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INTEGRATING INSTITUTIONAL DATA COLLECTION AND COLLABORATIVE MONITORING: THE ITALIAN WILDCAT PROJECT

COME INTEGRARE LA RACCOLTA DATI ISTITUZIONALE E IL MONITORAGGIO COLLABORATIVO: IL PROGETTO GATTO SELVATICO ITALIA

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Abstract. Over the past decades, advances in technology have radically changed the way environmental data collection can be performed. Web-based facilities and smartphone apps have become increasingly common, considerably widening the opportunities offered to contribute to monitoring activities. Biodiversity data gathering solutions inspired by citizen science principles have been successfully applied to several species, whose monitoring greatly benefitted from a network of potential observers. The time is ripe to widen the range of application of these potentialities to less easy-to-monitor species. The Italian Wildcat Project (www.gattoselvatico.it) is the first experience in Italy of a country-wide survey that builds upon the double remit of institutional wildlife monitoring and citizen science data collection, aiming at taking the most from the combination of both fields. A similar effort is only made possible by a network of private and public entities at the regional and national level and by the participation of passionate citizen scientists. An example to be possibly extended to other species of conservation concern.

Riassunto. *Negli ultimi decenni i progressi tecnologici hanno cambiato radicalmente il modo in cui può essere effettuata la raccolta di dati ambientali. Soluzioni basate su piattaforme internet e app per smartphone sono diventate sempre più comuni, ampliando notevolmente le opportunità offerte per contribuire ad attività di monitoraggio. Le soluzioni per la raccolta di dati sulla biodiversità ispirate ai principi della citizen science sono state applicate con successo su diverse specie, per le quali il monitoraggio ha beneficiato notevolmente di una rete di potenziali osservatori. I tempi sono maturi per ampliare il campo di applicazione di queste potenzialità a specie meno facili da monitorare. Il progetto Gatto Selvatico Italia (www.gattoselvatico.it) è la prima esperienza nazionale di un'indagine ad ampio livello che si basa sul duplice apporto del monitoraggio istituzionale della fauna selvatica e della raccolta di dati da citizen science, con l'obiettivo di trarre il massimo dalla combinazione di entrambi i settori. Un simile sforzo è reso possibile solo dalla collaborazione di una rete di enti pubblici e privati a livello regionale e nazionale, oltre che dalla partecipazione di appassionati cittadini-scienziati. Un esempio da estendere eventualmente ad altre specie di interesse conservazionistico.*

Introduction

Most Felids are known to be elusive species, whose detectability in the field is often limited by several factors (e.g. mainly crepuscular or nocturnal activity, low population densities, preference for dense cover; Sunquist & Sunquist, 2002). Gathering reliable data on their presence and distribution can hence be a demanding activity, hard to be carried out at a wide scale and in the long term. The European wildcat provides a leading example in this respect (Kilshaw *et al*. 2015). Historical national maps of the species suffered from paucity of data and were produced as a compendium of several information of different nature, unevenly distributed in time and space.

Mapping its presence at regional or national scale and gathering insights on its population trend is furtherly made complex by the indisputable difficulty to correctly identify the species. Limited number of field researches trained on the species, low population densities and consequent poor availability of first hand observations left no other solutions than relying on expert-based mapping and trends estimation.

Nevertheless, over the past decade, advances in technology have radically changed the way environmental monitoring can be performed. Web-based facilities and smartphone apps have become increasingly common, considerably widening the opportunities offered to data collection. Biodiversity data gathering solutions inspired by citizen science principles have been successfully applied to several species, whose monitoring greatly benefitted from a network of potential observers (Pocock *et al*. 2013).

Citizen science and wildlife monitoring

Citizen science can be defined as the non-professional involvement of volunteers in the scientific process (commonly in data collection, but it could also include other phases of the research

process). As highlighted by a recent report (European Commission 2020), the active involvement of people in the collection of environmental data is an emerging field of growing potentiality. EU and Member State authorities are already making use of citizen science data in the context of official environmental monitoring and reporting in several policy areas, such as to monitor the progress on the United Nations sustainable development goals, SDGs).

In some environmental areas, such as biodiversity, citizen science already provides large datasets on indicator species like butterflies (the European butterfly monitoring scheme: https://butterfly-monitoring.net) and birds (the pan-European common bird monitoring scheme: https://pecbms.info), hence demonstrating a great potential of application on other taxonomic groups. The need for complementary data was identified in the Commission's 2017 fitness check of reporting and monitoring of EU environment policy (COM 2017). That review concluded that tapping into new sources of data, including data collected by members of the public, could help to improve and streamline reporting, and make it more reliable, thereby strengthening the evidence base for environmental policy.

Member States have indeed used observations from volunteers and conservation groups at national or international level (e.g. Birdlife) for official reporting under Article 12 of the Birds Directive 2009/147/EC and Article 17 of the Habitats Directive 92/43/EEC. Several biodiversity indicators used to measure progress towards the targets in the EU's biodiversity strategy and the Aichi targets in the 2011-2020 strategic plan for biodiversity (i.e. the streamlined European biodiversity indicators, SEBIs) heavily rely on observations by volunteers.

Citizen science has hence the potentiality to play a role of growingly importance (European Commission 2020), even in traditionally less explored contexts.

In many cases the contribution can be really valuable, especially in those circumstances where the official monitoring alone could not produce the number of observations and the geographical and temporal coverage needed, actually reachable by thousands of volunteers.

Several leading examples on different species provide evidence that "traditional" wildlife monitoring can be effectively enhanced by data collection carried out with the help of people. Among others, a couple of recent papers on the subject (Van Der Wal *et al*. 2015; Zapponi *et al*. 2017), for example, provide evidence from the UK and Italy (respectively on two species of bumblebees and some species of xylophagous beetles) that citizen science data can effectively fill gaps of knowledge, spatially and temporarily complementing expert data. Remarkably, in the latter case this achievement also allowed reaching reliable results in a much shorter time span. Several other examples come from CS projects on Mammals, where volunteers can play a major role in supporting researchers, both directly in the field (by collecting first-hand data) or from their home, by offering their free time to interpret photos, identify patterns in pictures, and so on (Swanson *et al*. 2015). The internet and modern smartphones offer technological solutions able to empower anyone e.g. to take a high quality picture and a quite precise GPS position (often associated with relevant metadata) and to send them in real time to on-line databases. Mobile devices are also capable of running specific software and web services (including maps, AI applications and dedicated sensors). Most of these features were hard to be even only imagined no more than ten years ago. Nowadays e.g. orangutan nests can be spotted through small scale aerial surveys whose pictures can be identified by volunteers, enhancing the researcher's capability to identify and protect them with specific forest conservation measures (Knott *et al*. 2021), endangered Koalas can be monitored and their populations estimated through a specific citizen science project (Hollow *et al*, 2015), just to provide some samples.

The development and diffusion of modern camera traps, for example, had the effect of a real revolution, empowering researchers as well as passionate citizens with flexible and rather powerful tools to be used widely in the field. Early solutions to take pictures of wildlife in their natural habitat have been in use for over a century, since the beginnings of wildlife photography. Nevertheless, as a wildlife research tool they remained limited to a small number of users until the 1990s, when the first commercial devices were produced and began to spread. Modern digital camera traps came to prominence from the mid-2000s, soon becoming a standard tool (Wearn & Glover-Kapfer 2017).

Today, beside professional researchers, a growing number of people are using camera traps in the field, for many different purposes. This wide potential constitutes a virtually very useful and interesting source of information that deserves to be enhanced and correctly managed.

Many research institutions, Environmental Agencies and national biodiversity networks have developed solutions to feed citizen science data into their official databases to inform and complement policy decisions. One of the leading examples in this respect is the UK National

Biodiversity Network, a membership organisation built on principles of collaboration and sharing. Its vision is that: "Biological data collected and shared openly by the Network are central to learning and understanding biodiversity and are critical to all decision-making about nature and the environment." To achieve that vision the Network must deliver improvements to the recording, collection, verification, curation, aggregation, analysis and use of biological observations, including citizen science data.

In Italy the Ministry of the Environment and the Protection of the Territory and the Sea (currently Ministry of Ecological Transition) has promoted the NNB: "National Biodiversity Network" (Network Nazionale per la Biodiversità: www.nnb.isprambiente.it/en), which carries out a strong joint action in support of the National Strategy for Biodiversity. NNB, managed by the National Institution for the Protection of Environment (ISPRA), is a network of internationally and nationally accredited entities for the management of biodiversity records, which share data and information on biodiversity. It is a shared data management system consisting of a central node, which allows to perform search and management operations on the data, and peripheral nodes (databases that possess primary biodiversity data) aimed at guaranteeing consultation and efficient integration of information on biodiversity. The databases owned by the individual nodes communicate through the BioCASe Protocol. The latter also guarantees communication with the international community, part of the BioCASe network. The Network also ensures interoperability with similar international infrastructures (LifeWatch, GBIF, etc.) and with the National GeoPortal, in accordance with the provisions of the INSPIRE Directive (D.L. 32/2010). Specific data entry solutions have been recently developed to implement institutional datasets with observation coming from the widespread and well known INaturalist app (https://www.inaturalist.org), through the APIs made available by developers.

State of the art on wildcat distribution in Italy

The European wildcat is a species of conservation interest, included in Appendix II of CITES, in Appendix II of the Berne Convention and in Annex IV of Directive 92/43 / EEC HABITAT.

The species shows a wide distribution, ranging from Scotland in the North to South-Eastern Europe, including some Mediterranean islands. It was once widespread throughout Europe, before several populations underwent a drastic decline during the 19th century, mainly caused by direct persecution and habitat loss (Schauenberg, 1970). In Italy the species has been protected by national law since 1977. In recent times it has slowly recolonised portions of its former distribution range and, more recently, it successfully colonised portions of the central-Northern Apennines that were not part of its Known historical range (Ragni *et al*. 1994). The European wildcat is listed as a "particularly protected" species in Italy.

A recent revision separated *F. silvestris* and *F. lybica*, and ascribed the Sardinian population to the latter, further feeding the scientific debate on the taxonomic classification of the species. However the interpretation considered most correct by main authors and reported in several papers (e.g. Randi *et al*. 2001, Mattucci *et al*. 2016), is that of a polytypic species, *Felis silvestris*, constituted by various inter-fertile forms. The three subspecies occurring in Italy are *F. s. silvestris* (European wildcat), *F. s. lybica* (Sardinian wildcat) and *F. s. catus* (domestic cat). Occasional crossing with the domestic cat is a proven fact, which is likely to occur more frequently at higher incidence in isolated populations and in expansion areas of the wild subspecies (Mattucci *et al*. 2019).

In Italy the wild European form *F. silvestris silvestris* is considered nearly threatened (NT), like the Sardinian form *F. silvestris lybica*. Their main conservation threats are road mortality, habitat fragmentation, poaching and the interactions with the domestic cat (*Felis silvestris catus*), that can bring both to hybridation and pathogenic issues (Ragni 1993).

The species occurs in Italy in three main disjoint sub-areas: Apennine ridge (and ecologically connected areas) from Calabria to Romagna (with a recent expansion front along the Tuscan-Emilian Apennines up to Liguria, with currently only scattered data), Sicily (mainly the northern portion of the island), the North-East (Carnic Alps and Pre-alps, Tolmezzine Alps, Julian Alps and Pre-alps and Friulian Morainic Hills). In the last decade, these populations have expanded towards the west, permanently occupying the Belluno area, up to the Dolomiti Bellunesi National Park and the Grappa Massif. The Gargano promontory (Apulia) hosts a local population isolated from the main range of the species.

The historical sub-area of the species in western Liguria is still under study and needs confirmation with further recent objective data (see Gavagnin, this volume). In Sardinia lives the Sardinian (or African) wild cat *Felis s. lybica*. Little recent information is available on its current range.

PROJECT HIGHLIGHTS

Monitoring a species showing a secretive behaviour (along with low densities in natural conditions) on a large scale is undoubtedly a critical issue. The currently available European wildcat distribution maps show a highly fragmented range, with (often not interconnected) patches distributed over different countries. Remarkably, many regional maps have been built using records from diverse sources and/or following expert-based knowledge, with poor or limited confirmation rate over large portions of territories. This kind of data has also traditionally been the sole source of information to define the wildcat's conservation status (GIL-SÁNCHEZ *et al*. 2020).

Moreover, classically the output is mainly a static, large scale distribution map, printed in a book or a paper and difficult to update on a regular basis.

Italy is not an exception in this respect. A solution is needed to overcome what is a real limit to secure the basic knowledge to set up proper conservation measures. The Italian Wildcat Project aims at providing a solution to partially overcome this problem, building upon the huge potential resulting from the integration of data coming from official monitoring surveys (carried out by professionals, public authorities, protected areas, etc.) and occasional records collected by citizen scientists (roadkill casualties, occasional pictures and, remarkably, pictures and videos from camera traps).

The recent spread of camera-trapping has been already described above. However, the potential of the "grey data" regularly produced is still mainly untapped, cause records collected by a growing number of users, in the vast majority of cases, fail to be shared with the scientific community. Collecting citizen science opportunistic camera traps data is in fact quite a recent, although promising issue (HSING *et al*. 2018). A further increasingly common application of citizen science in this field take advantage from volunteer efforts to classify images. Citizen science has the power to engage the public in conservation science and accelerate processing of the large volume of images generated by camera traps.

Nevertheless, at least in Italy, the two currently most common scenarios are photos or video privately stored or posted in thematic forums and (most commonly) on social media, with the multiple aims of receiving a confirmation on the identification, starting a discussion on the topic or giving wide visibility to the results of a personal hobby. This growing amount of data might be lost if not retrieved, verified and pooled into a wider comprehensive dataset aimed at the conservation of the species.

Available interoperability solutions allow a reliable combination of records from different sources. Although pictures or videos not systematically taken may have several limitations in terms of their scientific use, if correctly verified and integrated with official records, they can represent a relevant source of information, able to fulfil basic data implementation needs, complement the knowledge-base of a species' distribution and address future studies.

The time is ripe to widen the range of application of these potentialities to less easy-to-monitor species, as the European wildcat.

The Italian Wildcat Project aims at creating a national network of potential contributors, recovering and classifying their "grey data" to integrate them with official records that underwent the same classification process, for the sake of creating a country-wide dataset openly viewable in a live map, constantly updated (Fig. 1).

The core of the historical data available on the European wildcat in Italy is that scrupulously collected and verified by the leading national expert on the species, the late Prof. Bernardino Ragni during his almost 40 years of scientific activity. His personal database will be integrated as the historical background of the project map.

Having an up-to-date picture of the distribution of the species to compare with historical data is indeed essential to evaluate variations of the range

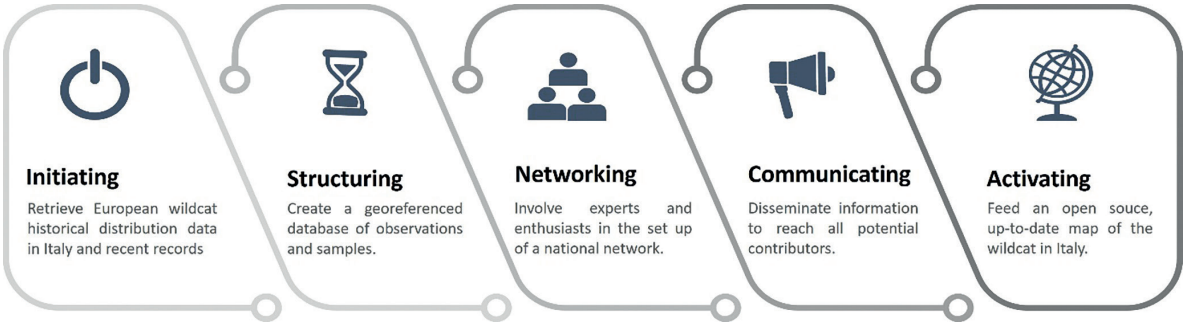

Fig. 1 - process followed in the setting up of the Italian Wildcat Project

and to set up proper conservation measures. In the case of the wildcat (as well as other secretive species), it is crucial to integrate historical data with recent reliable observations collected by researchers, in addition to verified records from formal reports and occasional but verified observations.

The silver lining of the above is that virtually anyone owning photos or videos of the target species can contribute by sending the observations (together with ancillary data) to the system, using the ``data entry'' form provided at the dedicated page of the portal (Fig. 2).

Data entered are sent to a verification map and, once validated and verified (Fig. 3), become visible on a public map hosted by the platform www.gattoselvatico.it, in the framework of the National Biodiversity Network.

In the public map, to safeguard the sensitive geographic information concerning the detailed location of data (especially for those coming from camera traps) an automatic feature has been set up to limit the zooming function. Scrolling over that limit the selected points disappear from the visualization layer.

Users can filter data by classification feature (see below) and/or date, with a set of different temporal combinations.

Up to three pictures for any observation can be uploaded in the system, while videos can be shared providing a link to a cloud service hosting the files. Sightings with no photos or videos are not accepted, as they won't be verifiable. Operational fact sheets on various topics of interest are under development and will be available shortly.

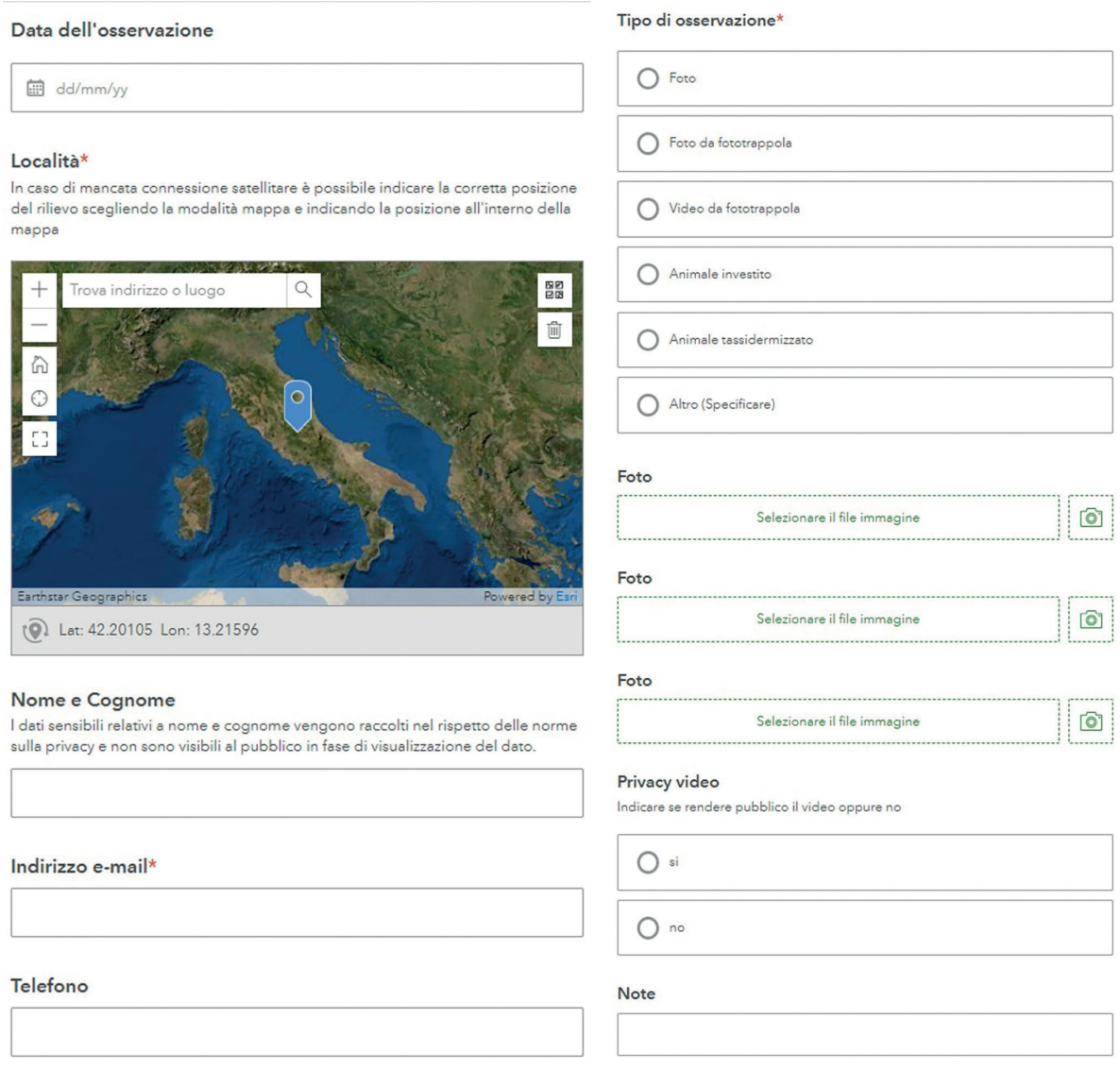

Fig. 2 - on-line data recording form, provided by ISPRA

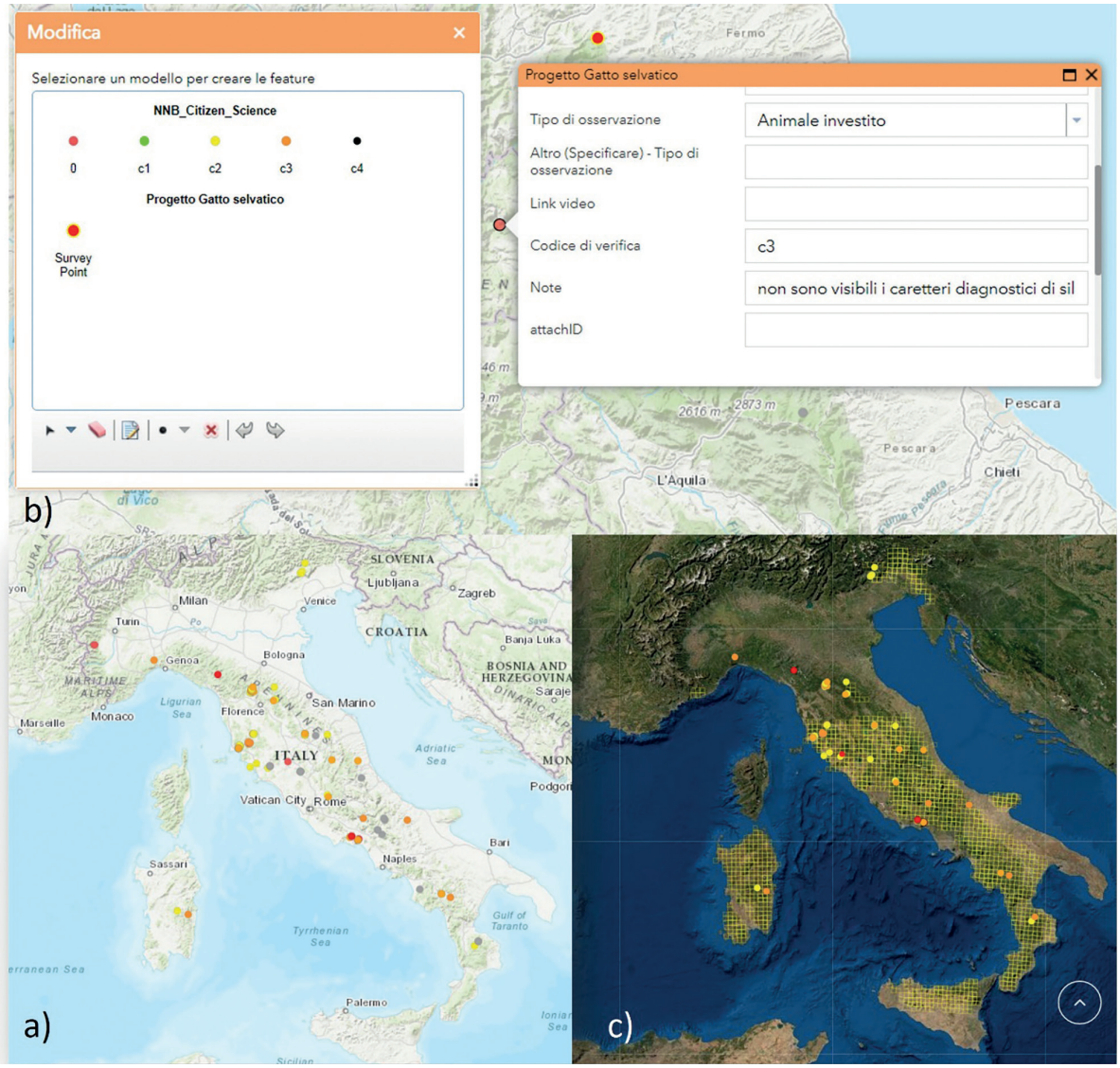

Fig. 3 - data verification procedure provided by ISPRA: a) verification map; b) detail of thew verification tools; c) public map showing verified data. Each colour corresponds to a different data classification category.

Classification of the observations

Identifying an European wildcat only from phenotypic characters poses some limits, and for this reason the sole picture or video, whatever its quality, is not sufficient to determine with certainty the species.

Extension and disposition of black and grey stripes on the coat have a specific diagnostic value, showing a clear ontogeny and age-evolution. In the early stages of life the fur of the kittens shows a marked spotted pattern that evolves, over time, into the final one. Some parts of the drawings (evanescent) tend to disappear almost completely, while others (permanent) characterize the coat-color pattern typical of adult individuals.

To make the picture even more complex, the European wild cat (*Felis silvestris silvestris*) and the common domestic cat (*Felis silvestris catus*) belong to the same species. They are, therefore, inter-fertile, giving rise to fertile offspring. In nature, there are usually ecological and behavioral barriers that limit the onset of crossings, but in many contexts, especially in anthropized areas close to populations of *silvestris* or in newly colonized areas, mating can occur between members of the two subspecies, with consequent introgression of domestic genes in the wild gene pool. It follows that the reliability of identifications made only on pelage characteristics should be considered with great caution. The similarity of the coat colour and pattern of the wild phenotype to those of some domestic (tabby) cats

or their hybrids is a matter of concern, affecting the process of data verification. Where a tissue sample is available, genetic analyses can provide a valid tool to discriminate among the different forms (subspecies). Since the collection of tissue samples (from the dead animals, e.g. roadkill casualties, or blood from captured individuals, hair from hair traps or samples from stuffed specimens) represents the minority of data collected, evidences from camera traps (and, to a lesser extent, photos of road killed animals or occasional pictures) represent the vast majority of data sources usually available. Despite phenotypic indexes and genetic analyses respectively constitute a well experimented and increasingly reliable tool, pictures taken from camera traps, depending on several factors such as their positioning in the field, local visibility conditions, distance, position and movements of the individuals, etc. may introduce further variables, limiting the effectiveness of the classification procedure.

The objectively complex identification of the species and the potential phenotypical and geographical overlap with domestic cats and hybrids impose the adoption of selective criteria to build up distribution maps based on reliable data. To avoid loss of information and to limit the probability of false positives, a reliability categories system can provide a solution to classify the observations collected. Most large carnivore monitoring programs in Europe (e.g. Kaczensky *et al*., 2009; Molinari-Jobin *et al*. 2012; Marucco *et al*. 2020) use the criteria defined "SCALP" to classify the quality of data collected on large carnivores. The SCALP (Status and Conservation of the Alpine Lynx Population) is a lynx conservation initiative in the Alps (www.kora.ch), that first developed standardized criteria for the interpretation of lynx monitoring data. Inspired by this approach, a similar set of criteria have been developed to classify pictures and videos of the European wildcat in the context of the www.gattoselvatico.it project. Namely, in the case of the Italian Wildcat Project, C1 are so-called hard-fact data, confirmed by genetic analyses and/or by gut index, C2 are wild phenotype individuals documented by photos, but not confirmed by other evidences, C3 pools individuals whose phenotype documented by photos is not totally visible or difficult to interpret, but might include some "wild type" characters, C4 enlist individuals whose phenotype shows some "wild" characters, but clearly not *silvestris* (potential hybrids), 0 are cats with a clear domestic pelage (Sforzi & Lapini, 2022).

Partnerships

The Italian Wildcat Project relies on a wide network of collaborations, which lay the basis for a shared approach, at the national and regional level. Moreover, it builds upon the double remit of institutional wildlife monitoring and citizen science data collection, aiming at taking the most from the combination of both fields. Project design, data structure and technical facilities are provided by a network made up by the Maremma Natural History Museum (Grosseto), the Ragni collection (namely the data, notes and materials gathered by the late Prof. Bernardino Ragni during his professional activity and recently donated by his family to the Spoleto Municipality to build up a dedicated collection), ISPRA (the Italian Institution for Environmental Protection, managing the National Biodiversity Network and running the Conservation Genetic Lab Unit at Ozzano Emilia, BO) and the Ministry of Environment (recently renamed as Ministry of Ecological Transition). An increasing portion of recent and current data are provided by citizen scientists uploading pictures or link to short videos (mostly form camera traps) through the form hosted in the portal www.gattoselvatico.it

Contributions are not limited to records from camera traps, but include also pictures of road-killed wildcats or occasional photos taken in the field.

Besides the partnership with leading national authorities, the project relies upon a regional network made up by associations, private and public institutions, protected areas and other entities that signed a formal agreement with the Maremma Natural History Museum, committing themselves to provide relevant support to the activities. That is intended as a constantly growing number of partners, depositaries of a remarkable local knowledge, essential not only to collect data, share archives and carry out surveys at the local scale, but also to activate a broader network of people (photographers, hunters, hikers, nature enthusiasts, etc.), enhancing the local participation of the public in the project and their sensitiveness for the conservation of this important species.

Final remarks

Setting up a country-wide survey requires time and energies. A similar effort is only made possible by a network of private and public entities at the regional and national level and by the participation of passionate citizen scientists.

In this respect the Italian Wildcat Project is the first experience of this kind in Italy. The success to the portal might pave the way to further projects on other species of vertebrates where a similar approach might result useful. That could help tapping into new sources of data, that can improve EU and local reporting, thereby strengthening the

evidence base for environmental policy. Scientific societies, Parks and any kind of realities interested in the conservation of the species in Italy are warmly invited to take part. That might act as an example to be applied in other European countries, in the framework of future collaborations that might share the structure, tools and data for the sake of engaging people, associations and institutions to a shared monitoring of the wildcat in Europe.

Moreover, while the output of the classical approach to distribution data (e.g. national or regional atlases) was static, large scale, distribution maps, with limited temporal value, the solution provided by the Italian Wildcat Project goes beyond it, enhancing the applicability of almost real time data. A step forward to monitor wildlife in the 21st century.

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