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Reassessment of the conservation status of the Iberian lynx *Lynx pardinus* for the IUCN Red List of Threatened Species

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Abstract

During the last 70 years, the Iberian lynx *Lynx pardinus* has experienced dramatic changes in its environment, range size, and population size. In a context of widespread support for Iberian lynx conservation, its recent downgrading from Critically Endangered to Endangered in the IUCN Red List has drawn some public concern. Here we expand the summarized account published in the IUCN Red List website to illustrate how assessments are performed in well studied species. Assessment requires assignment to the highest threat category for which the species qualifies according to any of five criteria. Using 2012 as the reference year, no decline was observed during the last three lynx generations, and criteria regarding Population size reduction (A1, A2 and A4) were not met. Under criterion B (Geographic range) the species should be listed as Vulnerable. Considering Criterion D (Very small or restricted population), the Iberian lynx should be assigned to the Endangered category because in 2012 the estimated number of mature individuals (168) was under the established threshold of 250. A complex population model incorporating the combined effects of climate change, prey availability and conservation strategies reveals the critical need of maintaining current reintroduction efforts to avoid lynx extinction. If this condition is fulfilled, the species should be downgraded to Endangered under criterion E (Quantitative analysis). If reintroductions are discontinued, the category Endangered would be assigned under criteria A3 (Projected population reduction) and C (Small population and decline). We discuss the objectivity, transparency and conservation implications of the Iberian lynx downlisting.
Keywords: geographic range, population models, reintroduction, risk factors, sustained management

Resumen

Durante los últimos 70 años, las condiciones ambientales, el área de distribución y el tamaño poblacional del lince ibérico *Lynx pardinus* han experimentado cambios sustanciales. Vivimos un periodo en el que la conservación del lince recibe un fuerte apoyo social y, en este contexto, la reciente catalogación de la especie como En Peligro en la Lista Roja de la UICN, rebajando su anterior estatus de En Peligro Crítico, ha despertado cierta preocupación. Usando el caso del lince ibérico, ilustramos con detalle cómo se evalúa el grado de amenaza y se catalogan en la Lista Roja de la IUCN las especies para las que existe mucha información biológica. Las especies deben catalogarse en la categoría de amenaza más alta resultante de la valoración independiente de cinco criterios. Tomando 2012 como el año de referencia, no encontramos indicios de declive desde hace tres generaciones y, por tanto, los criterios de reducción de tamaño poblacional A1, A2 y A4 no se cumplen. Considerando el criterio B, relativo a atributos del área de distribución, la especie debe clasificarse como Vulnerable. Según el criterio D, relativo a poblaciones pequeñas y de distribución restringida, el lince entra en la categoría En Peligro porque el número estimado de individuos maduros en el año de referencia (168) es inferior al umbral establecido por este criterio (250). La dinámica poblacional predicha por un modelo que considera el efecto combinado del cambio climático, la disponibilidad de presas y las estrategias de conservación señala la necesidad de mantener los actuales esfuerzos de reintroducción para evitar la extinción del

lince en las décadas venideras. Si estos esfuerzos se mantienen, el nivel de amenaza puede rebajarse a En Peligro, según el criterio E, relativo al resultado de análisis cuantitativos. Si, por el contrario, las reintroducciones se suspenden, el lince no solo se mantendría como En Peligro Crítico según el criterio E, sino que también se asignaría a En Peligro según los criterios A3 (reducción poblacional esperada) y C (combinación de poblaciones pequeñas y declive poblacional). Discutimos brevemente la objetividad, la transparencia y las implicaciones de conservación del cambio de categoría de amenaza del lince ibérico.
Palabras clave: área de distribución, factores de riesgo, gestión sostenida, modelos poblacionales, reintroducción.

Introduction

Poorly known 50 years back, the Iberian lynx *Lynx pardinus* (Temminck, 1827) has turned into one of the most thoroughly studied felids (Ferreras *et al.* 2010). Following growing scientific knowledge, citizens and governments began to realize and be concerned about lynx progressive scarcity and its probable causes. As a result, this Iberian endemism has become a paradigm of threatened species. Compliance to environmental regulations and increasing social awareness have allowed the continuity of governmental management programmes for both wild and captive Iberian lynx populations (Vargas *et al.* 2009, Simón *et al.* 2012a), as well as non-governmental conservation initiatives (Zofío *et al.* 2003, Calzada *et al.* 2010, 2013).

Accumulated ecological knowledge also helps to explain the way the Iberian lynx has been considered in the successive IUCN lists of threatened taxa. The earliest Red Data Book compilation by Simon (1966) did not identify the Iberian lynx as one of the most endangered mammals despite it was placed in Category 1 –"very rare and believed to be decreasing in numbers"- and considered a subspecies (of the Eurasian lynx *Lynx lynx* L.) of special importance "giving cause for some anxiety". Between 1986 and 1996, successive releases of the IUCN Red List of Threatened Animals tagged the Iberian lynx as 'Endangered'. Only the 1996 release specified the cause as a rapid rate of decline (IUCN 1996). Nowell & Jackson (1996) compiled data on ecological traits and threats to assess the relative vulnerability of wild cat species across the world. Their classification system led them to declare the Iberian lynx as the sole felid species in the category requiring the highest priority for conservation, both globally and regionally. Nowell & Jackson's review seemed to be an influential landmark for the international recognition of the Iberian lynx conservation status. In 2000 the IUCN adopted a more objective system of categories and criteria (IUCN 2001) which became a new standard for global Red List assessments. The first application of this quantitative system led to the upgrading of the Iberian lynx to the highest extinction risk category, namely 'Critically Endangered' (IUCN 2002). The species was kept in the top class of threat until the 2008 revision (von Arx & Breitenmoser-Würsten 2008) but was down-listed to 'Endangered' in the most recent assessment (Rodríguez & Calzada 2015). This recent downgrading reflects a positive change in lynx population trends between 2002, when the most pessimistic account on lynx conservation status was dated (Guzmán *et al.* 2004), and 2012, when the rather optimistic report by Simón *et al.* (2012a) was published.

The process of taxa assessment for the IUCN Red List is long and subjected to multi-tier quality control (IUCN 2013). Outstanding features of the assessment process are 1) exhaustive compilation and subsequent analysis of all relevant data (Rodrigues *et al.* 2006), 2) collective task involving consultation within the body of the IUCN Species Survival Commission, external enquire, and review by independent experts, and 3) adherence to guidelines and standards (IUCN 2012) to produce assessments consistent across different potential drafters, as well as to improve objectivity and transparency (Mace *et al.* 2008). Despite this claim for transparency, published reports just summarize the extended rationale behind the assessment. Given the singularity of the Iberian lynx within the Iberian vertebrate fauna and the social interest it draws, our aim in this paper is providing a more detailed account of the evaluation that led to downgrading its threat category in the IUCN Red List.

Assessment

We evaluated the Iberian lynx status between February and April 2014, and the drafted assessment was submitted on 15 April 2014. Distribution maps were submitted in June 2014. Suggestions and comments from four reviewers and the coordinator of the IUCN Species Survival Commission Cats Red List Authority were received at four revision stages between June 2014 and February 2015. After a consistency check and final corrections, the final assessment was uploaded in March 2015 and published in the IUCN Red List website on 11 June 2015. This sequence gives a hint of how the assessment proceeds (IUCN 2012, 2013, IUCN Standards and Petitions Subcommittee 2014). During drafting, the latest data available for Iberian lynx distribution and numbers corresponded to 2012. Note that the way IUCN defines population departs from the biological concept: population refers to the overall number of individuals, and distinct, unconnected sets of individuals are called subpopulations (IUCN 2012).

Assessment involves the evaluation of five criteria (IUCN 2012). Next we provide a discussion of whether each criterion was met for the Critically Endangered category.

Criterion A. Population size reduction

Generation length in the Iberian lynx and period of assessment

For the IUCN Red List, generation length is defined as the average age of parents of cohorts. Under this definition generation length may vary across years and is unknown for nearly every population, so it must be estimated. We calculated generation length as the age of maturity plus half the length of the reproductive cycle (Nowell *et al.* 2007). Although sexual maturity could be reached the year before, we set the age of maturity at 3 years because this is the age at which successful reproduction begins in nearly all cases (Palomares *et al.* 2005). This value is consistent with the way adult individuals are defined by managers (Simón *et al.* 2012a). As the maximum recorded age of late breeding is 9 years (Palomares *et al.* 2005), the maximum length of the reproductive cycle for adult females is 6 years. Then generation length can be estimated as 6 years, three generations correspond to a period of 18 years, and the reference year for criteria A1 and A2 is 1996. Considering generation length, a potential population reduction in the past should be assessed during the period 1996-2014.

Population size

In or around 1996 no reliable estimate of population size was published for the entire Iberian lynx range, so we need to seek figures calculated earlier or later.

Population size before 1996

For the period 1978-1988, Rodríguez & Delibes (1992) produced an estimate of 350 breeding females in Spain, or about 700 mature individuals (within the interval 571-714 lynx). For the period 1984-1994, Castro & Palma (1996) estimated that no more than 50 lynx remained in Portugal which, assuming a proportion of females of 0.5 in the reproductive cohort (Ferreras *et al.* 1997), correspond to about 25 mature individuals. Overall, a total population of 725 mature lynx was assigned to 1985, because this year falls within the 5-yr overlapping period of data collection in the two studies, and because a distribution map was built for 1985 (Rodríguez & Delibes 2002).

Considering demographic trends only in the extant populations, in 1987 the size of the Doñana subpopulation was estimated to be 10-15 breeding females (Palomares et al. 1991), or 25 mature individuals. This is in agreement with 29 adults reported by Gaona et al. (1998) from field data in the mid 1990s. For the period 1978-1988, Rodríguez & Delibes (1992) estimated a population size of 372 lynx older than 1 year in the then large Andújar-Cardeña subpopulation. As the proportion of subadults was estimated as 35% (Rodríguez & Delibes 1992), the number of mature individuals could be 242 in 1985. By averaging across years and summing up the figures, in 1986 the estimated number of mature lynx in Doñana plus Andújar-Cardeña was 267.

Population size after 1996

The extensive survey by Guzmán *et al.* (2004) primarily during 2001 yielded an estimate of 26-31 breeding territories which could correspond with a maximum of 62 mature individuals.

As Iberian lynx populations became smaller, more accurate population estimates were attempted in the framework of the successive European Union LIFE Nature conservation projects from 2002 to present. According to these numbers, population size triplicated during an 11-year period, from 52 mature individuals in 2002 to 156 in 2012 (Table 1).

Population trends

If we use estimates of population size before 1996, the number of mature individuals in 2012 was 42% of that estimated for Doñana plus Andújar-Cardeña in the mid 1980s, and a 78% decline results when the whole population of the Iberian lynx was considered. If we use figures estimated 5 years after 1996, the number of mature individuals in 2012 were three times higher than that estimated in 2001-2002.

The question arises of what explains the highly contrasting numbers between 1985 and 2002. Several agents of decline might have been involved alone or in combination (Ferreras *et al.* 2010) but perhaps the most plausible explanation is the catastrophic and lasting effects of the rabbit haemorrhagic disease (RHD) which affects the European rabbit (*Oryctolagus cuniculus* L.), the prey on which the Iberian lynx is highly specialized (Ferreras *et al.* 2011). In 1989, RHD was introduced in the Iberian Peninsula and had immediate effects. The RHD virus suddenly killed up to 60% of wild rabbits in Doñana (Villafuerte *et al.* 1994) whereas rabbit densities dropped by a factor of 5.7 and were kept at these very low levels at least for the next 15 years (Moreno *et al.* 2007). As a result, some sites within the Doñana area had rabbit densities 100 times lower than those allowing lynx reproduction (López-Bao *et al.* 2008). Similar impacts of the RHD have been reported across the historic range of the Iberian lynx (Guzmán *et al.* 2004, Delibes-Mateos *et al.* 2008).

As RHD emergence in 1989 might have accelerated the decline of the Iberian lynx, population size in 1996 would resemble estimates for 2002 more than estimates for 1985. Therefore a positive population trend, presumably resulting in part from intensive management (Simón *et al.* 2012a, 2012b), might be plausible during the period considered for assessment of criteria A1 and A2.

Suspected population reduction in the future

The effects of persistent scarcity of rabbits are uncertain, especially if current intensive management (Simón *et al.* 2012a) is discontinued. Real *et al.* (2009) proposed an unexpected side-effect of RHD on Iberian lynx persistence prospects. Rabbits from the southwestern and the northeastern halves of the Iberian Peninsula belong to two divergent lineages with different evolutionary and demographic histories (Branco *et al.* 2000, Branco & Ferrand 2003). Lower environmental favourability for rabbits, as defined after the arrival of RHD, occurs in areas where the southwestern lineage predominates. This may be because both lineages evolved different habitat requirements, but it is equally possible that genetic differences involve differential vulnerability to diseases as the RHD, or to other environmental hazards. The Iberian lynx is confined to the region of the Iberian Peninsula where this potentially vulnerable lineage of rabbits prevails (Rodríguez & Delibes 2002, Real *et al.* 2009), and where intensive conservation management for the Iberian lynx was done and is planned for the future (Simón *et al.* 2012b, Iberlince LIFE Project 2014).

Lasting suboptimal environmental favourability can be endured by small primary consumers with high reproductive potential, as rabbits. The Iberian

Table 1. Estimated numbers of Iberian lynx breeding females and mature individuals, assuming breeding females are half the total number of breeding individuals. Sources: 2002-2010 (Simón *et al.* 2012a); 2011-2012 (Simón 2013). Breeding females are called territorial females in these sources.

	Breeding females			Mature individuals
Year	Andújar-Cardeña	Doñana	Total	
2002	17	9	26	52
2003	20	10	30	60
2004	22	14	36	72
2005	28	14	42	84
2006	32	11	43	86
2007	31	14	45	90
2008	38	17	55	110
2009	45	18	63	126
2010	48	20	68	136
2011	51	19	70	140
2012	53	25	78	156

lynx exhibit quite different life-history traits, which may not allow its persistence under sustained rabbit scarcity (Real *et al.* 2009). Unfortunately this potential threat could not be quantified.

Projection of population size in the absence of reintroductions

Demographic models incorporating prey dynamics as well as habitat structure and suitability under climate change predict a mean number of mature individuals in the range 36-76 for year 2032 (Fordham *et al.* 2013). As the estimated number of mature lynx in 2012 was 156 (Table 1), projections of the population model after three generations forecast a 51%-77% reduction of population size decrease under two scenarios of climate change (with or without mitigation of greenhouse-gas emissions) and in the absence of reintroductions. A reduction in population size up to 44% was predicted by the model even in the virtually impossible case that CO_2 concentrations in 2032 will be equal to those in 2000, highlighting the importance of reintroductions for the persistence of the Iberian lynx.

Assessing whether criterion A is met

No sign of population reduction was observed during most of the period 1996-2014. Rather a clear increasing trend in population size was observed. As past declines are a condition for criteria A1, A2 and A4 (IUCN 2012), we conclude these were not met by the Iberian lynx during the last 18 years.

However, whether criterion A3 (population reduction projected in the future up to 100 yr; IUCN 2012) is or is not met requires further discussion as a potentially severe population reduction is plausible within the next 18 years (3 generations) due to two facts:

a) The indirect negative effect of an introduced pathogen (the RHD virus, alone or in combination with unidentified factors) on environmental favorability for the rabbit lineage prevailing in SW Iberia (Real *et al.* 2009), and
b) A strict need for continued reintroductions in the mid- and long-term (Fordham *et al.* 2013).

Long-term financial support for continuing reintroduction is not guaranteed at present. Moreover, the conservative (extreme) value of 77% projected reduction in population size due to climate change in the absence of reintroductions is very close to, but does not reach, the threshold value that makes a species qualify as Critically Endangered (80%; IUCN 2012). In other words, even when the whole range of uncertainty in projections of population size was considered, criterion A3 was not met for the Critically Endangered category. However, a potential difference in habitat suitability for the two Iberian rabbit lineages (Real *et al.* 2009), and its response to climate change, was not explicitly considered by Fordham *et al.* (2013). In the absence of definitive proof, we consider plausible that the 80% threshold might be exceeded if the potential effect of the environmental vulnerability of the southwestern rabbit lineage could be modeled and quantified.

Adopting a strict precautionary attitude (zero risk tolerance) we would conclude that criteria A3b and A3e are met for the Critically Endangered category of threat. This conclusion would be reached on the basis of an extreme value of projected population reduction plus added uncertainty about non-quantified vulnerability of one rabbit lineage, which for now is just a hypothesis. However, adopting the precautionary but realistic attitude recommended by the IUCN Standards and Petitions Subcommittee (2014; risk tolerance in the range 0.40-0.49), we conclude that under criterion A the Iberian lynx should be downgraded to Endangered.

Criterion B. Geographic range

Extent of occurrence

In 2012, the extent of occurrence (EOO) of the Iberian lynx, computed as the minimum convex polygon encompassing all population nuclei in the estimated distribution map prepared by Rodríguez & Calzada (2015), was 15595 km^2.

Area of occupancy

In 2012, the estimated area of occupancy (AOO) of the Iberian lynx, measured as the number of occupied cells on a 1-km grid (Simón *et al.* 2012a), was 1040 km^2 (Table 2).

Number of localities and fragmentation

Around 1985, 48 distinct distribution nuclei were identified by Rodríguez & Delibes (1992) in Spain, 44% of which occupied areas <100 km^2. Castro & Palma (1996) identified 7 nuclei and the largest one extended over 127 km^2. In Spain, area measurements were carried out on high-resolution vectorial distribution maps (approximate horizontal accuracy of 200 m; scale 1:50000; Rodríguez & Delibes 1990). In 2001, Guzmán *et al.* (2004) found only two subpopulations. Since 2002 these two subpopulations have persisted, and two new nuclei are being founded through reintroduction (Table 2; Simón *et al.* 2012a, Simón 2013).

In 2012, the Doñana subpopulation occupied 56% of the total AOO (Table 2), and its estimated population size was <100 individuals (Table 1), which is the threshold below which subpopulations are not considered fully self-sustained (IUCN Standards and Petitions Subcommittee 2014). Moreover, available evidence indicates that the two remnant populations were demographically isolated because the Euclidean distance between them was >200 km, and the functional distance for dispersal was even larger due to tracts of unsuitable intervening habitat (Rodríguez & Delibes 1992). Such separation is at least five times the maximum successful dispersal distance (Ferreras *et al.* 2004) and, indeed, no individual born in one subpopulation has been reported to settle into the other by natural means. A marked genetic differentiation further supports demographic isolation between both subpopulations for at least ten generations (Casas-Marcé *et al.* 2013). As >50% of total AOO is placed in a single isolated locality that might not support a viable population, the geographic range of the Iberian lynx can be considered as severely fragmented (IUCN Standards and Petitions Subcommittee 2014).

Trends in range size

Between 1985 and 2001 the geographic range of the Iberian lynx shrank by 91% (Rodríguez & Delibes 2002, Guzmán *et al.* 2004, Palomares *et al.* 2011a). Between 2001 and 2012, the lynx range apparently decreased a further 53%, but this decreasing trend could be artifactual, as the spatial resolution of AOO in 2012 (units of 1 km^2; Simón *et al.* 2012a) was 10 times larger than that of AOO in 2001 (units of 10 km^2; Guzmán *et al.* 2004). Since 2002, a three-fold increase in range size (Table 2) has paralleled the steady expansion of Iberian lynx populations (Table 1).

Assessing whether criterion B is met

Criterion B1 is not met for the IUCN Critically Endangered and Endangered categories because the estimated EOO of the Iberian lynx in 2012 was larger than 100 km^2 and 5000 km^2, respectively. However, as the estimated size of EOO was <20000 km^2, the species qualifies as Vulnerable under criterion B1 (IUCN 2012).

Criterion B2 is not met for the categories

Table 2. Annual estimates of the size of the Iberian lynx area of occupancy (AOO). Sources: 2002-2010 (Simón *et al.* 2012a); 2011-2012 (Simón 2013). For Doñana, figures of both sources are quite different and we report here those given in the most recent publication (Simón 2013). AOO size in 2012 also includes the size of areas used by lynx in reintroduction sites (Simón 2013).

	Area of occupancy (km^2)			Reintroduction areas	
Year	Andújar-Cardeña	Doñana	Total	Guadalmellato	Guarrizas
2002	125				
2003	135				
2004	153	174	327		
2005	204	245	449		
2006	203	307	510		
2007	221	249	470		
2008	224	335	559		
2009	236	412	648		
2010	264	445	709		
2011	282	591	873		
2012	339	580	1040	61	60

Critically Endangered or Endangered because the estimated AOO of the Iberian lynx in 2012 (1040 km^2) was larger than 10 km^2 and 500 km^2, respectively (IUCN 2012). Criterion B2 is not fulfilled for the category Vulnerable either because, although its AOO was less than 2000 km^2, the population was severely fragmented and there were less than 10 subpopulations, a decline or extreme fluctuations in the range size or in the number of mature individuals were not observed (see the assessments of criteria A and C).

Criterion C. Small population size and decline

Number of mature individuals

In 2012, the number of mature individuals was 156 (Simón 2013). If estimates of the number of mature individuals in the reintroduced populations (Simón 2013) were also considered as twice the number of territorial females (potential breeders), then the figure in 2012 would be 168 mature lynx.

An observed, estimated or projected continuing decline of mature individuals in one, two or three generations

No sign of decline has been observed or estimated since 2002. However, a potential decline could occur during the next three generations if current intensive management and reintroductions are discontinued and, at the same time, the potential vulnerability of the southwestern lineage of rabbits in the Iberia peninsula is expressed as a generalized and lasting scarcity of prey, similar to that observed after the emergence of RHD (Guzmán *et al.* 2004, Real *et al.* 2009; Fordham *et al.* 2013; see above). Specifically, in the absence of reintroductions and under optimistic scenarios of climate change, the expected decline in the number of mature individuals in three generations ranges between 51% and 77% (see the assessments for criteria A and E). Assuming that the projected decline is linear, in one generation population loss would be in the range 17%-25%, whereas in two generations it would fall in the range 34%-52%.

Number of mature individuals in each population

In 2012 the estimated number of mature individuals in the Andújar-Cardeña population was 106, whereas 50 were estimated to live in the Doñana population.

Percent of mature individuals in one population

In 2012, the percentage of mature individuals in Andújar-Cardeña and Doñana populations was 68% and 32%, respectively.

Extreme fluctuations in the number of mature individuals

Data shown in Table 1 suggest smooth inter-annual variation in the number of mature individuals. However, episodes of larger variation in the number of mature animals have been reported in the Iberian lynx. In 2007, an outbreak of feline leukaemia virus (FeLV) infected 12 individuals and killed four of them (all adult territorial males) in less than six months (López *et al.* 2009, Palomares *et al.* 2011b). Between 2006 and 2007, 13 territorial females were established in the Doñana population (Palomares *et al.* 2011b). For simplicity and consistency with previous estimates in the present report, we estimate the number of mature lynx at that time as twice the number of adult females holding a territory. Therefore, 46% of 26 mature lynx were infected and 15% died. The most important source in the Doñana lynx metapopulation (called 'Coto del Rey'; Gaona *et al.* 1998) suddenly remained without adult males during a period of apparent shortage of male floaters. A single translocated male mated with all adult females soon after release, and sired several litters during the next years (more details available at www.lifelince.org). Without close monitoring (Palomares *et al.* 2011b) and intervention (López *et al.* 2009) the outbreak could have spread across the entire population with catastrophic consequences.
This event illustrates the potential for small lynx populations, such as the one inhabiting Doñana, to experience large fluctuations in the number of mature individuals. However, even larger fluctuations, varying in one order of magnitude, are needed to satisfy condition C2b (IUCN Standards and Petitions Subcommittee 2014).

Assessing whether criterion C is met

In 2012 the overall number of mature individuals in persisting and reintroduced populations (168) was below the threshold established to qualify as Critically Endangered (250 individuals) if conditions C1 or C2 concur. As an increasing population trend was observed in the recent past, condition C1 would hold only if reintroduction programmes were discontinued and if the rate of decline as a consequence of climate change were linear. Under these circumstances, criterion C1 for the category Endangered (20% decline in two generations) would be met, but it would not for the category Critically Endangered (25% decline in one generation). As the risk remains for a new catastrophic decline in southern Iberia as a result of the regional dynamics of rabbit populations, C2 could be met provided that further conditions are also satisfied. Condition C2a(i) satisfies the threshold of category Endangered as both subpopulations hold less than 250 mature individuals, but it does not the category Critically Endangered where the threshold is set to 50 mature individuals. Condition C2a(ii) is not met, as no population contains 90% of total numbers. Condition C2b is not satisfied because extreme fluctuations are not observed. Therefore, under Criterion C the Iberian lynx could be listed as Endangered contingent on the abandonment of ongoing intensive reintroduction programmes.

Criterion D. Very small or restricted population

Assessing whether criterion D is met

In 2012, the estimated number of mature individuals was 168 (see section Criterion C). Criterion D satisfies the threshold of category Endangered because the number of mature individuals is less than 250. Under this criterion the Iberian lynx could not remain in the category Critically Endangered where the number of mature individuals should not exceed 50.

Criterion E. Quantitative analysis

A recent model comprehensively examines Iberian lynx population dynamics projected throughout the 21st century (Fordham *et al.* 2013). Coupled niche-population models are used to describe the dynamics of the Iberian lynx geographic range and populations as a function of the combined effects of climate change, prey availability and strategies of conservation management. This study also provides quantitative estimates of extinction risk. Modelling builds on the availability of a large body of empirical studies on lynx behavior, demography, and interactions with other species (reviewed by Ferreras *et al.* 2010). The model is highly realistic as it incorporates both the best estimates of demographic parameters and advanced knowledge about the processes driving population dynamics. Forecasts of abundance, number of populations, placement of populations and extinction probability are produced on a yearly basis for the period 2015-2090.

The main elements of the model are climate, predator-prey dynamics, distribution, ecological niche models, habitat suitability, demographic metapopulation models, climate change, management strategies, and estimates of extinction risk. Distribution, niche, habitat and demography were modeled separately for lynx and rabbits. The scenarios of climate change considered by Fordham *et al.* (2013) were defined as a) No climate change, b) Reference (CO_2 emissions stabilized at a concentration of 750 ppm), and c) Policy (CO_2 emissions stabilized at 450 ppm after substantial reduction). Among the conservation strategies defined by Fordham *et al.* (2013) we considered a) Geopolitical (reintroductions within the range occupied by the Iberian lynx during the 20th century), and b) Peninsula-wide (reintroductions in the best habitat patches, inside or outside the recent geographic range).

Expected trajectories of population size and extinction risk (Fordham *et al.* 2013) were used to calculate values for year 2032, corresponding to the length of three Iberian lynx generations, or 18 years from 2014, as required by criterion D (IUCN 2012).

Projection of population size in the absence of reintroductions

Mean estimates of population size in 2032 (5th and 95th percentiles of population size in brackets) under three scenarios of climate change are as follows (Fordham *et al.* 2013):

No climate change: 225 Iberian lynx (175-271)
Reference: 115 Iberian lynx (88-151)
Policy: 89 Iberian lynx (71-125)

As the number of territorial females is approximately 25% of total population size (Table 5 in Simón *et al.* 2012a), and in this report we estimate the number of mature lynx as twice the number of breeding females, in 2032 the estimated mean number of mature lynx would be:

No climate change: 112 mature individuals (88-136)
Reference: 58 mature individuals (44-76)
Policy: 46 mature individuals (36-63)

Projection of population size and number of subpopulations if continued reintroductions are implemented

In 2032, assuming strong mitigation of greenhouse-gas emissions (Policy scenario), the mean estimates of population size (5th and 95th percentiles of population size in brackets) under two scenarios of conservation management are as follows (Fordham *et al.* 2013):

Geopolitical: 173 Iberian lynx (139-230)
Peninsula-wide: 189 Iberian lynx (153-249)

And the mean estimates of the number of subpopulations (5th and 95th percentiles of number of populations in brackets) in 2032 are:

Geopolitical: 9 subpopulations (2-4)
Peninsula-wide: 10 subpopulations (8-15)

These projections were generated assuming (i) the release of 3 females and 3 males (aged between 1-4 years) each year for 3 years in each newly founded subpopulation, (ii) temporal stability in carrying capacity, and (iii) a similar survival rate of captive-born lynx and their wild conspecifics. Whether these assumptions will hold until 2032 is highly uncertain.

Probability of extinction in the wild

In the absence of reintroductions, Fordham *et al.* (2013) predicted that the Iberian lynx will go extinct in 2050, and the probability of extinction in 2032 (within 3 generations) will be larger than 0.5. However, since 2009 reintroductions are carried out in a way that closely resembles the procedures assumed by Fordham *et al.* (2013): six adult individuals with a sex ratio of 0.5 released each of three successive years in the reintroduction site (Simón *et al.* 2012a).

Regardless mitigation of climate change, keeping on reintroducing lynx until 2032 is predicted to ensure population size to grow at least until 2050, and the probability of extinction by the end of the 21st century is less than 0.05 (Fordham *et al.* 2013). In the absence of reintroductions, despite intensive habitat management is performed, the probability of extinction in 2090 will rise to 0.86-1.00 (Fordham *et al.* 2013).

Assessing whether criterion E is met

According to the quantitative analysis by Fordham *et al.* (2013), the role of reintroductions is crucial to forecast the conservation prospects of the Iberian lynx during the coming decades. Continued reintroductions seem to be required to cope with the adverse effects of climate change.

Although continued funding of an increasing number of reintroductions in the next 30 years is not secured, it does for at least the next few years (Simón *et al.* 2012b) when a new assessment of the Iberian lynx status will be performed. If we assume that reintroductions will go on indefinitely, then the probability of extinction of the Iberian lynx in the wild will be under 0.1 in about 100 years, and the species should not be considered as threatened. Perhaps more realistically, we assume that reintroductions will last only until the end of 2017, where funding for conservation projects has been granted. The probability of extinction may decrease until then but is expected to increase later if no new introductions are undertaken. Under this scenario, and based on model predictions (Fordham *et al.* 2013), we estimate that the probability of extinction might be somewhat larger than 0.2 in 18 years or three generations. As this probability should exceed 0.5 for the Iberian lynx to stay in the category Critically Endangered, under criterion E the Iberian lynx should be down-listed to Endangered provided that reintroduction will continue in the mid-term.

Conclusion

The Iberian lynx does not meet any of the criteria (A to E) to be classified in the category Critically Endangered (CR). The species, however, fully complies with criterion D to be classified as Endangered (EN). Likewise, it could meet criteria A3, C1 and E to be classified as Endangered only if the current scenario shifts during the coming years, specifically if a decline ensues the suspension of reintroduction programs or a further marked and lasting drop of rabbit numbers in southwestern Iberia. The species also meets criterion B1 to be classified as Vulnerable (VU). In summary, we conclude that the Iberian lynx should be classified as Endangered (EN D) in the IUCN Red List.

Discussion

Once the rationale behind the application of quantitative criteria has been presented, here we briefly expand the discussion with a couple of remarks about the objectivity and potential repercussions of the reassessment.

Categories of the IUCN Red List and criteria have been refined so that little room is left for subjective decisions when the required data is available (Rodrigues *et al.* 2006, Mace *et al.* 2008, IUCN 2012). The judgment of assessors in determining a threat category may play a more important role for species where only scarce, semi-quantitative and fragmentary information can be gathered (e.g. Wilting *et al.* 2015). The wealth of data collected for the Iberian lynx allows unequivocal assignment.

This is not to say that uncertainty can be completely removed. Major sources of uncertainty have been explicitly addressed in the above discussion. Other sources of uncertainty have been considered without explicit mention because they would affect little the final decision. For example, population decline would be a necessary condition to keep the species under the Critically Endangered category. Population sizes summarized in Table 1 have been derived from inconsistent sampling effort and different protocols over the years, and confidence intervals for the estimates have not been reported (Simón *et al.* 2012a). These methodological issues are far from unimportant as they increase uncertainty about the actual population trends. However, after close examination, we considered that the bias inconsistent measurements introduced in the estimates would not be large enough to hide a decline behind an apparent population increase.

Objectivity in category assignment was originally considered as equivalent to scientific rigour (Mace & Lande 1991). Consequently, efforts have been made to improve objectivity in the assessments. For example, methods have been devised to homogenize the attitudes that the assessors of the status of different species have towards uncertainty in the data (Akçakaya *et al.* 2000). However, subjective appreciations tend to persist, and our published assessment on the Iberian lynx is not completely free of them. In the assessment information section one can read "The improved status of this species is all due to intensive ongoing conservation actions" (Rodríguez & Calzada 2015). This statement cannot be defended for two reasons: formal scientific monitoring of conservation measures has been scarce (Rodríguez *et al.* 2012) and, in the absence of experimental evidence, causality cannot be formally attributed to any association between specific conservation measures and lynx response. As a disclaimer, that sentence was introduced after we submitted the final version and the text was under the only control of the Cat Red List Authority.

One of the aims of the IUCN Red List Categories and Criteria is to help users to understand how individual species were classified (IUCN 2012). Worries have been expressed that the down-listing of the Iberian lynx might have been premature. However, down-listing does not mean that the species is not threatened anymore; it simply means that seven years ago the Iberian lynx was closer to imminent extinction than it is today. Our assessment explicitly takes into account the demographic instability of both natural and newly founded populations through assisted colonization. As a matter of fact, we highlight the complete dependence of the Iberian lynx upon sustained intensive management (i.e. reintroduction). It follows that investment in conservation management should be maintained, if not increased.

The IUCN Red List seems to have some influence at high levels of political decision making. The IUCN Red List system has at least two tools to counteract the socio-political effects of potentially ephemeral or transitory improvements in the status of a species. One is the petition against the listing of any taxon, and the other is the frequency of assessments, which should be performed at least every 10 years, and preferably every 5 years (IUCN 2013). In the undesirable case that population trends of the Iberian lynx would revert again, the next reassessment would take into account that novelty.

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References

Akçakaya H.R., Ferson S., Burgman M.A., Keith D.A., Mace G.M. & Todd C.R. 2000. Making consistent IUCN classifications under uncertainty. *Conservation Biology*, 14: 1001-1013. doi:10.1046/j.1523-1739.2000.99125.x

Branco M. & Ferrand N. 2003. Biochemical and population genetics of the rabbit, *Oryctolagus cuniculus*, carbonic anhydrases I and II, from the Iberian Peninsula and France. *Biochemical Genetics*, 41: 391–404. doi:10.1023/B:BIGI.0000007774.39262.8e

Branco M., Ferrand N. & Monnerot M. 2000. Phylogeography of the European rabbit (*Oryctolagus cuniculus*) in the Iberian Peninsula inferred from RFLP analysis of the cytochrome b gene. *Heredity*, 85: 307–317. doi:10.1046/j.1365-2540.2000.00756.x

Calzada J., Matutano J. & Sabater A. 2013. *Ideas para conservar el lince ibérico*. SECEM, Málaga. 127 pp.

Calzada J., Mora-Ruiz M., Giles-Carnero R. & Márquez-Ruiz C. 2010. *Lince ibérico: aspectos jurídicos para la conservación de esta especie*. SECEM, Málaga. 190 pp.

Casas-Marcé M., Soriano L., López-Bao J.V. & Godoy J.A. 2013. Genetics at the verge of extinction: insights from the Iberian lynx. *Molecular Ecology*, 22: 5503-5515. doi:10.1111/mec.12498

Castro L.R. & Palma L. 1996. The current status, distribution and conservation of Iberian lynx in Portugal. *Journal of Wildlife Research*, 1: 179-181.

Ceia H., Castro L., Fernandes M. & Abreu P. 1998. *Lince-ibérico em Portugal. Bases para a sua conservação. Relatório final do projecto "Conservação do lince-ibérico"*. Technical report. Instituto da Conservação da Natureza, Lisbon.

Delibes-Mateos M., Ferreras P. & Villafuerte R. 2008. Rabbit populations and game management: the situation after 15 years of rabbit haemorrhagic disease in central-southern Spain. *Biodiversity and Conservation*, 17: 559-574. doi:10.1007/s10531-007-9272-5

Ferreras P., Beltrán J.F., Aldama J.J. & Delibes M. 1997. Spatial organization and land tenure system of the endangered Iberian lynx (*Lynx pardinus*). *Journal of Zoology*, 243: 163-189.

Ferreras P., Delibes M., Palomares F., Fedriani J.M., Calzada J. & Revilla E. 2004. Proximate and ultimate causes of dispersal in the Iberian lynx *Lynx pardinus*. *Behavioral Ecology*, 15: 31-40. doi:10.1093/beheco/arg097

Ferreras P., Rodríguez A., Palomares F. & Delibes M. 2010. Iberian lynx: the difficult recovery of a critically endangered cat. Pp. 507-520. In: D.W. Macdonald & A.J. Loveridge (eds.). *Biology and Conservation of Wild Felids*. Oxford University Press, Oxford.

Ferreras P., Travaini A., Zapata S.C. & Delibes M. 2011. Short-term responses of mammalian carnivores to a sudden collapse of rabbits in Mediterranean Spain. *Basic and Applied Ecology*, 12: 116-124. doi:10.1016/j.baae.2011.01.005

Fordham D.A., Akçakaya H.R., Brook B.W., Rodríguez A., Alves P.C., Civantos E., Triviño M., Watts M.J. & Araújo M.B. 2013. Adapted conservation measures are required to save the Iberian lynx in a changing climate. *Nature Climate Change*, 3: 899-903. doi:10.1038/NCLIMATE1954

Gaona P., Ferreras P. & Delibes M. 1998. Dynamics and viability of a metapopulation of the endangered Iberian lynx (*Lynx pardinus*). *Ecological Monographs*, 68: 349-370. doi:10.1890/0012-9615(1998)068[0349:DAVOAM]2.0.CO;2

Guzmán J.N., García F.J., Garrote G., Pérez de Ayala R. & Iglesias C. 2004. *El lince ibérico* (Lynx pardinus) *en España y Portugal. Censo-diagnóstico de sus poblaciones*. Dirección General para la Biodiversidad, Madrid. 264 pp.

Iberlince LIFE Project. 2014. Life+ Iberlince website. <www.iberlince.eu>. Accessed on 28 June 2014.

IUCN. 1996. *1996 IUCN Red List of Threatened Animals*. IUCN, Gland.

IUCN. 2001. *IUCN Red List Categories and Criteria: version 3.1*. IUCN, Gland.

IUCN. 2002. 2002 IUCN Red List of Threatened Species. <www.iucnredlist.org>. Accessed on 1 March 2005.

IUCN. 2012. *IUCN Red List Categories and Criteria: Version 3.1. Second edition*. IUCN, Gland and Cambridge.

IUCN. 2013. Rules of Procedure: IUCN Red List assessment process 2013-2016 (version 2.0). <www.iucnredlist.org>. Accessed on 9 October 2016.

IUCN Standards and Petitions Subcommittee. 2014. *Guidelines for Using the IUCN Red List Categories and Criteria. Version 11*. IUCN Standards and Petitions Subcommittee, Gland.

López G., López-Parra M., Fernández L., Martínez-Granados C., Martínez F., Meli M.L., Gil-Sánchez J.M., Viqueira N., Díaz-Portero M.A., Cadenas R., Lutz H., Vargas A. & Simón M.A. 2009. Management measures to control a feline leukemia virus outbreak in the endangered Iberian lynx. *Animal Conservation*, 12: 173-182. doi:10.1111/j.1469-1795.2009.00241.x

López-Bao J.V., Rodríguez A. & Palomares F. 2008. Behavioural response of a trophic specialist, the Iberian lynx, to supplementary food: patterns of food use and implications for conservation. *Biological Conservation*, 141: 1857-1867. doi:10.1016/j.biocon.2008.05.002

Mace G.M., Collar N.J., Gaston K.J., Hilton-Taylor C., Akçakaya H.R., Leader-Williams N., Milner-Gulland E.J. & Stuart S.N. 2008. Quantification of extinction risk: IUCN›s system for classifying threatened species. *Conservation Biology*, 22: 1424-1442. doi:10.1111/j.1523-1739.2008.01044.x

Mace G.M. & Lande R. 1991. Assessing extinction threats: Toward a reevaluation of IUCN threatened species categories. *Conservation Biology*, 5: 148-157. doi: 10.1111/j.1523-1739.1991.tb00119.x

Moreno S., Beltrán J.F., Cotilla I., Kuffner B., Laffite R., Jordán G., Ayala J., Quintero C., Jiménez A., Castro F., Cabezas S. & Villafuerte R. 2007. Long-term decline of the European wild rabbit (*Oryctolagus cuniculus*) in south-western Spain. *Wildlife Research*, 34: 652-658. doi:10.1071/WR06142

Nowell K. & Jackson P. 1996. *Wild cats: Status survey and conservation action plan*. IUCN, Gland.

Nowell K., Schipper J. & Hoffmann M. 2007. Re-evaluation of the *Felidae* for the 2008 IUCN Red List. *Cat News*, 47: 5.

Palma L.A. 1980. Sobre distribuçao, ecologia y conservaçao do lince iberico em Portugal. Pp. 569-

586. In: Actas I Reunión Iberoamericana de Zoología de Vertebrados. Ministerio de Universidades e Investigación, Sevilla.

Palomares F., López-Bao J.V. & Rodríguez A. 2011b. Feline leukaemia virus outbreak in the endangered Iberian lynx and the role of feeding stations: a cautionary tale. *Animal Conservation*, 14: 242-245. doi:10.1111/j.1469-1795.2010.00403.x

Palomares F., Revilla E., Calzada J., Fernández N. & Delibes M. 2005. Reproduction and pre-dispersal survival of Iberian lynx in a subpopulation of the Doñana National Park. *Biological Conservation*, 122: 53-59. doi:10.1016/j.biocon.2004.06.020

Palomares F., Rodríguez A., Laffitte R. & Delibes M. 1991. The status and distribution of the Iberian lynx *Felis pardina* (Temminck) in Coto Doñana area, SW Spain. *Biological Conservation*, 57: 159–169. doi:10.1016/0006-3207(91)90136-W

Palomares F., Rodríguez A., Revilla E., López-Bao J.V. & Calzada J. 2011a. Assessment of the conservation efforts to prevent extinction of the Iberian lynx. *Conservation Biology*, 25: 4-8. doi: 10.1111/j.1523-1739.2010.01607.x

Real R., Barbosa A.M., Rodríguez A., García F.J., Vargas J.M., Palomo L.J. & Delibes M. 2009. Conservation biogeography of ecologically-interacting species: the case of the Iberian lynx and the European rabbit. *Diversity and Distributions*, 15: 390-400. doi:10.1111/j.1472-4642.2008.00546.x

Rodrigues A.S.L., Pilgrim J.D., Lamoreux J.F., Hoffmann M. & Brooks T.M. 2006. The value of the IUCN Red List for conservation. *Trends in Ecology and Evolution*, 21: 71-76. doi:10.1016/j.tree.2005.10.010

Rodríguez A. & Calzada J. 2015. *Lynx pardinus*. The IUCN Red List of Threatened Species 2015: e.T12520A50655794. doi:10.2305/IUCN.UK.2015-2.RLTS.T12520A50655794.en

Rodríguez A., Calzada J., Revilla E., López-Bao J.V. & Palomares F. 2012. Bringing science back to the conservation of the Iberian lynx. *Conservation Biology*, 26:737-739.doi:10.1111/j.1523-1739.2012.01872.x

Rodríguez A. & Delibes M. 1990. *El lince Ibérico (*Lynx pardina*) en España. Distribución y problemas de conservación*. Instituto Nacional para la Conservación de la Naturaleza, Madrid. 116 pp.

Rodríguez A. & Delibes M. 1992. Current range and status of the Iberian lynx *Felis pardina* Temminck, 1824 in Spain. *Biological Conservation*, 61: 189-196. doi:10.1016/0006-3207(92)91115-9

Rodríguez A. & Delibes M. 2002. Internal structure and patterns of contraction in the geographic range of the Iberian lynx. *Ecography*, 25: 314-328. doi:10.1034/j.1600-0587.2002.250308.x

Simón M.A. 2013. Censo de las poblaciones andaluzas de lince ibérico, año 2012. <www.iberlince.eu>. Accessed on 28 June 2014.

Simón M., Arenas R., Báñez J.A., Bueno J.F., Cadenas de Llanos R., de Lillo S., *et al.* 2012a. *Ten years conserving the Iberian lynx*. Consejería de Agricultura, Pesca y Medio Ambiente de la Junta de Andalucía, Sevilla.

Simón M., Gil-Sánchez J.M., Ruiz G., Garrote G., McCain E.B., Fernández L., *et al.* 2012b. Reverse of the decline of the endangered Iberian lynx. *Conservation Biology*, 26: 731-736. doi: 10.1111/j.1523-1739.2012.01871.x

Simon N. 1966. *Red data book. Volume 1 – Mammalia*. IUCN, Morges.

Vargas A., Breitenmoser C. & Breitenmoser U. (eds) 2009. *Iberian Lynx ex-situ conservation: An interdisciplinary approach*. Fundación Biodiversidad, Madrid.

Villafuerte R., Calvete C., Gortázar C. & Moreno S. 1994. First epizootic of rabbit hemorrhagic disease in free-living populations of *Oryctolagus cuniculus* at Donana National Park, Spain. *Journal of Wildlife Diseases*, 30: 176-179.

von Arx M. & Breitenmoser-Würsten C. 2008. *Lynx pardinus*. IUCN Red List of Threatened Species. Version 2010.2. <www.iucnredlist.org>. Accessed on 10 August 2010.

Wilting A., Brodie J., Cheyne S., Hearn A., Lynam A., Mathai J., McCarthy J., Meijaard E., Mohamed A., Ross J., Sunarto S. & Traeholt C. 2015. *Prionailurus planiceps*. The IUCN Red List of Threatened Species 2015: e.T18148A50662095. doi:10.2305/IUCN.UK.2015-2.RLTS.T18148A50662095.en

Zofío J.B., Cobo J. & Vega I. 2003. *El lince Ibérico.* Único *en el mundo*. WWF-ADENA, Madrid.

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