Distribution of large carnivores in Europe 2012 - 2016: Distribution map for Golden Jackal (*Canis aureus*)

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Abstract
Regular assessments of species' status are an essential component of conservation planning and adaptive management. They allow the progress of past or ongoing conservation actions to be evaluated and can be used to redirect and prioritize future conservation actions. Most countries perform periodic assessments for their own national adaptive management procedures or national red lists. Furthermore, the countries of the European Union have to report on the status of all species listed on the directives of the Habitats Directive every 6 years as part of their obligations under Article 17. However, these national level assessments are often made using non-standardized procedures and do not always adequately reflect the biological units (i.e., the populations) which are needed for ecologically meaningful assessments.

Since the early 2000's the Large Carnivore Initiative for Europe (a Specialist Group of the IUCN's Species Survival Commission) has been coordinating periodic surveys of the status of large carnivores across Europe (e.g., von Arx et al. 2004; Salvatori & Linnell 2005, Kaczensky et al. 2013). These have covered the Eurasian lynx (*Lynx lynx*), the wolf (*Canis lupus*), the brown bear (*Ursus arctos*) and the wolverine (*Gulo gulo*). The golden jackal (*Canis aureus*) has been added to the LCIE prerogatives in 2014. The species is rapidly expanding in Europe (Trouwborst

et al. 2015; Männil & Ranc 2022), a large-scale phenomenon that resembles that of the other large carnivores. Golden jackals are thriving in human-dominated landscapes (Ćirović *et al.* 2016; Lanszki *et al.* 2018; Fenton *et al.* 2021), where they are often functioning as the top predators, despite having smaller body size that is typical for large carnivores. The expansion of the species triggers many questions among scientists, stakeholders, and policy makers (Trouwborst *et al.* 2015; Hatlauf *et al.* 2021), that are closely connected to those raised by the other large carnivores (e.g., potential conflicts with livestock or hunting). In this context, monitoring the species' expansion, delineating populations, assessing the species' legal and protection status, and addressing the concerns raised by this rapidly expanding carnivore requires a high level of coordination among regional experts.

These surveys involve the contributions of the best available experts and sources of information. While the underlying data quality and field methodology varies widely across Europe, these coordinated assessments do their best to integrate the diverse data in a comparable manner and make the differences transparent. They also endeavor to conduct the assessments on the most important scales. This includes the continental scale (all countries except for Russia, Belarus, Moldova and the parts of Ukraine outside the Carpathian Mountain range), the scale of the EU 28 (where the Habitats Directive operates) and of the biological populations which reflect the scale at which ecological processes occur (Linnell et al. 2008). In this way, the independent LCIE assessments provide a valuable complement to the ongoing national processes.

Our last assessments covered the period 2006-2011 (Kaczensky et al. 2013; Chapron et al. 2014) but, at the time, did not include golden jackals. The current assessment is based on the period 2012-2016 and broadly follows the same methodology. Explicit distinctions are made between classification based on empirical data and expert opinion. The population definitions used in this report follow those proposed in (Ranc *et al.* 2018); areas whose presence category was defined by expert opinion were not assigned to a specific population, though.

Methods

The mapping approach follows the methods described in Chapron et al. (2014) and Kaczensky et al. (2013). It updates the published Species Online Layers (SPOIS) to the period 2012-2016.

In short, large carnivore presence was mapped at a 10x10 km ETRS89-LAEA Europe grid scale. This grid is widely used for the Flora-Fauna-Habitat reporting by the European Union (EU) and can be downloaded at: http://www.eea.europa.eu/data-and-maps/data/eea-reference-grids-2

The map encompasses the EU countries plus the non-EU Balkan states, Switzerland, Norway, and the Carpathian region of Ukraine. Presence in a grid cell was ideally mapped based on carnivore presence and frequency in a cell resulting in:

1 = Permanent (presence confirmed in >= 3 years in the last 5 years OR in >50% of the time OR reproduction confirmed within the last 3 years)
3 = Sporadic (highly fluctuating presence) (presence confirmed in <3 years in the last 5 years OR in <50% of the time)

5 = Expert-based presence (high confidence) (expert-based opinion; very suitable habitat near permanent presence areas)
6 = Expert-based presence (low confidence or unconfirmed records) (expert-based opinion; suitable habitat near presence areas or unconfirmed C3 records of jackal presence)
7 = Expert-based absence (high confidence) (jackal presence according to coarse-resolution hunting bag data but experts think, with high confidence, the species is not present)
8 = Expert-based absence (low confidence) (jackal presence according to coarse-resolution hunting bag data but experts think the species is not present)

Where grid cells were assigned different values between neighboring countries; the "disputed" cells were given the "higher" presence values e.g., a cell categorized as "sporadic" by one country and "permanent" by another was categorized as "permanent". Data-based categories (1,3) were given priority over expert-based categories (5 through 8).

To assess the quality of carnivore signs we used the SCALP criteria developed for the standardized monitoring of Eurasian lynx (*Lynx lynx*) in the Alps (Molinari-Jobin et al. 2012):
Category 1 (C1): "Hard facts", verified and unchallenged large carnivore presence signs (e.g., dead animals, DNA, verified camera trap images);
Category 2 (C2): Large carnivore presence signs controlled and confirmed by a large carnivore expert (e.g., trained member of the network), which requires documentation of large carnivore signs; and
Category 3 (C3): Unconfirmed category 2 large carnivore presence signs and all presence signs such as sightings and calls which, if not additionally documented, cannot be verified.
See Hatlauf and Böcker (2022) for best practices regarding golden jackal records.

Usage Notes

The data available consists of a shapefile at a 10 x 10 km resolution compiled for the period 2012-2016 for the Large Carnivore Initiative of Europe IUCN Specialist Group and for the IUCN Red List Assessment.

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