Preliminary study on Alpine ibex (*Capra ibex ibex*, L.) and livestock distribution in Gran Paradiso National Park

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Abstract

In the last few decades there was a drastic decrease in Gran Paradiso National Park ibex population linked with a reduction of occupied territories. Causes are still not completely clear but drastic decline is in partly related to recent climate changes. The objectives of this work are:
1) to analyse ibex distribution in GPNP in 1985-2009 period and describe livestock distribution in the same area in 2000-2009;
2) to assess relation between distribution pattern and ibex population trend in 2000-2009.
To examine distribution patterns 5 landscape ecology metrics are been selected to assess the composition and spatial configuration of occupied areas. Spearman's rank correlation coefficient was used to test composition and configuration metric trends and their relation with ibex population size. Results showed a reduction of ibex occupied territories from 4587,50 hectares in 1985 to 2331,25 ha in 2009 (r_s= -0,818; P<0,001). Number of patches increased from 130 to 224 units (r_s= 0,784; P<0,001). Livestock distribution didn't show a particular trend ($r_s \approx 0$ or P>0,05). The relation between changes in ibex population trend and distribution patterns was not proven (all P>0,005). These results suggest that probably ibex distribution was influenced by different combined factors (landscape changes, climate change, anthropic activities) and they show how landscape ecology approach may become an useful tool to understand the degree of fragmentation and connectivity of landscape defined on species distribution. In conclusion, the understanding of processes behind Alpine ungulates distribution have to consider the influence of landscape patterns on environmental processes to improve the conservation efforts at management level.

Key words: Alpine ibex (*Capra ibex ibex),* livestock, distribution patterns, Gran Paradiso National Park, landscape ecology

Introduction

Ibex (*Capra ibex ibex*, L.) is currently classified at Least Concern by IUCN (International Union for Conservation of Nature, Temple and Terry, 2007). Considering the long time series of ibex population recorded in Gran Paradiso National Park (GPNP) a drastic decrease occurred in the last decades with a reduction of occupied territories. Causes are still not completely clear but this drastic decline is in partly due to recent climate changes (Mignatti et al. 2012). The objectives of this work are:

1) to evaluate the distribution of ibex in GPNP (Gran Paradiso National Park) in 1985-2009 period in different selected periods and describe the livestock distribution in the same area in 2000-2009;

2) to assess relation between distribution pattern and ibex population trend in 2000-2009 in order to understand if species distribution is influenced by population dynamics or environmental process.

Material and Methods

Description of dataset

Since 1956 in GPNP ibex populations are censused twice a year in July and September by Park wardens using block counts method. In 1985 they started to map ibex distribution in order to understand the characteristics of selected territories. Park area was divided in 36 surveillance zones with an average extension of 1100±185,2 ha (MEAN±SD). Wardens count the population walking over established routes and they record number of individuals distinguish them according to species and sex/age classes. Individuals were localised on UTM grid overlapped on GPNP territory map, the monitoring unit is a 250X250 m. Since 2000, park wardens collect data about the presence of cattle, ovine and domestic caprine over all the Park territories. The present study refers only to September ibex census data in three particular moment of population trend: 1985-1987; 1992-1994, 1999-2009; while livestock data analysed are 2000-2009 years.

Spatial pattern analysis

Maps were created and pre-processed using QGIS 2.6 (Quantum GIS Development Team. 2015), while Fragstats (Mcgarigal 2013) allowed to analyse ibex distribution pattern through different years. The proposed core set of landscape metrics is composed by 3 composition metrics and 2 spatial configuration metrics. According to literature, analysis was carried out using two different spatial scales (Turner et al. 1989; Wiens 1989) in order to explore the possible difference between the resultant of the two analysis. The two spatial scales were: the 250 m grid cell available from census data and the 500 m grid cell created using census data.

Composition metrics		**Spatial configuration metrics**	
Patch size (MPS)	Area of each patch (ha)	Radius of gyration (GYRATE)	Measure of patch extent
Total area (TA)	Sum of each patch (ha)	Patch cohesion index (COHESION)	Measure of physical connectedness of patches
Number of patches (NP)	Number of patches		

Tab. 1 | Selected landscape metrics and relative unit of measure.

Statistical analysis

Following the patch-centric perspective, distribution statistics selected to provide a statistical summaries of patch metrics are mean, standard deviation and coefficient of variation (Mcgarigal 2013). The Spearman's rank correlation coefficient was used to test composition and configuration metric trends in 1985-2009 period. The same test was used also to assess if ibex population dynamics play a role in shaping distribution using change values of ibex abundance and distribution patterns. Changes are $\Delta=t_2-t_1$ where t are values in two consecutive years. The considered period for this kind of analysis was 1999-2009. All statistical analyses were performed using R 3.1.2 (R Development Core Team 2015).

Results and discussion

Results showed a reduction of ibex occupied territories from 4587,50 hectares in 1985 to 2331,25 ha in 2009 (r_s= -0,818; P<0,001). There was a strong fragmentation in ibex distribution and number of occupied patches increased from 130 units to 224 units (r_s= 0,784; P<0,001). More in detail table 2 shows that these results are confirmed by both scales of analysis. On the other side there was not a particular modification in territories occupied by livestock (Table 2) and distribution values didn't show a particular trend (P>0,05) using both scales of analysis; the only exception are MPS and GYRATE at coarser scale that doesn't show a particular trend ($r_s \approx 0$). Correlation test values between changes in ibex population and landscape metrics are listed in table 3. The relation between changes in ibex population trend and distribution patterns was not demonstrated by Spearman's rank correlation (all P>0,005).
The obtained results show an effective change in Alpine ibex distribution. Composition metrics clearly showed a strong reduction and fragmentation of area occupied by wild ungulates, while a strong reduction in compactness and connectedness are shown by spatial configuration metrics. Livestock distribution seems do not show any particular modification.

Conclusions

With this study it is possible only suggest the factors affecting ibex distribution operating at different scales. Considered disturbance affecting ibex distribution are landscape modification (Gehrig-Fasel et al. 2007; Falcucci et al. 2006), climatic changes (Post et al. 2008; Pettorelli & Pelletier 2007) and anthropogenic disturbances (Iranzo et al. 2013; Hibert et al. 2010; Bagchi et al. 2004). Future development should be addressed to define landscape characteristics, considering the spatial segregation of ibex and spatio-temporal overlap between livestock and wild ungulates should be analysed in depth. These results suggest how the contrasting phenomena of land abandonment and pasture overgrazing tend to modify the Alps landscape with considerable effects on species distribution. In our human dominated landscape the nature conservation and maintenance of traditional activities are complementary objectives, therefore in protected areas management planning should be based on landscape management approach in order to preserve the high environmental diversity of our regions.

Ibex distribution patterns

	Mean patch size				Total area		Number of patches		Radius of gyration				Patch cohesion index	
	250		500		250	500	250	500	250		500		250	500
YEAR	**MPS±SD (ha)**	**CV (%)**	**MPS±SD (ha)**	**CV (%)**	**TA (ha)**	**TA (ha)**	**NP**	**NP**	**GYRATE±SD (m)**	**CV(%)**	**GYRATE±SD (m)**	**CV(%)**	**COHESION**	**COHESION**
1985	35,29±35,03	99,27	185,19±280,93	151,70	4587,50	10000,00	130	54	241,70±145,23	60,09	553,73±454,74	82,12	67,47	79,03
1987	37,54±42,08	112,07	265,91±528,86	198,89	5368,75	11700,00	143	44	249,23±170,26	68,31	624,53±690,12	110,50	69,80	87,34
1992	40,00±49,48	123,71	171,54±272,03	158,58	5400,00	11150,00	135	65	251,06±206,85	82,39	513,26±471,09	91,78	72,41	78,21
1993	29,18±45,24	155,04	144,79±267,90	185,02	4668,75	10425,00	160	72	215,72±170,30	78,94	462,81±459,89	99,37	68,60	78,59
1994	28,53±40,25	141,06	150,00±192,97	128,65	4393,75	10050,00	154	67	214,14±147,24	68,76	500,72±375,25	74,94	67,55	73,30
1999	23,11±26,96	116,67	132,41±232,25	175,41	4575,00	10725,00	198	81	193,05±117,54	60,89	483,93±442,18	91,37	60,20	75,28
2000	12,28±11,33	92,29	96,67±126,17	130,52	2800,00	8700,00	228	90	154,66±70,62	45,66	403,83±245,17	60,71	40,34	65,28
2001	12,27±11,01	89,76	92,42±122,39	132,43	2943,75	9150,00	240	99	154,75±61,24	39,57	413,26±272,95	66,05	40,42	63,99
2002	13,30±18,46	138,85	95,79±141,92	148,15	3018,75	9100,00	227	95	157,95±90,77	57,46	407,11±285,03	70,01	50,60	66,79
2003	13,60±19,14	140,76	120,57±202,35	167,83	3181,25	9525,00	234	79	162,69±84,31	51,82	469,17±404,52	86,22	48,33	74,08
2004	12,45±15,58	125,15	100,00±156,21	156,21	3025,00	9600,00	243	96	155,43±79,62	51,22	426,50±342,40	80,28	45,91	67,78
2005	13,20±18,75	142,08	102,69±155,43	151,36	3181,25	9550,00	241	93	156,21±87,67	56,12	442,47±352,86	79,75	49,75	69,60
2006	12,47±16,38	131,31	98,40±166,98	169,69	2918,75	9250,00	234	94	156,84±84,68	53,99	416,30±346,94	83,34	45,61	70,25
2007	12,21±16,14	132,15	86,90±155,35	178,75	2906,25	9125,00	238	105	152,44±71,42	46,85	387,90±335,11	86,39	44,88	69,64
2008	10,82±9,42	87,12	89,05±111,75	125,49	2812,50	9350,00	260	105	149,93±62,95	41,99	408,37±262,05	64,17	35,82	63,61
2009	10,41±11,80	113,34	85,05±106,45	125,16	2331,25	7825,00	224	92	144,18±56,24	39,01	415,24±288,92	69,58	35,67	62,70
r_s	-0,874, P<0,001		-0,862, P<0,001		-0,818, P<0,001	-0,700, P<0,001	0,784, P<0,001	0,808, P<0,001	-0,868, P<0,001		-0,712, P<0,001		-0,815, P<0,001	-0,765, P<0,001

Livestock distribution patterns

	Mean patch size				Total area		Number of patches		Radius of gyration				Patch cohesion index	
	250		500		250	500	250	500	250		500		250	500
YEAR	**MPS±SD (ha)**	**CV(%)**	**MPS±SD (ha)**	**CV (%)**	**TA (ha)**	**TA (ha)**	**NP**	**NP**	**GYRATE±SD (m)**	**CV(%)**	**GYRATE±SD (m)**	**CV(%)**	**COHESION**	**COHESION**
2000	25,26±48,84	193,30	108,06±201,35	186,32	2981,25	6700,00	118	62	196,95±144,47	73,36	409,37±317,06	77,45	66,19	74,19
2001	15,90±29,62	186,27	60,36±97,97	162,32	1606,25	4225,00	101	70	163,79±114,70	70,03	330,74±206,41	62,41	56,33	56,26
2002	30,42±65,80	216,34	86,36±130,06	150,60	912,50	1900,00	30	22	204,80±176,49	86,18	348,58±227,52	65,27	75,02	65,31
2003	35,29±70,78	200,59	126,25±158,47	125,52	3387,50	7575,00	96	60	245,31±252,76	103,04	467,28±338,21	72,38	75,68	69,49
2004	29,95±92,70	309,52	120,56±193,57	160,56	3593,75	7475,00	120	62	189,61±175,71	92,67	431,52±276,88	64,16	76,10	69,92
2005	30,72±73,73	239,98	114,58±180,99	157,95	2550,00	5500,00	83	48	203,07±207,69	102,27	417,51±297,87	71,34	76,22	70,34
2006	27,54±52,34	190,09	123,00±164,15	133,46	2781,25	6150,00	101	50	202,53±159,55	78,78	448,43±321,98	71,80	70,24	69,94
2007	13,06±16,31	124,92	80,00±90,00	112,50	1606,25	4800,00	123	60	158,39±80,81	51,02	370,74±209,47	56,50	46,22	61,23
2008	13,96±14,96	107,13	80,80±105,96	131,13	1550,00	4525,00	111	56	161,78±78,20	48,34	389,37±236,95	60,85	47,06	60,03
2009	14,52±22,33	153,78	84,00±131,41	156,44	1481,25	4200,00	102	50	160,60±94,51	58,85	381,12±275,09	72,18	54,26	66,93
r_s	-0,467, P>0,005		-0,139, P<0,005		-0,347, P>0,005	-0,236, P>0,005	0,255, P>0,005	-0,416, P>0,005	-0,539, P>0,005		0.07, P<0,001		-0,406, P>0,005	-0,212, P>0,005

Tab. 1-3 | The results of selected metrics. Values are listed according to spatial scales used (250 m and 500 m grid). For each index is reported the result of correlation coefficient to assess index trends.

Relation between ibex population and distribution pattern in 1999-2009 period		
Δ	**250**	**500**
MPS-ibex pop.	r_s=0,285; P>0,005	r_s =0,067; P>0,005
TA-ibex pop.	r_s =0,261; P>0,005	r_s =0,182; P>0,005
NP-ibex pop.	r_s =0,188; P>0,005	r_s =0,182; P>0,005
GYRATE-ibex pop.	r_s =0,030; P>0,005	r_s =-0,152; P>0,005
COHESION-ibex pop.	r_s =0,382; P>0,005	r_s =-0,091; P>0,005

Tab. 4 | Results of correlation test between changes in ibex abundance (ibex pop.) and distribution pattern. Values are listed according to spatial scale.

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