) correction factors in order to allow equal representability of all identified woody species on the basis of individual pollen productivity. Identified vegetational units are placed along the radiocarbon time scale and mapped to highlight the simultaneous distribution of different vegetation types.

RIASSUNTO - *Cluster analysis di dati palinologici della vegetazione olocenica dell'Irlanda del Nord: 12,000 a 1,000 anni BP. I. Metodo numerico* - Il Quaternario, 5(1), 1992, p. 77-84 - Dati palinolologici di 9 spettri pollinici ricavati da carotaggi effettuati in torbiere alte dell'Irlanda del Nord sono un gruppo ideale di dati per la valutazione di metodi della *cluster analysis* applicata alla palinologia. I carotaggi sono stati effettuati in un'area geograficamente ristretta; i singoli campioni sono stati effettuati ad intervalli di 20÷40 mm lungo il carotaggio; sono disponibili in media 9 radiodatazioni per carotaggio; le analisi sono state effettuate da 4 palinologi operanti nel medesimo laboratorio. Prima dell'analisi i dati sono stati corretti utilizzando i fattori di correzione di Andersen (1970), al fine di consentire una adeguata rappresentatività di tutte le specie arboree identificate in base alla produttività pollinica di ciascuna. Il tipi vegetazionali identificati vengono posizionati lungo la scala temporale delle radiodatazioni e mappati per evidenziare la simultanea distribuzione dei diversi tipi vegetazionali.

Key-words: Palynology, Northern Ireland, vegetation types, cluster analysis, vegetation chronosequences
Parole chiave: Palinologia, Irlanda del Nord, tipi vegetazionali, cluster analysis, cronosequence vegetazionali

1. INTRODUCTION

Numerical classification procedures have been applied to pollen data for almost 25 years; several examples of clustering of pollen data sets are available in the literature. An extensive summary can be found in Birks & Gordon (1985). One criticism of standard clustering algorithms applied to palynology has been the lack of stratigraphic constraints: levels widely apart are allowed to group together. Stratigraphic constraints have been introducted so that "only adjacent levels or clusters of levels could be fused together" (Birks & Gordon, 1985). This approach is useful for single sequence zonation; stratigraphic constraint is equatable to a time constraint in multisequence pattern recognition, and may not be suitable for the development of areal pollen zonations applicable to a number of different sites.

The primary objective of multisequence comparison of pollen data is the identification of structurally different vegetation units in time and geographical space. Consequently any technique which highlights this pattern is suitable, irrespective of both temporal and spatial constraints, given that 'zonation' is a form of data reduction reflecting an intrinsic property of the data itself.

Cluster analysis is used to isolate different vegetational units. Positioned along a timescale these may reveal temporal changes in vegetation distribution: availability of an suitable independent timescale based on ^{14}C dating can be used to test this latter assumption. Units may also be mapped according to site location.

Northern Ireland pollen cores collected over the last 25 years are an optimal data set to test formalized approaches used to evaluate changes in past pollen-identified vegetation. Data from a number of sites are subjected to non-hierarchical cluster analysis to highlight different vegetational structures in pollen-identified species. Identified vegetational units are successively mapped after being positioned along the radiocarbon timescale; this highlights plant migration patterns and the distribution and movement of Holocene vegetational units in the area (Evans, 1992).

2. THE DATA

Twenty-one sites have been sampled in Northern Ireland for palynological purposes; not all data have been published, and are available only in manuscript form.

Northern Ireland pollen data satisfies 4 fundamental criteria:

- extensive and detailed sampling in a restricted geo-

graphical area;
- extensive and detailed sampling within each core. On average samples are taken every 40 mm, frequently even at a finer scale;
- detailed radiocarbon dates are available for a number of cores, with an average of 9 ^{14}C dates per core;
- ntra-laboratory homogeneity of sample preparation techniques is achieved (Webb *et al.* 1978). Successive analysts have worked at the Paleœcology Centre, Queen's University, Belfast (UK).

Nine cores have been selected from the data set, those for which radiocarbon dating is available. Inter-analyst variance within the set is minimal, with 4 palynologists carrying out the pollen identification.

Selected sites are listed in Table 1 and positioned in Fig. 1. Radiocarbon dates for each site are given in Table 2. Pollen-identified species are listed in Table 3. Scores for each species have been reconverted to numerical values; univariate statistics of the sample are given in Table 4. Three variants of the basic data set have undergone clustering: these are defined as runs 1 to 3.

3. METHODS

Wishart's CLUSTAN statistical package (Wishart, 1969) has been used to cluster the data. Both hierarchical and non-hierarchical clustering procedures have been used.

The non-hierarchical procedure is a variant of MacQueen's (1967) basic k-means method whereby an initial partition is established with a set of seed points computed as centroids of a number of clusters; each case is assigned to the cluster with the nearest seed point; cluster number is systematically reduced with initial reassignment of cases to the reduced number of groups.

The hierarchical procedure was originally devel-

Table 1 - Sites and author(s) of each pollen diagram.
Siti ed autori di ciascun spettro pollinico.

Code	Site	Code	Author	Year
Site (1)	Killymaddy Lough core N	KLM	Hirons K.R. *et al.*	1986
Site (2)	Weir's Lough	WEI	Hirons K.R. *et al.*	1986
Site (3)	Gortcorbies core 1	GOR1	Goddard I.C.	1971
Site (4)	Gortcorbies core 2	GOR2	Goddard I.C.	1971
Site (5)	Sluggen Moss	SLM	Goddard I.C.	1971
Site (6)	Altnahinch	ALT	Goddard A.	1971
Site (7)	Slieve Gallion	SLG	Pilcher J.R.	1973
Site (8)	Ballynagilly	BAL	Pilcher J.R. *et al.*	1979
Site (9)	Meenadoan	MEE	Pilcher J.R. *et al.*	1982

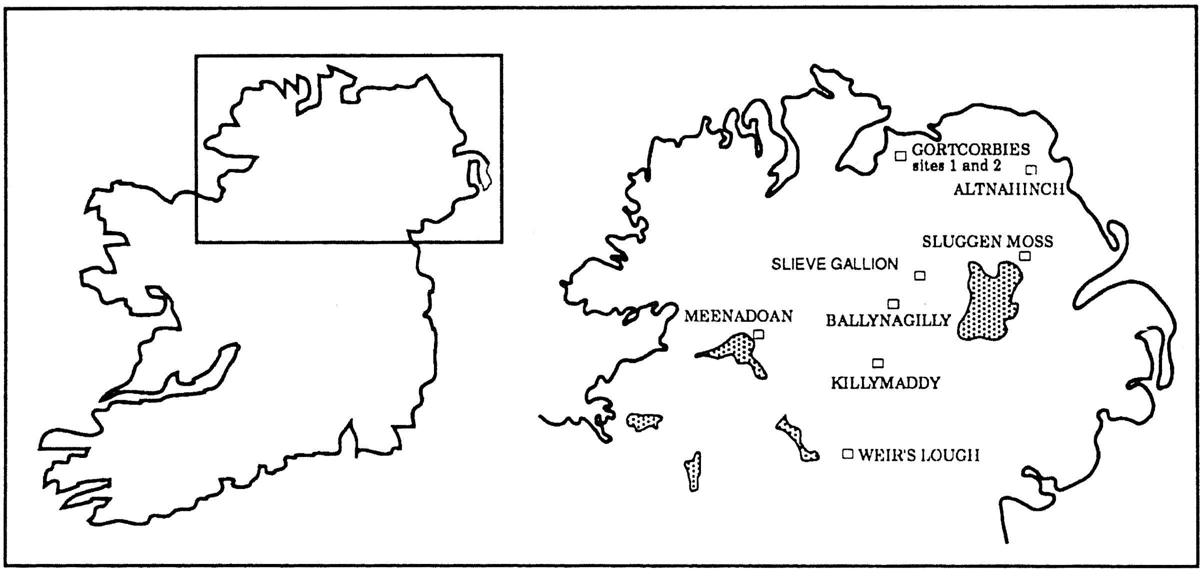

Fig. 1 - Northern Ireland. Site location; only sites considered in the paper are identified.
Irlanda del Nord. Località campionarie; sono riportate solo le località campionarie i cui dati vengono citati nel testo.

Table 2 - Radiocarbon dates from dated levels at each site, expressed as uncorrected yrs BP. The first digit of the code indicates the site, the remaining the sampled level in cm, from top to bottom of the core.

Radiodatazioni dei livelli radiodatati per ciascuna località, espressa in anni BP non calibrati. La prima cifra del codice indica la località, le rimanenti la profondità del campione in cm, dall'alto verso il basso del carotaggio.

Site	Code Level	Code Level	C^{14} code	C^{14} date BP	st. dev. ±
Site 1 Killymaddy	10050	10060	UB-2482	1535	65
	10089	10099	UB-2481	440	165
	10205	10215	UB-2479	2375	105
	10247	10257	UB-2478	2850	110
	10359	10369	UB-2476	4940	135
	10390	10400	UB-2475	5050	95
	10437	10447	UB-2474	7205	105
	10461	10471	UB-2473	8465	195
	10485	10495	UB-2472	8980	120
	10495	10501	UB-2471	10920	370
Site 2 Weir's Lough	20260	20268	UB-2497	2045	95
	20332	20340	UB-2496	895	75
	20364	20372	UB-2495	635	60
	20436	20444	UB-2494	1100	90
	20568	20576	UB-2492	2860	75
	20652	20660	UB-2491	3455	75
	20684	20692	UB-2490	3965	75
	20740	20748	UB-2489	4630	75
	20780	20788	UB-2488	5295	85
	20860	20868	UB-2487	6405	120
	20916	20924	UB-2486	7750	105
	20940	20948	UB-2485	8895	195
	20964	20972	UB-2484	10195	195
	20980	20990	UB-2483	10770	145
Site 4 Gortcorbies core 2	40041	40044	UB-389	730	65
	40090	40093	UB-388	1385	65
	40158	40161	UB-387	2025	65
	40209	40212	UB-386	3025	70
	40243	40246	UB-385	3605	70
	40263	40266	UB-384	4070	75
	40294	40297	UB-382	3975	74
	40312	40315	UB-237	4520	80
	40322	40325	UB-236	4500	80
	40325	40328	UB-235	4750	70
	40331	40333	UB-234	5160	75
	40333	40346	UB-233	4505	95
	40334	40336	UB-232	5115	85
	40336	40342	UB-231	5805	85
	40564	40368	UB-230	7755	90
Site 5 Sluggen Moss	50042	50047	UB-210	985	45
	50047	50070	UB-437	1635	75
	50124	50126	UB-438	2930	85
	50164	50166	UB-439	3945	85
	50230	50235	UB-219D	4500	80
	50230	50235	UB-219B	4520	80
	50230	50235	UB-219A	4650	75
	50238	50240	UB-441	4965	75
	50270	50275	UB-220D	5230	70
	50270	50275	UB-220A	5290	65
	50270	50275	UB-220C	5440	60
	50295	50300	UB-221	6760	90
	50365	50370	UB-223B	7975	70
	50365	50370	UB-223A	8195	65
	50365	50370	UB-223D	8360	60
	50406	50408	UB-442	8540	120
	50426	50428	UB-443	9360	150

Site	Code Level	Code Level	C^{14} code	C^{14} date BP	st. dev. ±
Site 6 Altnahinch	60063	60065	UB-428	1525	80
	60131	60147	UB-425	3005	70
	60148	60151	UB-410	2990	90
	60155	60159	UB-426	3165	90
	60241	60243	UB-423	4880	105
	60277	60279	UB-422	6340	100
	60317	60319	UB-421	7880	110
	60369	60371	UB-418	8890	115
	60381	60384	UB-419	9045	125
	60388	60391	UB-411	9555	135
Site 7 Slieve Gallion	70050	70052	UB-271	2670	80
	70080	70112	UB-273	3580	60
	70110	70112	UB-273	3580	60
	70140	70142	UB-274	4165	80
	70170	70172	UB-275	4895	65
	70200	70202	UB-276	5870	65
	70220	70222	UB-277	6735	65
	70234	70236	UB-278	7400	90
	70255	70252	UB-279	7880	75
	70266	70268	UB-280	8760	90
	70280	70282	UB-281	8760	75
	70294	70296	UB-298D	9660	105
Site 8 Ballynagilly	80040	80044	UB-242	695	80
	80120	80124	UB-244	2375	80
	80164	80167	UB-245	3135	60
	80178	80181	UB-246	3340	65
	80194	80197	UB-247	3620	60
	80204	80207	UB-248	3955	55
	80214	80217	UB-249	4025	65
	80226	80229	UB-250	4340	65
	80236	80239	UB-251	4540	65
	80244	80247	UB-252	4850	70
	80253	80256	UB-253	5145	70
	80261	80264	UB-254	5575	70
	80270	80273	UB-255	5920	60
	80310	80314	UB-257	7275	95
	80330	80334	UB-258	8095	80
	80376	80380	UB-322D	9535	110
	80376	80380	UB-322C	9180	110
	80380	80384	UB-260	9595	80
	80400	80404	UB-297	9595	125
Site 9 Meenadoan	90406	90422	UB-2108	3335	110
	90478	90498	UB-2109	4020	125
	90558	90578	UB-2110	4810	125
	90702	90718	UB-2111	5915	120
	90806	90822	UB-2112	7820	110
	91054	91070	UB-2136	8760	150
	91078	91094	UB-2137	9150	335
	91194	91202	UB-2139	11670	205
	91202	91218	UB-2140	11790	205
	91226	91242	UB-2141	12160	370
	21250	21260	UB-2142	11440	185

oped by Wolfe (1970) and seeks optimal partitions by assuming a multivariate normal distribution for each cluster and estimating the parameters of the maximum likelihood principle. Significance tests can be carried out on the partitioning of cases into clusters. Given however that multinormality is rarely achieved in palynological data sets, this method is unsuitable for the evaluation of pollen-identified vegetation.

Results of the k-means procedure will be given; comparable results were also obtained using the second procedure.

3.2 Run 1

Univariate statistics are given in Table 4. Cluster composition is given in Table 5, while Table 6 gives the resulting dominance structure of each cluster; the Lambda type indicates the percentage of cases in each.

Table 3 - Pollen-identified species.
Specie identificate nell'analisi pollinica.

Species	Variable code
Betula sp	BET
Pinus sylvestris	PIN
Ulmus sp	ULM
Quercus sp	QUE
Alnus sp	ALN
Fraxinus excelsior-type	FRA
Salix sp	SAL
Juniperus sp	JUN
Corylus-type	COR
Non Arboreal Pollen	NAP

It is clear that 2 variables dominate the set, namely *Corylus* and Non-Arboreal Pollen (NAP), and to a lesser extent *Alnus* and *Betula*. It is not surprising therefore that the cluster composition should reflect this. Any change which may be taking place at the canopy and shrub levels is consequently masked.

Table 4 - Sample univariate statistics.
Statistiche univariate del campione.

Species	Mean	St. Dev.
Betula sp	8.54	7.71
Pinus sylvestris	2.88	4.93
Ulmus sp	4.01	5.44
Quercus sp	8.24	6.51
Alnus sp	11.59	9.81
Fraxinus excelsior-type	0.97	2.31
Salix sp	2.49	4.21
Juniperus sp	0.63	4.68
Corylus-type	32.62	18.63
Non Arboreal Pollen	27.97	25.36

High *Corylus* values may reflect high pollen productivity, while high NAP % values result from the reduction in the values of other species; the percentage counting method means that if one species is reduced, one or more others must increase.

When the radiocarbon timescale is added to the vegetational units, 2 patterns become evident:

a) a significant change in the vegetational landscape from the late to the immediate post-glacial: cluster 2 is replaced by cluster 6 or 7 at most sites, marking the drastic drop in *Juniperus* values and a carry over of constant *Betula* values;

b) the recent decline in overall arboreal pollen values and the concomitant rise in NAP: cluster 1 is replaced by cluster 4.

Table 5 - Run 1: cluster composition expressed as percentage of species.
Serie 1: composizione dei raggruppamenti espressa come percentuale di ciascuna specie.

Cluster	Lambda	BET	PIN	ULM	QUE	ALN	FRA	SAL	JUN	COR	NAP
1	21.70	10.35	4.89	3.24	9.09	14.30	1.60	2.63	0.02	28.63	25.20
2	3.93	32.05	6.43	1.40	4.34	9.12	0.23	9.47	10.21	12.06	14.64
3	11.16	6.17	1.06	0.35	1.28	2.80	0.10	2.77	1.08	5.16	79.18
4	18.55	6.28	1.65	1.56	6.86	10.22	0.60	1.70	0.51	20.32	50.24
5	24.37	7.00	2.13	5.36	15.21	22.63	1.87	1.26	0.00	40.23	4.25
6	12.42	7.79	2.93	10.57	5.76	2.16	0.13	1.89	0.02	64.50	4.21
7	7.86	6.47	3.36	3.87	3.31	1.73	0.18	4.84	0.12	47.98	28.08

3.3 Run 2

This run attempts to allow equal representation of all variables. Correction factors are taken from the literature, developed originally for Northern Europe. Modern pollen-vegetation studies have been carried out in Northern Ireland (Goddard, 1971), but lack the necessary rigorous quantification of the vegetation surrounding the site: no local correction factors are therefore available. Original data is rescaled using Andersen's (1970) correction factors, as given in Table 7.

Table 8 gives the univariate statistics of data for run 2; Tables 9 and 10 give cluster composition and dominance structure of groups respectively.

Corylus values decrease and *Salix, Ulmus, Quercus* and *Alnus* participate in cluster formation, as

Table 6 - Run 1: dominance structure.
Serie 1: struttura di dominanza.

Cluster	1	2	3	4	5	6	7	8	9	10
1	COR	NAP	BET	ALN	QUE	PIN	ULM	SAL	FRA	JUN
2	BET	NAP	COR	JUN	SAL	ALN	PIN	QUE	ULM	FRA
3	NAP	BET	COR	ALN	SAL	QUE	JUN	PIN	ULM	FRA
4	NAP	COR	ALN	QUE	BET	SAL	PIN	ULM	FRA	JUN
5	COR	ALN	QUE	BET	ULM	NAP	PIN	FRA	SAL	JUN
6	COR	ULM	BET	QUE	NAP	PIN	ALN	SAL	FRA	JUN
7	COR	NAP	BET	SAL	ULM	PIN	QUE	ALN	FRA	JUN

shown in Table 10. When the scores are positioned along the radiocarbon timescale, the following patterns emerge:

- the late glacial to early post-glacial transition is identified by a change from cluster 6 to cluster 7;
- the recent decline of arboreal pollen values and the concomitant steady rise in NAP is identified by a shift from cluster 1 to cluster 7.

NAP values are still over-represented: the average value is almost double to that of run 1 (from 27.97 to 44.94%). Experimental work carried out on modern grass pollen emission and concentration fall-off from a point-source (Raynor *et al.*, 1972; Chamberlain, 1975; Hall, 1989) indicates that values drop by 40% at 60 m from the source, and concentrations decrease to below 1% at 1 km.

Table 7- Correction factors proposed by Andersen (1970).
Fattori di correzione proposti da Andersen (1970).

Taxon	Correction
Quercus, Betula, Alnus, Pinus	1:4
Corylus as a canopy tree	1:4
Ulmus	1:2
Fraxinus	1x2

Table 8 - Run 2: sample univariate statistics.
Serie 2: statistiche univariate del campione.

Species	Mean	St. Dev.
Betula sp	4.84	4.97
Pinus sylvestris	1.73	3.19
Ulmus sp	5.23	7.85
Quercus sp	5.27	5.24
Alnus sp	7.22	7.41
Fraxinus excelsior-type	3.93	8.58
Salix sp	4.94	7.22
Juniperus sp	0.80	5.80
Corylus-type	20.95	16.31
Non Arboreal Pollen	44.94	30.30

Table 9 - Run 2: Cluster composition expressed as percentage of species.
Serie 2: composizione dei raggruppamenti espressa come percentuale di ciascuna specie.

Cluster	lambda	BET	PIN	ULM	QUE	ALN	FRA	SAL	JUN	COR	NAP
1	13.99	5.96	3.32	2.81	4.42	7.21	4.57	7.02	0.24	16.52	47.87
2	20.02	5.60	1.48	7.42	13.07	18.51	3.76	4.01	0.01	35.23	10.86
3	6.11	5.67	0.14	3.39	6.15	10.97	32.78	3.24	0.01	17.08	20.52
4	28.93	2.47	0.56	0.87	1.72	2.71	0.92	2.52	0.47	6.36	81.34
5	14.48	5.05	1.78	2.68	3.96	5.51	1.90	2.95	0.14	16.61	59.38
6	4.10	8.39	2.73	3.50	1.18	0.59	0.00	30.44	14.54	11.29	27.28
7	12.38	6.08	3.45	19.86	4.33	1.81	0.10	4.48	0.06	47.14	12.65

Table 10 - Run 2: dominance structure.
Serie 2: struttura di dominanza.

Cluster	1	2	3	4	5	6	7	8	9	10
1	NAP	COR	ALN	BET	SAL	FRA	QUE	PIN	ULM	JUN
2	COR	ALN	QUE	NAP	ULM	BET	SAL	FRA	PIN	JUN
3	FRA	NAP	COR	ALN	QUE	BET	ULM	SAL	PIN	JUN
4	NAP	COR	ALN	SAL	BET	QUE	FRA	ULM	PIN	JUN
5	NAP	COR	ALN	BET	QUE	SAL	ULM	FRA	PIN	JUN
6	SAL	NAP	JUN	COR	BET	ULM	PIN	QUE	ALN	FRA
7	COR	ULM	NAP	BET	SAL	QUE	PIN	ALN	FRA	JUN

Consequently rescaling to 1/4 of the original NAP score has been carried out.

Table 11 - Run 3: sample univariate statistics.
Serie 3: Statistiche univariate del campione.

Species	Mean	St. Dev.
Betula sp	7.12	6.30
Pinus sylvestris	2.47	4.21
Ulmus sp	6.65	8.70
Quercus sp	7.08	5.72
Alnus sp	9.97	8.50
Fraxinus excelsior-type	5.42	10.60
Salix sp	7.41	9.83
Juniperus sp	1.23	7.44
Corylus-type	28.06	16.65
Non Arboreal Pollen	24.65	23.55

3.4 Run 3

Rescaling of NAP allows other species to participate in cluster formation. Univariate statistics of run 3 are given in table 11; Tables 12 and 13 give cluster composition and dominance structure of groups respectively.

4. RESULTS

Results are given in Table 14; vegetational units for each site are positioned along the radiocarbon time scale. Minimum temporal resolution is of 200-years, corresponding to an average second standard deviation of a radiocarbon date.

5. CONCLUSIONS

Clustering of pollen data has been shown to be a useful technique for the identification of different vegetation types in pollen data. Stratigraphic constraints on clustering, better suited to the identification of pollen zones in single sequences, are not useful in multi-sequence comparison. Northern Irish palynological data, corrected using the correction factors proposed by Andersen (1970) to balance out over-representation of a number of species resulting from excessive pollen productivity, is subjected to multi-sequence comparison using cluster analysis. Non-hierarchical cluster analysis identifies a number of different vegetational units. When the units are placed along the radiocarbon time scale, information on the migration patterns of single taxon, the distribution and movement of the vegetational units during the Holocene emerges. These are discussed in detail in another paper (Evans, 1992).

Table 12 - Run 3: Cluster composition expressed as percentage of species.
Serie 3: composizione dei raggruppamenti espressa come percentuale di ciascuna specie.

Cluster	lambda	BET	PIN	ULM	QUE	ALN	FRA	SAL	JUN	COR	NAP
1	13.08	6.60	3.74	21.81	4.79	2.39	0.16	4.80	0.06	51.41	4.18
2	25.92	9.43	4.70	4.73	7.10	10.05	3.80	8.18	0.14	28.80	23.01
3	4.54	9.03	2.27	3.30	1.02	0.62	0.00	37.62	18.98	13.45	13.65
4	10.46	5.66	0.92	0.64	1.19	2.41	0.65	8.52	2.86	4.77	72.33
5	20.10	5.82	1.62	8.10	14.22	20.28	3.99	4.16	0.01	38.09	3.65
6	7.92	6.83	0.16	3.38	6.89	13.13	35.81	4.16	0.01	20.13	9.44
7	17.99	6.13	1.23	2.56	5.77	9.21	3.36	4.96	0.10	19.53	47.10

Table 13 - Run 3: dominance structure.
Serie 3: struttura di dominanza.

Cluster	1	2	3	4	5	6	7	8	9	10
1	COR	ULM	BET	SAL	QUE	NAP	PIN	ALN	FRA	JUN
2	COR	NAP	ALN	BET	SAL	QUE	ULM	PIN	FRA	JUN
3	SAL	JUN	NAP	COR	BET	ULM	PIN	ALN	QUE	FRA
4	NAP	SAL	BET	COR	JUN	ALN	QUE	PIN	FRA	ULM
5	COR	ALN	QUE	ULM	BET	SAL	FRA	NAP	PIN	JUN
6	FRA	COR	ALN	NAP	QUE	BET	SAL	ULM	PIN	JUN
7	NAP	COR	AMN	BET	QUE	SAL	FRA	ULM	PIN	JUN

Table 14 - Chronological position of the vegetation units (clusters 1÷7).
Posizione cronologica delle unità vegetazionali (clusters 1÷7).

Years BP	Killymaddy	Weir's Lough	Gortcorbies	Sluggen Moss	Altnahinch	Slieve Gallion	Ballyna--gilly	Meenadoan
0	7							
200	7							
400	7						4	
600	7						7	
1000	7		2		5?		7	
1200	7		6-4	5	5		4-7?	
1400	7		2	5	5		4-7?	
1600	7		2	5-6	7		7	
1800	7		2	5-6	7		7	
2000	2-6-7		2-6	6	7		7	
2200	6		2	6	7		7	
2400	2		2	6	7		7	2-6
2600	6		2	6	2	7	7	2-6
2800	6		2	6	7	7	7	2-6
3000	6		2	5	2-7	2-7	2-7	2-6
3200	6		2	5	7	7	2-7	5
3400	6?		2	5	7	7	5-2	5
3600	6-5?		2	5	7	7	5-2	5-2
3800	6-5?		2	5	7?	2	2	5-2
4000	5?		2	5	2?	2	2	1
4200	5		2	5	2	7	2	5-1
4400	5		2	5	2	2	2	5-1
4600	5		2	5	2	7	2	1
4800	5		2	5	2	2	2	1
5000	5		2	5	2	7	2	1
5200	5		2-3	5	2	7	2	1
5400	5		2-3	5	2	2	2	1
5600	5	5	2-3	5	2	7	2	1
5800	5	5	3	5	2	4	2	1
6000	5	5	3	5	2	2	2	1
6200	5	5-1	3	5	2	2	2	1
6400	5	1	3	5	2	2	2	1
6600	5	1	3	5	2	2	2	1
6800	5?	1	3	5-1	2	2	2-3	1
7000	1?	1	3	1	2	2-7	2-7	1
7200	1	1	3	1	2	2-7	7	1
7400	1	1	3	1	2-7?	7	4-7	1
7600	1	1	2-3	1	2	2-7	4-7	1
7800	1	1	3	1	2	7	4-7	1
8000	1	1	3	1	7	4	4-7	1
8200	1	1	2-3	1	7	7	4-7?	1?
8400	1	1		1	7	2	2-3?	2-3?
8600	1	1		1	7	2	2-3	3
8800	1-2-3	1		1	4	2-7-4	2-3	3
9000	3	1		1	4	4	2	4?
9200	3	1		1	4	4		4
9400	3	1		1	4	4		4
9600	3	1		1	4	4		4
9800	3	1		1?	4?			4
10000	3	1-3		1?				4
10200	3	3		3?				4
10400	3	3						4
10600	3	3						4
10800	3	3						4
11000	3	3?						4
11200		4						4
11400		4						4
11600		4						4
11800		4						4
12000								4

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