Peregrine Falcon Populations – status and perspectives in the 21st Century
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Opportunities in falconry for conservation through sustainable use

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Abstract

Following the Convention on Biological Diversity, a European focus on protection-based conservation is starting to be complemented by the incentive-driven approaches, including large private spending on sustainable use of wild resources. Whereas protection has been strongly educational, the “sustain-by-use” approach can be less polarising in societies and landscapes, although it is also more complex and requires new tools to encourage cooperation between many interests. Falconry can be a useful complement to shooting because it has less impact on game stocks. Falconers pioneer raptor restoration, rehabilitation and research techniques, as well as the use of trained raptors for biological control and environmental education. They also have high conservation potential for monitoring through use of raptor populations, in ways that could reduce concern about production of hybrid falcons. Data from recent surveys indicate how falconry could best be managed to benefit conservation of the Peregrine Falcon and other wildlife, using governance principles based on the Bern Convention Charter for Hunting and Biodiversity.

Key words: Sustainable use, Economics, Monitoring, Falconry, Peregrine, Goshawk, Red Grouse

Introduction

The concepts of sustainable use and incentive-based conservation are not particularly new. At international level, they were pioneered by IUCN (The World Conservation Union) in the World Conservation Strategy of 1980 (McNeely 1988, Holdgate 1999). IUCN is a huge Government and Non-Government Organisation, founded in 1948 and in 2007 had 1 074 members, including 83 States, 111 State Agencies and 880 NGOs or affiliates, with about 1 100 staff and expert advisors worldwide. Strongly influenced by concepts promoted in IUCN, the Convention on Biological Diversity (CBD) that came from the Rio de Janeiro Summit in 1992 mentioned sustainable use in 13 of its 19 substantive Articles. Specifically, it is required that "each Contracting Party shall, as far as possible and as appropriate: Protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements" (Article 10); and "adopt economically and socially sound measures that act as incentives for the conservation and sustainable use of components of biological diversity" (Article 11). In contrast, protection of species and habitats is mentioned in just 2 of those 19 Articles.

In effect, conservation now has two main approaches. The first approach, of 'protection-based conservation', has been a focus for Europe in recent decades. Its aims are the protection of species, and the creation of reserves to protect habitats, as encapsulated for example in the 1979 Bern Convention on the Conservation of European Wildlife and Natural Habitats. This 'protect and reserve' approach has been highly successful in changing popular attitudes to wildlife. Unfortunately, it has been much less successful in preventing dramatic declines in wildlife populations due to agricultural intensification (Paine & Pienkowski 1997).

The second approach is 'incentive-driven conservation' (Hutton & Leader-Williams 2003). This approach is rooted in CBD article 11 on Incentive Measures "Each Contracting Party shall, as far as is appropriate, adopt economically and socially sound measures that act as incentives for the conservation and sustainable use of components of biological diversity". This approach embraces the utility of the components of biodiversity to encourage conservation. It notes that humans value and hence conserve what is useful to them (Webb 1997). This can attract public payments (e.g. agri-environment subsidies) for conservation of ecosystem services, such as flood abatement or natural degradation of sewage. Alternatively, uses such as hunting and wildlife-watching can attract private payments. Ecosystem services do not generally depend on the survival of individual bird and mammal species, so private resources, including funding and time, can contribute greatly to their conservation.

For conservation as a whole, both the protect-and-reserve and the sustain-by-use approaches are likely to be important. Some 11.5% (17 100 000 km^2)

of the terrestrial surface of the globe is in protected areas (Chape et al. 2003). However, estimates from species-area curves indicate that retention of biodiversity requires the application of conservation measures to some 50% of the land surface (Soulé & Sanjayan 1998). Protection measures might achieve some of this, but use of the incentive “carrot” as well as the protection “stick” is likely to achieve more, especially because “stick” alone can become counterproductive.

By itself, a protect-and-reserve approach can lead to polarised attitudes, with human resources squandered in conflict between different interest groups, and to polarised landscapes, with protected fragments of low productivity land as the alternative to intensive use (Pretty 2002, Adams et al. 2004). In developing countries, where it can be hard to maintain a minimum standard of living, successful implementation of restrictions can be elusive (Misra 2003). In these circumstances, positive incentives that include use of wild resources can be more powerful and cost effective for driving habitat and species conservation (Murphree 2003). For example, where land is relatively unproductive, sustain-by-use approaches frequently compete effectively with intensive uses: hunting or tourism can become more lucrative than livestock farming (Child 1995; papers in Prins et al. 2000). However, even where intensive use has high value, de-intensification measures that are critical for conservation can be afforded if reduction in yield is slight (Kenward & Garcia Cidad 2005).

The ideal may well be a dual approach to conservation (Inamdar et al. 1999). This would create “a much more biodiversity friendly mosaic of land uses driven by the livelihoods that are derived from the sustainable use of wild living resources, instead of landscapes with small islands of biodiversity in a sea of agriculture” (Hutton & Leader-Williams 2003). Protected areas still have an important part to play, by supporting core populations that render harvest more productive in surrounding areas (Roberts et al. 2002). Some extractive use may even be desirable in core areas, to maintain human practises that preserve habitats (Getz et al. 1999). In surrounding areas there may be fewer restrictions on use.

Where land is relatively unproductive, sustainable use of wild resources frequently competes effectively with intensive uses, for example where tourism or hunting are more economic than livestock farming in southern Africa (Child 1995; papers in Prins et al. 2000). However, where soil fertility and climate combine to give high productivity, as in Europe, there is less land on which sustainable use of wild resources is more cost effective than intensive cultivation or other development. Moreover, the residual low-productivity areas tend to be refuges for rare species, which can (ironically) inhibit conservation through sustainable use of wild resources. Grouse moors are an example (Redpath et al. 2004).

This situation has resulted in persistence in Europe of divergent attitudes to sustainable use. On one side are those who say, in effect, that "if we must have use then we should at least ensure that it is sustainable" and (at the extreme) "but no use is best". In this camp are those who promote sustainable agriculture, forestry, fisheries and tourism but are reluctant about extractive (consumptive) use of wildlife. In another camp are those who hold that "use of wild resources is acceptable as long as it is sustainable" and (at the extreme) "therefore is justified whether or not it delivers conservation or livelihood benefits".

Amman, Addis Ababa, Malawi, Strasbourg: Principles for Conservation through Use

Faced with continuing concerns about the sustainable use of wild species, IUCN used its 2000 World Conservation Congress in Amman to adopt a Policy Statement, on the Sustainable Use of Wild Living Resources (IUCN 2000), which includes the conclusion that "Use of wild living resources, if sustainable, is an important conservation tool because the social and economic benefits derived from such use provide incentives for people to conserve them". IUCN then held a workshop in Florida in 2001, after which it worked with CBD through regional workshops in Mozambique, Vietnam and Ecuador before a global workshop in Ethiopia produced the Addis Ababa Principles and Guidelines for the Sustainable Use of Biodiversity (AAPG). The 14 principles became a commitment of CBD signatories at its 7th Conference of the Parties in 2004 (CBD VII/12), together with a complementary set of 12 principles from a workshop in Malawi, known as the Ecosystem Approach (CBD VII/11).

Two features of the AAPG (http://www.biodiv.org/doc/publications/addis-gdl-en.pdf) and Malawi Principles (http: //www.biodiv.org/doc/meetings/cop/cop-04/information/cop-04-inf-09-en.pdf) are especially important. One is that they give as much consideration to social issues and economics as they do to ecological issues, as also recommended at the Johannesburg World Summit of Sustainable Development on 2002. The second is that the principles are intended not to be prescriptive but advisory. In 2007, Norway worked with the European Sustainable Use Specialist Group of IUCN Species Survival Commission (ESUSG) to use the Malawi and Addis Ababa principles as the basis for a Charter on Hunting and Biodiversity for the Bern Convention. The 26 principles were condensed to 12 simple recommendations that were adopted at Strasbourg in November 2007 by the annual meeting of the Bern Convention Standing Committee, as follows:

1. Favour multi-level governance that maximises benefit for conservation and society;
2. Ensure that regulations are understandable and respected;
3. Ensure that harvest is ecologically sustainable;
4. Maintain wild populations of indigenous species with adaptive gene pools;
5. Maintain environments that support healthy and robust populations of harvestable species;
6. Encourage use to provide economic incentives for conservation;
7. Ensure that harvest is properly utilised and wastage avoided;
8. Empower local stakeholders and hold them accountable;
9. Competence and responsibility are desirable among wild resource users;
10. Minimise avoidable suffering by animals;
11. Encourage cooperation between all stakeholders in management of harvested species, associated species and their habitats;
12. Encourage acceptance of sustainable and consumptive use as a conservation tool by the public and other conservation interests.

In the full text (http://iucn.org/themes/ssc/susg/sub/europe.htm), under each principle there is advice that conservation will be enhanced if a set of guidelines are followed. The guidelines are for all aspects of hunting and draw heavily on a set of Principles and Guidelines for Sustainable Hunting developed by a Wild Species Resources Working Group of ESUSG. A charter is a document that agrees responsibility of government towards citizens, effectively conferring rights, as well as responsibility of citizens, so the Bern Charter for Hunting and Biodiversity not only has guidelines for hunters, but also for regulators so that they too can help hunters to benefit conservation of biodiversity. This is a format pioneered in a draft by IUCN-ESUSG and its member the International Association for Falconry and Conservation of Birds of Prey (Kenward 2007). Although the guidelines are for hunting, the 12 Principles do not mention hunting specifically, and could therefore embrace (with appropriate specific guidelines) all aspects of conservation through use of wild resources

Economics for Conservation through Use

In the thinking behind CBD, the benefit of Sustainable Use lies not merely in ensuring that use of wildlife is ecologically sustainable, nor in conferring rights to use provided it is sustainable. The crucial importance of use, which must of course be sustainable, is to help biodiversity compete with other uses of land. In a rapidly developing world, the human footprint on land is heavy. Fertile and accessible areas which are not either protected, valuable for recreation or covered by construction tend to be used mainly for cultivation. New crops, such as bio-fuels, open more areas to cultivation and, as cultivation intensifies, biodiversity is lost. Newton (2004) reviewed research on declines of 30 European farmland bird species and identified 5 main associated factors: (i) weed control, (ii) early ploughing, (iii) grassland management, (iv) intensified stocking, (v) hedgerow loss & predation. However, all these intensification factors can be addressed by constraints that produce fractional reductions in yield. An early example is a small reduction in cereal crop yields when headland-edges are left unsprayed, which increases abundance of game birds and other wild fauna and flora (Boatman & Sotherton 1988; Sotherton 1991).

The economic potential for conservation through sustainable use was expressed very simply by ESUSG for an Inter-Ministerial Conference run Council of Europe for United Nations Environment Programme (Kenward & Garcia Cidad 2005). The aim of sustainable use of wild resources is to produce situations where income from use of wild resources (*U*), that is enabled by constraining land-use enough to provide those resources (giving income *C*), can be more profitable than merely using land intensively (giving *I*), in other words:

$$U + C \geq I$$

In effect, value from use of wild resources is leveraging biodiversity through minor constraints on crop production. Thus, where food shortage for deer in conifer plantations results in an uneconomic venison harvest and severe bark-stripping, a small loss of timber through including some deciduous woodland can be more than offset by gain in value of deer and reduced damage (Reimoser & Reimoser 1997). There is also the possibility of leveraging U with stewardship subsidies S to maximise scope for conservation (i. e. $U+C+S \geq I$).

This leveraging approach can in principle be applied to all land, but is there enough value in use of wildlife resources to conserving much biodiversity? The most rigorous data come from surveys of spending on wildlife-associated recreation that are run at 5-year intervals by the United States Department of the Interior Fish and Wildlife Service and United States Department of Commerce Census Bureau. The latest national survey (USDI & USDC 2002) estimates that 82 million US adults (31% of adults) watched, fished and hunted wildlife in 2001, spending $39, $36 and $21 billion respectively, or $108 billion including funds in common. That represents $140 for each of the 774 million hectares of the USA.

A less rigorous survey of participation and spending in the European Union estimated total spending on hunting, angling and bird-watching of at least €40 billion (Kenward & Sharp 2008), or at least €121 for each of the

331 million hectares of the EU, equivalent to $181/ha at the exchange rate in late 2007. In the UK alone, a survey in 2002 estimated annual income from a wide range of wild resources in the UK (including collection of plant products and fungi but excluding released game) at €7.2 billion, which was 30-50% the value of UK agricultural production and accounted for some 58 000 jobs (IUCN-UK & ESUSG 2004).

Private recreational spending on wild resources encompasses equipment, accommodation and travel as well as use of land, but there is clearly scope for funding to benefit diversity of wild resources. This is most obvious where land value is obtained purely from wild resources, as on grouse moors. Value can be enhanced by increasing the density of wildlife, but this may create additional management costs. Value can also be enhanced by maximising income per unit of wildlife, as occurs in trophy hunting. In Africa, trophy hunting can generate as much value per hectare as wildlife-watching, and with greater ecological sustainability because hunters tolerate less luxury than other eco-tourists (Bigalke 2000, Hurt & Raven 2000).

Unfortunately, it appears that some wildlife-related activities are declining in popularity. Hunter numbers have declined in Finland, Spain and quite rapidly in France after peaks in the 1980's (Martinez et al. 2002), and across the EU have decreased by 12-15% in the last decade alone (Kenward & Sharp 2008). Falls in numbers of wildlife-watchers in the USA (USDI & USDC 2002) and of young recruits for bird-ringing in the UK (Spence 1999) suggest that hunting is not the only outdoor activity adversely affected. However, this is not at all the case for falconry, which has increased greatly in popularity during recent decades (Fig. 1).

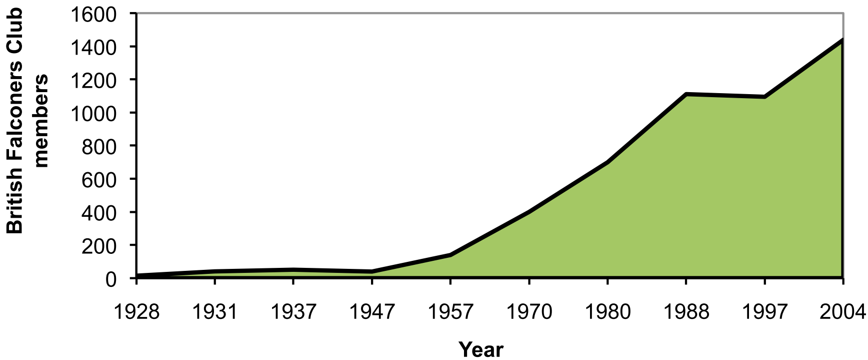

Figure 1. Growth in membership of the British Falconers' Club from 1927 to 2005.

Falconry and Conservation of Raptor Populations

Unfortunately, the early stage of a renaissance in falconry in the 1950's and 1960's coincided with steep declines in some raptor populations. Research eventually showed the declines to be due to agricultural use of new pesticides (Hickey 1969; Ratcliffe 1980; Newton 1986), but the blame had already been placed on falconry in some countries, not least because young were removed from nests of the last surviving wild Peregrine Falcons *Falco peregrinus* in Denmark & Schleswig-Holstein. Laws were passed against hunting with raptors in countries with little history of falconry, including Denmark and Sweden.

When Iain Presst and Derek Ratcliffe made the British Falconers Club aware of the pesticide problem, BFC members voluntarily restricted licence applications for wild British Peregrines. In the UK and North America, falconers also started raptor conservation organisations (Hawk Trust, Raptor Research Foundation and Peregrine Fund) and began trying to breed Peregrines, which had become extinct in parts of Europe and North America. Peregrines had first been bred in Germany in 1943 (Waller 1982), with isolated successes there and in the USA before systematic production started in 1973. In his Chairman's report to the Hawk Trust (now the Hawk and Owl Trust) that year, Philip Glasier wrote "I realise there are many who have said and still maintain that the breeding of birds of prey that are suitable for falconry will never take place", to which he later added "We now know that what might well be called the 'Big Break-Through' has happened. Cornell University have bred 20 Peregrines, some Prairie Falcons and some Lanners this year. "

From a production of about 20 large falcons in 1972 (10 in Germany), the number bred annually rose to more than 200 in 1975. By 1980, more than 100 Peregrines were being bred annually on each side of the Atlantic, almost entirely by falconers and almost entirely for release. Falconers ran 6 of 7 major release projects for Peregrines (in Germany, Poland and the USA), for Mauritius Kestrels *Falco punctatus* and did much of the technical work for California Condors *Gymnogyps californianus* (Cade 1986; Saar 1988, 2000; Jones et al. 1994; Trommer et al. 2000; Wallace 2001; Cade & Burnham 2003).

As domestic breeding developed further, it became the main source of raptors for falconry in Europe, not least because pressure for strict protection of raptors reduced licensing of wild species in most countries. Domestic breeding changed the relationship between falconers and wild raptor populations in ways predicted by previous differences in supply from the wild, as shown by a survey of BFC members in 1970 (Kenward 1974). Thus, Eurasian Kestrels *Falco tinnunculus* were recommended for beginners in the 1960's and were readily available from the wild under licence, but were seldom trained to take quarry and were mainly released back into the wild in their first year (Fig. 2). Peregrines and Merlins *Falco columbarius* flown by more experienced falconers were more likely than Kestrels to be lost during hunting in their first year, with fewer released. Goshawks *Accipiter gentilis* were costly imports, and even fewer were lost or released in their first year. However, 52% of Goshawks were lost or released eventually. These lost hawks, and others imported at the expense of falconers for release, were successfully re-establishing a native goshawk population (Kenward 2006).

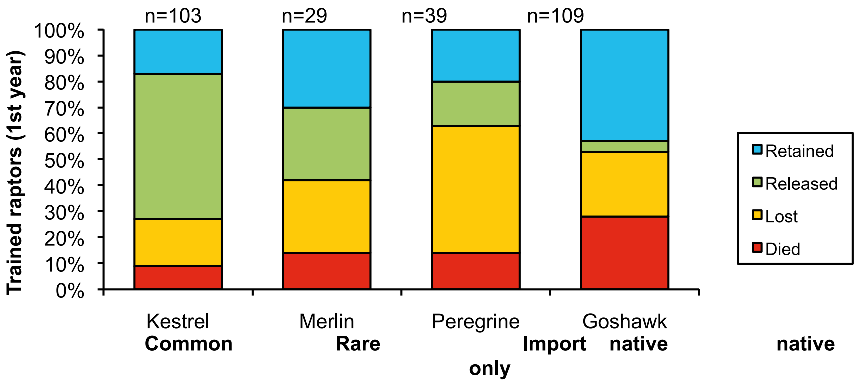

Figure 2. Kestrels, Peregrines and Merlins, obtained from the wild under licence by members of the British Falconers' Club before 1970 were more often lost or released in their first year of life than Goshawks, which were relatively expensive imports. Data from Kenward (1974).

As domestic breeding developed, species that were easy to breed enabled rapid growth of falconry (Fig. 1) and then saturated the market. For example, production of Kestrels in the UK peaked at more than 1 000 in 1987-88 and then declined (Fox 1995). However, other species were less easy to breed, which made native species relatively less available for falconry, while the cost of commercial production also reduced the tendency to release them. Among the large raptors, breeding developed fastest in Britain for Harris Hawks *Parabuteo unicinctus* from North America, which are a social raptor that is relatively easy to train. Domestic breeding also developed rapidly for large falcons, and took an interesting turn.

In 1971 a female Saker Falcon *Falco cherrug* and male Peregrine that each courted other falcons were, for want of other partners, put together in a breeding enclosure in Ireland and reared 2 young from 5 eggs (Morris & Stevens 1971). From this beginning grew a fashion for breeding falcon hybrids, initially partly as novelties and as proof of domestic parentage rather than laundering, and subsequently to obtain traits perceived as more advantageous than in the pure parent species. Subsequently, the use of 'DNA-fingerprinting' (Jeffreys et al. 1985) as a parentage test for raptors (Parkin 1987) provided a very strong deterrent against 'laundering' of wild birds (Williams & Evans

2000), so hybridisation was not needed as a proof of domestic origin. However, a growing demand in the Middle East for falcons with new capabilities made the breeding of hybrids for export very popular in Europe.

The result was that the spectrum of large raptors produced for falconry in the UK had changed dramatically by 2005 from that obtained from the wild prior to 1970 (Fig. 3). Just under half the birds bred were hybrids of large falcons, with more Harris Hawks than Goshawks (for which domestic breeding was especially slow to develop) or purebred Peregrines. The picture was similar from a survey conducted in 2006 by the International Association for Falconry and Conservation of Birds of Prey (IAF) for the European Commission (Morel 2007). Among 6, 889 raptors bred in 2005, which were 85% from Germany (n=2723) and the UK (n=3116), and would have represented about two thirds of a total production of some 10 000 raptors, 46% were hybrids. However, pure Peregrines were the second most abundant category in pan-European data, probably because they were still being bred extensively in Germany for the successful but very demanding project to re-establish Eurasian tree-nesting Peregrines.

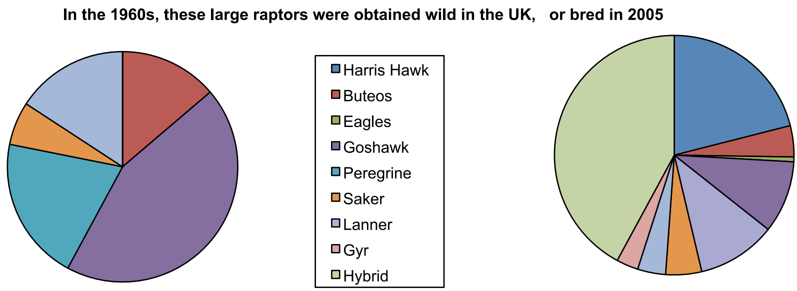

Figure 3. The proportions of different large raptors obtained from the wild for falconry in the UK prior to 1970 and produced by domestic breeding in 2005. Data from Kenward (1974) and the UK Department for the Environment, Food and Rural Affairs.

The large commercial production of hybrid raptors for the Middle East is a distortion when seeking to estimate what falconers currently use for hunting in Europe. An IAF survey in 2000 recorded the proportion of hybrids among trained raptors in the UK as 10% and in Germany as 2% (Kenward 2004). There may subsequently have been some increase in the UK, but falconers are now prohibited from flying hybrids in Germany (as in 6 other EU states), although breeding them is permitted until 2014.

In 2005, only 88 wild raptors (including 61 Goshawks and 8 Peregrines) were licensed for falconry in the European Union, which is tiny in proportion to domestic production. Although 9 states in the EU still permit use of wild raptors for falconry, use from the wild exceeds 5% of domestic production in only 3. This is a great contrast with countries like South Africa and the USA. The US Fish and Wildlife Service permits a harvest of up to 5% of wild raptor production and records the use of 800-900 wild raptors annually (Millsap & Allen 2006).

An examination of factors associated with differing levels of production of hybrids (from the IAF survey of the EU for 2005) or use of hybrids (from the IAF survey in 2000) showed a very strong tendency for few hybrids to be produced or used in countries that permitted enough wild raptors for 4-20% of their falconers annually (Fig. 4). The reason for this relationship is uncertain. Only where countries are permitting falconers to acquire a new wild raptor every 3-4 years would supply approach demand and reduce domestic production. A plausible explanation is that where falconers were obliged to depend on domestic progeny by early restriction of access to wild stocks, early development of commercial breeding gave producers experience and competitive incentives to develop a fashion for hybrids.

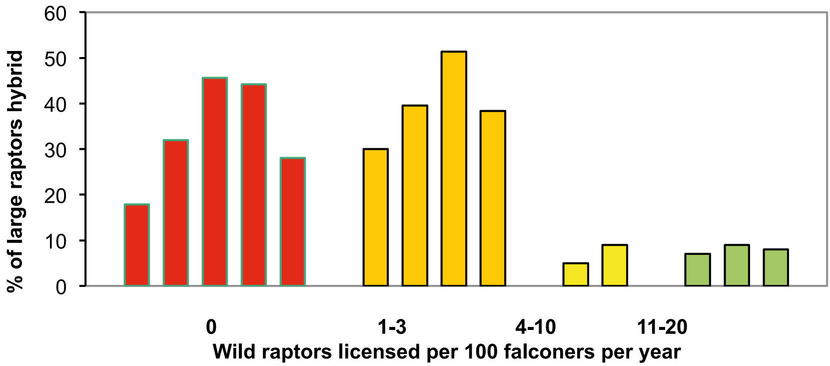

Figure 4. The proportion of hybrids among large raptors produced or flown (whichever was greater in the IAF surveys of 2000 and 2005) did not exceed 10% in countries where 4-20 wild raptors were permitted per 100 falconers each year. Data from Kenward (in press).

Fortunately, the production of thousands of hybrids annually in Europe for the last decade appears to have had little adverse effect on wild falcon populations. In the IAF survey of government authorities, four cases had been proven by genetic analysis in three countries, although one report was a 4-year natural hybridisation of a Saker Falcon and a Peregrine. Natural hybridisation has also been recorded between Peregrine and Prairie Falcon *Falco mexicanus* in North America (Oliphant 1991). It is also now clear from observation and genetic analyses that hybridization is not uncommon in zones where Sakers encounter Lanner Falcons *Falco biarmicus* or Gyr Falcons *Falco rusticolus* (Wink & Sauer-Gürth 2004; Nittinger et al. 2006). For the species involved to have maintained their phenotypic identity for millennia in the face of natural hybridization, which represents a lack of behavioural isolation mechanisms, suggests that there are strong selection pressures against survival of intermediate phenotypes.

Nevertheless, 8 of 22 national authorities for the Wild Birds Directive, expressed more than slight concern about hybrids when surveyed by IAF for the European Commission (Fig. 5), including 5 of 16 countries where falconry was practised officially. In contrast, no country with falconry had more than slight concern about the risk of introducing exotic species.

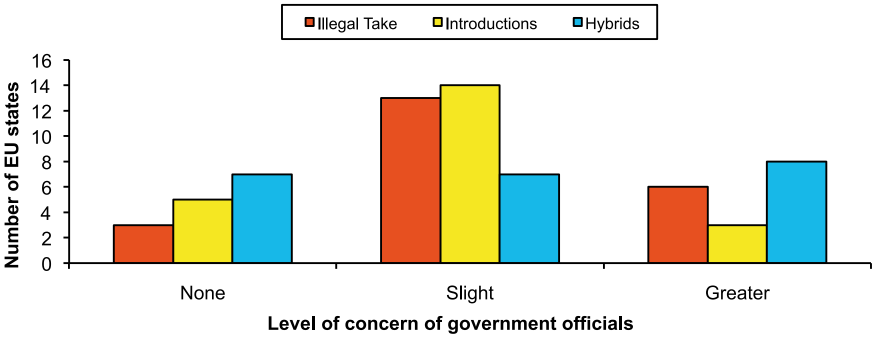

Figure 5. The level of concern noted by officials in 22 EU countries about risk to wild raptor populations from illegal take, introduction of exotic species and hybrid falcons.

The risk of raptors being taken illegally from the wild is greatly deterred by DNA forensics. Initial tests for laundering in the UK showed a minority of breeding claims to be false, and a subsequent random survey of 10 domestic raptor broods found no illegality (Williams & Evans 2000). It is also worth noting that the number of raptors used in falconry in Europe remains relatively low compared to the numbers breeding in the wild. Summary statistics gathered by Birdlife International in 2004 average a total of about 8 400 pairs of Peregrine Falcons and more than 55 000 pairs of Goshawks (Burfield & van Bommel 2004) in the European Union. A productivity of 1.7 Peregrines per pair (Craig et al. 2005) and 1.9 Goshawks (Kenward 2006) would give >14 000 young Peregrines annually and >100 000 young Goshawks, compared with at most 1 500 Peregrines and 1 000 Goshawks bred for falconry in the EU. If falconers were depressing populations of Peregrines and goshawks, one might expect smaller populations of these species in countries where falconry is popular. In fact, there is a non-significant positive trend for numbers of nesting Goshawks to increase with numbers of falconers and a highly significant tendency for wild Peregrine populations to be highest in countries with most falconers (Kenward in press). In the USA, the extensive restocking of Peregrines by falconers that was organised by the Peregrine Fund resulted first in de-listing under the Endangered Species Act, and then in restoration of permits to use wild Peregrines for falconry (Cade & Burnham 2003).

Falconry and Conservation of Game Habitats

In the UK, it has been estimated that shooting by 480 000 people provides 2.6 million days of work on habitat and wildlife conservation, equivalent to 12 000 full-time jobs (PACEC 2006). Falconry cannot compete in quantity, but gives interesting qualitative comparisons in two recent studies. In Croatia, Šegrt et al. (2008) arranged hunting by 5 falconers with Goshawks on an estate, and a week later with 5 guns, covering the same land with the same dogs. The falconers flushed 112 game, mostly Pheasant *Phasianus colchicus*, Partridge *Perdix perdix*, Quail *Coturnix coturnix* and Hare *Lepus europaeus*. The hawks killed 9 of them, an 8% success rate. With few game removed, 110 were flushed for the guns a week later, and 40 (36%) were shot. The impact of the falconers was less than a quarter that of the guns due to a lower success rate.

Further information comes from studies of Red Grouse *Lagopus lagopus scotticus*. This grouse is a fast-flying social species of open country, which makes it a favoured quarry for shooting when driven in coveys over a row of stationary guns. Although red grouse can also be shot by walking guns as they flush from working dogs, such rough-shooting may bring an estate only €1 600 per day, compared with €16 000 for driven grouse (Thirgood et al. 2000a). With a rough-shooting party of 3-6 guns, and a bag of 20-30 brace (40-60 birds) for the day, the estate income in 2003 was estimated as €27-40 per grouse (D. Baines, pers. comm.). With a bag of 75-150 brace of driven grouse, income was €100-200 per bird bagged. However, shooting driven grouse is practical only with professional game-keeping; labour-free value may not exceed €50-100 per grouse shot.

Flying at grouse is a falconry classic. It requires obedient dogs and well trained falcons. The dogs must hold an accurate point for several minutes while a falcon is "cast off" and climbs to a "pitch" of (ideally) more than 100m, to "wait-on" in small circles until the falconer and dogs flush the quarry. The accuracy of the point and obedience of the dog (s) determines whether the quarry can be flushed downwind just as the falcon turns downwind, such that wind-shear as well as a high pitch gives a maximal speed advantage in the resulting stoop.

For comparison with shooting, there are data on value of grouse from harvest by falconry at two estates. At one estate in northern Scotland, falconers in 2003 paid about €65 (£40) per grouse. They took 16 grouse in

56 falconer-days, or a harvest rate of 0.29 grouse per falconer-day. Moreover, because grouse can only be flown successfully in good weather after hawks have become fit, the 4 falconers also rented the house on the estate for 3 weeks, at a total cost including the bagged grouse of €5 200, or €325 per grouse.

Another grouse moor within the North Yorkshire National Park has been rented for more than 10 years by a group within the British Falconers' Club, with the aim of building a stock of about 20 grouse to a level that can support falconry (Callaghan 2003). The moor is a Site of Special Scientific Interest, so there are restrictions on how it may be managed. However, moorland in Britain is mostly a managed habitat, with traditional management of the habitat encouraged to benefit grouse and a variety of other wildlife. To increase the incentive for this beneficial management, removal of corvids is also permitted. With good management, the moor might eventually yield a harvest of 10-20 grouse per annum. With an annual rental of ca. €3 750, the rent per grouse would is €188-375, without taking account of considerable voluntary labour for management.

Table 1 summarises the estimates for these harvest values. The estimates for shooting represent relatively good bags on high quality estates, and the example harvest rate for falconry may be low. Nevertheless, it is clear that although shooters and falconers are prepared to pay similar levies per grouse killed, falconers have harvest rates 1-2 orders of magnitude lower. Falconers are also likely to be more valuable than shooters for local economies, on a "per grouse" basis, because their residence as visitors is likely to be longer.

Table 1. Harvest rates and values of hunted red grouse in 2003, as estimated for shooting by staff of the Game and Wildlife Conservation Trust and measured for falconers at an estate in northern Scotland.

Harvest parameters	Shooting (driven grouse)	Shooting (walking-up)	Falconry
Grouse/hunter/day	ca. 25	ca. 10	e.g. 0.3
Payment/grouse killed	est. € 100-200	est. € 27-40	e.g. € 65
Total value/grouse killed	est. € 100-200	est. € 27-40	e.g. € 325

The particular advantage of falconry in both cases is the low impact on prey populations, such that hunting with hawks can bring income in areas where there are either too few game for sustainable hunting with guns, or where shooting is unsafe. Thus, where low-impact hunting is intended for zones around protected core populations (Roberts et al. 2002), falconry may be ideal. In Italy, experimental partridge conservation is being based on training gun-dogs in core areas, outside which a zone is reserved for falconry, with shooting in a zone furthest from the protected core (Tout et al. in press). Unlike shooting, falconry can be practised close to human dwellings, and in Germany proved effective for removing a rabbit infestation that was damaging a refinery (Saar et al. 1999).

Opportunities for Conservation through Sustainable Use of Raptors

As part of the sustainable use community, falconers show unusual capability and engagement in conservation. Survey in the USA showed that 83% of falconers had tertiary education, compared with 47% for other hunters and 57% for wildlife-watchers (Peyton et al. 1995). They had twice as many days in the field as hunters and 6 times as many as wildlife-watchers. Their engagement in socially responsible activities was twice the public average. US falconers also had a remarkably high engagement as volunteers in rehabilitation of wild raptors (57%), conservation education projects (47%) and raptor reintroduction work (35%). In the EU, national authorities recognised similar contributions (Kenward in press). From 15 states with falconry, all but 1 recorded engagement in some aspect of raptor conservation, and regular engagement in at least 1 activity in 12 cases. Regular engagement was reported most frequently (10 states) for education and awareness-raising, and for rehabilitation of incapacitated wild raptors (Fig. 6). In Australia, Holz et al. (2006) found that rehabilitated hawks maintained weight better in the wild if flown with falconry techniques before release.

Although contributions to research were considered least regular, falconers have repeatedly been leaders in raptor studies. The earliest raptor density records come from Britain in the 11th century AD, with a remarkably complete record of eyries in the Domesday Book for the county of Cheshire (Yalden 1987). Within 200 years, Emperor Frederick II of Hohenstaufen was writing 'De Arte Venandi cum Avibus' (1248), for which he has been called the father of ornithology. In 'An Approved Treatise on Hawks and Hawking' (Bert 1619) reveals how sophisticated the veterinary treatment of trained raptors had become by the 17th century (Cooper 1979). In the 20th century, as well as pioneering breeding and reintroduction techniques (reviews by Sherrod et al. 1981; Cade 2000; see also Tordoff et al. 1998), falconers were responsible for year-round quantification of raptor predation (e.g. Craighead & Craighead 1956; Brüll 1964) and much technique development for radio-tracking. More information on the biological and conservation aspects of modern falconry can be found in Fox (1995); Cade & Burnham (2003) and on links from the IAF web-site (www.i-a-f.org).

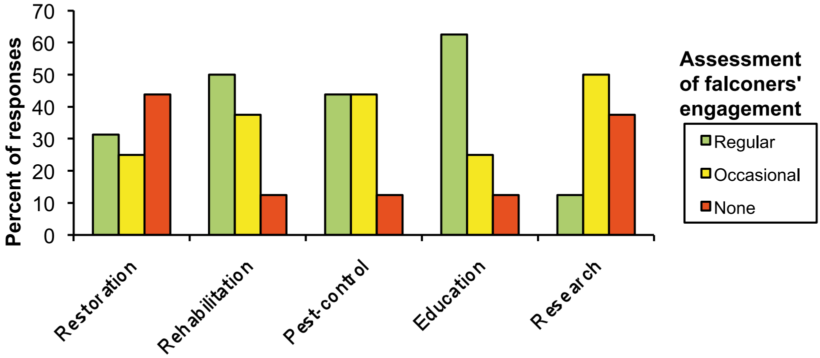

Figure 6. Engagement of falconers in conservation activities, assessed by government officials in 15 countries of the European Union. Data from Kenward (in press).

However, the greatest potential contributions of falconry to conservation through sustainable use are not shown on Fig. 6, because they are not yet widely implemented in Europe and were therefore not surveyed, despite being among the oldest conservation contributions from falconry. Falconry has motivated monitoring of wild raptors for nearly a millennium, and has probably preserved game habitats for longer. As well as mapping raptors in 11th century Cheshire, falconers provided maps of Peregrine nests in the mid-20th century that were crucial for survey and restoration of Peregrines (Cade & Burnham 2003). Among the oldest reserves in written records are those of Makkah and Medina in Saudi Arabia, set aside by the Prophet Mohammed at a time when falconry was the most respectable form of hunting.

There is a need for more research on the economics and ecology of falconry on grouse moors and other areas that provide the wide-open spaces suitable for flying falcons at game birds. Is falconry the most cost-effective use of land where sheep grazing or predation by wild raptors reduces grouse numbers below the density at which it is cost-effective to shoot driven grouse (Thirgood et al. 2000a, b), other than conversion to forest? Do falconer-tourists bring enough added income to local communities to compensate for income from an increased game-keeper density needed to shoot driven grouse? How much is the small ecological impact of falconry on game birds further reduced by the tendency of raptors to select weak and diseased prey?

There is also a need to study and pilot the monitoring of raptor populations by use of modern techniques that can involve falconry. Raptors can be monitored by counting all the breeding pairs in a given area, but this is a very labour intensive task if done on a scale adequate to detect declines (e.g.

Hargis & Woodbridge 2006), especially as some nests must be visited (and not merely checked for occupancy from a distance) if age-at-first-breeding is to detect decline in non-breeder numbers (Kenward 2006). However, if nests are being visited to harvest a single young, siblings and birds in non-harvested nests can be marked so that subsequent trapping can estimate population size by mark-recapture techniques. The accuracy of this approach has been tested for species that are trapped and translocated to reduce predation on game (Kenward 2006). However, it could also be useful for raptors trapped on migration for falconry, as recognised in an IUCN resolution in 2000 that requested "Saker range states and falconers work … to develop an internationally recognized system… that combines wildlife research and modern marking technologies to:

1. monitor populations and estimate sustainable yields;
2. regulate procurement and international movements with minimal administrative costs; and
3. motivate conservation of the species and its habitats throughout its range. "Such a system would be an effective and relatively inexpensive way for falconers to monitor Peregrine Falcon populations in North America.

This raises the question of whether falconers should have access to wild in Europe as freely as in other parts of the world, or be dependent on domestic breeding. Research in Eurasia and North America now shows that raptor populations can sustain much larger harvests than the 5% of juveniles currently permitted in North America (Millsap & Allen 2006). In Goshawks and large falcons such as Peregrines, falconers often prefer to fly females because these are the larger and more robust of the dimorphic sexes, so it is convenient that the sustainable yield of female goshawks was 53%, compared with only 16% for males due to their poorer juvenile survival in the wild (Kenward et al. 2007). For the Common Buzzard *Buteo buteo* with lower sexual dimorphism and higher juvenile survival, a harvest of 66% of juveniles should be sustainable. Absence of such detailed data on juvenile survival precludes similar estimation for Peregrines.

Nevertheless, consider this. At an average €750 per bird, the domestic production of raptors in Europe is worth €7.5m. A 1% harvest, of 1 000 wild Goshawks, would cover current demand in Europe and provide payments to landowners to compensate the predatory impact of this species as well as to fund monitoring. Although falconers in the USA have recently regained access to Peregrine populations that they helped to restore, harvesting Peregrines more widely in Europe would require complex agreements and even 5% (700 birds) would not meet demand for large falcons. Domestic breeding would therefore remain important for a species that has proved more vulnerable than the Goshawk to unexpected human impacts, and for other less common species. Maintenance of expertise and capacity in domestic breeding is important too, for providing insurance against problems that are detected so late in wild raptor populations that few are left, as in the case of Mauritius Kestrels, Californian Condors and the *Gyps* vultures. However, as with salmon, can there be a cachet on having a prize from the wild rather than a farmed product? Would falconers pay more for this, and thus raise further their level of contribution to conservation to species and habitats? In terms of conservation through sustainable use, "What pays, stays"!

Governance for Conservation through Falconry

As a minority interest, falconry is especially vulnerable to misunderstandings unless it is perceived to be beneficial for society. In the IAF survey, EU countries with least experience of falconry were most concerned about it (Morel 2007). Developing benefits from falconry for humans and conservation is therefore especially dependent on enlightened governance.

Governments and falconers need to learn the lessons of the last few decades, during which various approaches to the governance of falconry have been applied. Falconry in Europe and North America is controlled either by requiring birds to be marked to denote legal origin or by licensing the individual falconer. A system of certifying legal ownership of each raptor, but not licensing individual falconers, encourages growth of falconry through domestic breeding and hence increases human resources available for conservation, but amplifies administrative costs. Licensing falconers based on mentoring, with marking and DNA-forensics only where there is a genuine conservation need, can reduce administrative costs by placing more responsibility on falconers (Bern Convention Charter, Principles 1, 2 and 8).

Governments need to be aware that although watching birds can become an important recreation and business opportunity, its development should involve cooperation with other users of birds as a resource and not campaigning against them (BCC, Principles 11 and 12). When a few falconers are under pressure from a misinformed majority, prohibition may seem a tempting option to reduce lobbying pressure and costs of regulation. However, this risks loss of special raptor management skills (BCC, Principles 9 and 10) which take years to acquire.

Falconers need to be cautious in their use of hybrids and thoughtful about exotic species (BCC, Principle 4), but governments need to recall that these are the product of restricted access to wild populations. When raptor populations are threatened, encouraging domestic breeding makes good sense. However, the greatest cost to conservation associated with falconry in Europe may now arise from obliging falconers to depend on domestic production, instead of using their funding and volunteer effort to help conserve wild stocks of popular species, like Peregrines and Goshawk, which are not at risk in the wild but need monitoring to ensure that populations remain healthy (BCC Principles 3, 5 and 6). Note that the pesticide problem in Britain was detected because Peregrines were thought to be increasing (Ratcliffe 1980) and the *Gyps* vultures in southern Asia had almost vanished before their problem was addressed.

It is time for a new look at governance of falconry in order to optimise its potential for conservation through use of wild resources. It is time for governments, falconers and other stakeholders to be brave enough to agree on mutual responsibilities and privileges, in the way that falconers nearly pioneered with IUCN and which eventually took flight in the Bern Convention Charter for Hunting and Biodiversity.

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