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**BIODIVERSITY EROSION
IN THE VAUDA NATURE RESERVE
(Turin, Piedmont, NW Italy)**

ABSTRACT - The Vauda Nature Reserve (NW Italy) is a fragment of the “Po basin heathland”, a habitat unique to Italy, and hosts several rare species of flora and fauna. Although theoretically protected by the law, natural habitats in the Reserve are undergoing a continuous process of degradation. Many species of flora and fauna (dung beetles, birds, butterflies) have already disappeared or become extremely rare. Moreover, some important biotopes, especially the wetlands around the Malone River, are totally unprotected as they lie outside the borders of the protected area. Military activities with heavy armoured vehicles, conversion to agriculture, and encroachment by introduced plant species and by grasses, ferns and trees are threatening large tracts of the heathland. An irreversible degradation might occur in the area if urgent and quick actions are not taken.

RIASSUNTO - *Erosione della biodiversità nella Riserva Naturale Orientata della Vauda (Torino, Piemonte, Italia).*

La Riserva Naturale Orientata della Vauda (Italia nord-occidentale) tutela un ampio frammento di “Brughiera del bacino del Po”, un habitat presente unicamente in Italia, e ospita numerose specie rare di flora e fauna. Per quanto sulla carta siano protetti dalla legge regionale, gli habitat naturali della Riserva sono oggetto di un inarrestabile processo di degradazione. Molte specie di piante ed animali (Scarabaeoidea stercorari, uccelli, farfalle) sono già apparentemente scomparse o fortemente diminuite. Inoltre, alcuni importanti biotopi, in particolare le zone umide che fiancheggiano il corso del fiume Malone, sono totalmente privi di protezione, in quanto si trovano all'esterno dei confini dell'area protetta. Attività militari

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con veicoli corazzati, trasformazione in campi coltivati, invasione da parte di piante alloctone, di erbe, felci e vegetazione arborea minacciano ampi tratti della brughiera. Una degradazione irreversibile è sul punto di avvenire nell'area se misure urgenti di protezione non saranno intraprese al più presto.

INTRODUCTION

The Vauda Nature Reserve (Riserva Naturale Orientata della Vauda, 45°15'N 7°39'E) is an important part in the network of protected areas of north-western Italy, as it preserves a large fragment (approximately 1000 hectares) of the "Po basin heathland", a unique habitat (CORINE code 31.229, Devillers *et al.*, 1991) only found on the fluvio-glacial terraces around the high plains of the Po river system. Being at the edge of the Padana plain, where intensive agriculture now dominates the landscape, the Reserve has a particular value as it hosts populations of several locally, or even globally, threatened species.

The Vauda is mainly characterised by an open landscape, with abundant heather *Calluna vulgaris*, interspersed with small groves of Birch *Betula pendula* and Aspen *Populus tremula*. Other habitats in the Reserve, which has an area of 2,635 ha, include woods, dominated by various species of oaks *Quercus* spp. and small wetlands, which are frequent all over the protected area: these occupy the uncountable explosion craters that resulted from its use as a military training area since the early XIX century. Many of these small, roughly circular ponds host several interesting and often threatened plant species (Guglielmetto Mugion & Martinetto, 1995).

From a legal point of view, a large part of the territory of the Vauda can be classified within two priority habitat types ("European dry heaths", CORINE code 31.2 and "Species-rich *Nardus* grasslands", CORINE code 35.1) of Annex I of the Habitat Directive of the European Union (Directive 92/43/CEE of 21/05/1992). This means that Italy is legally bound to create and maintain protection areas for the preservation of these habitats. However, although the Vauda has been gazetted since 1993 as a regional Nature Reserve, its protection has always been problematic, as most of the land is owned by the Italian Army, which uses it as a military training area. Since the Italian Army is not subjected to all civilian laws, there is continuing and strong conflict of interests between the Park and Military authorities, who both claim to be in charge of the area.

In the last few years, the Vauda Nature Reserve has been the object of

field work that has gathered considerable evidence of progressive habitat deterioration and biodiversity erosion, which can be linked to both natural and man-related processes. In this paper I list the main findings of these surveys on various groups of flora and fauna, and argue that an irreversible degradation might occur if urgent and quick actions are not taken.

DATA SOURCES AND METHODS

When not specified otherwise, all the data presented in this paper are personal observations recorded from 1985 to the present.

Maps were prepared with the software Mapinfo 4.0 (© 1995 Mapinfo Corporation), and all distance and areas were also measured with this software. Figure 1 shows the study area and the position of all localities cited in the text.

I collected bird census data with the point count technique (Bibby *et al.*, 2000). The same 57 points were visited once in late May-early June each year from 1999 to 2002; each point was censused for 10 minutes by one observer, who recorded all the birds within a 100m-wide belt.

Butterfly data were collected in the years 2000-2002. Over 70 visits were done in the area between April and October, by one or two observers working together. Butterflies were identified with field guides (Tolman, 1997), and difficult species determinations were confirmed by extracting male genital structures following Higgins (1975). Details on the study methods of dung beetles are described in Borghesio *et al.* (1999). Data on Amphibians and plants were collected during numerous (> 100) visits to the area at different times of the year between 1995 and 2002.

RESULTS

1. Dung Beetles (Coleoptera Scarabaeoidea)

The Reserve is known to host a fauna of 16 species of dung beetles (Borghesio *et al.*, 1999), including the scarce, large-sized, *Copris lunaris*. However, this number is substantially lower than the 27 species collected in the near (about 10 km) La Mandria Reserve (Barbero *et al.*, 1999). Even relatively common species, such as *Anoplotrupes stercorosus* and *Onthophagus coenobita* were not found in the Vauda Reserve, suggesting that these species, if not totally absent, are at least quite rare in the area. Numerical decreases and range collapses of European dung beetles have been repeat-

edly reported by various authors (Lumaret, 1990; Biström *et al.*, 1991), who linked them to the widespread abandonment of traditional pastoral activities on our continent. Although the Vauda is still used as a pasture for cattle and sheep, the stocking level has been progressively decreasing in recent decades, and large parts of the Reserve are now ungrazed for long periods. Even where grazing still occurs, it is usually restricted to only a few months of the year (late May - mid July), and does not seem to provide a constant food resource for dung beetles.

2. Butterflies (Lepidoptera Rhopalocera)

The butterfly fauna of the Vauda was studied in the years 2000-2002. Sixty-three species were collected in this period. On the whole, Vauda's butterfly community includes some rare species, such as *Lycaena dispar* and *Maculinea alcon*, both considered threatened in Europe (Van Swaay & Warren, 1999) and globally Near Threatened (Hilton-Taylor, 2000). Another interesting record is that of *Carterocephalus palaemon*, a rare Hesperiiidae butterfly that reaches here its lowest altitude limits in Piedmont (450 m a.s.l.) (Soldano, 1990). However, *Carterocephalus palaemon* is only known from a small heathland fragment near Grosso Canavese (point 1 in fig. 1). This area is presently unprotected, as it is about 1300 m outside the borders of the Reserve, and is at risk of irremediable degradation through ploughing and conversion to agriculture.

Comparing the Vauda to other reserves with similar habitats (La Mandria, listed by Casale *et al.*, 1993; Baraggia, listed by Raviglione & Boggio, 2001), the absence of some species is striking. Above all, the absence of *Coenonympha oedippus*, a globally Near Threatened species (Hilton-Taylor, 2000), is particularly disturbing as habitat requirements of this rare butterfly seem to be matched by the Vauda environment. As *Coenonympha oedippus* was reported both from La Mandria (SW of the Vauda) and from the Baraggia Reserves (NE of it), I believe that this butterfly was probably present in the Vauda in the past, but might now be locally extinct.

Five more species were recorded from the Vauda at the beginning of this century (E. Balleto, pers. comm.): *Melitaea diamina*, *Araschnia levana*, *Cupido minimus*, *Melitaea britomartis* and *Brenthis hecate*. Their apparent absence in the years 2000-2002 suggests that a degradation of the Vauda as a butterfly habitat has already occurred; the probable local extinction of these species is of particular concern as most of them are decreasing both in range and population across most of Europe (Van Swaay & Warren, 1999).

Lycaena dispar now occurs in only two small and widely separated sub-

populations: one of them, near the town of Lombardore, at the eastern side of the Reserve, is presently unprotected, as it lies outside of the border of the Reserve by only 550 m (point 2 in fig. 1). Moreover, the small ditch where the butterflies live is threatened by a car racecourse, which was increased in size in recent years. The second subpopulation of *Lycaena dispar*, in a small wetland close to the village of Palazzo Grosso (point 3 in fig. 1), in the central part of the Reserve, was severely damaged in late 1999 and again in January-March 2002 by bulldozing work carried out by the Italian Army. This wetland is now in danger of progressive drying-up, and the vegetation is severely disturbed by the huge amounts of dust raised by armoured military vehicles. These activities are also threatening one of the local sub-populations of *Maculinea alcon*, which lays its eggs on a rare plant (*Gentiana pneumonanthe*) that grows in the surroundings.

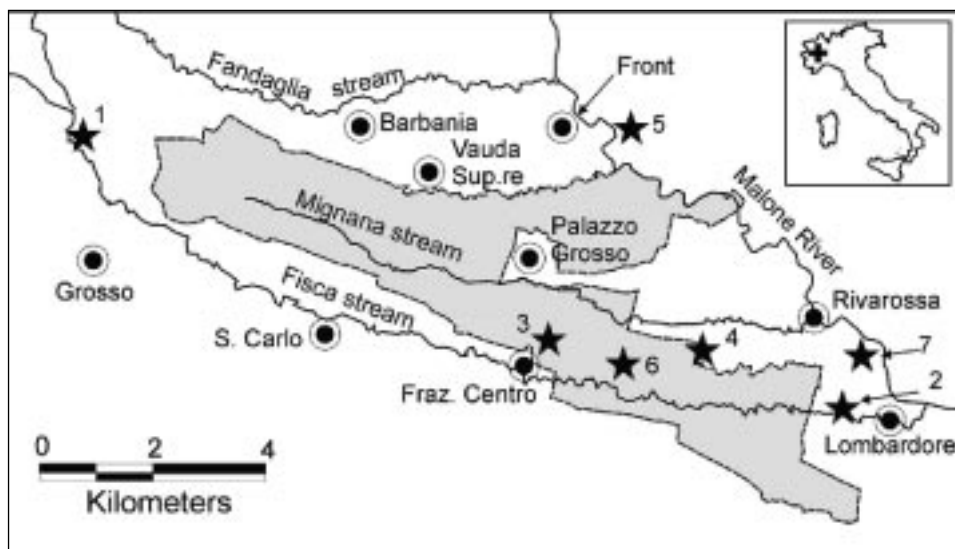


Fig. 1 - A schematic map of the study area, showing the Vauda Reserve (light grey shading), and the main rivers, streams and towns in the area. Stars numbered 1 to 7 mark places where rare species of flora and fauna were found. 1: presence of the butterfly *Carterocephalus palaemon* – 2 and 3: presence of the butterfly *Lycaena dispar* – 4: breeding area of Common toad *Bufo bufo* – 5: wetland with Spotted crane *Porzana porzana* – 6: former presence of *Carex hartmanii*, recently wiped out by the construction of a racecourse – 7: rich aquatic flora, *Hottonia palustris*, *Matteuccia struthiopteris*.

3. Amphibians

The Reserve is characterised by the presence of a large number of small freshwater ponds, which have large densities of newts (*Triturus cristatus*, *Triturus vulgaris*) and Anurans (*Hyla meridionalis*, *Rana dalmatina*, *Rana esculenta* “complex”). These species do not seem to be threatened or decreasing according to the available evidence. However, near Cascina La Diletta (point 4 in fig. 1) one artificial fishing pond is the breeding ground of a huge population (about 500 individuals) of Common toad *Bufo bufo* during the late Winter months (late February – early March). This population appears to be the largest in the Vauda, but is outside the protected area by just a few metres, and is flanked by a tarmac road that is crossed by the toads during their seasonal migration between the nearby woodland and the pond. The crossing of the road always takes a heavy toll on the animals (e.g. over 80 dead toads counted on one day in March 2001). A survey of the population trend of Common toad in the area is needed to understand if this heavy mortality is still within sustainability.

4. Birds

One-hundred-thirty bird species have been recorded in the Vauda (Cattaneo 1990, L. Borghesio, unpublished observations), which has particularly dense populations of several declining European species (Tucker & Heath, 1994), such as Red-backed Shrike *Lanius collurio*, Stonechat *Saxicola torquata* and Bee-eater *Merops apiaster*. Unfortunately, direct habitat destruction and progressive natural re-forestation of the heathland are threatening its avifauna.

On the whole, the Vauda Reserve, as has also been shown in many other European lowland heathlands (Tucker & Evans, 1997), is being progressively encroached upon by woody vegetation, as a consequence of the decreased stocking rate and, at least in some areas, of a reduction of the low-intensity fires that were traditionally used to manage this habitat (Ellenberg, 1986). Cattaneo & Biddau (2000) have already shown that trees and shrubs increased substantially in a 40 ha section of the Reserve between 1992 and 1999, and suggested that this increase favoured woodland species of lower conservation concern (such as tits *Parus* spp., Blackcap *Sylvia atricapilla* and Blackbird *Turdus merula*) at the expense of open habitat birds (e.g. Corn bunting *Miliaria calandra*, Skylark *Alauda arvensis*, Red-backed shrike *Lanius collurio*) that have an unfavourable conservation status in Europe (Tucker & Heath, 1994). These data were confirmed by point count censuses of 1999-2002: Figure 2 shows some results from this data set for four woodland (Great and Blue tits, Blackcap, Chiffchaff), and

six open habitat species (Corn bunting, Hortulan bunting, Red-backed shrike, Skylark, Tree pipit, Stonechat). Although no bird species presently seems at risk of disappearing from the Reserve owing to the increase of woody vegetation, this problem is likely to become more and more serious in the future. Bird populations in the Reserve should be carefully monitored in future in order to spot progressive decreases that could lead to species loss.

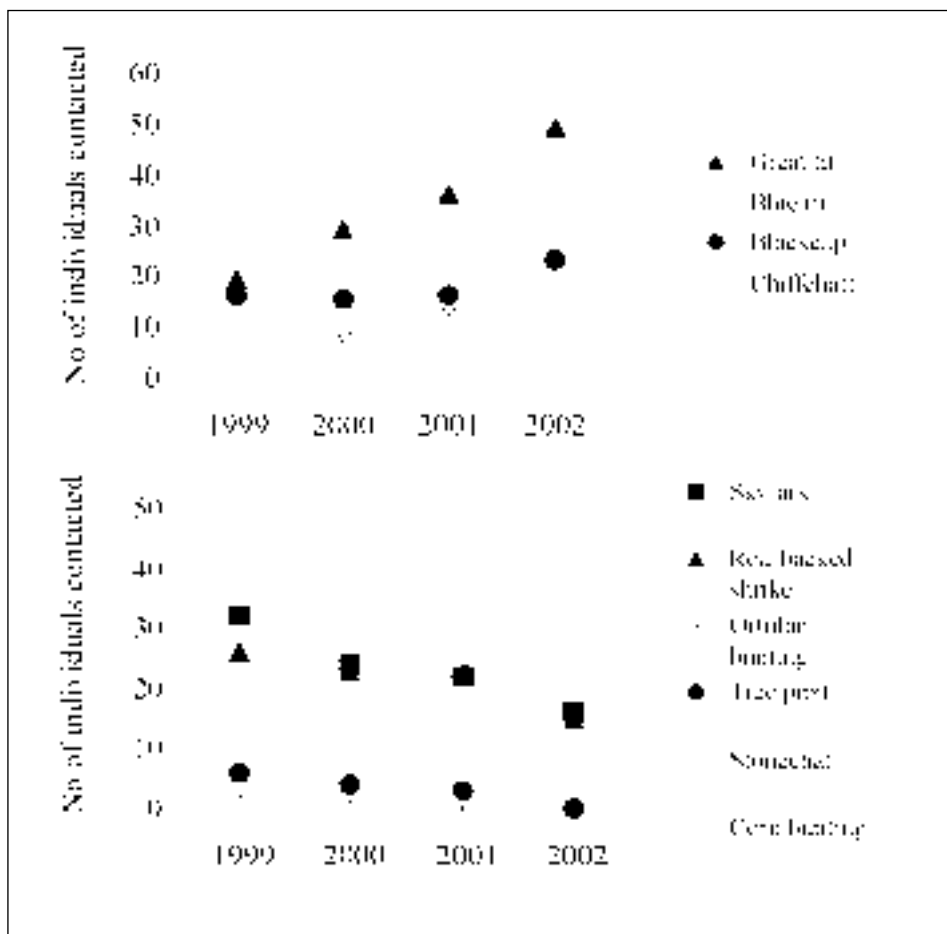


Fig. 2 - Abundance trends of two groups of birds censused with the point count method in the years 1999- 2002. Upper graph: woodland species; lower graph: open habitat species.

Other observations suggest that several rare and interesting birds either decreased or disappeared from the Vauda during the last two decades. Here follows a list of these species:

- Grey partridge *Perdix perdix*. Extinct in the Reserve, although still reported from the area in the 1980s (Spanò, 1988).
- Spotted crane *Porzana porzana*. The nesting of this rare species was confirmed in 1984 in Murtis, a small wetland near the town of Front (Cattaneo & Boano, 1988). The area is 600 m outside the reserve (fig. 1, point 5) and has been heavily degraded by partial reclamation in the succeeding years. The Spotted crane is almost certainly extinct in the area at present.
- Common quail *Coturnix coturnix*. The Reserve had high densities of this species until 1988-1990. Point counts and casual observations suggest that quails strongly decreased in the last decade, probably by over 80%.
- Western red-footed falcon *Falco vespertinus*. An uncommon but regular visitor during spring migration until 1992. No more observed after this date.
- Lesser grey shrike *Lanius minor*. It nested in the Reserve until early 1990s (Boano, 1988), but it seems now locally extinct.

5. Plants

Although no comprehensive list exists at the moment, Ferrari (1913) already listed 750 vascular plant species from the eastern part of the Vauda (mainly in the area between Leynì and Rivarossa). Altogether the Reserve may well have a flora of over 1,000 species. Rosenkrantz & Tosco (1978) and Guglielmetto Mugion & Martinetto (1995) listed several interesting plants occurring in the area and suggested that the rarest and most threatened species are those of wetland habitats (ponds, streams, bogs etc.).

Information gathered in recent times suggests that many rare species either already disappeared from the area, or are extremely threatened. Here follows a list of these species:

- *Isoetes malinverniana*. This threatened species (listed in Annex I of Berne Convention and Annex II of EU Habitat Directive) is probably the only endemic plant of the Padana plain, where it is known from only a few localities (Conti *et al.*, 1992). Rosenkrantz & Tosco (1978) listed 7 localities in the Vauda where this species was found. In at least one of these sites *Isoetes malinverniana* was still thriving in late 1979 (Rosenkrantz & Tosco, 1978). All but one of these localities are located along the Malone River and are presently outside the borders of the Reserve. In February-March 2002 I visited all these sites and found no

trace of the species. In most cases its disappearance seems due to habitat degradation (eutrophication, lowering of water level, wetland reclamation). *Isoetes malinverniana* is probably extinct in the Vauda.

- *Carex hartmanii*. This species, whose presence in NW Italy has been reported only recently (Guglielmetto Mugion & Rivella, 1995), is classified as Vulnerable in the Red List of the plants of Italy (Conti *et al.* 1992). Four localities are known for this species in the Vauda, but one of these (point 6 in fig. 1) was destroyed in December 1999 by the opening of a test area for armoured vehicles.
- *Scutellaria minor*. This plant is seriously threatened in Italy (Conti *et al.* 1992), and probably on the brink of extinction in the country. Guglielmetto Mugion & Martinetto (1995) reported its presence in the Vauda, where it is known in only two localities, one of them with only one or a few individuals surviving. The larger of these two sites has been, by a lucky chance, spared by the construction of a tank test area in 1999. In May 2002 E. Martinetto and I re-visited the known sites of this species and found strong population decreases, probably due to competition by the dense shrubs and herbs that grow in the area.
- *Hottonia palustris*. Another Vulnerable species in Italy according to the WWF Red Data Book (Conti *et al.* 1992). It was formerly abundant in an oxbow lake on the orographic right of Malone River, just after the town of Rivarossa (point 7 in fig. 1). Dumping and eutrophication in the last years have progressively degraded the lake, and much of its rich aquatic vegetation (including *Isoetes malinverniana*) has now disappeared. Only one isolated pond has been spared, where *Hottonia palustris* still thrives. This area is presently unprotected (750 m outside the borders of the Reserve).
- *Rhynchospora fusca*. A Threatened species in Italy according to the WWF Red Data Book (Conti *et al.* 1992). This species is known from only two sites in the Vauda. In May 2002 one of these wetlands was being encroached upon by grasses (especially *Molinia arundinacea*) and *R. fusca* had strongly decreased compared with the early 1990s (E. Martinetto, pers. obs.)
- *Serapias vomeracea*, *Spiranthes aestivalis*, *Spiranthes spiralis*. These three orchids, all of them very rare in the Padana plain (Pignatti, 1982), were reported in the Vauda by Ferrari (1913). Despite much searching they have not been re-found recently.

A further threat to the local flora is posed by a still undetermined species of Poaceae, *Panicum* sp. This grass, not listed by Pignatti (1982), and therefore new to the Italian flora, has been introduced in the eastern

section of the Reserve (near the town of Lombardore; area 1 in fig. 1). It has been observed in the area beginning from the 1990s, and is now spreading westwards. It seems strongly competitive and forms dense and compact, almost monospecific mats, where the presence of other herbs is strongly reduced. If its spread continues the entire herbaceous community of the heathland could be threatened.

6. General trends and threats to the natural habitats in the Vauda

The natural habitats of the Vauda have been steadily decreasing in size during the last century. Moreover, in recent times, many areas are undergoing a process of continuous degradation of their quality. Here follows a list of the most important threats:

- *Habitat destruction due to military activities.* As has previously been pointed out, much of the Vauda Reserve is presently owned by the Italian Army and is used as a military training and vehicle test area. In the last years, most of the activities of the Army have been concentrated in the eastern section of the Reserve (area 1 in fig. 3); the movement of armoured vehicles in this area causes a strong degradation of the grass cover, which has been totally removed over large tracts. On the whole, the area affected extends over 168 ha. A further serious episode of land degradation occurred in late 1999, when a 5 km-long racecourse for armoured vehicles was opened in the central section of the Reserve (area 2 in fig. 3). As has already been reported in the previous sections (see sections 2 and 5 of the Results), the construction of this racecourse destroyed one of the few sites of *Carex hartmanii* and seriously damaged a wetland where the butterfly *Lycaena dispar* lives; other sites with rare plants such as *Scutellaria minor*, and breeding grounds for the butterfly *Maculinea alcon* were also seriously threatened. In early 2002, the same area was further affected by the construction of a massive perimetric wall around the racecourse. At least 30 ha of heathland have been completely wiped out by these activities, but on the whole the surface affected (area 2 of fig. 3) extends over about 114 ha.
- *Wetland reclamation and pollution of freshwater habitats.* The Vauda is characterised by the presence of numerous wetlands, which can be subdivided in two main types: the small artificial ponds created by exploded bombs, and the natural wetlands flanking the Malone River, in the eastern section of the area. While the former seem under no major threat at the moment, the latter (areas 3 and 4 in fig. 3) receive no official protection, as they are outside the borders of the protected area, and are seriously threatened by pollution and conversion to cultivated

fields. Many threatened species of flora and fauna have already disappeared from these habitats, including the endemic aquatic fern *Isoetes malinverniana* and the Spotted crane, while the residual populations of plants such as *Matteuccia struthiopteris* and *Hottonia palustris* and the breeding grounds of Amphibians (*Triturus* spp.) are steadily decreasing. These wetlands will completely disappear within a short time if not adequately protected.

- *Conversion of the heathland to agriculture.* The conversion of the heathland to agriculture has been a major cause of destruction of natural habitats in the Vauda during the last 150 years. A comparison of land maps dated to the mid-XIX century with the present situation shows that the heathland was reduced by approximately 50% during this period. Conversion to agriculture has slowed down, but not yet stopped, in the last 20 years. Particularly, an estimated 59 ha of land in the central

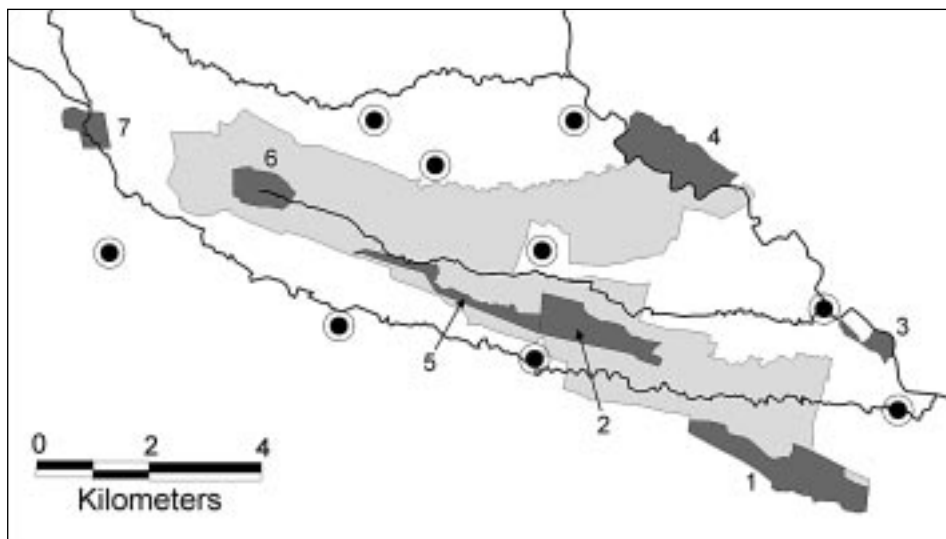


Fig. 3 - Main zones of environmental concern in the Vauda Reserve and its surroundings. Number 1 to 7 mark areas referred to in the Results. 1: intense use by military vehicles and invasion by *Panicum* sp. - 2: racecourse for armoured vehicles - 3 and 4: residual wetlands along Malone River - 5: heathland areas converted to agriculture in the last 20 years - 6: area invaded by Bracken *Pteridium aquilinum* - 7: unprotected heathland fragment with rich butterfly fauna.

section of the Reserve (area 5 in fig. 3) have been ploughed and converted to manured hayfields since 1980. Ploughing and manuring have caused the complete disappearance heathland vegetation, which, even if agricultural activities were discontinued, would take a very long time to regenerate, owing to the alteration of soil conditions, particularly to the increase of pH and ion exchange capacity, which are much lower in typical heathland soils than in cultivated fields (Ellenberg, 1986; Tucker & Evans, 1997).

- *Encroachment of the heathland by trees and shrubs.* As most of European heathlands, the Po basin heathlands were created by man. Extensive grazing, especially by sheep, burning, turf cutting and harvesting of vegetation for fodder have been practised for centuries on these soils, which, until the development of modern farming techniques, were unsuitable for agriculture. These activities determined a progressive impoverishment of the soils and the disappearance of woods, which were substituted by open habitats dominated by *Calluna vulgaris* and a few other species of grasses and low shrubs (Gimingham *et al.*, 1979, Noirfalise & Vanesse, 1976). In the second half of XX century, the progressive abandonment of traditional farming techniques has been followed by an increase of shrubs and trees, which is one of the most important threats to heathland across all of Europe (Tucker & Evans, 1997). Encroachment by woody vegetation is apparent even in the Vauda, and in the long run will determine the disappearance of open habitats of high biodiversity value, which will be substituted by impoverished young woodland, often dominated by introduced species such as Black Locust *Robinia pseudoacacia*, and of generally low conservation value. Ornithological research in the Vauda gathered evidence that this process is indeed already occurring (see section 4 of the Results), and its consequences should be carefully monitored in the future to avoid the possible local extinction of species and habitats.
- *Encroachment on the heathland by grasses and ferns.* Various different processes can be classed within this heading. On the one hand, it has already been pointed out that most of the eastern section of the Reserve (area 1 in fig. 3) is being encroached upon by an unidentified species of grass, *Panicum* sp., which seems able to almost completely dislodge autochthonous species. This process, although still limited at present, is potentially a serious threat and should be carefully monitored in the future to understand its importance.

A second ongoing process, which is apparent in the western part of the Reserve, is the invasion by Bracken *Pteridium aquilinum*. This could be

due to an excessively high rate of burning, as the underground rhizomes of this fern are very resistant to fire. Bracken develops into dense and uniform stands, and is a serious problem for heathland management in Northern Europe (Marrs, 1988). Presently about 168 ha are affected by invasion by Bracken in the Vauda (area 6 in fig. 3). However, even in the most affected areas, fern density does not seem to be such that it threatens floral diversity. Moreover, ornithological data (L. Borghesio, unpublished observations) suggest that Bracken stands may be important as nest sites for birds such as Corn bunting and Hortulan bunting. Summing up, the spread of Bracken does not seem to need any particular conservation measure at the moment, except for a regular monitoring of the surface affected.

A third process, which affects more or less the whole territory of the Reserve, is the progressive increase of Tall moorgrass *Molinia arundinacea*. The spread of this species has already been reported in the Vauda by Guglielmetto Mugion (1996), who linked it to excessively high fire frequency. Although fire has already been suspected to favour the increase of *Molinia* spp. in heathlands (Sartori *et al.*, 1988), many studies have also found that this is often due to an increased supply of nutrients in the soil (Berendse *et al.*, 1994; Ellenberg, 1986). Various authors have already pointed out that atmospheric pollution is probably the primary cause for the increased deposition of nutrient substances, especially Nitrogen oxides, in northern Europe, and this phenomenon has been repeatedly linked to grass expansion in heathlands (Angold, 1997; Tucker & Evans, 1997). At present, the increase of *Molinia* and other grass species, although widespread, does not seem a serious cause of concern for ecosystem conservation in the Vauda, but future developments should receive careful attention. However, if atmospheric pollution was its main cause, grass expansion could become a serious issue in the future.

DISCUSSION

Before the arrival of man, a forest dominated by oaks *Quercus* spp. and Hornbeam *Carpinus betulus* covered most of the Padana Plain. Since Roman times, much of these forests were cleared and substituted by crops. However, some areas, like the Vauda, where the soils were poor and water supply was insufficient for agriculture were converted to open habitats where pastoralism was the main activity. Grazing and periodic burning

contributed to maintaining these habitats, and also removed nutrients from the soils, contributing to the creation of the peculiar conditions that allow the persistence of the heathland and its flora and fauna. The heathlands of northern Italy, as those of the rest of Europe, are characterised by a relatively low species diversity compared to other “natural” habitats, but also by an abundance of rare and threatened species, and have a high value for nature conservation (Tucker & Evans, 1997). In recognition of this value, many heathland reserves have been created in Europe. However, since natural habitats are dynamic entities, the creation of a reserve does not guarantee their conservation and persistence. In the last decades, farming techniques have drastically changed: deep ploughing and heavy input of fertilisers have allowed the cultivation of marginal areas, while traditional pastoralism has been decreasing. In turn, these processes have brought about a steady reduction of natural habitats, while the management of the few surviving heathlands has been almost completely discontinued, thus threatening their fragile equilibrium. The data presented in this paper suggest that if urgent and quick actions are not taken soon, the biodiversity value of the Vauda Reserve could be seriously reduced.

Table 1 presents a list of the major threats to natural habitats in the Vauda, and gives an estimate of their importance in the past and in future

Table 1 - A abstract of the threats to the natural habitats of the Vauda Reserve and its surroundings.

Threat	Scale of threat	
	Past	Future
Loss of animal and plant species	High	High
Habitat destruction due to military activities	High	High
Destruction of wetlands along the Malone River	High	High
Conversion of the heathland to agriculture	High	Medium
Encroachment of the heathland by trees and shrubs	Low	Medium
Encroachment of the heathland by introduced <i>Panicum</i> sp.	Low	Medium
Encroachment of the heathland by Bracken <i>Pteridium aquilinum</i>	Low	Medium
Encroachment of the heathland by <i>Molinia</i> and other grasses	Low	Medium

years. As is apparent in table 1, 7 of 8 identified threats are expected to maintain or increase their importance in the future, while only one is likely to decrease.

Ultimately, the loss of animal and plant species is clearly the most important threat to a protected area. I have presented evidence for species extinction in the Vauda Reserve, and listed several species that are seriously threatened with disappearing in the near future. No single cause can be given for the extinction of a species, as can be understood by the data presented in the Results. Habitat destruction, pollution, competition with introduced species, lack of management and direct disturbance certainly all play a part in this process. What is clear is that our knowledge in regard to the animals and plants living in the Reserve is poor: many groups (Mammals, Fungi, most of the Insects) are insufficiently known, or even not known at all. Obviously, there is a high chance of losing species without even noticing it. I suggest that the first priority for nature conservation in the Vauda should be that of listing the species living in the area and identifying the biotopes where the most threatened taxa are found. Many of these biotopes are small, and could be destroyed even by simple actions, such as the enlargement of a road, or the passage of a vehicle. A better knowledge of species distribution in the Reserve is of primary importance for preserving them. A second important action, which could help preserve the most threatened plants, would be that of growing them in a small botanical garden, which could be created in one of the Park premises. Seeds and young plants could then easily be reintroduced in suitable areas within the Reserve.

A second serious threat is habitat destruction due to military activities. In truth, it is to be said that the natural habitats of the Vauda have been spared by agricultural expansion thanks to the presence of a military training area. Military operations in the past have also been instrumental in creating important wetland biotopes where many rare plant species live. With a proper planning, this could also be the case in the future. However, in the last few years, military operations have generated much damage to local biotopes. Offroad use of heavy armoured vehicles, and the opening of large tracks used in the testing of these vehicles were done with complete disregard for the presence of rare or threatened species, and large areas of the heathland were damaged. There is an urgent need for a better dialogue and exchange of information between the Military and Park Authorities, so that the environmental impact of military operations can be assessed and reduced.

The destruction of the natural wetlands along the Malone River is an

other serious issue. The environmental value of the few remaining areas is already much compromised. It is not likely that any of them will survive for long at the present rate of destruction. It is very urgent that these sites (areas 3 and 4 in fig. 3, with a total surface of 173 ha) are included within the protected area, so that they can receive legal protection. Also the small fragment of woodland and heathland where the butterfly *Carterocephalus palaemon* was collected (area 7 in fig. 3, total surface 41 ha) should urgently be included in the protected area.

The conversion of the heathland to agriculture was certainly the principal cause for the destruction of natural habitats in the past. Luckily, this process has slowed down with the creation of the Vauda Reserve in 1993, since the law officially prohibits to “modifying the living conditions of the animals” and to “damage or destroy plants of any kind or species” (L.R. 7 June 1993 no 23, article 6). However, these restrictions do not apply to the Italian Army, and even among civilians there is the feeling that normal agricultural practices (such as ploughing or fertilising) do not result in permanent damage to natural habitats. On the contrary, it must be stressed that the conversion of heathland to agriculture implies the complete disappearance of the wild flora and fauna, and that even if agriculture was discontinued, vegetation recovery could take centuries. In the Vauda, areas under cultivation before the Second World War, but which have remained fallow since that time, are still engulfed by dense vegetation dominated by Bramble *Rubus* spp. and Black locust *Robinia pseudoacacia*. This vegetation has no environmental value, and there is still no sign that heathland might ever regrow there.

The encroachment on the heathland by trees and shrubs and various species of grasses and ferns is the most poorly known among the perceived threats to the Vauda ecosystem. However, these processes are a serious issue in north European heathlands (Marrs, 1988; Tucker & Evans, 1997), and it is likely that in the near future their importance will grow also in the Vauda. As it has been pointed out in the Results (section 6), there is no single cause for them, and in some cases they are the result of opposite factors. Indeed, the spread of woody plants is mainly determined by the abandonment of pastures and the reduction of fire frequency, while, on the contrary, that of Tall moorgrass and Bracken could be due to excessive grazing and high fire frequency. This suggests that different sections of the Reserve are subjected to unequal levels of exploitation. In most places, the heathland is no longer used as a pasture, while in a few others, there seems to be an excessive density of grazing animals. The spread of grasses and ferns could also be due to atmospheric pollution, as has been suggested in

northern Europe (Angold, 1997; Tucker & Evans 1997). This is as of now just a hypothesis, but the issue should be considered seriously if the expansion of grasses and ferns continues in the future. Also the encroachment of the eastern part of the Reserve by an introduced herb (*Panicum* sp.) is presently a problem of limited relevance, but it would be important to evaluate the ability of this species to invade and destroy local grass communities and the speed of its spread to the rest of the Reserve. There is an urgent need to better understand the causes and the possible future consequences of the increase of grasses, ferns and introduced plant species in the Reserve.

The conservation of natural biodiversity in the Vauda Reserve is an urgent problem, which needs to be tackled by developing a detailed strategy of environmental management, based on the understanding that protected, "natural" habitats are not by definition safe and self-perpetuating. Natural and man-driven processes may be at work even within the borders of a protected area, and they may cause a slow, but continuous habitat degradation that can lead to an irreversible loss of species. Many protected areas in Italy and in the whole of Europe may be experiencing similar changes, and, given the present rate of fragmentation and reduction of natural habitats within our continent, this could have extremely negative consequences.

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