Peregrine Falcon Populations – status and perspectives in the 21st Century
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Evolution and current situation of the French Jura mountains Peregrine Falcon population from 1964 to 2007

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Abstract

In the Jura Mountains, the Peregrine Falcon had experienced a drastic decline prior to 1970. The most significant and damaging reason was chemical contamination from organochlorine pesticides. There was a number of additional different factors such as hunting or the robbery of young for falconry. Since these time, the Peregrine. population in this area has multiply by almost 7 fold between 1974 to 2007. Three distinct periods can reveal interesting trends in the Peregrine population taken from surveys of the species in this region: a clear decline before 1970, then a slow and later fast recovery between 1974 and 1994, and most recently a slowing of their recovery between 1994 and 2002 developing into steady balance or slow decrease after 2002. Between 1990 and 2002, the occupation of favourable nest sites by Peregrines has led new pairs to colonise new cliffs which are more vulnerable to the weather conditions, as well as terrestrial predators. This evolution has created a natural restraint in the development of the Peregrine population in this region, and is creating a greater pressure on the spread of the species than the availability of food resources. This is shown by the slow rate of reproduction by breeding pairs. It has not increased much since the end of the 1970's.

Stabilisation, and even decline of the population, initiated since 2002 seems to be related particularly to expansion of the Eagle Owl *Bubo bubo*, rather than the effects of disturbance by people participating in outdoor pursuits or fresh chemical contamination by polychlorinated biphenyls (PCBs), as has been recorded once again in some clutches.

Key words: Peregrine Falcon, population, pairs, cliff, prospect, Jura

mountains, decrease, recovery, site, Eagle Owl, predation, disturbance, organochlorine pesticides, DDT, PCB.

Figure 1. Satellite location of the Jura mountains

Introduction and acknowledgments

A survey on the Peregrine Falcon population in the French Jura mountains was initiated as early as 1963 . It has been realised thanks to the involvement of many people - passionate birdwatchers and local raptor protection groups including the Fonds Régional d'Intervention pour les Rapaces and Fonds de Sauvegarde de la Faune Jurassienne have been involved. However, many members of the Study Group for the Peregrine Falcon have to be thanked. They include volunteer birdwatchers dedicating most of their free time to surveying the local Peregrine population, often in very harsh weather: Marc Albrecht, Gabriel Banderet, Pierre Basset, Philippe and Jacques Bassin, Daniel Beuchat, Marc Briot, Christian Bulle, Marcel Challet, Daniel Cretin, Emmanuel Cretin, Jean-Yves Cretin, Georges Contejean, Mr et Mme Enay, Mr. and Mrs. Espinasse, Jean-Marie Gisiger, Bernard Gougeon, Daniel Goy, Mr et Mme Hartridge, Jean-Pierre Herold, Henri Journot, Michel Juillard, Rodge Guillet, Marc Kery, Claude Lepennec, Simon Lovy, Gilles Malejac, François Méjat, Jacques Michel, Dominique Michelat, Laurent and Claude Molard, Louis Morlet, Vincent Oeuvray, Yvan Orechioni, Patrick Paubel, Jean-Philippe Paul, Pierre Piotte, Philippe Pommier, Gérard Ponthus, Jean-Pierre Prost, Fred Ravenot, Michel Rebetey, Jacques Roblin, Jean-Claude

Robert, Jean-Louis Rolandez, Pierre Roncin, René Ruffinoni, Régis Saintoyan, Pascale Thery, Michel Truche, Gérard Viret, Éric Wolf.

Geographic description

Jura is a limestone mountainous arc located in eastern France spreading from South-West to North-East, along the France-Switzerland border for 250 km from South to North and 50 to 60 km from West to East. Altitude is increasing through tabular successive plateaux from Saône river lowlands in the West around 200 meters asl. - to the hilly higher ridges in the East culminating from 1000 to 1700 meters asl.

Cliffs ranging from 20 to 200 meters high are located all over the range. Sites localisation is in direct relation with cliffs localisation, see map.

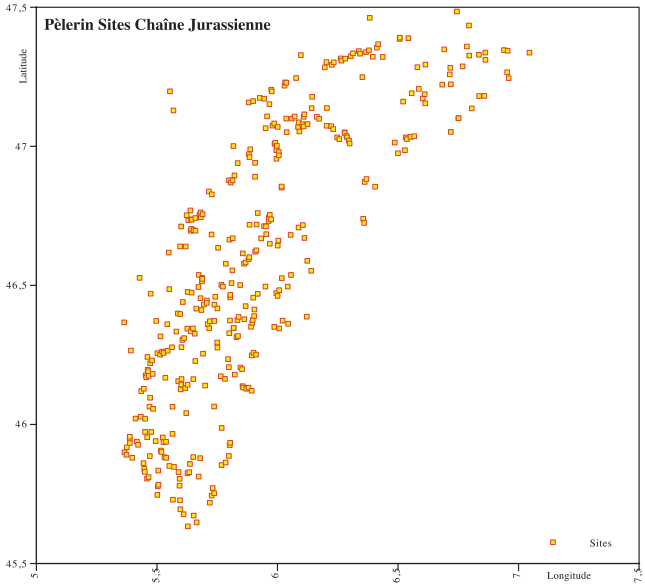

Figure 2. Peregrines sites distribution in French Jura

Climate and habitat

The medium altitude range of mountains and hills in the Jura Mountains region is a natural barrier to the humid winds coming from the west inducing heavy rains in spring and autumn; however the climate is continental in winter and summer. The area is largely covered with forest opened with pastures on the plateaux. Deciduous forests cover the western parts of the lower altitude, and from 600 metres upwards, there is mixed deciduous and evergreen

forest covering most of the eastern parts. Birds are relatively abundant here and the natural orientation of the ridges make it a natural corridor for migration in the spring and autumn.

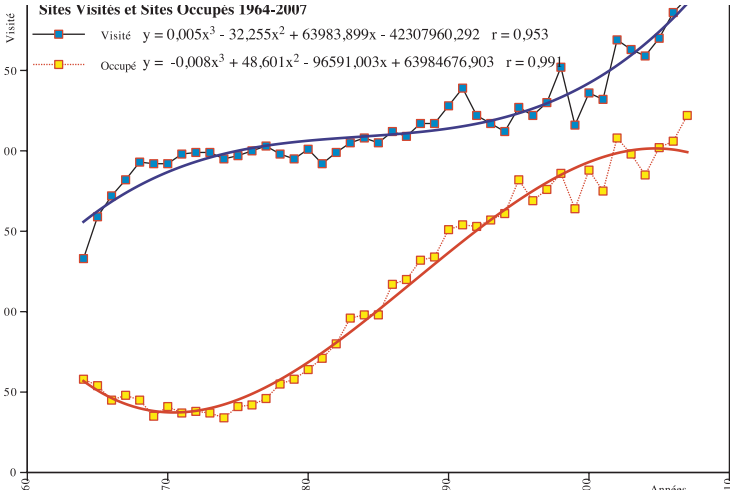

Figure 3. Visited and occupied sites 1964-2007

Method of checking for nest sites

Checking for Peregrine nests began as early as summer 1963 by spotting favourable sites that Peregrines may use. Systematic exploration really began in spring 1964. Potential sites have been visited 3 times minimum each spring and some have been visited up to 15 times: 1 to 3 times between February-March period to check on the position and locality of established pairs; 1 to 3 times between March-April to count the number of nesting pairs; 1 to 5 times between April-May to count the number of breeding pairs and 1 to 5 times between May-June to count the number of chicks fledging.

Our observations are encoded using the following criteria shown in the table below:

Visited sites, VS, site occupied by at least one bird; Oc, established pair; Cc, of unknown age; adult pair, Ca; nesting pair; Cn = egg laying pairs among the adult pairs; reproducing pairs, Cr = pair with hatched eggs among the nesting pairs; young observed in the eyrie, JA; fledging or young observed at eyrie a few days before first flight; JV, pair with adult male and juvenile female; Cfi, undetermined birds; Ind, solitary adult male Mas; solitary adult female, Fas; solitary juvenile male, Mis; solitary juvenile female, Fis; adult

pair + juvenile female, C+Fi; adult pair + adult female, C+Fa; pair with adult female and juvenile male, CMi.. Note: young older than 40 days are considered as having fledged.

Année	Visité	Occ	Cc	Ca	Cn	Cr	J Aire	J Vol	CFi	Ind	Mas	Fas	Mis	Fis	C°Fi	C°Fa	CMi	
1964	133	58	58	34	23	19	28	27	0	0	0	0	0	0	0	0	0	
1965	159	54	53	45	24	18	31	30	0	2	0	0	0	0	0	0	0	
1966	172	45	44	39	32	22	42	36	0	0	0	1	0	0	0	0	0	
1967	182	48	40	36	21	19	37	37	0	0	5	3	0	0	0	0	0	
1968	193	45	29	20	10	8	19	19	3	1	10	5	1	2	1	0	1	
1969	192	35	19	18	10	7	11	10	0	2	9	5	0	4	1	0	0	
1970	192	41	23	21	12	9	10	9		3	4	8	3	1	1	1	0	0
1971	198	37	23	20	14	11	18	17	2	2	9	2	1	1	0	0	0	
1972	199	38	21	17	15	10	17	15	4	2	11	4	0	0	0	0	0	
1973	199	37	23	20	18	12	23	23	3	2	8	3	1	2	2	0	0	
1974	195	34	29	23	20	15	35	35	6	1	4	0	2	2	1	0	0	
1975	197	41	32	27	23	19	38	40	5	1	5	1	1	1	0	0	0	
1976	200	42	37	29	28	21	42	42	7	2	3	0	3	4	3	0	0	
1977	203	46	44	39	37	27	54	53	4	1	2	0	1	5	4	0	0	
1978	198	55	47	43	40	32	64	65	3	2	4	0	4	9	9	0	0	
1979	195	58	52	47	38	35	78	77	5	1	2	3	2	4	3	2	0	
1980	201	64	59	55	46	42	97	97	2	1	2	1	2	5	3	1	0	
1981	192	71	64	54	46	36	84	81	6	3	1	1	3	8	5	0	0	
1982	199	80	71	63	55	52	113	112	4	7	2	3	3	4	3	1	0	
1983	205	96	77	70	56	44	86	85	3	10	5	3	1	8	6	0	0	
1984	208	98	90	82	65	58	121	121	6	4	4	4	4	2	2	3	0	
1985	205	98	91	90	64	54	117	117	0	0	5	3	5	6	5	2	0	
1986	212	117	102	95	84	59	134	122	5	6	4	2	4	1	1	1	1	
1987	209	120	114	106	95	72	163	152	8	5	1	1	0	3	3	0	0	
1988	217	132	120	113	107	80	152	142	3	3	4	5	4	6	4	1	3	
1989	217	134	125	122	114	81	171	173	4	3	7	2	4	5	6	1	0	
1990	228	151	136	131	122	95	193	206	0	3	9	2	5	12	3	0	1	
1991	239	154	143	138	130	101	239	216	2	2	2	9	2	9	2	1	2	
1992	222	153	142	141	134	92	88	177	0	6	4	1	2	7	0	0	1	
1993	217	157	152	151	136	114	103	241	0	1	1	1	2	4	0	0	0	
1994	212	161	157	156	137	74	22	146	1	1	2	5	2	7	0	0	0	
1995	227	182	177	172	136	79	90	121	5	1	3	6	3	5	0	1	0	
1996	222	169	164	161	143	115	190	235	1	1	1	1	1	0	1	0	2	
1997	230	176	166	165	138	102	133	228	2	1	2	1	5	9	0	0	0	
1998	252	186	172	169	152	102	117	213	2	1	5	4	2	4	1	0	0	
1999	216	164	158	155	130	76	53	139	3	2	2	3	2	4	2	0	0	
2000	236	188	178	173	141	104	208	246	6	1	7	4	0	3	1	0	0	
2001	232	175	164	162	121	64	67	131	1	1	8	6	3	1	0	0	0	
2002	269	208	203	201	176	107	176	200	2	2	2	5	0	3	0	0	0	
2003	263	198	194	191	172	104	194	197	3	0	1	3	0	2	0	0	0	
2004	259	185	168	166	153	97	161	135	1	3	14	9	0	4	1	0	1	
2005	270	202	186	180	152	103	171	138	4	4	15	9	1	5	1	0	0	
2006	288	207	189	186	143	97	168	135	3	3	14	13	2	6	1	1	0	
2007	287	221	204	201	154	114	203	168	4	3	13	6	6	8	0	0	0	

Figure 4. Full table of observations of Peregrine Falcon in French Jura 1964-2007

Data analysis

Numerical data have been processed with the statistical software Cricket Graph III. . Correlation curves are mostly polynomial curves of third order, which gives the best correlation factor r, with raw data. Formulas and correlation factor are presented by data symbols.

Visited sites

Figure 3 shows changes:

- of the number of visited sites, blue curve.
- of the number of occupied sites by at least one bird, red curve

Population size change

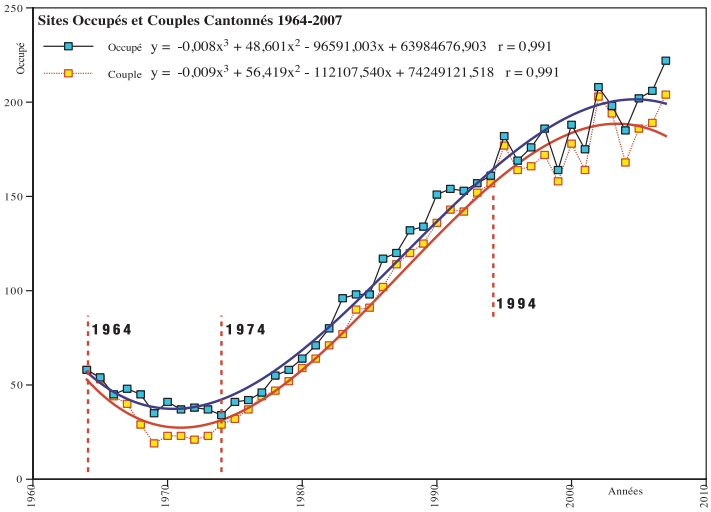

Figure 5. Peregrines - established pairs and occupied sites in the French Jura Mountains 1964-2007

Figure 5 shows the evolution of occupied sites, blue curve, and established pairs, red curve.

Figure 6 shows variation in the number of: adult pairs, red curve, nesting pairs, light blue, and reproductive pairs, dark blue. These graphics underline that the evolution of the population size can be divided in 3 distinct periods. Their patterns relate to the obvious evolution of the population over time:

- before 1974, a decrease in the population,
- from 1974 to 1994, an increase in the population,
- after 1994, stabilisation of the population and signs of a decline.

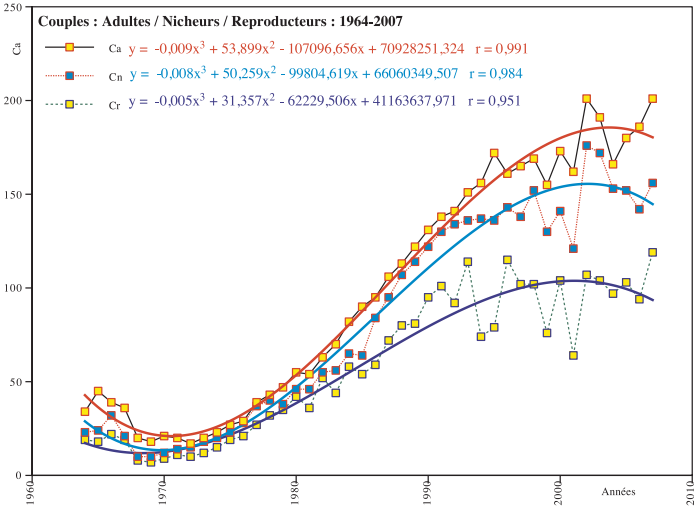

Figure 6. Adult, nesting and reproductive pairs of Peregrines in the French Jura Mountains 1964-2007

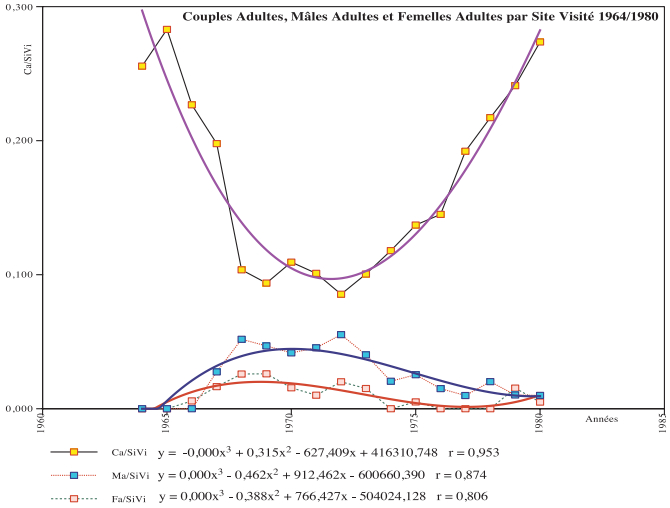

Figure 7. Adult pairs, adult males and adult females per visited site

For the following part of this paper, the varying number of annual visits – itself linked to observer's availability as well as weather conditions – may induce a bias in the data analysis. The data is now presented in relation to the number of sites visited rather than using the raw values.

Before 1974

The number of occupied sites, as well as the number of established pairs decreased rapidly between 1964 and 1969 – 58 occupied sites were found in 1964 and only 35 in 1969. It reached a stable level between 1969 and 1974 with 34 occupied sites found before a steady increase in population took place until 1994 with 157 occupied sites.

Curves in figures 7 and 8 suggest that:

- Decrease in the numbers of adult pairs (light blue curve Ca/Sv), is more related to the decrease in solitary adult females (red curve Fa/Sv), than the decrease in solitary adult males (dark blue curve Ma/Sv), which were in greater numbers compared to solitary females during this period (Fig. 7).
- Reverse variation in the number of adult pairs and the number of solitary males, zone A in figure 8, suggests that during the period 1968-1974, the stabilisation of the number of established pairs, followed by the increase in their number, is more related to the creation of new pairs from local solitary adults rather than arrival of birds externally.

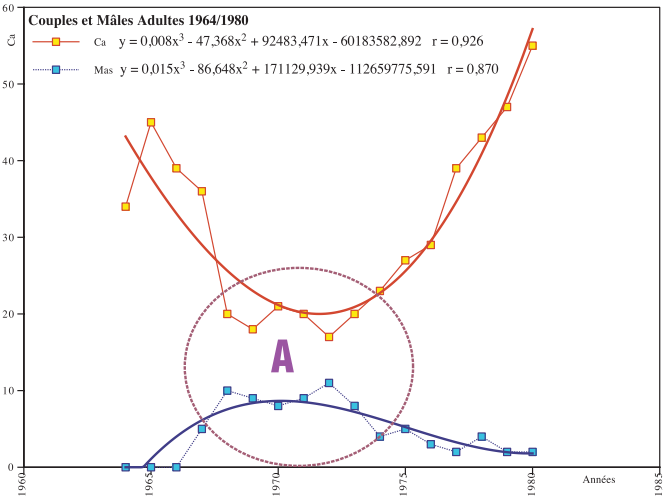

Figure 8. Adult pairs and adult males from 1964 to 2007

Field observations shows the pre-eminence of the male for creating new pairField observations shows the pre-eminence of the males to create new pairs. New established pairs appear first at solitary male sites and more rarely in sites occupied by solitary females. These observations also seem to confirm the greater vulnerability of females. Indeed, they are more often absent than males from breeding sites during winter – they are probably migrating away to other areas where they may also be more exposed to accidents and

chemical pollution.

Three combined factors would explain the rapid decrease in the population observed before 1974:

- shooting of adults on nest sites at a time when raptors were not protected in France,
- poaching of young – chick trafficking often related to German falconry,
- females being exposed to chemical contamination on wintering grounds – DDT and PCB detected in infertile clutches, from 13 to 16 ppm of DDT and/or PCB.

From 1974 to 1994

The "Peregrine Project" was carried out by the French Ministry for Nature Protection between 1972 and 1985. At the initial stage it consisted of collecting contaminated clutches in order to verify if Peregrines were able to relay a fresh clutch (as other birds do a few days after the first clutch has been lost). The second clutch was supposed to be less contaminated - as organochloride pesticides are essentially fixed on fat, which the egg yolk is made up of. This part of the project was carried out between 1972 and 1974, and concerned 3 pairs on the Jura mountains for 2 years (18 eggs) and 1 pair from the northern Alps (3 eggs). The first clutches laid by Peregrines during this time were incubated for a maximum of 2 weeks before breaking under the weight of the incubating adult bird. The second clutches were incubated by parents for much longer, some of them even hatched young. Experiments proved that the second clutches were effectively less contaminated.

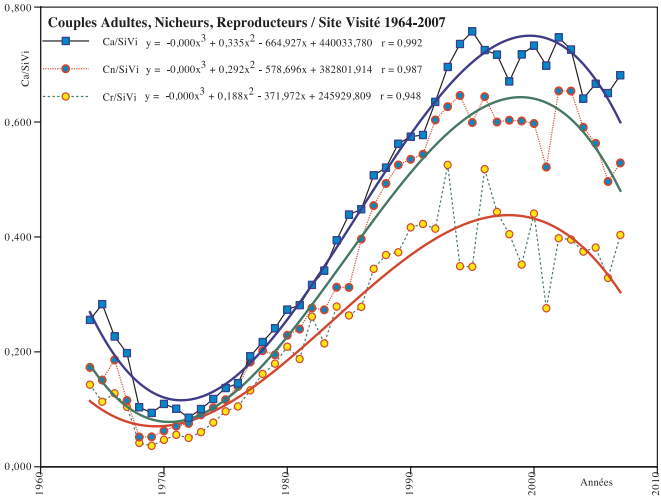

Figure 9. Adult pairs, breeding pairs and successfully reproducing pairs per visited site 1964/2007

At the second stage of the project, the collection of eggs was extended to include more pairs - 7 pairs of Perergines and their resulting 23 eggs were used . The collected eggs were incubated artificially. Some of the young obtained through artificial incubation have been reintroduced at less productive wild eyries, while the rest were kept for captive breeding. A total of 40 young have been reared in captivity and have been reintroduced back into the wild by fostering them in less productive natural eyries and twice by using the hacking method. The project finished in 1985 as it was established that the local Jura Mountain Peregrine population was on its way to a successful recovery.

In any case, the recovery initiated after 1974 continued steadily until the period 1990-1994 as shown in Fig. 9 by the evolution of the number of adult pairs (blue curve Ca/Sv), nesting pairs (green curve Cn/Sv) and those successfully reproducing (red curve Cr/Sv). Comparison between these three numbers shows that the ratio between them remained stable until between 1990-1992. From this period, the greater variability of values indicates the beginning of change in the population behaviour which we considered as the start of the 3rd period.

After 1994

Evolution of established pairs, Cc:

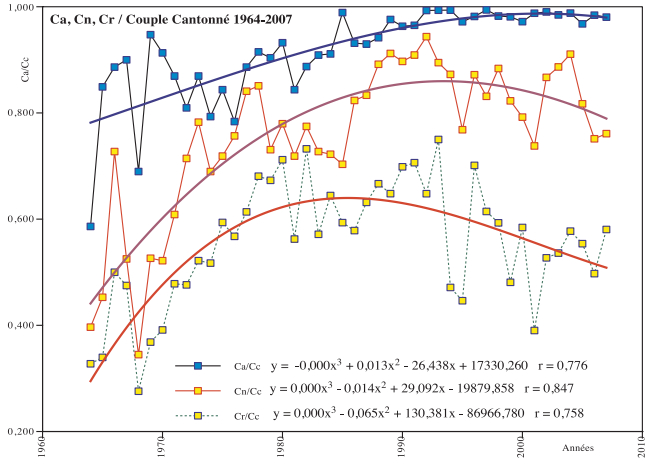

Figure 10. Adult, breeding and reproductive pairs per territory pair 1964/2007.

The most striking fact during this period is the increased seasonal instability of the number of nesting pairs (Cn/Sv), and especially the number of reproducing pairs (Cr/Sv). This variance is all the more obvious when looking at figure 10 which shows the numbers of adults pairs (Ca), nesting

pairs (Cn) and successfully reproducing pairs (Cr) related to the established pairs (Cc).

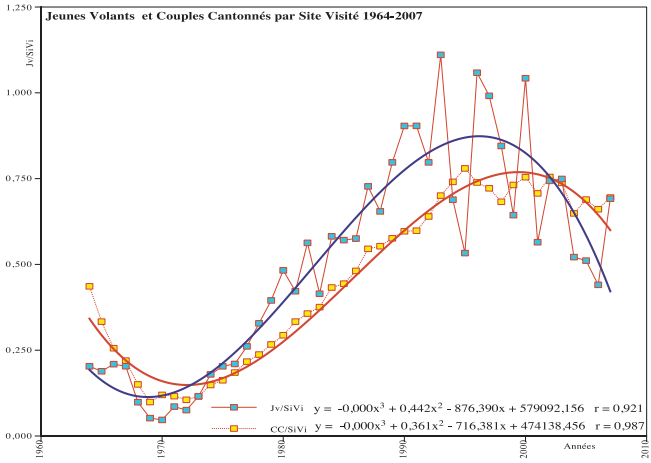

Figure 11. Fledglings and territory pairs per visited site: 1964/2007

Productivity

Figure 11 shows that the number of fledglings observed (Jv/SiVi), which increase directly with the number of established pairs (CC/ViSi), until 1990-1994 when thereafter they were subject to larger variations. These variations can be explained partially by an increased difficulty in monitoring more occupied sites - but it is not the only factor as the number of visits had also increased (Fig. 4).

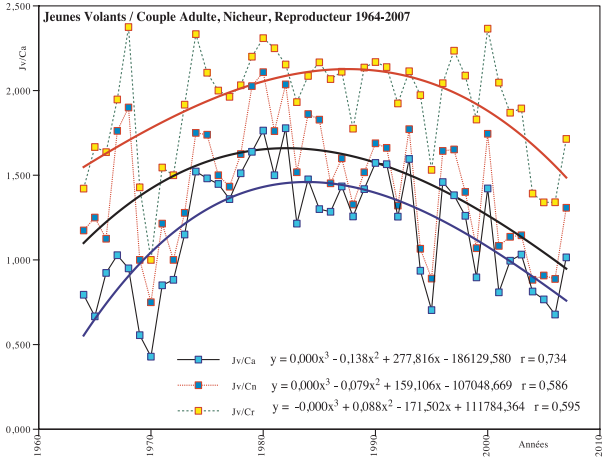

Figure 12. Fledglings per adult pairs, breeding and successfully reproducing pairs 1964/2007

As early as the beginning of the 1980's, one could see a parallel decrease in the ratio of fledging by adult pairs (Jv/Ca) and by nesting pairs (Jv/Cn) (Fig. 12). At the same time, the ratio between young flying and reproductive pairs (Jv/Cr) remained stable during the 1975-2003 period (red straight line in Fig. 13). This discrepancy suggests that the intrinsic fecundity of the pairs is still good and relatively stable, while on the contrary, the overall fecundity has decreased with the colonisation of new and less favourable sites - the best ones being already occupied.

Around 2000, the increase in the number of pairs seems to be related any more to the colonisation of new sites, but to the simple repositioning of pairs on sites previously occupied and temporarily deserted. Thus, in all due logic, the productivity should have stayed unchanged, though apparently it changes with an obvious decline from 2003.

Although on some sites a renewed contamination by PCBs has been recorded, the observations shows that across the country, the number of young being reared by nesting pairs is still high – frequently 3 to 4 young are recorded in the 10 days following hatching at the sites which can be monitored without disturbance. Therefore, chemical contamination does not seem to explain the decline for the moment.

On the other hand, weather conditions seems to play a major role in the success or failure of brood - rainy and cold springs from March to May induce a sharp decrease in productivity at less favourable sites. This finding leads us to begin fitting artificial eyries into places to increase productivity and allow for some compensation to a certain extent for those failures attributed to weather conditions and human disturbances at natural nest sites.

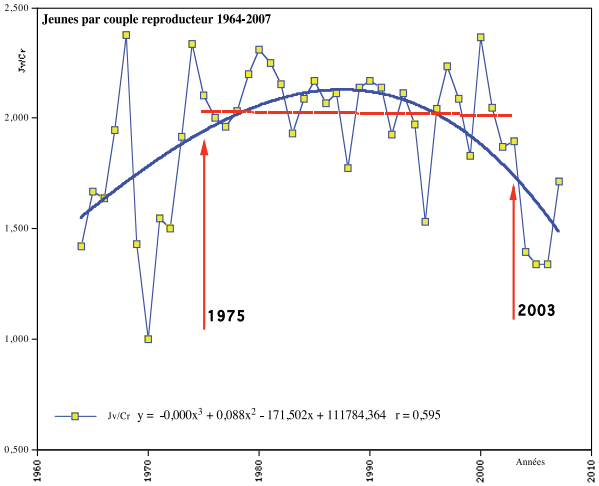

Figure 13. Fledglings per reproductive pairs 1964/2007

With all things considered after 2002, the only determining variable is the increasing expansion of the Eagle Owl's range. The appearance of the large, nocturnal predator on the same, or adjacent sites occupied by Peregrines has lead to numerous disturbances. It could be a lack of egg laying or the stopping of incubation that is causing this change. However, the direct predation of the young Peregrines during the period before or after their first flight and more unusually (because they escape more easily) the predation of the adult birds themselves that may also be causing the decline

To support this hypothesis, we have seen changes in where and how Peregrines make their nests. As noted during the 1970's and 1980's, Peregrines often used very open ledges and made their nests on areas deprived of vegetation cover. However, we now observe (at sites we can monitor) more and more Peregrines laying eggs in concealed eyries with vegetation cover. Further observations should confirm or weaken this phenomenon.

Conclusion

The Peregrine Falcons of the French Jura Mountain range whose numbers were plunging before 1970 have seen their population multiply by almost 7 fold between 1974 and 2007. From 1990 onwards, the occupation of most favourable sites has led to new pairs colonising cliffs where they are more vulnerable to the weather conditions, as well as terrestrial predators. This evolution has created a natural restraint in the development of the population, more so than the availability of food resources – as the rate of reproduction by reproducing pairs has not changed greatly since the end of the 1970's.

Stabilisation, even decline, initiated from 2002 seems to be related to the expansion of the Eagle Owl. The threat by this top predator is more of a concern across the region than the effects of outdoor activities and pursuits such as rock-climbing, paragliding or backpacking which concern very specific sites. However, these tourist activities are a serious and potential threat as they are introduced at the more attractive sites in the Jura Mountains. They can cause disturbance to nesting pairs and challenge the ability for the Perergine to survive here.

In the past these "naturally unreachable" sites have been shelters for the species, when population were on the brink of extinction.

Today, if the expansion of the Eagle Owl remains the same or if new chemical contamination - as has been noticed – causes a decrease in the population, the more favourable sites would no longer be the ultimate refuge for the species.

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