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The Persian Leopard Prowls Its Way to Survival

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Abstract

The Persian leopard *(Panthera pardus saxicolor)* is endangered throughout its distribution area in the Middle East. In this article, we briefly describe its global range and then emphasize the status, distribution, and threats in Armenia. The principal factors jeopardizing the long-term survival of the Persian leopard in Armenia are disturbance, poaching, and wildfire. Currently, the work is underway to identify and describe the coarse-scale range, fine-scale range, and the Priority Leopard Conservation Areas (PLECAs) in the country. Because the leopard distribution is spatially exclusive of inhabited human settlements, the fine-scale range is defined as the coarse-scale one without villages and towns. The statistical information on both ranges is presented. Its comparative analysis has shown that the fine-scale range contains, with statistical significance, a smaller area of the mountain meadows and much shorter lengths of the main asphalted roads than its coarse-scale counterpart. The PLECAs are areas of permanent presence of the predator, which therefore must be granted the highest priority for conservation. The first candidates for the status of PLECAs in Armenia are identified.

Resumen

El leopardo perso (*Panthera pardus saxicolor*) está en vías de extinción en toda de su distribución en el Oriente Medio. En éste artículo, describimos brevemente la distribución mundial y enfatizamos el estado, la distribución, y las amenazas en Armenia. Los factores principales que hacen peligrar a la supervivencia del leopardo perso en Armenia son los disturbios, el cazar, y el incendio fuera de control. Ahora el trabajo está en progreso a identificar y describir la habitación de escala aproximada y la de escala precisa, y las Áreas Principales de la Conservación del Leopardo (PLECAs) en el país. La habitación de escala precisa se defina como la aproximada sin las pueblas y las aldeas, porque la distribución del leopardo no incluye espacialmente los asentamientos humanos. Se presenta la información estadística en ambas distribuciones. El análisis ha mostrado que la habitación de escala precisa contiene, con un significado estadístico, un parte más pequeño de los prados montañeses y unos tramos mucho más cortos de las calles principales que la habitación de escala aproximada. Las PLECAs son áreas de presencia permanente del depredador, y por eso se deben darlas la prioridad más alta por la conservación. Se identifican los primeros candidatos por el status de las PLECAs en Armenia.

Introduction

The leopard (*Panthera pardus*) has been traditionally recognized a common species due to its frequent appearance in the popular wildlife TV programs. In practice, however, this wild cat can be regarded as common only in savannas and tropical rain forests of Sub-Saharan Africa where it is widely filmed and even somewhere allowed for trophy hunting within the official quotas (Anonymous 2003). In the meantime, eight leopard subspecies are listed in the 2004 IUCN Red List of Threatened Species as either "endangered" or "critically endangered" and seven of them are living today in Asia (IUCN 2004). Without taking active, targeted, and large-scale conservation measures, they are in imminent danger of extinction from the Earth. The Persian leopard (*P.p. saxicolor*) is one of the subspecies in danger of disappearance (figure 1).

The Persian leopard's current range extends over the Middle East and its total number does not exceed 1,300 individuals. Most of the cats are found in Iran (550–850 animals) and especially in its northwestern portion adjoining southern Armenia and Azerbaijan (160–275; Kiabi et al. 2002). The number in Afghanistan is unknown, but should be at least several hundred (Habibi 2004); however, today's rampant leopard fur trade on the Kabul market and overharvest during and after the long-term civil unrest pose the greatest threat to survival of this predator in the country (Mishra and Fitzherbert 2004). In northeastern Iraq contiguous to western Iran and southeastern Turkey and elsewhere in the country, the leopard was considered rare as early as the late 1950s (Hatt 1959), and now this war-torn country is believed to no longer contain this carnivore. The southern edge of Turkmenistan holds 78 to 90 leopards (Lukarevsky 2001). The most recent and highly mysterious case of killing an old male leopard in southern Kazakhstan (Shakula 2004) raises an important question about the cat's status in Uzbekistan and Tajikistan from where the animal could have come, but since the late 1970s virtually nothing is known about the leopard in either of these countries (Lukarevsky 2001). Pakistan's North-West Frontier Province also holds the Persian leopard population, but of unknown size (Zulfiqar 2001). Armenia and Azerbaijan together are unlikely to harbor more than 30 cats, of which a maximum of 10 to 20 may live in southern and southwestern Armenia (Khorozyan 2003) and the others roam over Azerbaijan's Naxcivan Republic and in the Talis Mountains (Askerov 2002). Some transient individuals can penetrate to Georgia; recently, a good-looking young male was captured by photo-traps in Vashlovani Reserve in the extreme southeast of the country (Butkhuzi 2004). The presence of the leopard in European Russia's North Caucasus mountains is questionable (Semenov 2002), but a sort of evidence was recently reported for the triangle between the republics of Daghestan and Ingushetiya, southeastern Georgia, and northwestern Azerbaijan (Anonymous 2004; V. Lukarevsky and E. Askerov, pers. comm.). It is unknown whether the leopard from northeastern Turkey close to Georgia belongs to the Persian

Figure 1. The Persian leopard *(Panthera pardus saxicolor)* captured by photo-trap on 9 March 2005 at 1:54 a.m. on Meghri ridge, southern Armenia. Authors: A. Malkhasyan, I. Khorozyan, M. Boyajyan. Financial support: Aalborg Zoo, PTES, WWF.

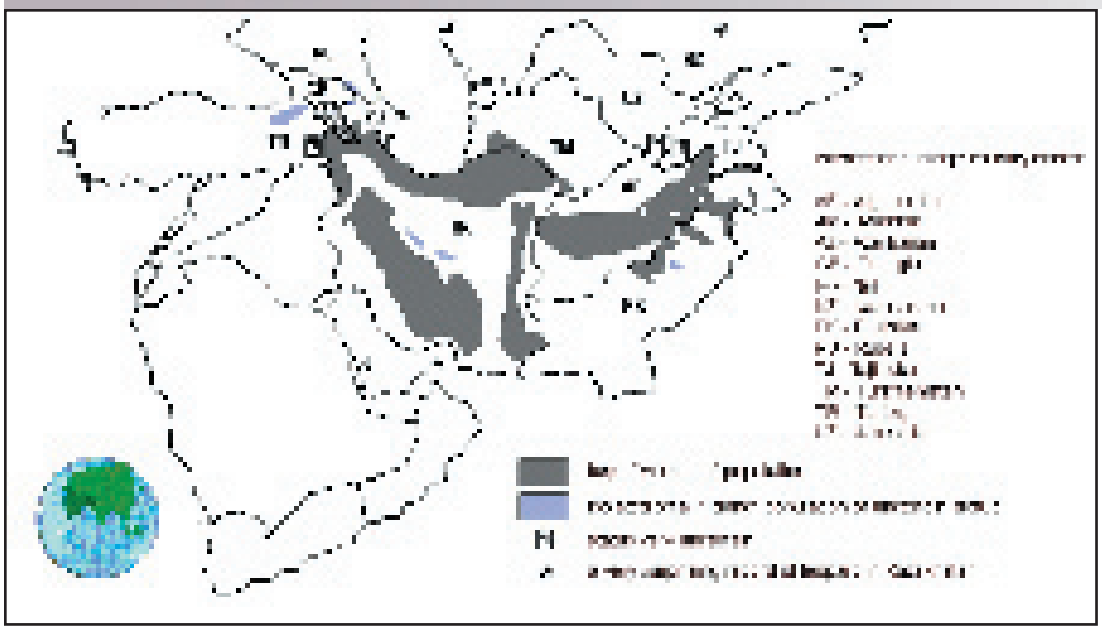

Figure 2. The Persian leopard range in the Middle East. The outline map is retrieved from www.worldatlas.com and the references are those indicated in the text. Produced by I. Khorozyan.

subspecies (Baskaya and Bilgili 2004), but it should be separated from the Caucasus because there are no records from adjoining parts of southwestern Georgia and western Armenia. The map of the Persian leopard range is depicted in figure 2.

There is much debate on how many leopard subspecies exist in the Middle East, but we do not discuss this topic in detail here. Before 1990, when Armenia, Azerbaijan, Georgia, Russia, and Turkmenistan were the Soviet republics, the scientific names of the leopard used in these countries were *P.p. tulliana* (Valenciennes 1856) and *P.p. ciscaucasica* (Satunin 1914), whereas the name *P.p. saxicolor* (Pocock 1927) had been traditionally used by the western specialists for the cats in Iran and, partially, Afghanistan. Current international regulations consider both *ciscaucasica* (Caucasus leopard) and *saxicolor* (Persian leopard) as synonyms and use only one, *saxicolor* (IUCN 2004) because these races are identical morphologically (Khorozyan 1999) and should be so genetically (Miththapala et al. 1996), and because the leopards occasionally move between Iran and Armenia. The name *tulliana* (Anatolian leopard) applies to the leopard in southwestern Turkey.

Historically, the Caucasus[1] was inhabited by three big cats: Asiatic lion (*P. leo persica*), Caspian tiger (*P. tigris virgata*), and Persian leopard. Moreover, until 15 A.D. the Armenian princes imported the Asiatic cheetahs (*Acinonyx jubatus venaticus*), tamed them, and used in high-rank hunts (Nowell and Jackson 1996). The lion disappeared here in about 10 A.D. (Nowell and Jackson 1996) and the last tiger was shot in 1932 near Prishib village in Talis, Azerbaijan (Gadjiev 2000). The principal reasons of their disappearance were extermination of predators and their prey and habitat destruction. Later, this tiger subspecies had vanished forever and the Asiatic lion is confined now to a single population in west India. The leopard has outlived them all, but can be wiped out if the authorities at all levels do not express more political will and support.

In Armenia, the leopard has co-

[1] Here, we consider "Caucasus" as a geopolitical region that includes Armenia, Azerbaijan, Georgia (all – South Caucasus) and south of European Russia (North Caucasus). This notion is not the same as the "Caucasus Biodiversity Hotspot" and the "Caucasus Ecoregion" introduced recently by WWF and Conservation International, which include also the parts of northeastern Turkey and northwestern Iran.

Figure 3. The leopard hunt on the bezoar goats (*Capra aegagrus*) carved on rock by prehistoric people. Mt. Azhdaak, Geghama ridge. Picture by A. Malkhasyan.

existed with humans since the Holocene (ca. 5,000 years ago) and carvings and paintings of it made by prehistoric people from approximately 3,000 years ago are not uncommon (Mezhlumyan 1985). Most of them depict the predator hunting its staple prey, the bezoar goat (*Capra aegagrus*), or being hunted by men (figure 3). It was common until the large-scale eradication of all large carnivores began in early 1900s when Armenia and other regions of the Russian Empire were struck by political turmoil and most of adult population was armed. Before 1972, when at last the leopard was declared an officially protected mammal and entered the Red Data Books of Armenia and the USSR as "endangered," it was officially killed as vermin and for valuable skins, which were sold by hunters to the governmental stocking centers (Gasparyan and Agadjanyan 1974). As a result, in the mid-1970s the cat has disappeared from northern Armenia and its entire range shrank to its present status (*ibid*.).

Current State

Today, the leopard's coarse-scale range extends over southern and southwestern Armenia from Garni district of Khosrov Reserve down to Armenian-Iranian state border (figure 4). It is bounded by the Vardenis and Geghama ridges in the north, by the Azat river in the northwest and by plain semi-deserts and croplands of the Ararat Valley in the west. The landscapes used by the leopard are juniper sparse forests, arid and mountain grasslands, and subalpine and alpine meadows, whereas the semi-deserts, nival, and harsh nival zones are ignored as unfavorable with no proper prey and shelter. The alpine belt is expected to be suitable only in snow-free time, as the predator's high footing pressure makes it plod and fail to hunt in deep snow (Pikunov and Korkishko 1992). The weather in these habitats is cold and misty in winter, rainy and warm in spring and fall, and very hot and dry in summer. The terrain is very rough, with an array of canyons, cliffy massifs, and stony substrates (figure 5). The rugged relief does not enable leopards to do long stalking, but provides plenty of opportunities for them to lurk and kill prey by ambush.

Prey sufficiency is the key factor, apart from human impact as described below, underlying the carnivore's existence. The bezoar goat is quite common throughout the leopard range, but especially in Khosrov Reserve, where it makes over 90% of the predator's diet (Khorozyan and Malkhasyan 2002). The wild boar (*Sus scrofa*) is widespread, but is taken very reluctantly in Khosrov and more frequently elsewhere in southern Armenia (Khorozyan and Malkhasyan 2002; unpubl. data). The roe deer (*Capreolus capreolus*) lives in southern Armenia and is absent in Khosrov, and is readily fed upon by the leopard (unpubl. data). The Indian crested porcupine (*Hystrix indica*) and European hare (*Lepus europaeus*) are taken opportunistically. That the wild prey base is sufficient for the leopard in Armenia is indirectly proved by the fact that the livestock losses to leopard

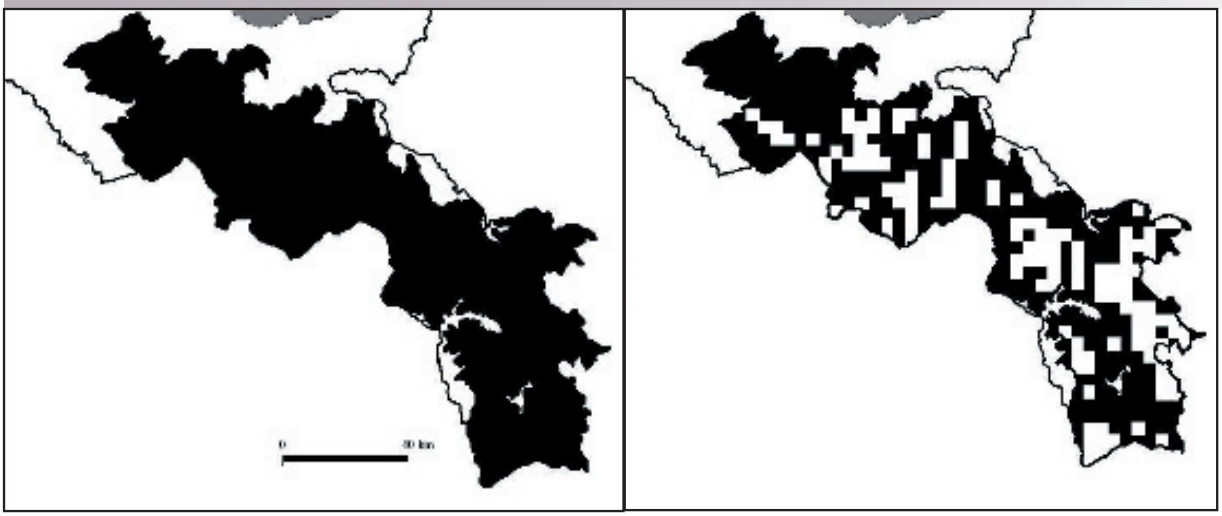

Figure 4. The coarse-scale (left) and fine-scale (right) ranges of the leopard in Armenia. White quadrats represent the grid cells that contain inhabited settlements and are thus excluded from the coarse-scale range. Produced by I. Khorozyan and S. Asmaryan.

predation are sporadic and negligible compared to those inflicted by the gray wolf (*Canis lupus*) and brown bear (*Ursus arctos*).

The long-term persistence of the small, but definitely resident, population in Armenia implies its connectivity with the much larger population in northwestern Iran. There are several places along the borderline Arax river where this river is narrow and shallow and where the mountain ridges descend from both countries to the riverside, making them ideal linkages with fords.

Threats

The leopard in Armenia is threatened by disturbance, poaching, and wild fire, but which of these factors are most stressful for this cat is still unclear.

Human disturbance is widespread, especially in spring and early summer when local people gather edible plants and mushrooms, in fall when occasional hunts take place in some favorite haunts, and in late fall when villagers cut trees and collect branches as fuelwood for winter. Gathering is a century-old tradition of rural Armenians, which possibly reflects the efforts to compensate the deficiency of plant proteins and vitamins in their diet. The most popular plants gathered are horse fennel (local name "bokhi," *Hippomarathrum microcarpum*), falcaria ("sibekh," *Falcaria vulgaris*), and *Astrodaucus orientalis* ("mandak") (Takhtajyan 1973) and the mushrooms are field blewit (*Lepista personata*), *Pleurotus eryngii*, St. George's mushroom (*Calocybe gambosum*), and field mushroom (*Agaricus campestris*) (Nanagulyan 1987). The gatherers disperse over the slopes and communicate to one another by shouts, so their behavior poses a serious harassment to animals, particularly to the ungulates fed upon by the leopard. In response, they become more vigilant and shy, but rarely escape to other places (pers. observ.). The numbers of gatherers in the period from April to June are significant. For example, between May 5 and 13 of 2004, we recorded 50 gatherers in Khosrov Reserve. Most of them arrived on foot (42%), horseback (28%) and on motorcycles (14%), whereas fewer used vehicles and donkeys (8% each). This information implies that the roadblocks, which are easily rounded by hikers and horse-riders, would be an inefficient way to close up the villagers' access to the gathering sites. Potentially, this problem could be solved by raising public awareness, but people's motivation to gathering is very strong.

Poaching is traditionally believed to be an important factor of risk for the leopard, other large carnivores, and its prey, especially since early 1990s when the newly independent Armenia waged the war with neighboring Azerbaijan over Nagorno Karabakh and which

Figure 5. Juniper sparse forest on the ridgetops, the typical habitat of the leopard in Armenia. Khosrov Reserve, with the biblical Mt. Ararat on the background. Picture by A. Malkhasyan.

has eventually left numerous firearms in local people's hands. Currently, the narrow isthmus of southern Armenia, which is squeezed from both sides by Azerbaijan has been officially considered a "borderline territory." According to anecdotal information, one leopard has been killed in Armenia every year or two, mainly as a result of snow tracking. As the leopard is officially protected and the poacher will be fined and jailed, all cases are treated in a "shoot, shovel, and shut up" fashion provoked by human fear.

Wildfire destroys the leopard's favorite habitats and forces it to move away to other places. The main reason of fire is human neglect, which can cause ignition during the extremely dry months of June–September from a single match, piece of glass, campfire ember, or ashes left by livestock keepers or plant gatherers. The habitat's propensity for burning is increased because of xeric vegetation, scarce precipitation, significant tracts of lands covered by coniferous sparse forests (junipers), strong winds blowing alongside the slopes and the lack of technical capacities in local conservation entities to timely quench the fire. Some small plots can be deliberately burned down, as this practice is still strongly believed by villagers to stimulate the growth of fodder for their livestock. Instead, it destroys soil structure and kills soil invertebrates, small mammals, and ground-nesting birds.

All these threats are expected to closely correlate with human densities, i.e., the higher densities will intensify pressure and thus decrease the probabilities of occurrence of the leopard and its prey. In the meantime, we agree that human activities can affect the carnivore populations also in remote areas with low human densities, so human attitudes and practices can be more important than density *per se* (Cardillo et al. 2004; Woodroffe 2000). However, in most of today's developing countries where human behavior and resource use have not been properly controlled or managed, the probability of large carnivore extinction is positively related to human density until favorable wildlife management practices are introduced and enforced (Linnell et al. 2001). We have found out that livestock breeding present in the leopard range in Armenia at the temporary shepherd camps located far away from the villages has been tolerable by the leopard, but is a serious threat to its long-term survival if not properly managed (Khorozyan 2003). Meantime, the leopard distribution is spatially completely separated from inhabited settlements (*ibid*).

Methods

Within the project supported by People's Trust for Endangered Species (UK), we have been using GIS technologies, particularly software programs ArcView GIS 3.2, 3D Analyst and Spatial Analyst, to outline the fine-scale leopard range and identify the Priority Leopard Conservation Areas (PLECAs) in Armenia, which would then be recommended to the national government and international foundations for the enforcement of predator research and conservation.

The coarse-scale range defined above contains inhabited human settlements with their vicinities where the leopard does not live, so there is a need to define where it lives certainly (fine-scale range), permanently (PLECAs) and occasionally during movements (linkages between PLECAs). Correspondingly, the PLECAs will be granted the highest priority for conservation, linkages – high, lands fringing the PLECAs and their linkages – medium, and all other lands – low priority. This approach is similar to that employed for defining the priority areas for the tiger (*Panthera tigris*) (Wikramanayake et al. 1998).

Parameter	Coarse-scale range	Fine-scale range	Notes
Natural features			
Arid grassland, km^2	1052.4	657.5	1
Sparse forest, km^2	1318.3	838.5	1
Mountain grassland, km^2	2335.0	1438.8	1
Subalpine meadow, km^2	1911.9	1673.6	1
Alpine meadow, km^2	879.6	834.3	1
Total area, km^2 % of Armenia	7497.2 25.2	5442.7 18.3	1
Landscape diversity	1.6	1.5	2
Terrain ruggedness	8.0 ± 0.2	7.6 ± 0.2	3
Anthropogenic features			
Human population, people density, per km^2	235165 31.4	> 250 > 0.05	4, 5
No. towns	10	0	4
No. villages	150	0	4
Cattle, heads density, per km^2	65176 8.7	> 156 > 0.03	4, 6
Sheep and goats, heads density, per km^2	87443 11.7	> 438 > 0.08	4, 6
Distance to the nearest village, km	-	6.7 ± 0.2	1, 7
Main asphalted roads, km density, km^{-1}	1044.4 0.1	463.1 0.08	1
Dirt roads, km density, km^{-1}	3444.0 0.5	2518.9 0.5	1

Table 1. Some key characteristics of the coarse-scale and fine-scale leopard ranges in Armenia.

Table 1 Notes:

1. As measured on our GIS maps which were built on a basis of georeferenced topobase map of Armenia of scale 1:200000.

2. Landscape diversity was calculated as Shannon's index $H = -\sum_{i=1}^{n} P \ln P$, where *Pi* is the proportion of the area of the i-th landscape to the area of all landscapes (Sutherland 2000).

3. Terrain ruggedness index (*TRI*) was calculated as = *TNC x TNF / (TNC + TNF)*, where *TNC* is total number of topographic 40-m distance contours intersecting the selected transect (top-right corner to down-left corner diagonal of the grid cell) and *TNF* is total number of changes in topographic aspect along the same transect (Fjellstad et al. 2003). Its value is given as arithmetic mean ± standard error of index values across the grid cells.

4. This information valid thru Jan. 1 of the years 2000, 2001, 2002, 2003 and 2004 derives from our databases on individual settlements compiled from statistical information provided by Manasyan et al. (2002), regional authorities and departments of the National Statistical Service (Armstat), and The Results … (2003) in Ararat, Vayots Dzor and Siunik provinces encompassing the leopard range in Armenia. The livestock data on one village in Ararat are lacking.

5. People in the fine-scale range include those living temporarily at shepherd camps and permanently outside of towns and villages, e.g. Khosrov Reserve rangers and the staff of outreach border facilities. About 150 people are estimated to live in Khosrov Reserve alone (Khorozyan 2003).

6. We do not have yet complete information on numbers of livestock maintained by people seasonally or permanently outside of towns and villages across the entire fine-scale range (see Note 5). Up to 156 cattle and up to 438 small livestock are estimated to graze seasonally in Khosrov Reserve alone (Khorozyan 2003).

7. We did not measure the distance to the nearest village in the coarse-scale range, because its grid cells themselves contain the inhabited settlements. In the fine-scale range, it was measured from the center of the cell to the center of the village and is given as arithmetic mean ± standard error of values across the grid cells.

To define and quantify the coarse-scale and fine-scale leopard ranges in Armenia, we have produced the grid of 16 km^2 quadratic cells covering the map of southwestern and southern Armenia. We defined the fine-scale range as the coarse-scale one without the cells with inhabited settlements, but the cells containing only outskirts of one village (not town) were not excluded from the fine-scale range. Both types of ranges are illustrated in figure 4 and their characteristics are provided in table 1.

Results

The statistical comparison of the ranges for parameters listed in table 1 has shown that the fine-scale range contains a smaller area of the mountain grasslands ($t = 2.38$, $df = 1030$, $P < 0.05$) and much shorter lengths of the main asphalted roads ($t = 4.85$, $df = 1048$, $P < 0.001$) than the coarse-scale one. The natural features do not differ significantly between ranges ($P > 0.05$). As expected, the most striking difference between the ranges is the significant numbers and densities of people and livestock in the coarse-scale range and their negligible values in the fine-scale range. We used two-sample t-test assuming equal or unequal variances, and the variances were checked by F-test. All relevant procedures were done in Microsoft Excel 2003.

This result makes sense for several reasons. The mountain grassland is the most suitable habitat for animal husbandry and, not surprisingly, 44% of all towns and villages of the range are located just within this landscape zone; therefore, its significant portion was left behind the fine-scale range with exclusion of the settlements (figure 4, table 1). Similarly, as the main roads connect the settlements their most important legs lie outside the fine-scale range. In general, population of these settlements makes only 7.3% of all Armenia's population and consists of 61% urban and 39% rural people.

Thus, the fine-scale range, which makes almost three-quarters (72.6%) of the coarse-scale one, represents the environment least disturbed by human activities and located quite distantly from the settlements. Because both ranges do not differ in the key natural characteristics, we could anticipate that the leopard might have been able to expand its distribution by 2054.5 km^2 from the fine-scale to the coarse-scale range, provided that much more conservation activities are implemented to enforce the man-leopard coexistence in human-dominated landscapes. This would be a great achievement for such a small and land-deficient country as Armenia. Both ranges are sufficiently large to maintain the leopard population in the long run, being much larger than the threshold area, i.e., the minimum area known to support a population of particular species (412 km^2 for the leopard; Smallwood 2001).

In order to identify and map the PLECAs, we plotted the leopard scat sites found during our regular field trips. Assuming that, by definition, the PLECAs must contain the predators with detection probability close to 1, meaning their constant and current presence there, we visited certain study areas at intervals approximately every 5 months to allow the animals of a low-density population to revisit the area.

The first candidates for holding the status of PLECAs in Armenia are central and eastern Khosrov Reserve in the northwesternmost part of the range and the locality to the north of Shvanidzor and Nuvadi villages in the extreme southeast. We walked 93.8 km in April and October 2004 in Khosrov and 94.6 km in May and November 2004 in the Shvanidzor-Nuvadi area and collected the scats. After the fecal bile acid thin-layer chromatography of these samples gives us an answer on their unambiguous leopard origin by the end of the project, it will be possible

to determine if these areas are real PLECAs and then to describe them in detail. We use the PRESENCE software (www.mbr-pwrc.usgs.gov/software) to calculate the detection probability, which enables us to discriminate between presence with detection, presence without detection, and absence without detection (Henschel and Ray 2003). Since we used the same sampling techniques in all trips, no other field researchers were involved (i.e., no observer bias) and the habitats and weather conditions do not generally differ much between study areas and seasons (other than winter), we assume that the scat detection probabilities in our work were unbiased. We have been doing this work also in other study areas in an attempt to find more PLECAs.

Conclusion

Research of endangered wildlife makes no sense without conservation. The first efforts to promote the leopard conservation in Armenia were launched in 2002 by two projects supported by the Rufford Small Grant for Nature Conservation program (UK) and the World Wide Fund for Nature (Switzerland). The former project was targeted on seven species of large mammals and has identified the leopard, bezoar goat, and Armenian mouflon (*Ovis orientalis gmelini*) as taxa that deserve the most urgent conservation actions in the country. The latter project provides practical measures, from technical assistance to outreach education campaigns.

In 2004, our Whitley Awards project (UK) expanded and deepened the conservation of the leopard and these two ungulates and included the technical assistance and large-scale education and training of rural people, soldiers, and military personnel at the Armenian-Azerbaijani and Armenian-Iranian state borders. Bringing real change and success, such conservation activities must be enforced and expanded throughout the leopard range in close cooperation between the scientists, practitioners, local people, border military, local and national conservation entities, and authorities (Khorozyan 2004).

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The Curious Case of the Fat Pocketbook Mussel, *Potamilus capax*

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Abstract
Native freshwater mussels (Family: Unionidae), often referred to as the most 'endangered' organisms in North America, typically reach their greatest abundance in gravelly shoals in medium-sized to large rivers in the United States. However, one species, the endangered fat pocketbook mussel, *Potamilus capax* Green 1832, is very common in deep deposits of fine-grained sediments in man-made ditches or in slow moving rivers, streams, sloughs, and bayous in the St. Francis Watershed in Arkansas. An early study reported the status of this species as 'tenuous;' however, research conducted in the last 20 years indicate that in appropriate habitat *P. capax* usually exhibits good evidence of recent recruitment and can comprise more than 10% of the mussel assemblage. Hundreds or even thousands of individuals can occur in 1- to 5-km-long reaches of rivers or ditches. Endangered species management should take advantage of accurate information on distribution, abundance, and life history. Confusion and misinformation about this mussel must be overcome to improve management plans and decisions concerning this species. In this article we examine the status of *P. capax* based on a review of the literature and our recent surveys in the St. Francis Watershed.

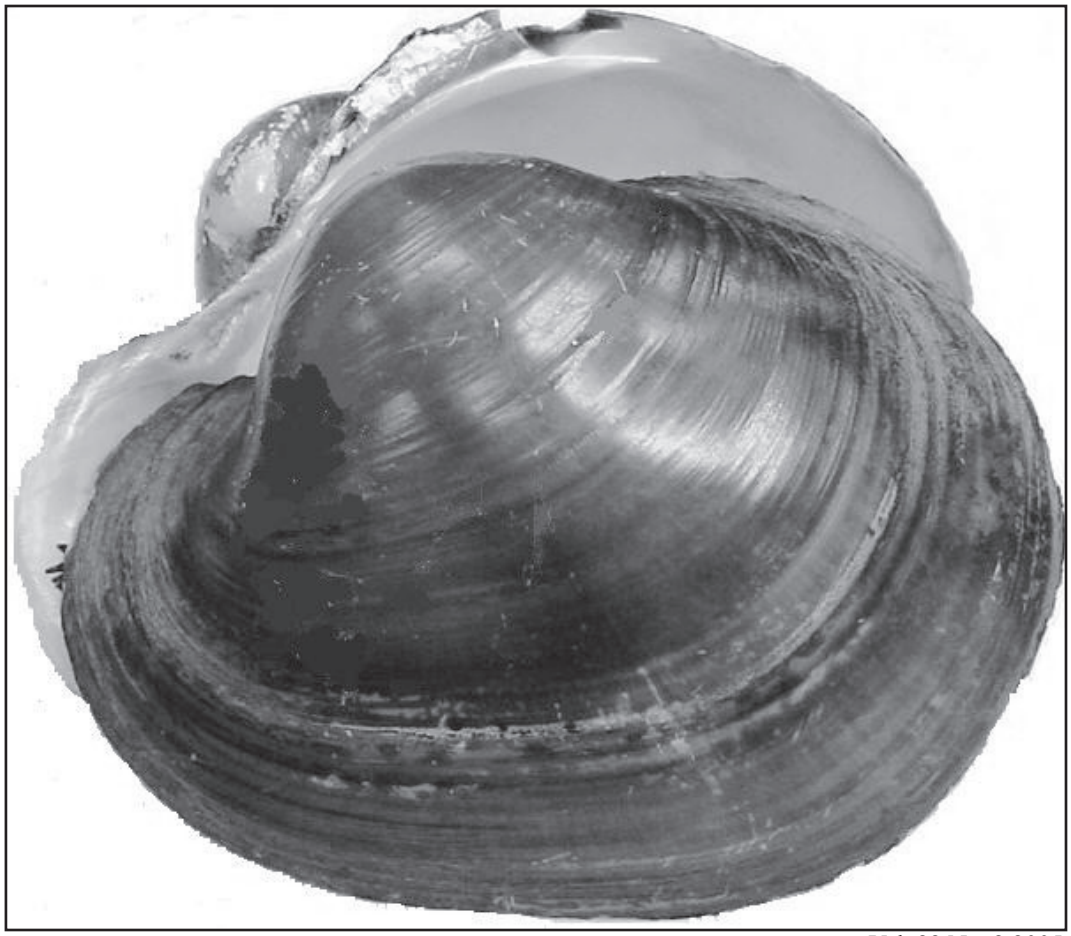
Resumen
Mejillones nativos de agua dulce (Familia: Unionidae), a menudo se llaman los organismos más en peligro de extinción en Norteamérica, atienen típicamente su abundancia más grande en bancos de arena y gravilla en ríos de tamaño medio a largo en los Estados Unidos. Sin embargo, un especie, *Potamilus capax*, es muy común en depósitos profundos de sedimentos de grano pequeño en zanjas hechas por humanos o en ríos lentos, arroyos, pantanos y ciénagas en St. Francis Watershed en Arkansas. Un estudio temprano dijo que el status del especie fue tenue, pero investigaciones realizadas en los últimos 20 años indican que en una habitación apropiado *P. capax* usualmente muestra evidencia buena de reclutamiento reciente y puede constituir más que 10% de la ensamblaje de mejillones. Cientos o miles de individuos pueden ocurrir en tramos de 1-5 kilómetros de los ríos o las zanjas. La gestión de los especies en peligro de extinción deben aprovechar la información correcta de la distribución, la abundancia, y la historia de la vida. La confusión y la desinformación sobre éste mejillón se deben superar para mejorar los planes de la gestión y las decisiones con respecto a éste especie. En este artículo examinamos el status de *P. capax* basa en un estudio de la literatura y nuestra investigación en St. Francis Watershed.

Introduction

Native freshwater mussels (Family: Unionidae) are often referred to as the most "endangered" organisms in North America (Williams et al. 1993). However, the status of one species, the fat pocketbook mussel (*Potamilus capax,* figure 1) has been reported to be "improving" (U. S. Fish and Wildlife Service (USFWS) 1996, State of Arkansas 2005). This has not happened recently: in a 1990 review of 81 listed invertebrates, the USFWS first gave this favorable report on *P. capax* (Bean 1993). These statements counter those made by Bates and Dennis (1983) in a report on mussels in the St. Francis, White, and Cache Rivers in Arkansas and Missouri. They concluded that *P. capax* had experienced a range reduction of 90% within the basin and the continued viability of a single refugial population located on an eight-mile reach of the lower St. Francis River was "tenuous." They felt that this was "probably the *only remaining viable population*" anywhere over its original range.

The simple reason for the above discrepancy is that Bates and Dennis (1983) missed virtually all *P. capax* in the St. Francis watershed. In a subsequent survey, Clarke (1985) collected from 1 to 10 live specimens at nearly 100 sites located along a 70-km reach of the St. Francis River and an adjunct slough. On six reaches he estimated *P. capax* density to range from one to seven individuals/1000 m^2 and total population size to range between several hundred to more than 2,000 individuals. Clarke concluded, "we are not dealing with a rare, sedentary, or spatially-restricted species, but rather a common, actively-moving and widespread one." The recovery plan for *P. capax* (USFWS 1989) cited Bates and Dennis (1983) and Clarke (1985) but did not address differences between

Figure 1. *Potamilus capax*.



the surveys. Additional studies in the watershed (Harris 1986, 2001, 2002; Ahlstedt and Jenkinson 1991; Jenkinson and Ahlstedt 1993; Dardeau et al. 1995; Miller and Payne 2002, 2003) have verified Clarke's original statement. In appropriate habitat in the St. Francis Watershed, *P. capax* is common.

This article examines the status of *P. capax* based on a review of the literature and our recent surveys in the St. Francis Watershed. We examine its past and present distribution, its habitat requirements, and its population and community dynamics. Our experiences were obtained during a mussel translocation project conducted in the fall of 2002. *Translocation* is defined as the capture and transfer of organisms from one part of their range to another (Kleiman 1989). This translocation took place in a 5.7-km reach of Stateline Outlet Ditch, located near Blytheville, Arkansas (Miller and Payne 2003). Work was funded by the Memphis District of the U.S. Army Corps of Engineers following Section 7 consultation with the USFWS. The goal was to hand collect 95% of the *P. capax* in the ditch, estimated to be 2000, and then move them to safe locations outside the project area.

Freshwater Mussels and *Potamilus capax*

Background

Worldwide, there are approximately 31,000 species of bivalve molluscs. There are approximately 300 freshwater species in North America with 55 to 60% listed as extinct or imperiled (Master 1990, Eisner et al. 1995). Bivalves are characterized by a pair of calcareous shells, or valves, held together with an elastic hinge ligament. The organism is laterally compressed and the visceral mass lies within fleshy folds of tissue that secrete the shell. The majority of bivalves feed by removing particulate organic matter from water that is circulated through the gills by cilliary activity. In addition to their alimentary function, the gills are also used for respiration. Sexes are separate and the female incubates the young for a variable period of time on its gills. In most freshwater species the immature forms, once released from the female, must spend a development period of several weeks on the fins or gills of a fish. When immature forms are released they burrow into suitable substratum where they usually remain for their entire lives (Fuller 1974, Russell-Hunter 1979).

Although freshwater mussels can be collected in virtually any permanent waterbody, they typically reach their greatest density (50-100 individsuals/m^2) and richness (25-35) in stable sand and gravel shoals in medium-sized to large rivers in the United States (Miller and Payne 1993, 1998, 2004; Payne and Miller 1989, 2001). Because of their longevity, sedentary nature, and reliance on suspended food and clean water, biologists frequently express concern over the effects of water resource development on these organisms (Stansbery 1970, Fuller 1974, Master 1990, Bogan 1993, Seddon et al. 1998, Hayes 1998, Williams et al. 1993, Neves 1999).

Potamilus capax *Distribution*

Potamilus capax was proposed for listing by the USFWS on September 26, 1975 (40 FR 44392-44333) and formally listed as endangered on June 14, 1976 (41 FR 24062-24067). Although the Federal Register did not state why it was listed, range reduction, based on historical records, and the present or threatened destruction, modification, or curtailment of its habitat or range, were probably significant factors. Reasons for its range reduction were not discussed in the plan (USFWS 1989) although there were general references to the negative effects of water resource developments such as channelization, impoundments, dredging, water pollution, and sedimentation.

Based on information in Bates and Dennis (1983) and the recovery plan (USFWS 1989), the historical distribution of *P. capax* included the St. Francis River, Arkansas, upper Mississippi River north of St. Louis, and the Wabash River, Indiana. Information on distribution comes from two sources: actual physical specimens catalogued in museums and descriptive material in early papers. Typically these records do not include details such as the number of organisms collected (i.e., density estimates), or quantitative data on types of habitats sampled. This is a well-known reality of distributional data for virtually all species; one cannot always be sure whether designated locations represent a single find, multiple finds, or a viable population.

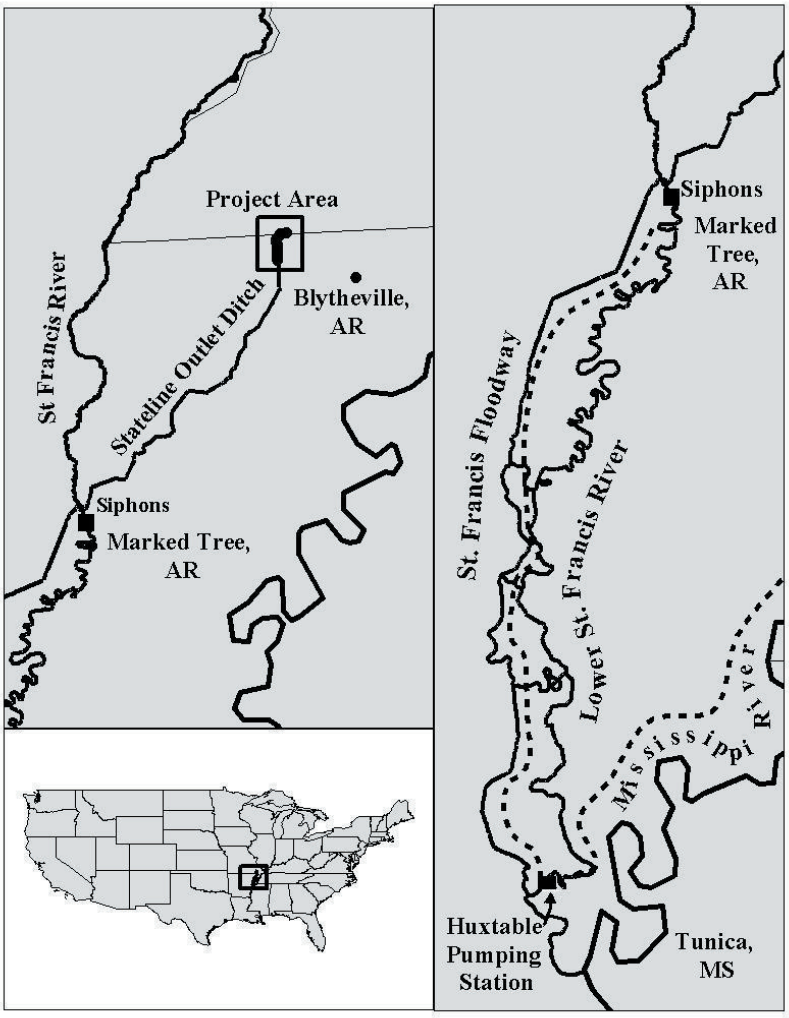


Figure 2. Location of the project area, west of Blytheville, Arkansas (left panels). Relationship of the St. Francis River, St. Francis Floodway, and levee system (heavy dashed line), located south of the project area (right panel).

Although range maps depict this species along the Ohio and Wabash Rivers, large numbers of live *P. capax* have not been reported outside the St. Francis watershed. For example, Sickel (1987) collected only two live specimens (one was gravid) where the Cumberland River joins the Ohio River. Cummings et al. (1987) found nine live adult and juvenile *P. capax* in the lower Wabash River. A subsequent search of the upper and middle Wabash River and the Little Wabash River failed to yield live *P. capax* (Cummings et al. 1988, 1989). *Potamilus capax* has not been collected recently in the upper Mississippi River, although shells were found in the 1980s. In a 1930–1931 survey along a 1100-km reach of the upper Mississippi River between Cairo, Illinois, and Point Au Sable, Minnesota, Max Ellis (as reported by van der Schalie and van der Schalie (1950)) collected nearly 7,000 live mussels and 39 species but found only 47 live *P. capax* (0.68%). Even by modern standards this was an extensive survey; Ellis sampled 254 stations (live mussels were found at 86) using sieves and rakes, a 6-ft^2 dredge, and hand collecting.

Most species of freshwater mussels are nondescript and difficult to distinguish from one another. Although *P. capax* has some obvious distinguishing features (size, inflation, condition of shell) it is often confused with closely related species, even by experts. Bates and Dennis (1983) describe four cases of mistaken identity with *P. capax* either in published reports or museum specimens. One of these errors was made by Green, who originally described the species (see Frierson (1927)). None of these identification errors are responsible for the historical distribution records in the recovery plan (USFWS 1989); however, these errors emphasize that this is an uncommon species about which little is known.

Potamilus capax *Habitat Requirements*

Ahlstedt and Jenkinson (1991) reported that *P. capax* was most likely to be found in a mixture of sand, clay, and silt, which they referred to as "sticky mud." The description "sticky mud" hardly does justice to the reality of these habitats in Arkansas. The mud in these areas can be up to 100 cm deep, which is virtually impossible to walk through. Because of its very thin and globose shell, *P. capax* tolerates deep deposits of fine-grained silt substratum and would not survive in gravel substratum with erosive flows—habitats usually dominated by heavy, thick-shelled bivalves. Historically, *P. capax* was probably most common in large river sloughs and oxbows with silt substratum, which were more common at the mouths of rivers before developments such as locks, dams, levees, and bank protection measures. Such modifications virtually eliminated all adjacent depositional habitats. The few specimens collected by Ellis in the early part of the 20th century (as reported by van der Schalie and van der Schalie (1950)), and Sickel (1987) must represent remnants of much earlier populations. It is possible that before the development of the inland waterway system, *P. capax* was locally abundant in depositional habitats adjacent to the Mississippi and Ohio Rivers. However, we are unaware of any extensive slack water systems outside the watershed, such as the system of ditches and sloughs along the St. Francis River, which could support large numbers of *P. capax*.

Potamilus capax Translocation in Stateline Outlet Ditch

Study Area and Field Methods

Stateline Outlet Ditch is located west of Blytheville, Arkansas, in predominantly flat, agricultural land (figure 2). Mussels were removed from a 5.7-km-long reach of the ditch that was scheduled for cleanout to improve water conveyance. The upper two thirds of the ditch in the project area was approximately 35 m wide, and sinuous with reasonably firm, silt-sand substratum. The downstream section was 50 to 60 m wide, straight, and substratum consisted of flocculent mud, 20 to 100 cm deep. Water depth varied from 20 to 200 cm when the translocation was done. The ditch originates near the Arkansas-Missouri border, flows south, then connects to the St. Francis River, which ultimately joins the Mississippi River near mile 672, west of Tunica, Mississippi.

The St. Francis River was extensively modified in the early to mid-20th century to reduce flooding and improve drainage. Near the town of Marked Tree, Arkansas, the river splits into the manmade St. Francis Floodway to the west and the lower St. Francis River to the east. The lower reach of the St. Francis River, south of Marked Tree, is isolated by surrounding levees, the Huxtable Pumping Plant to the south, and a pair of one-way siphons to the north. The St. Francis Floodway is an unconstrained link between the upper watershed (including Stateline Outlet Ditch) and the Mississippi River (figure 2).

Figure 3. Collecting *P. capax* in a reach of Stateline Outlet Ditch, Arkansas, 2002.

The project area was divided into 18 reaches and 5 to 13 collectors formed a line and then walked or crawled along each reach retrieving live mussels by digging or feeling in the top 5 to 10 cm of substratum (figure 3). The water was too turbid to collect visually. Sampling per reach varied from 45 to 90 minutes, depending on the number of mussels collected. Poor retrieval, due to the number of mussels present and the difficulty of collecting, meant that some reaches were worked as many as seven times without removing all live *P. capax* (figure 4). After a single pass along a reach, live mussels were sorted, counted, and identified, and all *P. capax* were measured. Eleven days were spent on the project and 1,090 person hours were expended collecting. General information on mussel sampling can be found in Miller and Payne (1993) and Strayer and Smith (2003). A more detailed description of this translocation can be found in Miller and Payne (2003) and results of two smaller translocations in this watershed can be found in Dardeau et al. (1995) and Miller and Payne (2002).

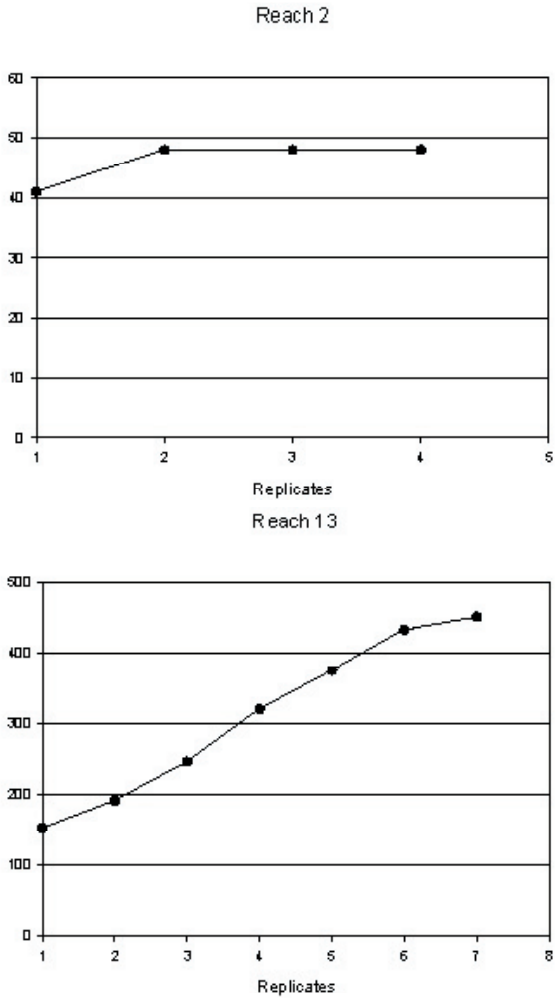


Figure 4. Cumulative number of *P. capax* collected along 106-m-long Reach 2 (top) and 498-m-long Reach 13 (bottom) of Stateline Outlet Ditch. Sandy substratum in Reach 2 allowed for all *P. capax* to be removed in just a few passes. In Reach 13 extensive deposits of fine-grained sediments required 7 passes, which probably still did not remove all *P. capax*.

Community and Population Dynamics

In Stateline Outlet Ditch, *P. capax* was fourth in abundance among 19 species and overall represented approximately 13% the fauna. In two downstream reaches of Stateline Outlet Ditch it comprised nearly 20% of the fauna. Total mean density was 6.1 and 10.8 individuals / 1,000 m^2, and average catch per unit effort was 4.4 and 6.1 individuals / hour in the up- and downstream reaches, respectively. More *P. capax* (77.7%) were taken from the downstream silty reaches than the upstream more sandy reaches.

A shell length frequency histogram was prepared for *P. capax* based on slightly more than 2,000 organisms (figure 5). Because of the sampling method (search by feel while crawling or swimming), collectors were slightly biased toward large individuals and probably missed small specimens. The population of *P. capax* in Stateline Outlet Ditch included individuals ranging in length from approximately 10 to 145 mm with about 70% between 75 and 110 mm long. The overall demography of the population suggests low but relatively steady annual recruitment, high longevity, and moderately low annual mortality during the middle, relative to the earliest and latest parts of the lifespan. The rapidly declining abundance between 110 to 145 mm probably indicates the size at which age-related mortality takes place. The findings of this study are similar to those of Harris (2001), who collected by searching within 1-m^2 quadrats, a method that could obtain small individuals. However, he collected only 30 live specimens as compared to the more than 2,000 collected and measured in this study. Regardless,

results of both studies indicated that moderately large mussels comprised most of the population, although juveniles were present.

Summary and Conclusions

Since it was originally listed, much has been learned much about *P. capax;* the Endangered Species Act (ESA) was the impetus for elucidating much about its density, distribution, and habitat requirements. First, it is tolerant of depositional areas that are indisputably the antithesis of high-quality freshwater mussel habitat described by Stansbery (1970). This is not a "lotic" organism as indicated in the Recovery Plan (USFWS 1989) that is negatively affected by high sedimentation rates. Second, we have found no evidence that *P. capax* was ever abundant outside Arkansas although it was collected along the Ohio and Wabash Rivers. However, based on habitat conditions in the St. Francis drainage, it is difficult to imagine it being very common at those locations. Finally, man-made ditches, as well as existing bayous, sloughs, and streams in the St. Francis Watershed, provide suitable habitat for *P. capax*. The decision in 1989 to move 2,000 specimens to a reach of the Mississippi River in Missouri (USFWS 1989) was not in the best interest of *P. capax* (see also Clark et al. (2001)).

Although this is a low-density species, current numbers in appropriate habitat are not what one would consider to be dangerously low. For example, Eisner et al. (1995) noted that a median population size of species when listed is usually about 1,000. Although restricted, this watershed is approximately 5,180 km^2 and provides sufficient habitat (see Shaffer 1981). In comparison with at least some federally listed molluscs, *P. capax* comprises a fairly large component of the species assemblage. For example, in the upper Mississippi River, the endangered *Lampsilis higginsii* comprised approximately 0.5% of the unionid assemblage in archeological deposits (Havlik and Marking 1981) as well as at sites not affected by zebra mussels (*Dreissena polymorpha*) (Miller and Payne 1998). The endangered pink pearly mucket mussel (x*Lampsilis abrupta*) comprises less than about 1 percent of the molluscan assemblage in the Tennessee River (Miller and Payne, unpublished information). The endangered orange-footed pimpleback mussel (*Plethobasus cooperianus)* makes up approximately 0.1 percent of the unionid fauna at a species-rich bed in the lower Ohio River (Payne and Miller 2001).

It is misleading, although not inaccurate, to state that the status of *P. capax* is improving. The survey by Clarke (1985) illustrated that this species was more common than previously thought. Funding for field surveys and translocations, made available by passage of the ESA, was responsible for a better understanding of *P. capax*. This species was simply listed before obtaining detailed information on its distribution, local density, and abundance. It is ironic, but the status of *P. capax* probably *is* improving in the St. Francis watershed—as a result of increased agricultural developments and therefore construction of more ditches. A negative feature is the isolation of the lower St. Francis River

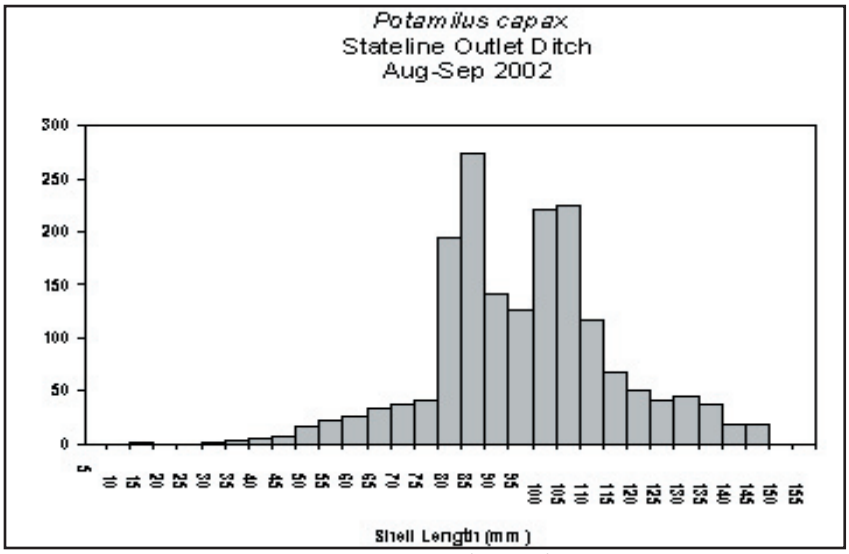


Figure 5. Length-frequency histogram for *P. capax* collected in a 5.6-km reach of Stateline Outlet Ditch using qualitative (search by feel) methods.

by the siphons and pumping plant (figure 2), which restricts passage of potential host fishes. However, fishes and mussels do have access to ditches and streams outside the isolated areas.

Our intent in reviewing the status of *P. capax* is similar to that of Peterson (2001), who cautioned that the interests of the ESA are not necessarily served if peripheral species, those at the extension of their range, are afforded federal protection. With respect to this species, lotic habitats in the Wabash, Ohio, and Mississippi rivers are peripheral and probably not critical to its continued existence. Regardless, we agree that invertebrates do not receive the attention from the ESA that they deserve (Kellert 1985, 1993; Opler 1987; Bean 1993; Murphy 1991; Hughes et al. 2000; Black et al. 2001). There can be no doubt that converting free-flowing rivers to run-of-river-reservoirs for commercial use can limit species that require firm substratum and pool-riffle habitat (Bogan 1993, Williams et al. 1993, Neves 1999). Palmer (1985) lists 18 and Eldredge (1998) lists 13 now extinct species of freshwater mussels; most were lost in the 20th century as the navigation system was developed. However, not every freshwater mussel is dependent on gravel substratum and sediment-free conditions for survival. Furthermore, the philosophical and practical difficulties of translocations (Cope and Waller 1995, Losos et al. 1995; Griffith et al. 1989; Parmalee and Bogan 1998) beg the question as to why *P. capax*, which is surviving well in man-made ditches in Arkansas, needs to be moved at all. Such translocations do little to further an overarching goal of the ESA, that of protecting the ecosystems on which vulnerable species depend (Doremus 1991, Eisner et al. 1995).

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Protected areas of the Democratic Republic of Congo: A habitat gap analysis to guide the extension of the network.

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Abstract

To evaluate the coverage of the currently mapped protected areas (PAs) within the seven phytogeographic zones of the Democratic Republic of Congo (DRC), this paper had two objectives: a habitat gap analysis and boundary reality-check. We used satellite images and the geographical information systems to combine White's vegetation map of Africa, AFRICOVER Project land cover map, and the terrestrial eco-regions maps. We delineated habitat types, calculated proportions of habitat per each phytogeographic zone and proportions of each habitat type within all protected areas, and extracted land use. The lowland forest occupies *approximately* 40% of the national territory while the mangrove shares only *about* 0.03%. Overall approximately 17% of the country has been converted to open land by human activities. Fresh water swamp and related aquatic vegetation are the least represented biome with the current PA network. We suggested that 14% of this zone needs to be protected. Only about 26% of mapped PAs is accurate. Any extension of the current PA network should therefore be preceded by a systematic boundary mapping of all existing PAs.

Resumen

Este papel tiene dos objetivos para evaluar el recorrido de las áreas protegidas actualmente diagramadas (PAs) dentro de siete zonas fitogeográficas de la República Demócrata del Congo (DRC): Un análisis del hueco de la habitación y un revisión de las fronteras. Usamos imágenes de satélite y el sistema de información geográfica para combinar el mapa de la vegetación africana de White, el mapa de la cobertura del la tierra del Proyecto AFRICOVER, y los mapas terrestres de las regiones ecológicas. Delineamos los tipos de habitación, el uso de la tierra, y calculamos las proporciones de hábitat por cada zona fitogeográfica y las proporciones de cada tipo de habitación dentro de todas las áreas protegidas. El bosque de la tierra bajo ocupa *aproximadamente* 40% del territorio nacional mientras los mangles comparten *solamente* 0.03%. En total, aproximadamente 17% del país se ha convertido en tierra abierta por las actividades humanas. Los pantanos de agua dulce y otra vegetación acuática son los biomedios menos representados en la red de las PAs. Sugerimos que 14% de ésta zona necesita protección. Solamente cerca 26% de las PAs son precisas. Alguna extensión de la red de las PAs deben ser precedida por un trazado en mapa sistemático de las límites de todas las PAs existentes.

Introduction

The Democratic Republic of Congo (Figure 1) is at a particular time of its history when plans for the future are being crafted. While needs for economic development are pressing new agendas, conservation agencies, pushing through the national pledge to set aside 15% of national territory as protected areas (PAs), are pleading for the expansion of the existing PAs network to include viable samples of the country's seven phytogeographic regions (Inogwabini et al. 2005; Sayer 1992; Ministère de l'Environnement et Conservation de la Nature (MECN) 1990; World Conservation Union (IUCN)1989). Because economic needs will affect the country's social structures and resources as well as shake the ecological landscapes, the call to extend the PA network is sensible. The expansion has to be supported, however, by an assessment and a nation-wide gap analysis of the habitat and species representativeness to determine the highest priority in the existing PA network (Inogwabini et al. 2005; Rodrigues et al. 2003). The habitat gap analysis is one of the most important keys in assessing the irreplaceability of specific biomes and provides the first step. A sound habitat gap analysis requires precisely demarcated PAs' boundaries, but unfortunately most of PAs in DRC do not have precise boundaries.

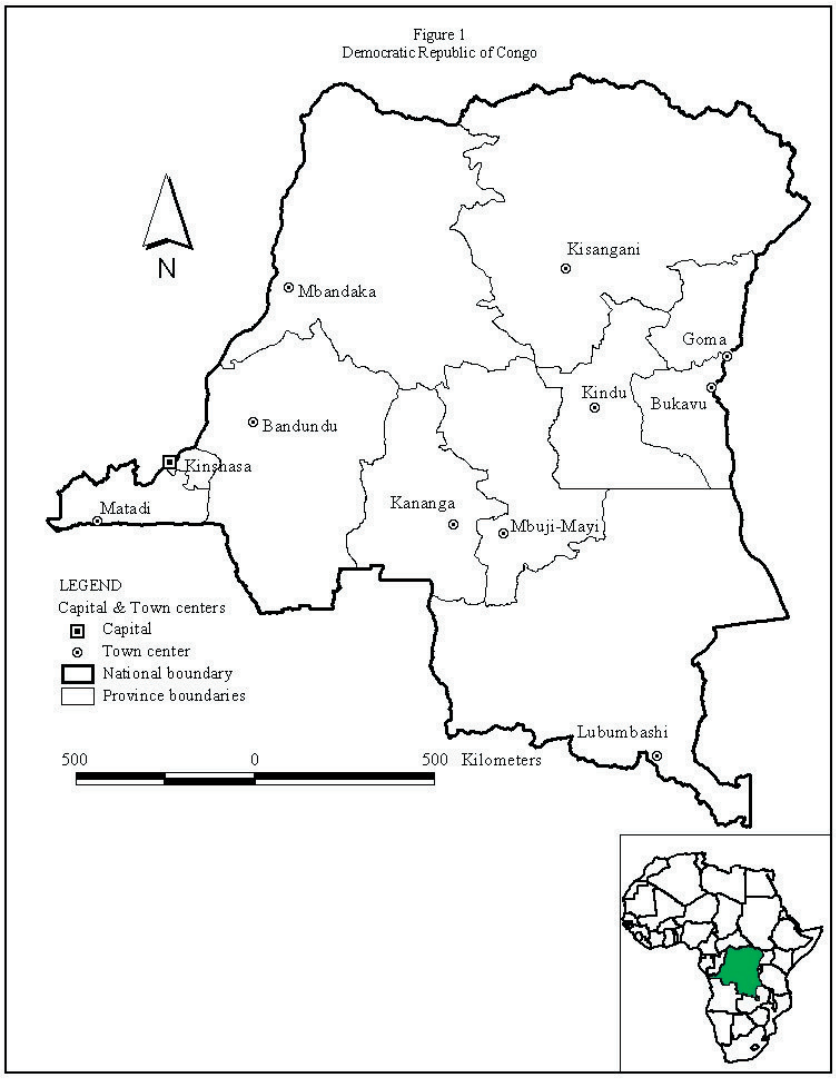


Figure 1
Democratic Republic of Congo

This paper has two complementary objectives: (1) a habitat gap analysis and (2) boundary reality-check. The first reason to carry out the habitat gap analysis, even though there are imperfections in PAs boundaries, is to help evaluate the current mapped coverage of each phytogeographic zone. The second aim is to provide an informed opinion about the extension of the PA network. Hence, the global objective of this paper is to positively contribute to the debate about whether there is a need to extend the current PA network in DRC and, if so, which areas are critical not only geographically but also in their representativeness of critical biomes not represented in the current PA network or insufficiently covered. It is obvious that a habitat gap analysis is not the single parameter to take into account in this venture. The habitat gap analysis has to be complemented by other equally important elements such as the biological, socio-cultural values, available resources and the political will. Despite these precautions the concept of habitat has a deep ecological significance. The assessment of different types of habitat remains one of the most important components of the conservation biology (Magurran 1988; Sutherland 2000, 1997).

Data and Methods

Habitat gap-analysis

We defined the seven recognized phytogeographic zones of the DRC based on Chidumayo (1997), Richards (1996), White (1993), Sayer (1992) as: (1) mangrove, (2) mountain forest, (3) lowland rain forest, (4) Miombo forest, (5) Sudano-guinean savannahs, (6) Zambezi woodland and savannahs (southern swampy savannahs (Kabala 1975)) and (7) fresh-water swamp and related aquatic vegetation (permanently and seasonally flooded vegetations). We used White's (1983) vegetation map of Africa as our base map. To delineate different habitat types, we combined White's (1983) map with the AFRICOVER Project land cover map of DRC, (Food and Agriculture Organization (FAO) 2002) and the terrestrial eco-regions maps (Toham 2000), using the union geoprocessing tool of ArcView GIS 3.2 (Environmental System Research Institute (ESRI) 1999). The habitat gap analysis used the Rodrigues et al.'s (2003) method, overlaying maps of PAs on the distribution of the seven phytogeographic zones. Then, using the area-calculating tool of the Geographic Information Systems (GIS), we obtained areas of phytogeographic zones. We used Access to sum up these areas by use of cross-tabulation query tool. We extracted the land use from the AFRICOVER map. AFRICOVER project used Geographical Vector Interpretation System (GEOVIS) to delineate different habitat mosaics from cloud-free Landsat 7 ETM imagery 2000-2002. GEOVIS is a vector-based editing system specifically designed for thematic interpretation. Major land use attributes were (1) cultivation and (2) human settlement zones, represented as zones, which are noted as (8) and (9). Due to difficulties in differentiating other land use attributes such as mining zones and other human extractive activities (e.g., collection of fuel wood) that are compatible with canopy cover with human settlements and cultivated zones; we limited our analysis to the two activities categories above. We subtracted land use areas from the main phytogeographic zones to obtain the actual relatively "intact" surface for each phytogeographic zone. We then mapped all known DRC's PAs on these phytogeographic zones. We considered a phytogeographic zone as "covered" by the PA network if any portion of the PA overlapped any extent of its mapped distribution (Rodrigues et al. 2004). Finally, to refine the phytogeographic coverage, we calculated areas of each PA intersecting with each phytogeographic zone. With these measures, we calculated percentages of each phytogeographic zone represented within the current PA network, which is a crude measure of each habitat type protection.

Boundary-reality check

There were no ground-truthed data to check the accuracy of protected areas' boundaries. Thus, we had to rely on a surrogate method to judge whether available limits are accurate or not. We used available shapefiles of protected areas (e.g., Institut Congolais pour la Conservation de la Nature (ICCN) 2004; De Temmermann and De Wasseige 2003) to calculate each protected area's surface. We then compared these with figures provided in legal decrees. All PAs whose calculated surfaces were within the margin $\pm$10% of decreed surface were classified as having accurate limits.

Results

Phytogeographic zones and land use

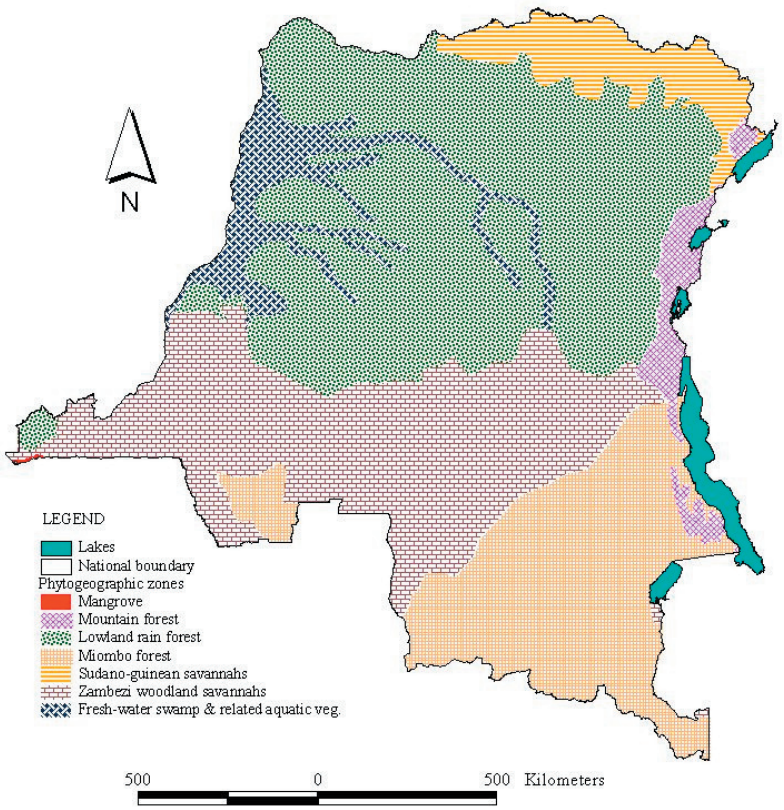
The lowland forest, with 923,175.14 km^2 (approximately 40% of the national territory) is the most extensive phytogeographic zone while the mangrove (704.85 km^2, approximately 0.03%) is the least extensive (Table 1, Figure 2). Overall and excluding water bodies, about 17% of the country has

been converted to open land by human activities. Different land use practices occupy 28948.35 km^2 (43.34%) of the mountain forest, 117,080.55 km^2 (12.69%) of the lowland rain forest and 28.4 km^2 (4.03%) of the mangal region (Tables 1 & 2, Figure 2). Water bodies and associated vegetations occupy extensive regions of different phytogeographic zones: 21.92% of the mangrove, 10.26% of the lowland rain forest, 11.52% of the Sudano-guinean savannahs and 7.73% of Zambezi woodland and savannahs (Table 2).

Protected areas representation within phytogeographic zones

With 43.20%, the Sudano-guinean savannah is the most represented phytogeographic zone within the current PA network, followed by mangrove (29.68%), and mountain forest (10.24%). The least represented phytogeographic zone is freshwater swamp and related aquatic permanently and seasonally flooded vegetations vegetation (0.75%).

Figure 2
Seven phytogeographic zones of DRC.



Boundary reality-check

Using differences between mapped and decreed surfaces of 27 PAs, only 7 had accurate limits. These are: Garamba, Salonga, Kahuzi-Biega, Kundelungu, Maiko, Luki and N'sele (Table 4). The remaining PAs are either over or undersized compared to their decreed surfaces.

Discussion

Phytogeographic zones

Comparable data on phyto-geographic zones delineation are difficult to obtain within Central Africa, and have not been collected systematically (Wilkie and Laporte 2001; Laporte and Justice 2001). However, our estimated cover of the lowland rain forest (39.66%) is close to the 40% reported by Laporte & Justice (2001) and the 40.6% reported by Sayer (1992). Our estimates of the mountain forest 66,791.93km^2 or 3.33% of the national territory) and fresh water and related aquatic vegetation (168,667.11km^2 or 7.25%) are higher than 2.6% and 5.5% previously estimated by Sayer (1992) for the same phytogeographic zones respectively. These results do not imply major expansion of these zones between 1992 and 2002, the year the mosaic we used was produced. Possible explanations for these differences would include the accuracy of tools used and differences in methods. Sayer (1992) used coarse resolution delimitation of phytogeographic zones while our study relies on cloud-free 7 ETM landsat vegetation classifications, which provides a better vegetation cover. Even with these differences, however, mountain forest size oscillates around 3% of the national territory, which

LANDCOVER	PHYTOGEOGRAPHIC ZONES							TOTAL
	Zone1: Mangrove	**Zone 2**: Mountain	**Zone 3**: Lowland	**Zone 4**: Miombo	**Zone 5**: Soudano-Guinean	**Zone 6**: Zambezi woodland	**Zone 7**: Freshwater and related aquatic vegetation	
1	521.92	-	-	-	-	-	-	**521.92**
2	-	21,926.23	-	-	-	-	-	**21,926.23**
3	-	-	665,555.85	-	-	-	-	**665,555.85**
4	-	-	-	183,810.12	-	-	-	**183,810.12**
5	-	15,027.76	45,788.55	-	99,339.74	-	2,161.17	**162,317.22**
6	-	266.78	-	192,422.57	-	445,357.13	-	**638,046.48**
7	154.53	622.81	94,750.19	11,450.94	15,338.52	46,063.00	151,259.06	**319,639.05**
8	10.15	28,868.01	116,559.17	50,017.11	18,433.67	103,247.60	14,987.82	**332,123.53**
9	18.25	80.34	521.38	1,329.02	91.34	1,303.18	259.06	**3,602.57**
TOTAL	**704.85**	**66,791.93**	**923,175.14**	**439,029.76**	**133,203.27**	**595,970.91**	**168,667.11**	**2,327,542.97**
%	**0.03**	**3.33**	**39.66**	**18.86**	**5.72**	**25.61**	**7.25**	**100.00**

Table 1. National Phytogeographic and Land use Surface [km^2]

Table 2. % Broken-down vegetation and land use description/phytogeographic area

LANDCOVER	PHYTOGEOGRAPHIC ZONES						
	Zone1: Mangrove	Zone 2: Mountain	Zone 3: Lowland	Zone 4: Miombo	Zone 5: Soudano-Guinean	Zone 6: Zambezi woodland	Zone 7: Aquatic vegetation
1	74.05%						
2		32.83%					
3			72.09%				
4				41.87%			
5		22.50%	4.96%		74.58%		1.28%
6		0.40%		43.83%		74.73%	
7	21.92%	0.93%	10.26%	2.61%	11.52%	7.73%	89.68%
8	1.44%	43.22%	12.63%	11.39%	13.84%	17.32%	8.89%
9	2.59%	0.12%	0.06%	0.30%	0.07%	0.22%	0.15%
TOTAL	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.01%**	**100.00%**	**100.00%**

implies that results from this study are not far from previous estimates.

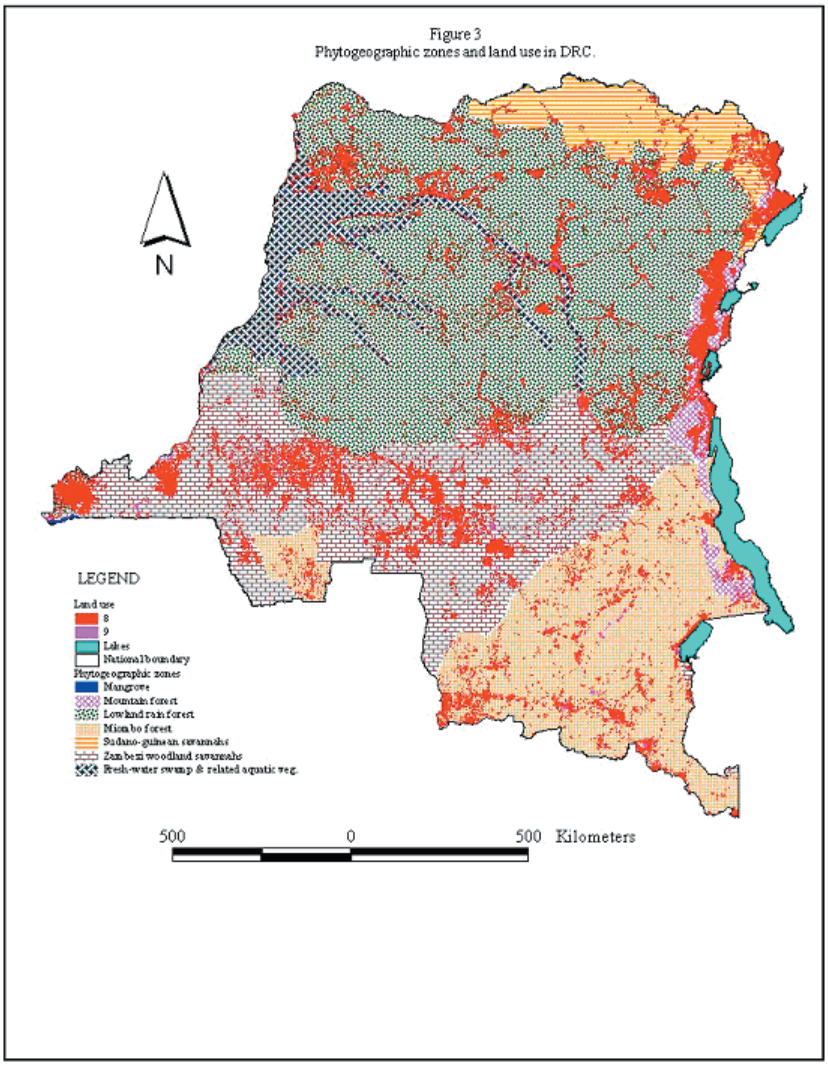
Land Use

Land use results show that in the DRC 12.69% of the lowland rain forest (3), the most extensive phytogeographic zone, is used for human activities, while 43.34% of the mountain phytogeographic zone (2) is under different human uses has the highest human impact. These results need to be viewed as minimum areas under human use, as they represent only land cover but not activities that can happen without clearing vegetation cover. Size-wise, the mountain forests are the second least important in the DRC (Table 1) and among the least extensive in Africa, occurring only in the Cameroonian highlands and the eastern fringes of the DRC (Whitmore 1990). In the DRC, mountain forests historically stretched from the Virunga complex down to the southern edges of the Itombwe massif at the shores of Lake Tanganyika (Whitmore 1990). Based on land cover, they are the most threatened habitat in the DRC. Causes for this state are high human densities (Inogwabini et al. 2000; Inogwabini et al. 2000), which

increased need for agricultural land and commercial plantations (Meyers 1985).

Patterns of land use (% for zones 4, 5, and 6; Table 2) as presented in the figure 3 agree with the general picture of the country, describing three major areas of high human settlements and activities: the mountains of the former Kivu complex, the south-western belt running from Kinshasa down to Katanga, through the Kasais and the northern agglomerations stretching westward from the border with Uganda up to the Ubangi River (De Saint Moulin 2003 & 1991; Institut National des Statistiques (INS) 1984). All three zones of high human settlements are mineral-rich and the Kivu complex, particularly in the north, is known to harbor volcanic fertile soils. All PAs have been used to some extent, although our analysis is limited to a broad picture of vegetation cover (Fig.5). The degradation of the vegetation cover of some of them (e.g. Virunga, Tshangalele, Kundelumgu, Bili-Uere complex) reach over 1,000 km^2.

Figure 3
Phytogeographic zones and land use in DRC.



Because of discrepancies between mapped and decreed areas in most PAs, these land use figures may be an overestimation. The Virunga complex exhibits higher degradation of habitat caused by human activities. Virunga is in the mountain forest zone, which has high human densities. PAs are under stress by human activities but these are not necessarily pictured at the land cover level such as hunting and collection of non-timber forest products, mining, and fuel wood. This pressure on PAs is mainly due to weaknesses in law enforcement and armed conflicts.

PA representation within phytogeographic zones

Freshwaterhabitatsshouldnotbeviewed as simple appendages of protected terrestrial ecosystems as it is currently the case. The over-representation of the Sudano-guinean savannahs (5) in the PA network is not surprising because the Bili-Uere complex, the largest DRC PA, is entirely located in this zone. The fresh-water swamp and permanently and seasonally flooded vegetations are the least represented zone because fresh water attracts the least attention of the conservation community. Even where water bodies and related vegetation are included in PAs, they are not carefully managed; extractive activities of fish and other non-timber products are allowed (e.g. Inogwabini 2005).

The DRC has an extensive river network, lakes and wetlands (Groombridge 1992; CEFDHAC 2001). The Congo River Basin, with approximately 4,000,000 km^2, is the second largest in the world (Chapman 2001; Groombridge 1992; Bailey 1986). The Congo has natural divides through

PA's Name	Total [Km^2]	1	2	3	4	5	6	7
Bili-Uere	32,791.53635			649.35032		32,142.18603		
Bombo-Lumene	1,088.58722						1,088.58722	
Bomu	10,678.82038			271,62586		10407,19452		
Bushimaie	4,330.39931						4,330.39931	
Gangala-na-Bodio	9,858.76247			31,96287		9,826.7996		
Garamba	4,948.69716					4,948.69716		
Kahuzi-Biega	5,617.82555		599,22881	5018,59674				
Kundelungu (Est)	2,461.30293				2,461.30293			
Kundelungu (Ouest)	5,580.14422				5,580.14422			
Luama-Katanga	3,402.85774				3,402.85774			
Luama-Kivu	3,908.23289				321.26894		3,586.96395	
Lubudi Sampwe	3,417.63179				3,417.63179			
Lufira	667.24558				667.24558			
Luki	304.6358			7.93926			296.69654	
Maika-Penge	1,506.40052			1,506.40052				
Maïko	10,485.89795			10,485.89795				
Mangai	36,381.13853			2,851.56606			33,529.57247	
Mangroves	215.47767	209.19812					6.27955	
N'Sele	34.44674						34.44674	
Okapi	8,625.89547			8,625.89547				
Rubi-Tele	6,226.95753			6,226.95753				
Rutshuru	853.05792		853.05792					
Salonga (Nord)	16,034.54315			16,034.54315				
Salonga (Sud)	18,466.53591			17,508.35593				958.17998
Swa-Kibula	993.77452						993.77452	
Tshangalele	2,933.74234				2,933.74234			
Upemba	13,440.72162				13,440.72162			
Virunga	6,203.57286		5,385.45527	603.84579		214.22915		0.04265
Yangambi	2,213.05534			1,912.99487				300.06047
Total in PAs		209.19812	6,837.742	71,735.93232	32,224.91516	57,539.10646	43,866.7203	1,258.2831
Phytogeographic		704.85	66,791.93	923,175.14	439,029.76	133,203.27	595,970.91	168,667.11
% In PAs	**9,1%**	29.68	10.24	7.77	7.34	43.20	7.36	0.75
National proportion		0.000045	0.004995	0.05949	0.02829	0.00858	0.038415	0.010875
15% National Territory		104.7394337	11,626.07714	138,465.5313	65,846.19062	19,970.31868	89,412.56319	25,312.0298
To include in PAs [Km^2]		-104.46	4,788.34	66,729.60	33,621.28	-37,568.79	45,545.84	24,053.75
% To include/zone	**5,9**	-14.82	7.17	7.23	7.66	-28.20	7.64	14.26

Table 3. Protected areas within the seven phytogeographic zones

its course to the Atlantic Ocean, mostly comprised of rapids and falls that are major barriers for species dispersal (Chapman 2001): the upper Congo, the mid Congo, and the lower Congo (Groombridge 1992; Bailey 1986). The Congo, in its three segments, has more fish species than any other African river (Groombridge 1992). Lake Tanganyika (approximately 32,893km^2), the largest lake of the Albertine Rift contains a unique fauna of about 1300 species of vertebrates and invertebrates, of which 214 are fish species (CEFDHAC 2001; Groombridge 1992). Lake Tanganyika is one of the oldest (CEFDHAC 2001) and, with an approximately 80% rate of endemism, it is also one of the most important areas for the conservation of the world's freshwater fish species (Groombridge 1992), although the fish species numbers have not been properly

Table 4. Accuracy of demarcated boundaries

Protected Area	Decreed Area (km²)	Mapped Area (km²)	Difference	% Difference	Boundary Accuracy
Virunga	8,000	6,207.5008	1,792.4992	22.41	Less accurate
Garamba	5,000	4,958.42586	41.57414	0.83	Accurate
Upemba	10,000	13,440.72171	-3,440.7217	-34.41	Less accurate
Salonga	36,000	34,501.08053	1,498.9195	4.16	Accurate
Kahuzi-Biega	6,000	5,617.82532	382.17468	6.37	Accurate
Kundelungu	7,600	8,041.47516	-441.47516	-5.81	Accurate
Maiko	10,000	10,485.89805	-485.89805	-4.86	Accurate
Okapi	13,726.25	8,625.89691	5,100.3531	37.16	Less accurate
Bili-Uere	60,000	43,622.63733	16.377.363	27.30	Less accurate
Bombo-Lumene	3,500	1,088.58735	2,411.4127	68.90	Less accurate
Bushimaie	3,500	4,330.39936	-830.39936	-23.73	Less accurate
Luama	3,435	7,311.09375	-3,876.0938	-112.84	Less accurate
Lubudi-Sampwe	614	3,417.63198	-2,803.632	-456.62	Less accurate
Maika-Penge	2,500	1,506.40057	993.59943	39.74	Less accurate
Mangai	11,768	36,381.46566	-24,613.466	-209.16	Less accurate
Rutshuru	1,000	856.57384	143.42616	14.34	Less accurate
Swa-Kibula	1,400	998.26912	401.73088	28.70	Less accurate
Yangambi	2,500	2,213.05376	286.94624	11.48	Less accurate
Luki	330	304.63577	25.36423	7.69	Accurate
Lufira	147	667.24558	-520.24558	-353.91	Less accurate
Rubi-Tele	9,080	6,226.95786	2,853.0421	31.42	Less accurate
N'sele	35	34.44676	0.55324	1.58	Accurate
Tshangalele	425	2,933.7416	-2,508.7416	-590.29	Less accurate
Gangala-na-Bodio*	8,636.25	9,859.53231	-1,223.2823	-14.16	Less accurate
Mangrove	768	215.47765	552.52235	71.94	Less accurate

* Include Azande and Mondo-Misa reserves.

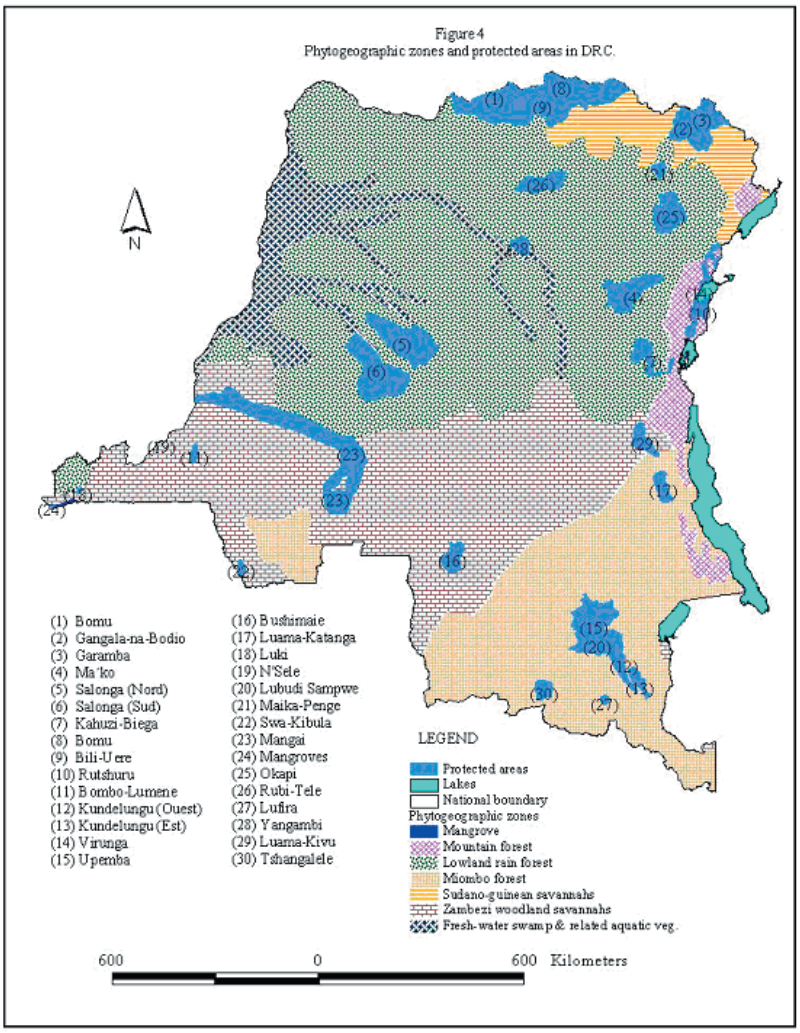
documented (Bailey 1986). People living along the Congo River depend on fish resources both for substance and commerce (Banister 1986). As many as 70,000 tons of fishes are consumed in DRC per year (CEFDHAC 2001; Leonard 1987), and fish contribute a large portion of protein to these people. Furthermore, freshwater swamps play an important ecological role in mitigating floods and as well as in providing fish breeding sites (Brown 2003). These reasons plead for the inclusion of segments of fresh water and related vegetation for their own importance in the current PA network.

Other phytogeographic zones that are under-represented within the current PA network include the lowland rain forest and the Miombo (Table 3). The lowland forest is the most extensive (Table 1), albeit the least inhabited and the least disturbed phytogeographic zone in DRC (Figure 3; De Saint Moulin 2003 and 1991; Institut National des Statistiques (INS) 1984). Relatively low human densities across the forested zone and a feeble terrestrial road network may explain the fact that this zone exhibits frail gaps in vegetation cover. The lowland forest has an enormous potential for timber production, although it has been only minimally harvested largely because of difficulties accessing the interior, which have been compounded by the recent period of civil strife (Aveling et al. 2003). Over the next decade, however, the government of the DRC intends to increase production from its current level of 44,000 m^3 per year to around 10,000,000 m^3 per year (Aveling et al.

2003). This enormous pressure on timber resources will severely impact the entire lowland rain forest phytogeographic zone; already about 46% of the Central Congo Basin, locally known as the '*cuvette centrale*' is already under active or latent logging concessions (Inogwabini et al. 2005; Reinartz and Inogwabini 2001; Wolfire et al. 1998). These factors, combined with the fact that the lowland rain forest phytogeographic zone is under-represented within the current PA network, support the creation of new PAs in this zone. Our analyses suggest that to reach the target of including 15% of the national territory in the PA network, we still need to set aside 7% of the lowland forest phytogeographic zone as PAs (Table 3). Nevertheless, precautions such as biological surveys, national territory zoning, local population involvement, and socio-cultural values, need to be taken to prevent an anarchical implementation of PAs.

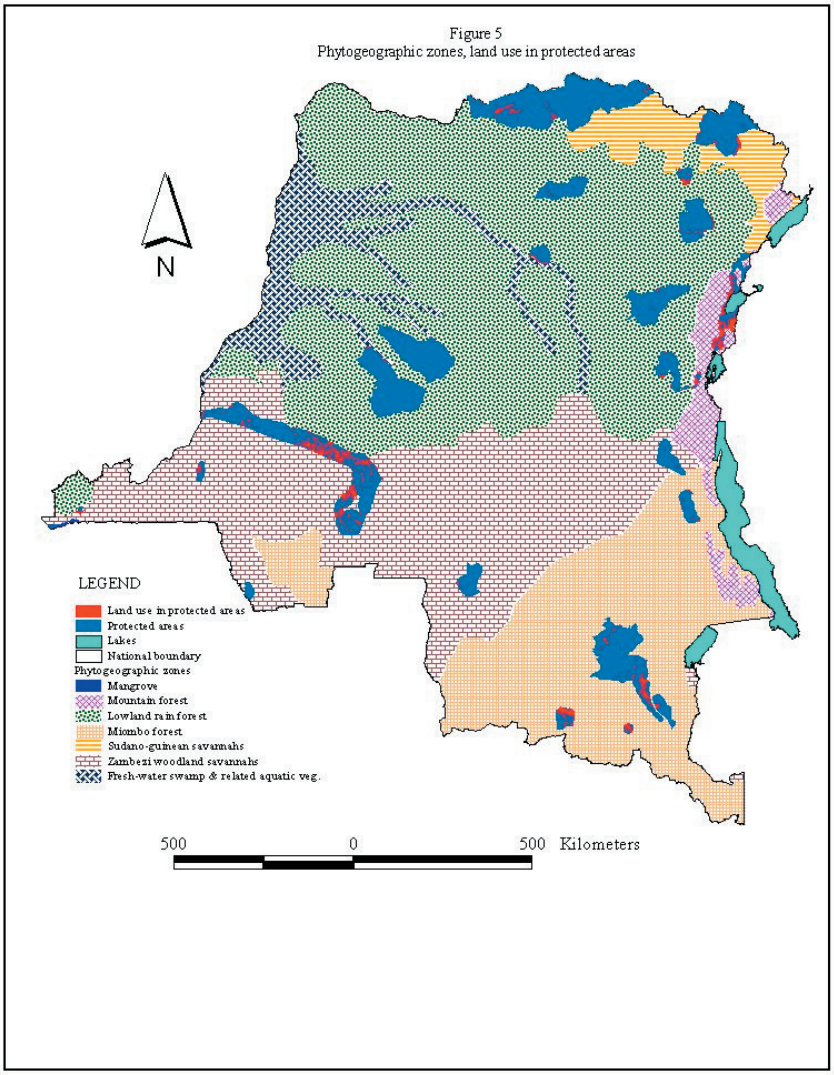
The Miombo zone protects watersheds of the main rivers (e.g. Kasai and Luvua) that feed rivers system in DRC. Miombo forests play an important role both ecologically as carbon sink (Beyers 2001), and socially as source of foods and commodities for rural people as well as for those in the main cities (e.g. charcoal, fuel wood, timber). These products are particularly necessary for the poorest households during periods of food shortage (Frost & Desanker 1998). Threats to this zone include increasing human population, which implies the expansion of slash-and-burn agriculture (Scholes 1996), intensive mining activities, and unmanaged fires. Changes in land cover caused by these human activities will affect the watersheds and the regional hydrology (Desanker et al. 1997). The Miombo zone is one of the least protected biomes in DRC (Table 3). Thus, the zone is one of the best candidates for new PAs, again with all precautions stated above and paying particular attention to mining activities.

Figure 4
Phytogeographic zones and protected areas in DRC



PAs map accuracy-check

One of the most important aspects of this work is the comparison between the decreed surface for each PA and its related actual map. A major output of this process is that most PA maps are inaccurate; the worst cases being those of Tshangalele, Mangai, Lubudi-Sampwe, and Luama, whose mapped areas are more than 100% greater than decreed areas (Figure 4; Table 3). These major discrepancies are all an indication of bad boundary demarcations. Most PAs in DRC had no sound feasibility studies before they were created and most maps were recently drawn, in many instances by hand just to respond to the ICCN's need for a physical representation of



where the PAs would be located (G.N. Zasy personal observation).

Recommendations

The main object of this paper is to determine the representativeness of phytogeographic zones in the DRC's PAs. Our analysis revealed that the fresh water swamp and related aquatic vegetation were the most missing biome within the current PA network. The gap analysis suggested that 14% of this phytogeographic zone needs to be included within the PA network. Therefore, we first recommend including freshwater swamps in the PA network. Second, before creating any new PA, there is a need to evaluate the biological, socio-economic and cultural values of the candidate PA. The habitat gap analysis provides a guide toward that end by providing proportions of each phytogeographic zone to include in the PA network (Table 3). Third, before extending the current PA network national conservation authorities should initiate systematic boundary mapping of all existing PAs using legal decrees and local knowledge to demarcate PAs from other land use and human activities.

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News Release: Long Thought Extinct, Ivory-billed Woodpecker Rediscovered in Big Woods of Arkansas

Multiple sightings, video footage show bird survives in vast forested areas

BRINKLEY, Ark. – Long believed to be extinct, a magnificent bird – the ivory-billed woodpecker – has been rediscovered in the Big Woods of eastern Arkansas. More than 60 years after the last confirmed sighting of the species in the United States, a research team announced that at least one male ivory-bill still survives in vast areas of bottomland swamp forest.

Published in the journal Science on its Science Express Web site (April 28, 2005), the findings include multiple sightings of the elusive woodpecker and frame-by-frame analyses of brief video footage. The evidence was gathered during an intensive year-long search in the Cache River and White River national wildlife refuges involving more than 50 experts and field biologists working together as part of the Big Woods Conservation Partnership, led by the Cornell Laboratory of Ornithology at Cornell University and The Nature Conservancy.

"The bird captured on video is clearly an ivory-billed woodpecker," said John Fitzpatrick, the Science article's lead author, and director of the Cornell Laboratory of Ornithology. "Amazingly, America may have another chance to protect the future of this spectacular bird and the awesome forests in which it lives."

"It is a landmark rediscovery," said Scott Simon, director of The Nature Conservancy's Arkansas chapter. "Finding the ivory-bill in Arkansas validates decades of great conservation work and represents an incredible story of hope for the future."

Joining the search team at a press conference in Washington DC, Secretary of the Interior Gale Norton announced a Department of the Interior initiative to identify funds for recovery efforts.

Through its cooperative conservation initiative, the Fish and Wildlife Service has a variety of grant and technical aid programs to support wildlife recovery.

"These programs are the heart and soul of the federal government's commitment to cooperative conservation. They are perfectly tailored to recover this magnificent bird," Secretary Norton said. "Across the nation, these programs preserve millions of acres of habitat, improve riparian habitat along thousands of miles of streams and develop conservation plans for endangered species and their habitat."

The largest woodpecker in North America, the ivory-billed woodpecker is known through lore as a bird of beauty and indomitable spirit. The species vanished after extensive clearing destroyed millions of acres of virgin forest throughout the South between the 1880s and mid-1940s.

Although the majestic bird has been sought for decades, until now there was no firm evidence that it still existed.

The rediscovery has galvanized efforts to save the Big Woods of Arkansas, 550,000 acres of bayous, bottomland forests and oxbow lakes. According to Simon, The Nature Conservancy has conserved 18,000 acres of critical habitat in the Big Woods, at the request of the partnership, since the search began. "It's a very wild and beautiful place," Simon said.

The Search and the Evidence

While kayaking in the Cache River National Wildlife Refuge on Feb. 11, 2004, Gene Sparling of Hot Springs, Ark., saw an unusually large, red-crested woodpecker fly toward him and land on a nearby tree. He noticed several field marks suggesting the bird was an ivory-billed woodpecker.

A week later, after learning of the sighting, Tim Gallagher, editor of the Cornell Lab of Ornithology's Living Bird magazine, and Bobby Harrison, as-

sociate professor at Oakwood College, Huntsville, Ala., interviewed Sparling. They were so convinced by his report that they traveled to Arkansas and then with Sparling to the bayou where he had seen the bird.

On Feb. 27, as Sparling paddled ahead, a large black-and-white woodpecker flew across the bayou less than 70 feet in front of Gallagher and Harrison, who simultaneously cried out: "Ivory-bill!" Minutes later, after the bird had disappeared into the forest, Gallagher and Harrison sat down to sketch independently what each had seen. Their field sketches, included in the Science article, show the characteristic patterns of white and black on the wings of the woodpecker.

"When we finished our notes," Gallagher said, "Bobby sat down on a log, put his face in his hands and began to sob, saying, 'I saw an ivory-bill. I saw an ivory-bill.'" Gallagher said he was too choked with emotion to speak. "Just to think this bird made it into the 21st century gives me chills. It's like a funeral shroud has been pulled back, giving us a glimpse of a living bird, rising Lazarus-like from the grave," he said.

The sightings by Sparling, Gallagher and Harrison led to the formation of a search team, which later became the Big Woods Conservation Partnership. On April 5, 10 and 11, three different

searchers sighted an ivory-bill in nearby areas. The views were fleeting, leaving little opportunity to take photographs.

David Luneau, associate professor at the University of Arkansas at Little Rock, said he thought the best chance to film the elusive bird would be to have a camcorder on at all times. On April 25, Luneau captured four seconds of video footage showing an ivory-billed woodpecker taking off from the trunk of a tree.

Frame-by-frame analyses show a bird perched on a tupelo trunk, with a distinctive white pattern on its back. During 1.2 seconds of flight, the video reveals 11 wing beats showing extensive white on the trailing edges of the wings and white on the back. Both of these features distinguish the ivory-billed woodpecker from the superficially similar, and much more common, pileated woodpecker.

On three occasions, members of the search team heard series of loud double-raps, possibly the ivory-billed woodpecker's display drumming. On Feb. 14, 2005, Casey Taylor of the Cornell Lab of Ornithology heard the drumming for 30 minutes, then watched as an ivory-billed woodpecker, being mobbed by crows, flew into view.

In addition, autonomous recording units detected sounds, among thousands of hours of recordings, which resembled double-raps and possible calls of the ivory-bill – reminiscent of the sound of a tin horn. Researchers say ongoing analyses of the recordings have not yet enabled them to rule out other potential sound sources, such as the calls of blue jays, which are notorious mimics.

In all, during more than 7,000 hours of search time, experienced observers reported at least 15 sightings of the ivory-bill, seven of which were described in the Science article. Because only a single bird was observed at a time, researchers say they don't yet know whether more than one inhabits the area.

So far, the search team has focused its efforts in approximately 16 of the 850 square miles in the bottomland forests of Arkansas. Fitzpatrick of the Cornell Lab of Ornithology said that the next step will be to broaden the search to assess whether breeding pairs exist and how many ivory-bills the region may support. To expand the area being monitored and minimize disturbance to the endangered woodpecker, the team will continue to use acoustic monitoring technologies as well as on-the-ground

searching. Fitzpatrick said the team will also encourage others to search for the ivory-bill elsewhere in suitable habitats throughout the South.

Simon of The Nature Conservancy said that over the years, state and federal agencies, conservation organizations, hunters and landowners have aggressively worked to conserve and restore the bottomland hardwood and swamp ecosystem. "Now we know we must work even harder to conserve this critical habitat – not just for the ivory-billed woodpecker, but for the black bears, waterfowl and many other species of these unique woods," he added.

The partnership's 10-year goal is to restore 200,000 more acres of forest in the Big Woods. The effort will include conserving forest habitat, improving river water quality, and restoring the physical structure of the river channels, focusing in locations with maximum benefit in reconnecting forest patches and protecting river health.

"The ivory-bill tells us that we could actually bring this system back to that primeval forest here in the heartland of North America," said Fitzpatrick, who is also a former member of The Nature Conservancy's board of governors. "That's the kind of forest that I hope some generation of Americans and citizens of the world will get to come and visit."

For more information about the search and the efforts to save the ivory-billed woodpecker and the Big Woods, visit www.ivorybill.org.

The Cornell Laboratory of Ornithology is a nonprofit membership institution with the mission to interpret and conserve the Earth's biological diversity though research, education, and citizen science focused on birds. From its headquarters at the Imogene Powers Johnson Center for Birds and Biodiversity in Ithaca, N.Y., the Lab leads international efforts in bird monitoring and conservation, and fosters the ability of enthusiasts of all ages and skill levels to make a difference.

The Nature Conservancy is a nonprofit organization that preserves plants, animals and natural communities representing the diversity of life on Earth by protecting the lands and waters they need to survive. To date, the Conservancy has been responsible for protecting more than 15 million acres in the United States and more than 102 million acres in Latin America, the Caribbean, Asia and the Pacific. Since The Conservancy's Arkansas office opened in 1982, it has worked with the U.S. Fish and Wildlife Service, the Arkansas Natural Heritage Commission, the Arkansas Game and Fish Commission as well as private citizens, corporations, and foundations, to bring into conservation management more than 120,000 acres in the Arkansas delta.

The Big Woods Conservation Partnership includes the Cornell Lab of Ornithology, The Nature Conservancy, Oakwood College in Huntsville, Ala., Louisiana State University, the University of Arkansas at Little Rock, the Arkansas Natural Heritage Commission, the Arkansas Game and Fish Commission, the U.S. Fish and Wildlife Service, Birdman Productions, LLC, and Civic Enterprises, LLC.

News From Zoos

'Going Ape' Over New Great Ape Trust Facility

It's a world-class scientific research facility for great apes that may give a whole new meaning to architecturally innovative and technologically advanced primate housing. The Great Ape Trust of Iowa, located in Des Moines and certified by AZA, is setting new standards with the completion of a $10 million facility in April that will be home to a colony of eight bonobos. Bonobos often walk upright and share over 98 percent of their genetic make-up with humans. Found in the wild only in the Democratic Republic of the Congo, bonobos are classified as endangered and continue to be threatened with the omnipresence of habitat destruction. In addition to bonobos, the Great Ape Trust also houses the three other species of great apes: orangutans, chimpanzees, and gorillas.

A far cry from the common perception of research animal housing, the Great Ape Trust's unique environment was designed to provide stimulation and enrichment for primates used in an admirable list of renowned research programs. Various noninvasive research investigates language, tool use, abstract thought, and music, among other behaviors within the bonobo colony. Such research is likely to be aided by the innovative building design.

The state-of-the-art building contains 18 rooms, and is equipped with 32 cameras and 36 computer hookups so that researchers around the world can monitor the apes. However, this is not the extent of the exhibit design and technology that make the building unique. To an extent, the bonobos have the ability to decide what goes on inside their home. An observation area is closed to visitors unless the apes type in a combination of computer keystrokes and push a button that opens a door. They have specially made toilets that flush automatically, and will be able to turn on their own showers and drinking fountains. The 13,000 square foot building with curved walls also includes a heated floor, an indoor pool with a waterfall and a 1,600-square-foot greenhouse. While visitations to the facility are limited, information on these ape accommodations may be viewed on the Web at www.GreatApeTrust.org.

Cloning for Conservation: Where to Draw the Line?

The Audubon Nature Institute's Center for Research of Endangered Species in New Orleans hopes to integrate cloning as a tool for conservation. An increasing number of zoos and researchers are banking animal tissues to be preserved in "frozen zoos," which now number close to a dozen worldwide. These serve as an assurance that if an animal goes extinct, its genetic material remains available. The Audubon Nature Institute's research facility contains tanks of liquid nitrogen, which in turn contain the genetic material for over 1,000 species that can remain frozen for hundreds of years. As with any debate over the role of humans in the creation of living creatures, cloning has created an ethical predicament in certain conservation communities.

Critics of cloning argue that conservationists need to focus on issues such as human overpopulation and habitat degradation; they fear that otherwise, there might not be a place for animals to live in the future. The rebuttal by proponents of cloning follows that we could save entire habitats worldwide, but what if there are no animals left to fill them? Another concern expressed by critics is that the technology used for cloning is diverting efforts from the traditional goals of conservation. According to scientists at the Audubon Nature Institute, money that is used to improve cloning technology is donated specifically for that purpose, and is not diverted from contributions for other forms of conservation. They see cloning as yet another tool working for conservation, not against it.

There are also points of debate that could require both critics and proponents to re-evaluate the definition of individual species. The cloning procedure involves using the nuclear DNA from an adult cell of the animal to be cloned and inserting it into the donor's egg as the new DNA. This egg is then implanted in an animal's womb, where it grows into a clone and is born with the title "chimera," meaning a blend of different species. Since cloning for conservation efforts usually involve endangered species, the egg and womb are often supplied by a different, yet similar species. When using an African wildcat's DNA to clone an offspring, scientists used the egg and womb of a domestic house cat. Thus the question remains, if the DNA is from the African wildcat and the

egg and womb are from a domestic housecat, can the offspring technically be labeled an African wildcat?

The scientific community may have yet to face the challenge of agreeing on an ethical and moral baseline for conservation, but one thing is certain. As conservation dilemmas become more complicated, zoos, aquariums and research centers appear to formulate equally innovative solutions at an unprecedented pace.

Potawatomi Zoo's Cranes: Helping Conservation Abroad

White-naped cranes are listed as vulnerable in their native countries of China, Russia, and Mongolia due to habitat destruction. The Potawatomi Zoo in South Bend, Indiana, continues to play an integral role in the reintroduction of these magnificent birds, which now maintain wild populations between 4,900 and 5,400. Each year, the zoo's monogamous pair of white-naped cranes delivers an egg or two, which are shipped overseas to contribute to the wild crane population. Shipping the eggs before the chicks hatch alleviates much of the red tape and permits required for sending live animals.

The proposition of transporting a vulnerable species' eggs half-way around the world might seem daunting in itself, but is well worth the trouble to those involved with the program. The eggs are driven to Pittsburgh, flown to Los Angeles, then Seoul, then Kakbarovsk, Russia where they take a nine-hour train ride and arrive at their new home in the Khingansky Nature Reserve. And if that schedule isn't enough of a testament to the dedication of conservationists, once the chicks hatch, their caretakers dress as puppets during all interactions so the chicks aren't imprinted on humans. While Russian authorities notify the donor zoos when their eggs hatch, there is currently no method of tracking each crane once they fledge. Several research projects involving satellite tracking have been conducted in the past; hopefully some will continue into the future to reveal information about recovering crane populations.

Northwest Institutions Aid in Recovery of the Western Pond Turtle

Anyone in rural areas of the eastern United States can attest to the choral thrumming of bullfrogs throughout the summer months. Unfortunately, this stately amphibian is a non-indigenous species in the Pacific Northwest, and as such it provides one of the greatest hurdles for reintroducing the vulnerable western pond turtle. The species declined precipitously in the early 1990s, when less than 200 Western pond turtles were estimated to exist in the wild at the Columbia Gorge in Washington State. This serious decline in population numbers was due to a respiratory disease that killed nearly a quarter of all breeding females.

The Western Pond Turtle Project was initiated in light of this crisis, and with financial assistance from sources such as AZA's Conservation Endowment Fund, it has significantly helped to increase the turtle population. The Oregon Zoo, Woodland Park Zoo, Bonneville Power Administration (BPA), Washington Department of Fish and Wildlife (WDFW), and U.S. Fish and Wildlife Service (USFWS) form the basis of collaborators who continue to support this recovery.

With summer just around the corner, scientists are preparing to release this year's brood of young turtles into the wild in late June. Adult female turtles are also counted and tracked with radio transmitters that help locate nest sites. The nests, which are deposited in the ground, are surrounded with wire netting for protection from predators. Once the hatchlings emerge in the fall, they're collected and transferred to the two zoos where they are allowed to get a "head start." They are raised at the zoos for about 10 months and fed throughout the winter, allowing them to reach the ideal size of 70 grams in time for an early summer release. This allows the turtles to evade the non-indigenous bullfrogs and fish that make an easy lunch of hatchlings. Current estimates are that close to 1,000 turtles are now living in the ponds of Washington State.

Submitted by Amanda Strandquist
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FOCUS ON NATURE ™

Insight into the lives of animals

No light, only total darkness. Therefore, no eyes or pigment in the skin. The translucent, 5-inch-long **TEXAS BLIND SALAMANDER** (*Typhlomolge rathbuni*) is gently suspended in the clear, subterranean streams of the Edwards Aquifer here in south-central Texas. Because the water supports his weight his legs are toothpick-thin. His fin-like tail helps with mobility around the limestone labyrinth. No sound. The only perceptible waves are caused by movement of aquatic invertebrates. When sensed, the salamander's flattened snout cuts through the water to find the prey. Red, feathery, larval gills adorning the sides of this adult salamander's neck oxygenate his blood. This species has made many remarkable adaptations over the millennia enabling it to occupy this ecological niche. Other troglodytic (cave-dwelling) species living here, along with the humans living above, need these clean, life-giving waters. *Artwork and text by Rochelle Mason* *www.rmasonfinearts.com*

Notes

Instructions to Authors

The Endangered Species UPDATE is committed to advancing science, policy, and interdisciplinary issues related to species conservation, with an emphasis on rare and declining species. The UPDATE is a forum for information exchange on species conservation, and includes a reprint of the U.S. Fish and Wildlife Service's Endangered Species Technical Bulletin, along with complementary articles relaying conservation efforts from outside the federal program.

The UPDATE welcomes articles related to species protection in a wide range of areas including, but not limited to:

-Research and management of rare and declining species;
-Theoretical approaches;
-Strategies for habitat protection and reserve design;
-Policy analyses and approaches to species conservation;
-Interdisciplinary issues;
-Emerging issues (e.g., wildlife disease ecology).

In addition, book reviews, editorial comments, and announcements of current events and publications are welcome.

Subscribers to the UPDATE are very knowledgeable about endangered species issues. The readership includes a broad range of professionals in both scientific and policy fields including corporations, zoos, and botanical gardens, university and private researchers. Articles should be written in a style that is readily understood but geared to a knowledgeable audience.

Acceptable Manuscripts

The Endangered Species UPDATE accepts several kinds of manuscripts:

1. Feature Article — on research, management activities and policy analyses for endangered species, theoretical approaches to species conservation, habitat protection, and interdisciplinary and emerging issues. Manuscripts should be approximately 3000 words (8 to 10 double spaced typed pages).

2. Opinion Article — concise and focused argument on a specific conservation issue; may be more speculative and less documented than a feature article. These are approximately 450-500 words (About 2 double spaced typed pages).

3. Technical Notes/Reports from the Field — ongoing research, application of conservation biology techniques, species conservation projects, etc., at the local, state, or national level. These are approximately 750 words (3 double spaced typed pages).

4. Species at Risk — profiles of rare and declining species, including the following information: taxonomy, distribution, physical characteristics, natural/life history, conservation status, and economic importance. These profiles are approximately 750-1500 words (3 to 6 double spaced typed pages).

5. Book Reviews — reviews should include such information as relevant context and audience, and analysis of content. Reviews are approximately 750-1250 words (3 to 5 double spaced typed pages). Please contact the editor before writing a book review.

6. Bulletin Board — submissions of news items that can be placed on the back page. These items can include meeting notices, book announcements, or legislative news, for example.

Manuscript Submissions and Specifications

Submit the manuscript to:
Editor, Endangered Species UPDATE
School of Natural Resources and Environment
University of Michigan
440 Church Street
Ann Arbor, MI 48109-1041

To submit your manuscript electronically, e-mail the manuscript as a Word file or rich formatted text (.rft) attachment to: esupdate@umich.edu.

Manuscripts should be typed, double-spaced, with ragged right margins to reduce the number of end of line hyphens. Print must be in upper- and lower-case letters and of typewriter quality. Metric measurements must be given unless English measurements are more appropriate, in which case metric equivalents must be given in parentheses. Statistical terms and other measures should conform to the Council of Biology Editors Style Manual. All pages should be numbered. Manuscripts must be in English.

Initial acceptance of a proposal or manuscript does not guarantee publication. After initial acceptance, authors and editors work closely on all revisions before a final proof is agreed upon.

Citations, Tables, Illustrations, and Photographs

Literature citations in the text should be as follows: (Buckley and Buckley 1980b; Pacey 1983). For abbreviations and details consult the Editor and recent issues of the Endangered Species UPDATE.

Illustrations and photographs may be submitted as electronic documents or as hard copies. If hard copies are submitted, the author's name and the figure number should be penciled on the back of every figure. Lettering should be uniform among figures. All illustrations and photos should be clear enough to be reduced 50 percent. Please note that the minimum acceptable resolution for all digital images is 300dpi.

Author credit instructions for each author of the article should accompany the manuscript.

Policy on Reviewing Proofs

Authors are asked to do the final copy editing of their articles. It is in the authors' power to save themselves and the journal the embarrassment of having to explain mistakes that could have been avoided.

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