Considerations on the Dynamics of the Mountain Grasslands in the South Carpathians (Romania)

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The geographical location, the geomorphologic diversity with a balanced distribution between plains, hills, and mountain areas spreading from the Black Sea, the Danube floodplain and delta to heights exceeding 2,500 m of altitude in the Carpathians provide a wide range of conditions which give Romania one of the richest biological diversity in Europe.

The mountain area of Romania covers more than one third of the country's area. It is represented mainly by the Carpathian mountains, but by the old Dobrudja mountains too.

The mountain area of the Romanian Carpathians covers 66,303 squar kilometers (or 27.8 per cent of country's area), between the altitude of 500 m and 2,544 m, the highest peak (Moldoveanu peak in the Fagaras Mountains).

The Romanian Carpathians represent 54 per cent of the European Carpathians and form the southern sector of the chain.

The Romanian Carpathians are divided into three branches according to their geographical location, namely, the Eastern, the Southern, and the Western branch with different climatic and vegetation conditions.

Natural Conditions

The average climate and soil conditions of the Romanian Carpathians illustrated briefly by the altitude gradients show a decrease in the average annual temperature by 0.5°C, an increase of the average precipitation of 45 mm and of the average wind velocity by 0.5 m/s for every 100 meters increase in the altitude, and simultaneously decreasing soil trophic properties (*Table 1*).

These climatic characteristics are determined by the stronger continental character of the climate and account for the differences in altitude of the belts of natural vegetation in the Carpathians compared to other European mountain chains (Alps, Pyrenees). temperature is also lower and precipitation higher in the north of the Eastern Carpathians which causes a differentiation of the vegetation belts boundaries in the Eastern Carpathians compared to the Southern Carpathians.

According to these climatic and soil conditions we meet a primary mountain forest vegetation between (400) 500 m and up to 1,600-1,800m, between 1,900m and 2,200m there are sub-alpine bushes and the alpine grasslands grow above this limit (*Figure 2*). The primary and secondary grassland associations are listed below in *Table 2*.

Area of the mountain grasslands

After the intervention of man and his animals the forest vegetation was replaced by grass vegetation resulting in natural pastures of secondary origin which together with the natural grasslands of primary origin (alpine, steppe, silvosteppe, floodplains, salty soils, sandy soils, etc.) currently cover over 4.9 million hectares in Romania; that means 20 per cent of the country's area.

Out of this total area in the pre-mountain and mountain area (above 500 m altitude) an area of 2.0 million hectares is covered by primary and especially secondary grasslands, accounting for 40 per cent of the total grassland area in Romania. It provides substantial amounts of grass. The area is used mainly for grazing by farm animals (sheep, cattle), but also as meadows (*Table 3*).

Over 90 per cent of the mountain grasslands are located in the area of permanent households and seasonal settlements of the Southern Carpathians situated between 500 m and 1,500 m altitude. Above this line there are the pastures of the high mountains used mainly for grazing by sheep and cattle.

In the forest belt the ratio between the primary forest vegetation and the secondary grass vegetation varies by altitude (*Table 4*). The largest grassland areas are located between 600 m and 1,000 m.

Since many plots were turned into agricultural use and the forest areas substan-

Table 1: **Mean conditions of climate and soil in the Romanian Carpathians (after T. MARUSCA 1995)**

	Climate			Soil		
Altitude (m)	Temp.(°C) (annual mean)	Precipitation (annual sum) (mm)	Wind (m/s) Velocity Mean	Soil depth (cm)	Horizont A pH_{H2O}	Horizont A V %
2,000-2,200	0	1400	9	35	3.9	12
1,800-2,000	1	1350	8	50	4.2	18
1,600-1,800	2	1250	7	65	4.5	24
1,400-1,600	3	1150	6	80	4.8	30
1,200-1,400	4	1050	5	95	5.1	36
1,000-1,200	5	950	4	110	5.4	42
800-1,000	6	850	3	125	5.7	48
600-800	7	800	2	140	6.0	54
Gradients for 100 m altitude	- 0.5	+ 45 mm	+ 0.5 m/s	- 7.5 cm	- 0.15	- 3 %

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tially reduced, at lower altitudes (600 m - 800 m) the grassland areas increased considerably, although we are there in full nemoral area. In the higher belts of forest vegetation, although trees and bushes were cut, they were replaced by meadows or pastures but not into areas of human settlement or arable land, so that forests are still dominant.

Thus, we can summarize the anthropic impact on forests, by its action in two major directions, namely, lower down towards the expansion of agricultural households, pastures, meadows, crops on arable lands, orchards of fruit trees and higher up towards the expansion of the summer pastures.

The general ratio of forest to grassland is 1:0.5 with a maximum at 600 m - 800 m altitude (1:2.08), and a minimum at 1,000 m - 1,200 m (1:0.14).

This process is changing continuously.

Currently, at least for the time being, the process favors the expansion of forests on grasslands in different degrees of abandonment which occurred during the past decade both at high altitudes and in the hills and the plains.

Grassland productivity

The yield of useful phytomass of montain and alpine grasslands on the control plots was 1.57 tonnes of dry matter per hectare with a relative maximum (1.90 t/ha) between 1,000 m and 1,400 m altitude. Between these limits, the grasslands formed by *Agrostis capillaris* and *Festuca rubra* reached the highest average values of 2.27 tonnes dry matter per hectare (*Table 5*).

Table 2: **Primary and secondary grassland vegetation in the Romanian Carpathians***

	East	Nord	South	West
Alpine belt				
B_{37**} (Alpine grassland and heaths)	**>1,900m**	**>2,000**	**>(2,100) 2,200-2,545**	**>2,200m**
Primulo-Caricetum curvulae Br.-Bl.26 em.Oberdorfer 59				
Oreochloo-Juncetum trifidi Szafer et al.27				
Potentillo chrysocraspedae-Festucetum airoidis(Domin 33) Boscaiu71.				
Oxytropido carpaticae-Elynetum myosuroidis (Puscaru et al 56) Coldea 84				
Alchemillo-Poëtum alpinae ((Beldie 67) Resmerita-72				
Seslerio-Festucetum versicoloris Beldie 67				
Diantho tenuifolii-Festucetum amethystinae (Domin 33) Coldea 84				
Selerio bieltzii-Caricetum sempervirentis Puscaru et al. 56				
Sub-alpine belt				
C_7, C_{14} (Carpathian dwarf mountain pine scrub);	**(1,350) 1,400-1,850 (1,900)m**		**(1,750) 1850-(2,100) 2,200m**	
Potentillo chrysocraspedae- Festucetum airoides (Domin 33)Boscaiu 71				
Seslerio haynaldianae-Caricetum sempervirentis Puscaru et al 56				
Scorzonero roseae-Festucetum nigricantis (Puscaru et al 56) Coldea 87				
Festuco rubrae-Agrostetum capillaris Horvat (51)52				
Seslerio bielzii-Caricetum sempervirentis Puscaru et al 56				
Violo declinatae-Nardetum Simon 66				
Boreal belt				
D_{55} (Boreal spruce forest)	**900- 1,700 (1,750)**		**1450-1750**	**1350-1750m**
Potentillo chrysocraspedae-Festucetum airoides (Domin 33) Boscaiu 71				
Scorzonero roseae-Festucetum nigricantis (Puscaru et al. 56) Coldea 87				
Violo declinatae-Nardetum Simon 66				
Nemoral belt (b)				
F_{92} (Fir - beech mixed forest)	**700-1400(1600)**		**800-1,250**	**(600) 900-1,350 (1,450)m**
Festuco rubrae-Agrostetum capillaris Horvat (51)52				
Violo declinatae-Nardetum Simon 66				
Nemoral belt (b)				
F_{79} (Montain beech forest, Fagus sylvatica) (climatic inversion) **+ F_{81}** (Montain beech forest, Fagus moesiaca)	**(400)500-1,100 (1,400)**		**700-1,450 (1,550)**	**600-1,350m**
Festuco rubrae-Agrostetum capillaris Horvat (51) 52				
Nemoral belt (b)				
F_{82} (Hornbeam and beech mixed forest)	**300-850**	**350-650**	**500-800**	**450-800m**
Anthoxantho-Agrostetum capillaris (Sillinger 33) Jurkó 69				
Lolio - Cynosuretum Tx37				
Festuco rubrae-Agrostetum capillaris Horvat (51) 52				
Agrosti-Genistelletum Boscaiu 70.				

* after Vegetatia României, DONITA et al. 1992

** indicatives of Europe vegetation map

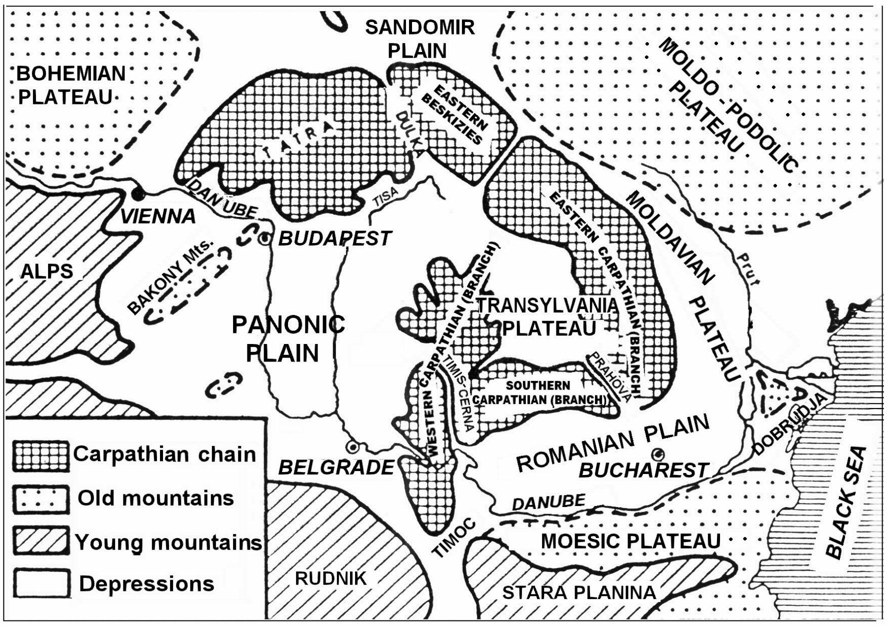

Figure 1: **Carpathian chain**

Compared to the useful production presented earlier, a case study (Bucegi Mountains, southern branch of the Carpathians, Poiana Stânii at 1,250 m altitude and Piatra Arsa at 1,995 m), we notice an interesting dynamics of biomass and necromass during the vegetation period (*Figure A*). Research was conducted on the montain grasslands with *Festuca rubra* at Poiana Stânii and on the sub-alpine pastures with *Festuca airoides* at Piatra Arsa. It reflects the persistence within the structure of the phytocoenosis of about 15 per cent of the dry material of previous years for the first grassland (*Festuca rubra*) and of almost 50 per cent for the pasture with *Festuca airoides*. The montain grassland is richer than the sub-alpine grassland in species belonging to other botanical families than the gramineous than the sub-alpine grassland, and the moss represents a significant part of the biomass in the case of the latter grassland.

The mass of the underground organs is almost twice as large as the aboveground biomass in both grasslands. The energy value of the alpine grassland biomass (4,700 kcal/g dry material) is higher than the energy value of the mountain grassland (4,300 kcal/g d.m.). In both cases the aboveground biomass had a higher energy value than the underground biomass (3,700 kcal/g d.m.).

Though the ecological efficiency of the mountain grassland with *Festuca rubra* is higher (1.06%) than the efficiency of the sub-alpine grassland with *Festuca airoides* (0.91%) due to significantly higher primary production.

Dynamics of forest and grassland production for the same mountain area

A general comparison of the useful production of forests and grasslands in Romania by different altitude levels reveals a differentiated evolution between the useful production of the forests (wood) and the one of the grasslands (grass) expressed by gradients and displayed in parallel, confirms a maximum in the Southern Carpathians for both of them between 1,000 m and 1,200 m altitude (*Figure 3*).

The productivity of the mountain forest ecosystems at the age of one hundred years, starting from the line of 600 m, oin average by 15 cubic meters per hectare (wood production 430 m^3 - 490 m^3) volume of wood mass up to 1,000 m - 1,200 m altitude after which it decreases by 30m^3 (wood production 490 m^3 - 310 m^3) for every 100 m of altitude towards the upper limit of their areal.

The productivity of grassland ecosystems increases on average by 0.5 t/ha/year (with a yield between 7 t - 9 t) green mass of grass up to the same altitude of 1,000 m - 1200 m, after which it decreases by 1.0 t/ha/year (with a yield between 9 t - 3 t) for each 100 m up to the same altitude of 1,800 m.

The maximal forest and grassland yields recorded between 1,000 m and 1,200 m altitude are conditioned by an average annual temperature of 4°C - 6°C, the average temperature of the warmest month of 13°C - 15^{0}C, by 150-180 days with average temperatures above 5°C, by 110 days - 140 days with average temperatures above 10°C, by average annual precipitation of 900 mm - 1050 mm, by soils with pH value of 5.0 - 5.5 in water and 35% - 45% trophicity (V%). The ecosystems between these limits are 63 per cent of fir forest, 30 per cent mountain beech forests, 17 per cent boreal spruce forests; when the forests were cleared the secondary pastures were formed of 65 per cent *Festuco rubrae - Agrostetum capillaris*, 15 per cent *Scorzonero roseae - Festucetum nigricantis* and 20 per cent *Violo declinatae - Nardetum*, from the overall area of the ecosystems located at this altitude.

The decrease of productivity of forests and pastures with increasing altitude is due to the lack of warmth at higher and to the lack of humidity in the case of the lower altitudes.

Coming back to the case study in the Bucegi Mountains, now regarding the herbaceous populations of dominant or characteristic species growing on the grassland of *Festuca rubra* at Poiana Stânii at 1,250 m altitude and on the grassland of *Festuca airoides* at Piatra Arsa at 1,995 m altitude (published by

Table 3: **Distribution of mountain and pre-mountain grassland on the altitude (after TEACI et al. 1980)**

Altitude (m)	Pasture	Meadow	Total	%
	(thousands ha)			
Above 2,000	44	2	46	2
1,501 - 2,000	154	21	175	8
1,001 - 1,500	227	131	358	17
751 - 1,000	311	291	602	30
501 - 750	488	375	863	43
TOTAL	1224	820	2044	100

Table 4: **Ratio between forest - grassland at the same altitude along a gradient (after T. MARUSCA et N. DONITA, 1995)**

Altitude(m)	Surface (thousand ha) Forest	Grassland	Ratio Forest : Grassland	Direction of anthropic impact	Causes of deforestation
1,600 - 1,800	90	70	1 : 0.78	↓	Extension
1,400 - 1,600	310	105	1 : 0.34	↓	of pasture
1,200 - 1,400	660	120	1 : 0.18	↓	meadow
1,000 - 1,200	1130	160	1 : 0.14	Forest	- - - - - - - - - - - - - - -
800 - 1,000	700	500	1 : 0.71	↑	Settlement. meadow,
600 - 800	310	675	1 : 2.08	↑	arable land, orchard
TOTAL	3200	1600	1 : 0.50		

* The ratio is influenced by natural limits of forest (North - about 1600 m alt. and South -1800 m) according with the latitude.

Table 5: **Phytomass (yield) production of some alpine and mountain grassland (after PUIA et al. 1976)**

Grassland formation	Altitude (m) 601-800	801-1,000	1,001-1,200	1,201-1,400	1,401-1,600	1,601-1,800	above 1,800	Mean
	t d. m./ha							
Agrostis capillaris	1.64	2.21	-	-	1.62	-	-	1.82
Agrostis capillaris +Festuca rubra	2.22	1.46	1.67	2.18	1.08	1.48	-	1.68
Festuca rubra	1.40	-	2.27	1.80	1.65	-	1.24	1.67
Festuca rubra + Nardus stricta	-	-	1.27	1.51	0.92	2.01	0.84	1.30
Nardus stricta	1.38	-	-	1.21	1.25	-	0.73	1.14
Festuca airoides +Nardus stricta+Agrostis rupestris	-	-	-	-	-	1.16	0.93	1.05
Mean on altitude	1.66	1.84	1.90	1.90	1.30	1.55	0.89	1.57

Table 6: **Milk production (cow) during grazing on fertilized pasture ($N_{200}P_{100}$ kg/ha) in M. Bucegi – Piatra Craiului (Recalculated data. after MARUSCA and SCURTU 1996 – 1998)**

Altitude(m)	Grass production (fertilized pasture) t d. m./ha	No. of cows per ha	Mean period of grazing (days)	Milk product. mean l / head / day	Specific consume Kg d. m. per 1 l milk	Efficiency of milkproduction l/ha	l/ha/day
1,600 -1,800	6.5	5.3	85	11.0	1.3	5,000	60
1,400 -1,600	8.0	5.6	100	11.8	1.2	6,800	68
1,200 - 1,400	9.5	5.9	115	12.6	1.1	8,600	76
1,000 -1,200	9.6	5.4	130	13.4	1.0	9,600	74
800 -1,000	8.8	4.8	145	14.2	0.9	9,800	68
600- 800	8.0	4.2	160	15.0	0.8	10,000	62

Altitude: 1,800 m	↑	↑	↑	↑	↑	↑ 1,800m	↑
Gradients 1,200	-0.75 t	-0.15	-7.5 days	-0.4 l	+0.05	-900 l	-4 l
Per 100 m altitude	+0.40 t	+0.02				-100 l	+3 l
Altitude : 600 m						600 m	

PAUCA-COMANESCU 1973), we assessed the difference in height, weight, and in other morphological characters or physiological processes, but presented here only as mean values (*Figure B*), (*Table A-D*).

The growth in height of the individuals is very active and sudden in time for all species of large dimensions (*Festuca rubra, Anthoxanthum odoratum, Trifolium pratense, Viola declinata* on the mountain grassland), represented graphically by an angle of almost 90°; the growth was much slower for small and average height plants (*Potentilla ternata, Nardus stricta*) (*Figure B*). The first category was observed mainly in gramineous and especially for lower altitudes.

In all situations, for the same species or equivalewnt species the populations growing at higher altitudes, the size of plants decreases according to the well-known altitude law. The amplitude of the variation depends on the species and it is limited to the site, the annual differences being due to the temperature difference. The difference in shoot length during the final period of growth represents the population variations of this trait. The growth in length during spring is not a continuation of the growth in autumn, the autumn shoots of too large size being destroyed in their upper portion during winter.

The water content of the biomass varied little during the day, but is large throughout a vegetative season; the mean values show only differences between the two sites (*Table A*). Except for *Viola declinata* and *Trifolium pratense*, the other populations have a xerophylous character. The analyzed populations are oligo-

Table A: Physiological features at some mountain populations

Mean values during vegetation period

Species	Site	Water content % (daily mean)	Transpiration mg/g/h	Osmotic pressure (atm)	pH of cellular sap	Growth rate mg/day	Net assimilation g/dm²/day	Energetical value Kcal/g d.m
Festuca rubra	P.Stânii	56.55	671.60	19.10	4.62	0.0208	0.279	4.428
FestucaAiroides	P.Arså	57.15	445.20	23.20	4.22	0.0139	0.135	4.876
NardusStricta	P.Stânii	56.62	576.10	13.87	4.31	0.0160	0.033	4.565
	P.Arså	58.59	516.10	22.34	4.22	0.0111	0.154	4.598
Anthoxanthum odoratum	P.Stânii	59.00	705.10	17.48	4.57	0.0090	0.094	4.465
	P.Arså	60.29	445.20	17.95	4.40	0.0137	0.122	4.520
PotentillaTernata	P.Stânii	66.81	904.70	18.32	4.73	0.0098	0.057	4.275
	P.Arså	66.87	665.30	19.62	4.62	0.0144	0.094	4.453
Viola declinata	P.Stânii	76.65	700.50	18.11	4.59	0.0168	0.396	4.313
TrifoliumPratense	P.Stânii	73.45	460.40	19.18	4.58	0.0234	0.348	4.309

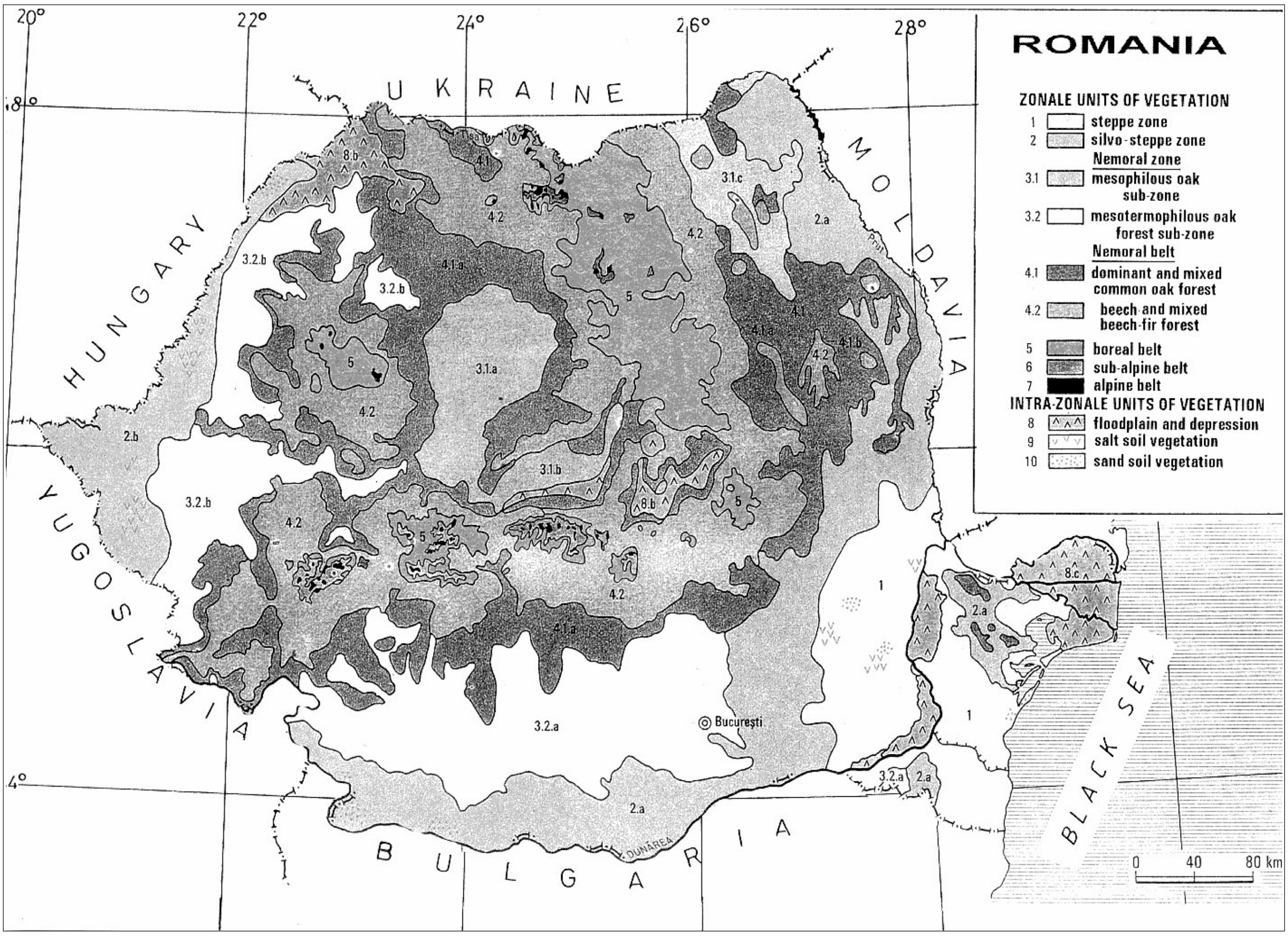

Figure 2: **Romania**

hydric–isohydric (transpiration being under 460 mg/g/h, with a variation amplitude under 100 per cent) in the sub-alpine grasslands, but polyhydric poikilohydric in the montain grasslands. The osmotic pressure is high, correlated to the amount of carbohydrates of the gramineous. For other species of dicotyledonous the potassium ions play an active role in osmosis. The carbohydrate amount increases during the vegetation period close to autumn and differs according to species. The accumulation speed and amount is higher in sub-alpine populations. The seasonal dynamics of proteins show a peak of accumulation in the early stages of all plants; proteins are lower in higher altitude populations and lower in gramineous than in other dicotyledonous species, in both grasslands. The mean values are presen-

Table B: **Accumulation of different organic and mineral matter at some mountain population**

		Mean value during vegetation period (%)								
Species	Site	Carbohydrate	Protein	Cellulose	Ligneous	Lipid	Ash	Phosphor	Potassium	Calcium
Festuca rubra	Poiana Stânii	10.7	13.52	33.48	13.13	7.23	7.58	0.36	1.70	1.39
Festuca airoides	Piatra Arsa	13.0	11.51	30.14	16.18	4.42	4.48	0.19	0.86	0.90
Nardus stricta	P. Stânii	9.0	13.38	33.75	13.85	6.06	5.49	0.34	0.89	0.75
	P. Arsa	12.6	11.03	29.23	14.71	10.42	3.98	0.18	0.79	0.52
Anthoxanthum	P. Stânii	11.6	15.25	32.18	18.18	13.47	6.32	0.43	1.63	1.70
odoratum	P. Arsa	12.1	13.30	30.78	12.91	7.60	5.47	0.42	1.65	1.03
Potentilla ternata	P. Stânii	12.2	17.45	21.24	17.23	3.96	9.54	0.77	2.51	4.62
	P. Arsa	11.8	13.38	18.74	15.69	8.10	8.00	0.37	1.19	3.37
ViolaDeclinata	Poiana Stânii	11.7	18.47	18.70	11.86	9.62	6.54	0.56	2.56	5.68
Trifolium pratense	Poiana Stâni	9.7	13.60	26.09	8.48	11.48	8.08	0.43	1.75	5.08

Table C: **Dimension changes of some mountain populations**

	Dimensions of Piatra Arsa populations as to Poiana Stânii population (%)							
Species	Shoot weight	Total height	Culm length	Leaf length	Stomata length	Floral parts perianth	Floral parts gynaeceum	Seed length
Festuca airoides as to Festuca rubra	52	29	31	60	99	37	-	83
Nardus stricta	224	52	45	29	83	112	110	80
Anthoxanthum odoratum	75	40	39	68	86	79	97	94
Potentilla ternata	50	52	50	47	95	94	89	99
Viola declinata	-	-	-	94	-	85	93	96

Table D: **Number changes of certain morphological features at some mountain populations**

	Piatra Arsa population as to Poiana Stânii population (%)				
Specia	Shoot number	Leaf number	Stomata number	Flower number	Seed number
Festuca airoides as to Festuca rubra	218	84	77	52	28
Nardus stricta	113	84	113	100	-
Anthoxanthum Odoratum	220	95	165	70	70
Potentilla ternata	-	65	143	69	68

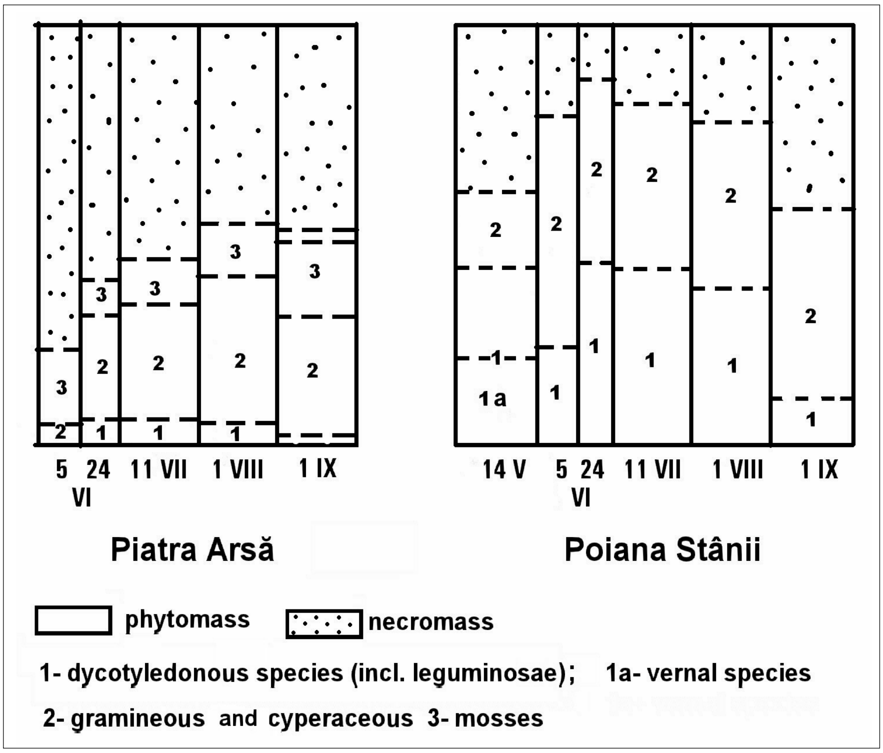

Figure A: **Components ratio of the aboveground biomass during vegetation period (%)**

ted in *Table B*. Cellulose accumulation showed an inverse ratio with protein in the studied populations.

The most intense net assimilation occurred in the populations at Piatra Arsa, but in a differentiated manner. According to the species and stratification of the vegetation in *Nardus stricta* has increased five times compared to Poiana Stânii and only one third in *Potentilla ternata* and *Anthoxanthum odoratum*. *Nardus stricta* at Piatra Arsa changed its position in the vertical structure passing to the higher layer of phytocoenosis (*Table A*). Nevertheless, the assimilation period was much shorter for populations of the subalpine pasture. During the same period, assimilation was more intense in the species with higher biological productivity and the most intense during the interval of vegetative organs' growth. The highest growth rate in weight corresponds to the period of maximal assimilation, the highest values being recorded for the most productive species.

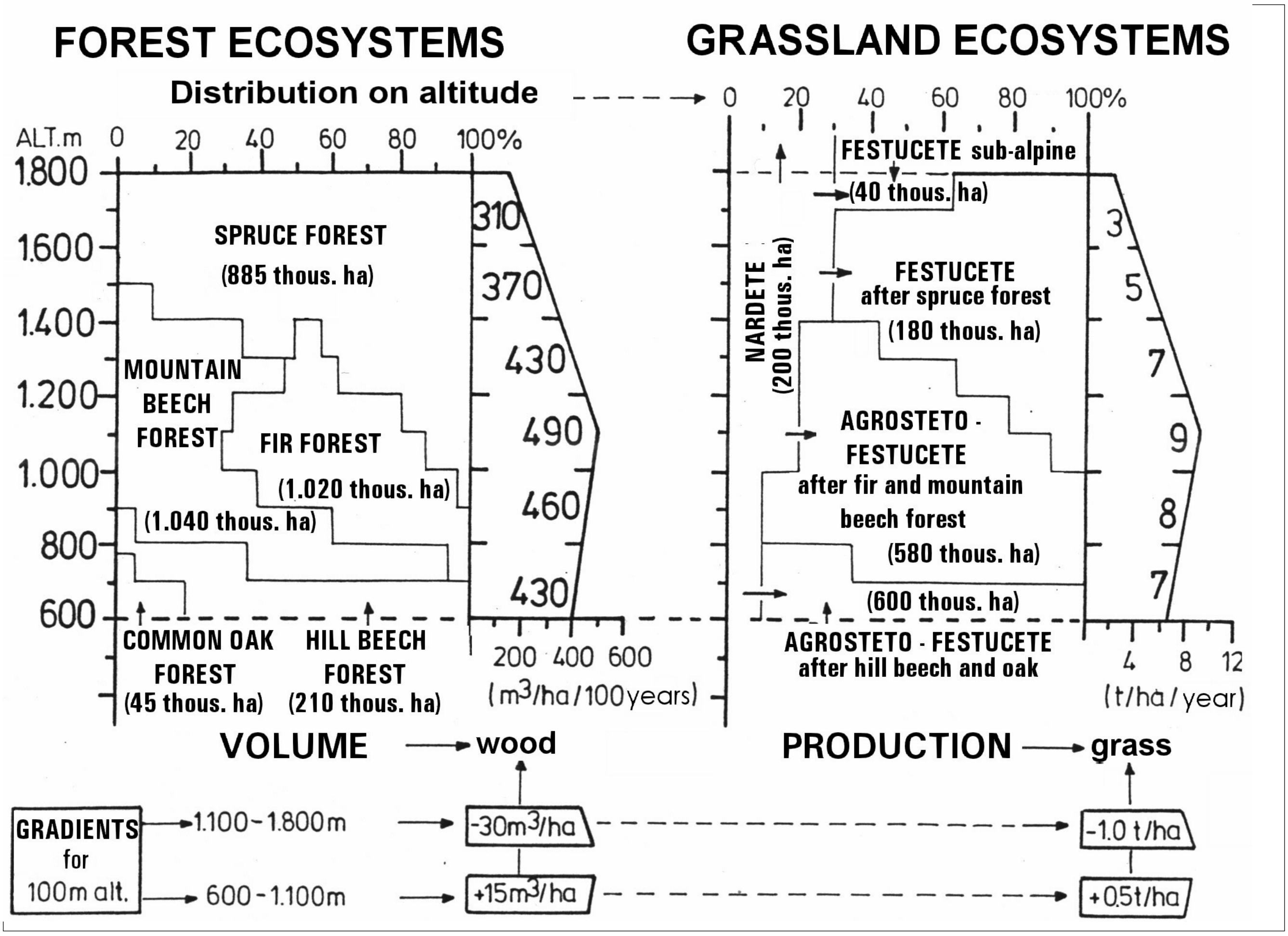

Figure 3: **Dynamics of forest and grassland production**

The energy value of the populations growing at higher altitudes was always higher and during the early stages it was even higher than in the maturity stages. Gramineous always had more energy than dicotyledonous in both sites.

The germinating capacity of seeds was low, averaging below 50 per cent in dicotyledonous and between 50 per cent and 80 per cent in gramineous. *Festuca rubra* had one of the highest values; all investigated populations needed a post-maturation period of 90 days and all were aphotoblste. The germination speed was characteristic to each species, but in all cases it was longer in the higher altitude sites.

Biometrical measurements of the populations revealed lower values of the vegetative organs and of the whole shoot for the individuals from the sub-alpine pasture compared to the individuals from the montane pasture in their ecological optimal environment (*Table C*), except for *Nardus stricta* suffocated by the dominant species.

The reduction was much smaller for the generative organs, but they kept the same direction. The numerical changes of the same population seem to be less systematic (*Table D*), but the number of shoots was clearly higher for plants growing at higher altitudes than for plants growing at lower altitudes.

The number of leaves, flowers, and seeds was generally lower for plants growing at higher altitudes, the reduction differing from one species to another. For the number of stomata of the leaves, we can observe that the number was higher in the sub-alpine populations than in the populations growing at lower altitudes, given they belong to the same species.

Fertilized mountain grasslands

The yield of mountain pastures improved by fertilization increased three to five times following the use of $N_{200kg/ha}$ shown in *Table 6* for all the mountain pastures in Romania. The highest yields averaged 9.5 t d.m./ha - 9.6 t d.m./ha, and they were obtained between 1,000 and 1,400 m altitude, equal to the highest yields of the non-fertilized pastures.

By the conversion of the grass yield of fertilized pastures into milk yield we obtained 10,000 litres per hectare at between 600 m and 800 m altitude, decreasing up to 1,600 and 1,800 m altitude, where the most recent experiments took place in Bucegi mountains at Piatra Craiului.

These results show the very high potential for animal production of the Romanian mountain pastures, provided appropriate measures for improving and proper use are taken.

Current issues regarding the mountain pastures

1. Decrease of animal stock

In 1998, compared to 1989, the stock of cattle decreased by 50 per cent, from 6.291 million to 3.143 million animals.

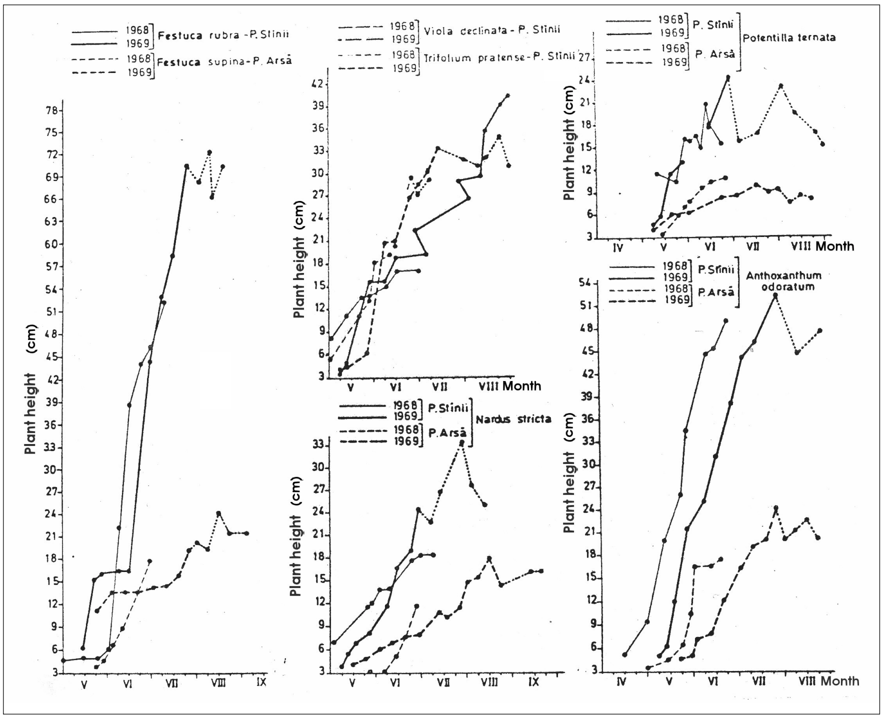

Figure B: **Height growth of plant populations in sub-alpine and montane grassland, during vegetation period**

Likewise, sheep and goats stocks fell from 17.288 million heads in 1989 to 9.616 million heads currently (45 %). In 1989 there were 16 million sheep and 1 million goats.

The drastic decrease of animal stocks occurred mainly due to the dissolution of state farms and farmer associations, although the animal stock of almost every household increased after land was to the the peasants.

The dramatic decrease of animal stocks which were based on the production from pastures decreased dramatically and caused under-used pastures or even large-scale abandonment of grasslands, resulting in the growth of wood vegetation and their eventual transformation into forests. Extended meadows areas are being harvested sporadically or are even abandoned, and consequently invaded by ferns or wood vegetation.

This situation could be observed in a case study conducted inthe Padurea Craiului Mountains, the Western branch of the Carpathians (MARUSCA 1998, manuscript). It revealed the current state of the existing types of pastures and meadows as well as the derived types of pastures in this area (*Figure C*). Their pasture value ranges from 35 per cent to 65 per cent which situated them between an average and a good pasture with the possibility of maintaining one up to two heads of large cattle/ha/year, providing 165 days of grazing and 200 days for stabulation. The identified types exemplify very well the current state of pastures in the absence of any controlled activity characterized by the invasion of *Nardus stricta* or by their temporary abandonment deschampsiete and pastures invaded by ferns (*Pteridium aquilinum*).

2. Changes in the structure of animals grazing the pastures

Due to the massive imports of cheap high quality wool from Australia and New Zealand during the past decade, domestic production of wool was seriously affected; the sheep being raised mainly for milk and meat. Therefore, in the higher mountain areas, the traditional areas for sheep raising, cows appeared and their number is increasing continuously in order to increase milk and cheese production on mountain pastures. On the extensive areas of abandoned arable land in the hills and plains, large stocks of sheep are grazing, making it unnessesary to take them to the mountains as they did in the past in widespread transhumance.

The stock of predators (bears, wolves) also increased which endanger the animals as well as the people herding the animals on the mountain pastures. This is another reason for the reduced use of isolated areas in the mountains.

3. Increased areas of natural pastures

Compared to 1989, when the pastures accounted for 4.426 million hectares (3.029m ha of pastures and 1.398m ha of meadows), they increased by 11 per cent up to now (1998) at the expense of abandoned arable plots reaching 4.904 million hectares (3.397m ha of pastures and 1.507m ha of meadows). It is difficult to tell how much of the almost 500,000 hectares of pastures are located in the mountain areas, but most certainly there is also an important increase of this area which is less accessible and less favorable for agricultural crops.

Human resources

The institutions involved in the study of mountain pastures in Romania belonged mainly to the university network, where the first investigations started in the 1860s: these were the Faculties of Biology and the Institutes of Agronomy at the Universities of Bucharest, Cluj, Timisoara, and Iasi. Currently, the network is much expanded including the faculties which appeared later in Arad, Bacau, Bracov, Craiova, Oradea, Pitesti, and Sibiu.

Since 1945, within the Institute of Agronomic Research, the Central Station for the Study of Pastures, Hayfields and Forage Plants was established, first at Halchiu, then at Mãgurele, near Bracov, with experimental stations at Jucu (Cluj), Pitesti (Arges), Timisoara (Timis) and Vaslui. Other agricultural stations with pratological investigations are located at Suceava, Oradea, Sighetul Marmatiei.

Since 1958, Institutes of Biological Research with departments of ecology and phyto-coenology were established within the Romanian Academy at Bucharest, Cluj, and Iasi.

Some of the institutes subordinated to the Academy of Agricultural and Forestry Sciences conduct researches on pastures: ICPA Institute of Pedology and Agrochemistry Research; IBNA Institute for Biology and Animal Nutrition; ICPCB Research and Production Institute for Cattle Production.

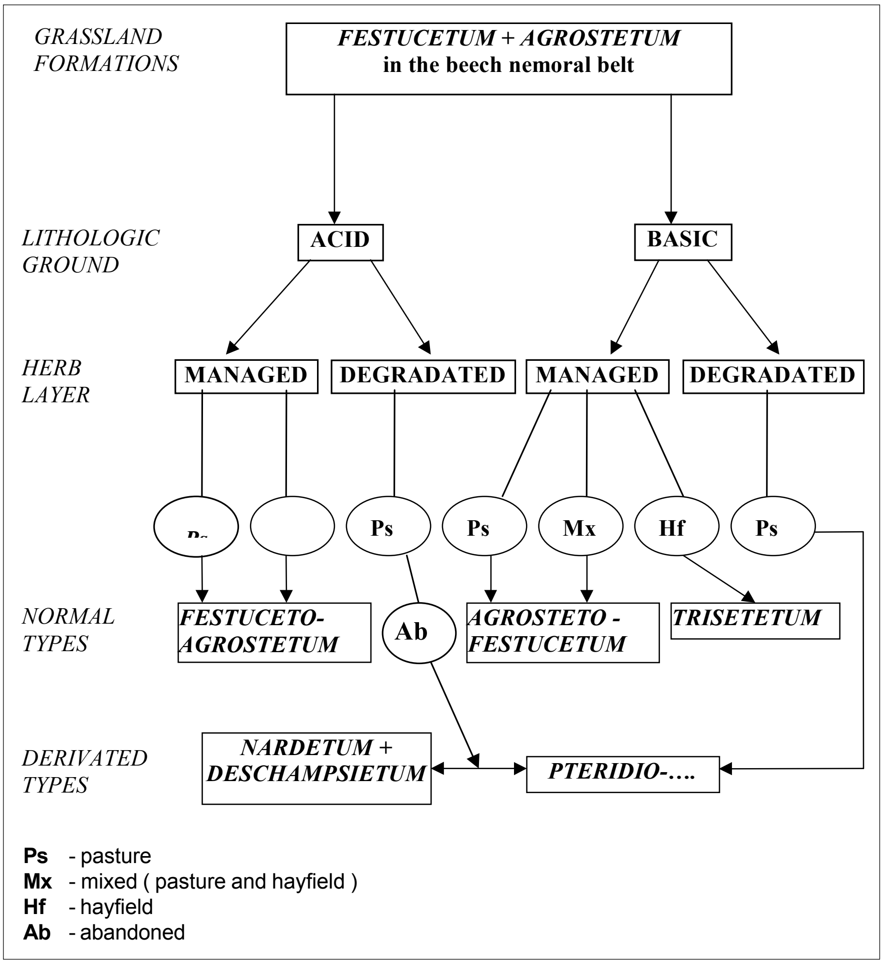

Figure C: **Grassland types classification in Padurea Craiului**

Historical data regarding mountain grassland research

Several stages in pasture research can be distinguished starting about 1850 when mountain loving botanists from universities or just nature lovers collected, identified and published data on the flora of alpine pastures, rocky soils or meadows in the mountain areas, besides - less spectacular - vegetation of nearby forests.

Since 1935 we can talk of the study of mountain pasture vegetation, beginning with the publications of Al. BORZA, E. NYÁRÁDY; in addition, in 1936 I. SAFTA initiated the pratological study of pastures in Romania. In 1945, the first Station for pasture, hayfields, and forage plants research, once within the Institute of Agronomic Research, was inaugurated near Brasov preoccupied with knowledge and improvement of the production of natural pastures, especially of their feeding value, for the creation of gramineous and leguminous cultivars with better feeding qualities, the development of technologies for the improvement and appropriate development of pastures, seed production for overseeding or for the establishment of new pastures.

The first monographs including the results of complex research on mountain pastures concerned the Bucegi and Parâng mountains and they were published between 1955 and 1965 under the coordination of Evd. PUSCARU in Bucharest and Al. BUIA in Craiova.

Many phytocoenological studies or studies for the better understanding of the biodiversity of mountain pastures in different areas of the Carpathians intensified during the 1960s and continued up to the present. Here are some well-known names: Al. BELDIE, N. BOSCAIU, I. BUICULESCU, Gh. COLDEA, V. CRISTEA, M. CIUCA, St. CSÜRÖS, M. CSÜRÖS-KAPTALAN, Gh. DIHORU, C. DOBRESCU, D. MITITELU, E. NYARADY, M. PAUN, A. PAUCA, A. POPESCU, Gh. POPESCU, E. SCHNEIDER, V. SANDA, N. STEFAN.

The ecological and ecophysiological study of pasture herbaceous populations or from high altitude marshes were conducted during the 1970s by M. PAUCA-COMANESCU, and L. STOICOVICI.

At the same time the studies of useful productivity of grasslands were developed, their quality classification as well as pasture improvement. Some well-known scientist are: Gh . ANGHEL, C. BARBULESCU, P. BURCEA, V. CARDASOL, J.A. KOVACS, Gh. LAZA, T. MARUSCA, M. NEACSU, K. NIEDERMAIER, Gh. OBREJAN, V. PANAIT, I. RESMERITA and D. TEACI.

Between 1980 and 1985 a first typology of the Romanian pastures was finalized under the coordination of I. TUCRA, carrying on the activity started by Gh. ANGHEL, Gh. MOTCA, and C. BARBULESCU in this field.

The most pressing problem regarding grassland ecological research in Romania is the reduced financial support and scientists looking for other fields, as forest ecology wetland restoration or nature conservation seem to be meet greater interest in the world today.