Project LIFE18 NAT/IT/000972 - LIFE WolfAlps EU
"Coordinated Actions to Improve Wolf-Human Coexistence
at the Alpine Population Level"

Action C4

Technical Report

THE WOLF ALPINE POPULATION IN 2020-2022 OVER 7 COUNTRIES

The integrated evaluation of the status of the wolf Alpine population in 2020-2021 and 2021-2022

April 2023

Indication for citation:

Wolf Alpine Group (2023). The wolf Alpine population in 2020-2022 over 7 countries. Technical report for LIFE WolfAlps EU project LIFE18 NAT/IT/000972, Action C4.

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This document is based on the strategy and criteria defined in:

Wolf Alpine Group (2022). The integrated monitoring of the wolf Alpine population over 6 countries. Report for LIFE WolfAlps EU project LIFE18 NAT/IT/000972, Action A5.

Summary

1. Introduction and objectives of the document

The wolf population in the Alps has been identified as one population segment by Linnell et al. (2008) regarding functional demography and distribution. Wolves began naturally recolonizing the southwestern Alps at the beginning of the 1990s from the north Apennines wolf subpopulation (Fabbri et al. 2007), after being extirpated from the Alps in the early 1900s. Simulations of the wolf natural re-colonization process showed that a total of 8-16 effective founders explained the genetic diversity observed in the western Alps in the first years of recolonization (Fabbri et al. 2007). Although it is genetically and demographically connected to the Italian wolf population in the Apennines (Fabbri et al. 2007), this population segment of wolves in the Alps is considered autonomous because of its ecological and socio-economic contexts (Linnell et al. 2008), that strongly differ from those of other regions, defining it as a management unit. Over the years, dispersals have been documented towards the north-western Alps and central Alps over the different countries (Valiere et al. 2003; Ciucci et al. 2009; Marucco et al. 2022). Recently, a similar process of recolonization began in the eastern Alps as individuals from the Dinaric-Balkan population dispersed and reproduced in the Alps as well (Fabbri et al. 2014; Marucco et al. 2022). The Alpine population is also slightly connected to the Central European lowlands and to the Carpathian population, with evidence of few individuals from these populations that reached the Alps. This recolonization process is also demonstrated by the case of a GPS collared male wolf from a Slovenian pack that travelled through Austria to finally settle with a female from Western Italy in the Italian Eastern Alps (Ražen et al. 2016). Hence, the recolonization of wolves in the Alps is occurring over the entire mountain chain comprising 7 countries: Italy, France, Austria, Switzerland, Slovenia, Liechtenstein and Germany, making the development of a unique and coordinated monitoring program particularly challenging. This requires an efficient and objective strategy for population monitoring at the appropriate biological scale.

The Wolf Alpine Group (WAG) - a team of wolf experts from Alpine countries who have been working together since 2001 to homogenise monitoring approaches - have built a solid partnership over time to coordinate the monitoring of the wolf Alpine population across its entire range. A significant effort will nevertheless be required given the ongoing expansion of the population. New challenges are already occurring, such as the increasing densities in some areas to the point that it is becoming very difficult and expensive to count and distinguish packs, or to deal with wolf recolonisation of hill and plain areas with little to no snow cover during winter (making it harder to detect their presence). These new constraints mean that acquiring detailed knowledge of wolf abundance and distribution with the same approaches as used in the past might no longer be feasible, and hence that monitoring approaches need to evolve. This is evidenced by discussions taking place in every country on how to adapt the monitoring system to its current biological reality when the size of the wolf population becomes increasingly larger. It is also necessary to ensure a comparison with data collected in the past so that the evolution of the population (distribution, abundance) over time can be assessed. Building on this WAG common understanding and in the

framework of the LIFE WolfAlps EU project, we conducted several international workshops to discuss the best cost-effective strategies to optimise the integrated monitoring of the species. We already designed a panel of standardised criteria and approaches for wolf population monitoring to allow for a common and coordinated evaluation of the wolf Alpine population within the species' entire Alpine range (WAG, 2022). The present document has the main objective to provide an update of the status of the wolf Alpine population in 2020-2021 and 2021-2022, based on these shared standard monitoring rules.

2. Wolf Alpine Group: goals and summary of activities

The Wolf Alpine Group (WAG) has brought together research and management experts from Italy, France, Switzerland, Austria, Slovenia and Germany in charge of wolf monitoring in the Alpine area since 2001. In 2023, Liechtenstein's experts joined the group. Associated research groups (especially genetic labs involved in wolf monitoring) also regularly contribute to the WAG workshops. The aim of the WAG is firstly to exchange biological scientific knowledge among countries on wolf distribution and demography over the Alps, at the population level. Secondly, we evaluate and implement common standards to produce a robust assessment of the status of the wolf population according to the available sources of data. Finally, the WAG aims to continuously improve methodological approaches designed to monitor distribution and demography of the Alpine wolf population (WAG, 2008, 2014, 2018).

Here we further update the list of workshops and products regularly developed by the WAG (Table 1). Briefly, in 2001, a first workshop on wolf monitoring organised in France gathered experts from France, Italy and Switzerland who were concerned about the recent recolonization by the wolf of western Alpine areas. The main objective of the workshop was to set up an effective collaboration among the three countries in order to exchange scientific data to effectively monitor the wolf population in the Alps as a whole and to exchange about transboundary pack occurrences. Since then, the Wolf Alpine Group has continued to foster significant progress and strong collaboration among wolf experts, particularly regarding information exchanges and common/practical methodologies (WAG 2003). Twelve years after the first discussions, the Wolf Alpine Group met for the 7th time in Jausiers (France) on the 19-20th of March 2013, with the main goal of producing an update of the status of the wolf population in the Alps within the different countries. After defining the population segment of interest and according to previous results and future goals, Austria, Germany and Slovenia joined the group to cover practically the entire Alpine range. A WAG logo was defined in April 2014. In 2015, the 8th WAG workshop was organised in Stelvio National Park, Italy, in the framework of the first LIFE WolfAlps project. On this occasion, the first transboundary monitoring standards, fundamental to producing reports on the status of the wolf Alpine population, were considered. In addition, a discussion was held among the genetic labs involved in the genetic analysis of biological samples from wolves in the Alps, with the ultimate goal of continuing to have a joint genetic approach to monitor the wolf population over the Alps as techniques continued to evolve. In 2018, the 9th WAG workshop was held in Slovenia, and the discussion on both topics continued. The agreed transboundary monitoring standards for the wolf

Alpine population (WAG, 2022) were finalised during the 11th WAG workshop, held online in January 2022 in the framework of the LIFE WolfAlps EU project. The most recent and 12th workshop was held in December 2022 in Barcelonnette (France), in the framework of the LIFE WolfAlps EU project. The present document is the output of the discussions held during this workshop, which led to combining the datasets of 2020-2022 from different countries in order to produce a shared evaluation of the transboundary wolf population in the Alps. For this last document, researchers from Liechtenstein have also officially joined the Wolf Alpine Group, which now encompasses all 7 Alpine countries.

Table 1. List of WAG meetings/workshops and the relative documents produced.

YEAR of WAG Workshop	Location	Document produced
2001: 1st meeting	Briancon (France)	
2003: 2nd meeting	Boudevilliers (Swiss)	https://lciepub.nina.no/pdf/635422306659583899_2nd_WAG_Workshop_Swiss_2003.pdf
2004: 3rd meeting	Entracque (Italy)	https://lciepub.nina.no/pdf/635422307907903901_3rd_WAG_Workshop_Italy_2004.pdf
2005: 4th meeting	St Martin (France)	
2007: 5th meeting	La Fouly (Swiss)	https://lciepub.nina.no/pdf/635422309699107383_5th_WAG_Workshop_Swiss_2007.pdf
2010: 6th meeting	Entracque (Italy)	
2013: 7th meeting	Jausiers (France)	https://lciepub.nina.no/pdf/635422311267073434_WAG_report_2014.pdf
2015: 8th meeting	Bormio (Italy)	https://lciepub.nina.no/pdf/636744930769081011_WAG_report_2015_2016_final.pdf
2018: 9th meeting	Podcerkev (Slovenia)	
2020: 10th meeting	Online	https://www.lifewolfalps.eu/wp-content/uploads/2022/05/A5_Deliverable_Monitoring-Standards-of-the-Wolf-alpine-population.pdf
2022: 11th meeting	Online	https://www.lifewolfalps.eu/wp-content/uploads/2022/05/A5_Deliverable_Monitoring-Standards-of-the-Wolf-alpine-population.pdf
2023: 12th meeting	Barcelonnette (France)	Present document

3. Standard criteria for classifying and interpreting data on wolf presence

Within the Wolf Alpine Group, researchers from each country aim to harmonise as much as possible the methodology used to monitor the wolf Alpine population. First by setting common unit definitions (e.g., packs, pairs, area of occurrence) and parameters (e.g., sampling units, data needed to confirm units), and then by defining standard criteria for classifying and interpreting data collection.

Although common non-invasive monitoring tools were used for a long time over each country, a final document of standard criteria was defined and accepted at the Alpine level after the LIFE WolfAlps EU workshops held in 2022 (WAG, 2022) in order to get a standard way of data

interpretation. For simplicity, here we report again the standard criteria agreed and used to produce the common evaluation of the Alpine wolf population for 2020-2022.

3.1 Standard criteria for classifying wolf observations

WAG scientists have agreed to adopt standard criteria for classifying wolf sign of presence in the same way of the one used by the SCALP (expert group for the "Status and Conservation of the Alpine Lynx Population"), observations are classified according to their verifiability into C1 = hard facts, C2 = confirmed observations, and C3 = unconfirmed observations (Kaczensky et al. 2009, Reinhardt et al. 2015, Marucco et al. 2014, 2020, Zimmermann et al. 2021, Duchamp et al. 2012). Researchers from Alpine countries set how the data are assigned to these different categories of verifiability.
A few preconditions nevertheless apply:

- For the evaluation of field data, at least one experienced person must be available.
- A person is considered "experienced" if he/she has extensive experience in the collection of field data on wolves, meaning that he/she is practised in recognising and interpreting signs left by the species in the field. Such a person must have recently taken part in relevant field work in the framework of national or internationally recognised scientific wolf surveys.
- All observations must be checked for genuineness to rule out the possibility of intentional deception.

The letter "C" stands for "category". The numbers 1, 2 and 3 below denote the level of validation for an observation. In Table 2, classification criteria for all cases of observations are reported.

C1: Hard evidence = Hard fact, i.e., evidence that unambiguously confirms the presence of a wolf.
C2: Confirmed observation = Indirect signs technically documented either confirmed by an experienced person in the field or reported and controlled from a third party (documentation is country-dependent).
C3: Unconfirmed observation = All observations that are not confirmed by an experienced person or observations which by their nature cannot be confirmed.
False observations are not considered and are entirely ruled out.

Table 2. Standard Criteria for classifying observations of wolf signs.

Criteria Category C1 – Hard evidence
Animals captured or rescued alive
Dead animals
Whatever DNA evidence confirms the biological sample (i.e., scats, hair, blood, urine, saliva, regurgitated, bones)
Telemetry locations
Good quality video and photos
Criteria Category C2 - Confirmed observation
Documented tracks with typical trend/pattern assessed by an expert and followed for at least 100 m
Documented scats checked by an expert
Predation signs with typical bites and/or consumption, only if combined with other C2 data

Howl with wolf pups' presence, checked by an expert
Criteria Category C3 - Unconfirmed observation
Tracks followed for less than 100 m in snow or single footprint
Scats not confirmed by an expert and not associated with snow tracks
Heavily eaten kills, livestock depredations not technically documented, or not combined with other C2 data
Single howls
Sightings not supported by photos or videos
Bad quality videos and pictures preventing unambiguous identification of the species
Observation not categorised, excluded from database
Inappropriate documentation provided by third party

3.2 Definitions and criteria for data interpretation

The WAG agreed on specific unit definitions and common parameters used in wolf monitoring over the Alps. We have moreover defined criteria for data interpretation to combine results at the Alpine level, then updating definitions used in 2018 (WAG 2018) (Table 3). Wolf biology, requirements under the Habitats Directive, and data needs for Large Carnivore Initiative for Europe (LCIE) reporting, have all been considered in these criteria definitions (i.e., mapping wolf occurrence at European level). **The basic social units of a wolf population are packs and pairs** (Mech and Boitani 2003). A pack is defined by at least 3 individuals travelling together while holding a territory or by pup occurrence. A pair is defined as one male and one female who mark their territory. Dispersers or solitary individuals are not considered in the evaluation of the population trend as represented by the number of packs and pairs but are included in wolf occurrences on the map. Packs have been defined as "transboundary" (Tr) or likely "transboundary" (Ltr) once evidence was documented either with genetic matches in areas across national borders or based on the interpretation of the spatial distribution of wolf signs. It has become ever more difficult to distinguish adjacent packs when an area becomes saturated with wolf packs. Therefore, new criteria for distinguishing adjacent packs have been defined at the international scale following Reinhardt et al. (2015) (WAG, 2022). Intensive application of genetic methods, or simultaneous camera trapping and wolf howling recordings (also through songmeters) are necessary to distinguish one pack from another in case of high pack density. Two or more adjacent packs can be distinguished best with the genetic identification of each pack (pack pedigree) or through simultaneous evidence of pack reproduction in both areas (through pups' howls or videos/photo). If an individual is clearly recognizable (e.g. hanging ear, missing paw, etc) based on good pictures or videos, this criteria can also help to identify individuals and distinguish adjacent packs. Telemetry may be helpful when available to identify a pack's territory if wolves from adjacent packs are also monitored, however it is not a method that could be applied at a large scale.

Table 3. Definitions used in wolf monitoring and agreed criteria for data interpretation at the Alpine level.

UNIT	DEFINITION	DATA NEEDED
monitoring year	Biological year for wolves (from reproduction to next reproduction)	From the 1st of May to the 30th of April
Pair	Only 1M +1F holding a territory and travelling together but not (yet) having reproduced	C1 that confirms the pair bonding together: ● video/photo/genetic ● or a track of the pair with genetic proof of the couple
Pack	Reproductive unit identified by either pup occurrences or by at least 3 individuals travelling together and holding a territory	● Reproduction confirmed with one C1 or C2 ● or at least 2 independent C2 showing the pack travelling together (tracks) ● or ≥ 3 individuals confirmed by C1 (genetics / photo / video)
Wolf Occurrence (Cell)	10x10 km cell (EU grid) where the species has been detected within the monitoring year	At least one C1 or two independent C2
Representation of the Territory	Area held by the resident wolf/wolves to point its approximate localization over space	Circle of about 200 km^2 centred on the centroid of the MCP constructed on the collected C1-C2 wolf signs
Adjacent packs	Two adjacent packs need to be clearly distinguished to be considered two units (or more) by either: ● genetic data for pack identification ● simultaneous proof of reproduction ● telemetry data from radio collared wolves belonging to one of the adjacent packs	C1 data needed

4. The integrated evaluation of the status of the wolf Alpine population

Following the Guidelines for Population Level Management Plans for Large Carnivores, wolves living within the Alpine range are therefore considered to be a single functional population unit, irrespective of which of the 7 different Alpine countries they occur in, as they live in the same ecological region. In line with the objective of monitoring changes of the population status, we will stand to demographically and spatially evaluate the population within the Alpine ranges to continue documenting comparable trends of population expansion over the years. Every country will nevertheless count wolves at the country level beyond the Alps territory, which under the Alpine Convention is considered the spatial extent of the international Alpine wolf population (red line in Figure 1).

The observation effort is also of concern to account for the imperfect detection of individuals (not all animals alive in a given year are documented). Wolf monitoring at large scale therefore requires extensive fieldwork in order to detect first a possible occurrence in new areas, usually gathering the coordinated effort of people networking. Then once detected, more intensive field efforts are needed to assess the dynamics of the settlement of new packs to finally set up the overall trend of the demographic social units of the species. Whereas this monitoring strategy is largely implemented over each European country at the first stage of the wolf colonisation process (see Hystrix Vol 23 review), it becomes very challenging once the population and pack density increase. Distinguishing packs then requires high sampling effort and a mix of different methods to understand who is who over space and time. At this advanced stage of transboundary wolf expansion over the Alps and to document trends (i.e. grid of occurrence, number of packs), we think it is more robust to track indexes of wolf presence and reproductive units (i.e. packs and pairs) over space and time instead of trying to estimate wolf population size, e.g. by means of capture-recapture models, which are excessively difficult to conduct in terms of funding and effort. At the colonisation front, however, greater effort using sharper indexes of population monitoring will certainly be required and maintained. Therefore, hereafter, we estimated the number and distribution of packs/pairs at the transboundary scale as key indexes to monitor the expansion of the wolf population over the Alps.

4.1 Wolf occurrence

Wolf occurrence has been defined by validated C1 and C2 wolf signs considering the biological year (from 1st of May to the 30th of April) (Table 3). All signs of presence from 2020-2021 and 2021-2022 respectively have been projected on the EEA EU 10x10 km european grid (ETRS89- LAEA). The area of interest focuses on the Alpine range (i.e. red line), although we agree to document occurrences beyond that area (Figure 1). The transboundary wolf occurrence is reported in Figure 1 for 2020-2021, and in Figure 2 for 2021-2022. Compared to previous documented wolf occurrence at the Alpine scale (WAG 2012, 2016), we notice an increase in wolf occurrence in the entire Alps, with signs of presence documented in the 7 countries. The western part of the Alps is almost entirely occupied, while the eastern and central part of the Alps still have 10x10 km grid cells with no detections (Figure 1). Compared to 2016, the eastern (Austria) and central part (northern Italy) of the Alpine range are the most concerned for new areas of presence, showing the wolf distribution is still increasing in 2021.

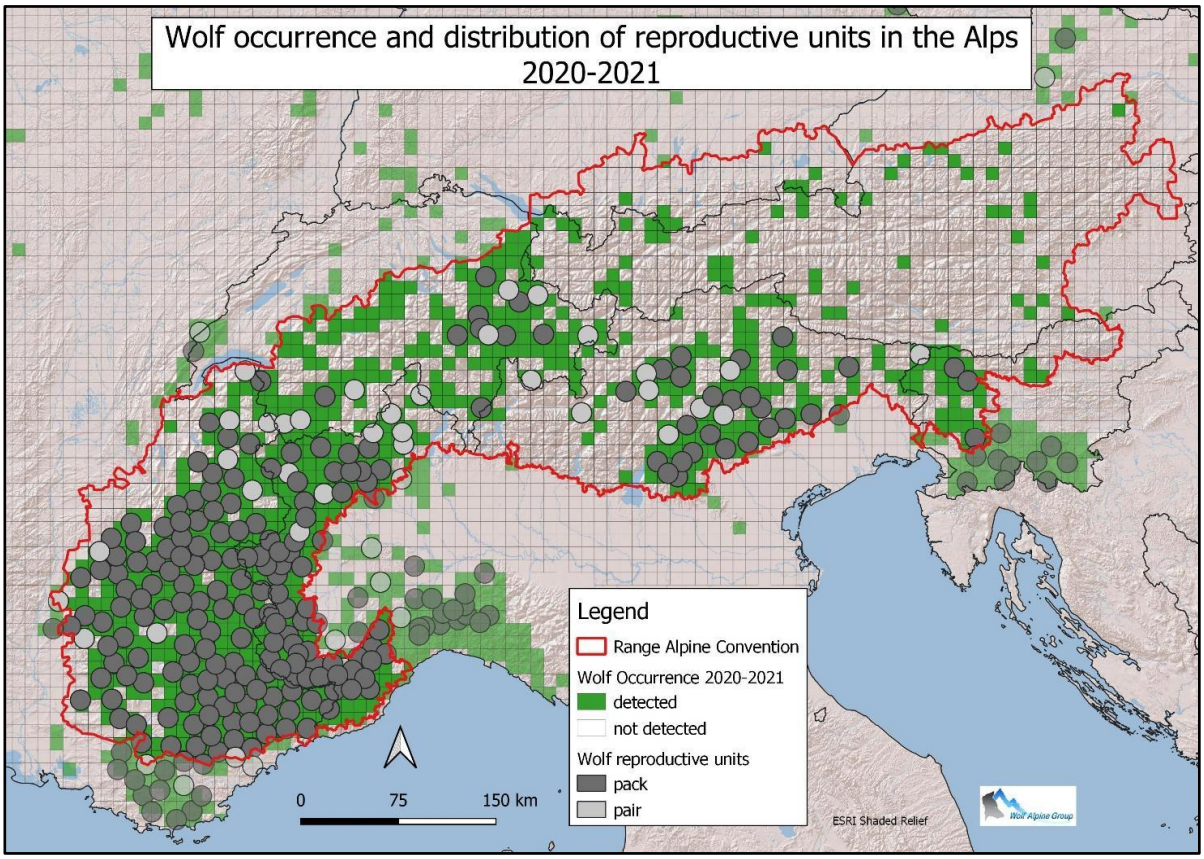

Figure 1. Wolf occurrence and distribution of reproductive units in the Alps in 2020-2021.

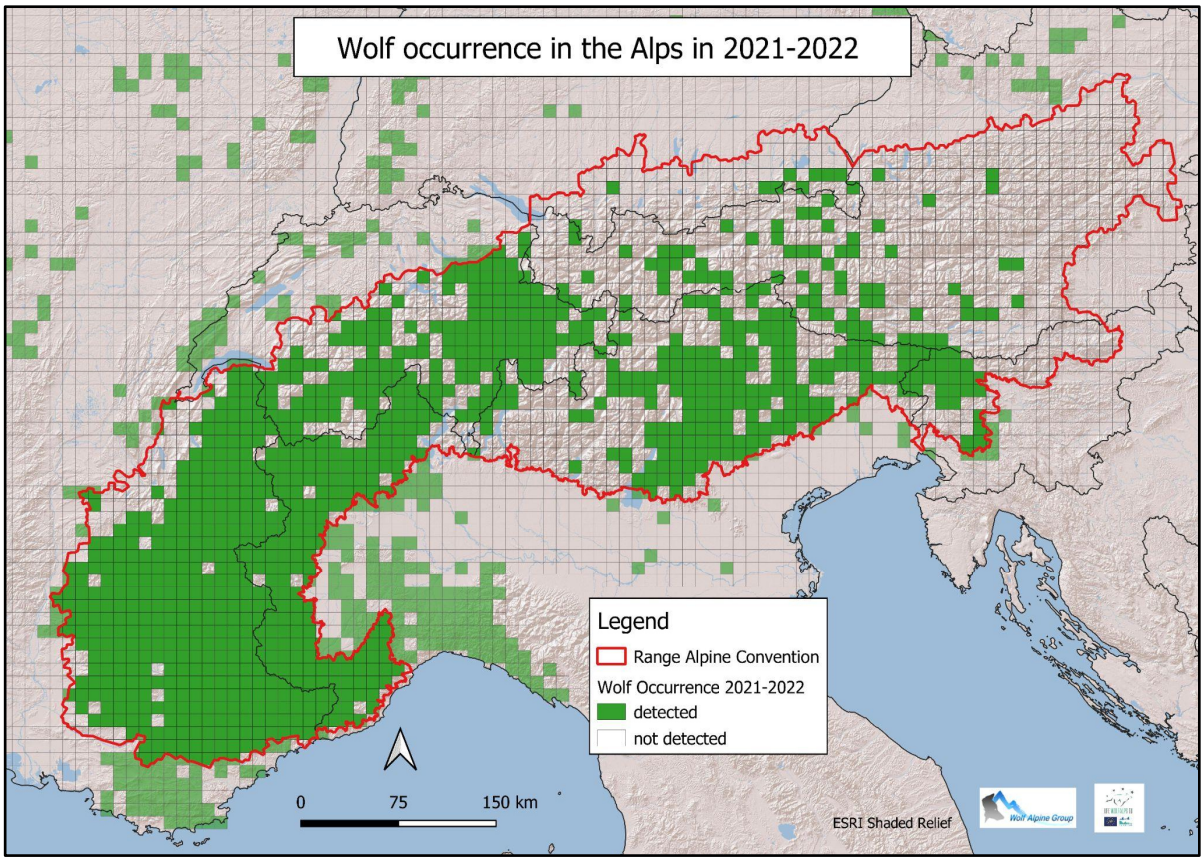

Figure 2. Wolf occurrence in the Alps in 2021-2022.

4.2 Wolf packs distribution and trend

The Wolf Alpine Group criteria consider changes in the number of wolf packs and pairs as the biologically meaningful index of population trend and distribution (WAG 2014, 2018 and 2022), such as in other wolf monitoring systems worldwide (Mech and Boitani, 2003). Also in this case, the biological year is defined from May 1st to April 30th the year after, corresponding to the wolf reproduction period. We documented here pack distribution on the common map for the year 2020-2021 (Figure 1). Without knowing the homeranges of each pack also changing from one year to another an indicative buffer of 8 km around the pack centroid location is used to schematize pack territory of about 200 km² on the map (Table 3).

Defining adjacent packs needs lots of data and genetic information so this exercise cannot be conducted regularly by every country, especially in high density areas. Hence, wolf pack distribution will be documented at the Alpine scale not on a yearly basis, especially for Italy and Slovenia, but only in years 2020-2021 (Figure 1) and then in 2023-2024, to match the requirements of the Habitats Directive (HD) and LCIE products (WAG, 2022). For areas where wolves are believed to be active across borders, detailed information is exchanged to substantiate the cross-border status of territories. Common genetic investigations or tracks followed from one side to the other as well as spatial point aggregation are used to state about the (likely) transboundary nature of each pack.

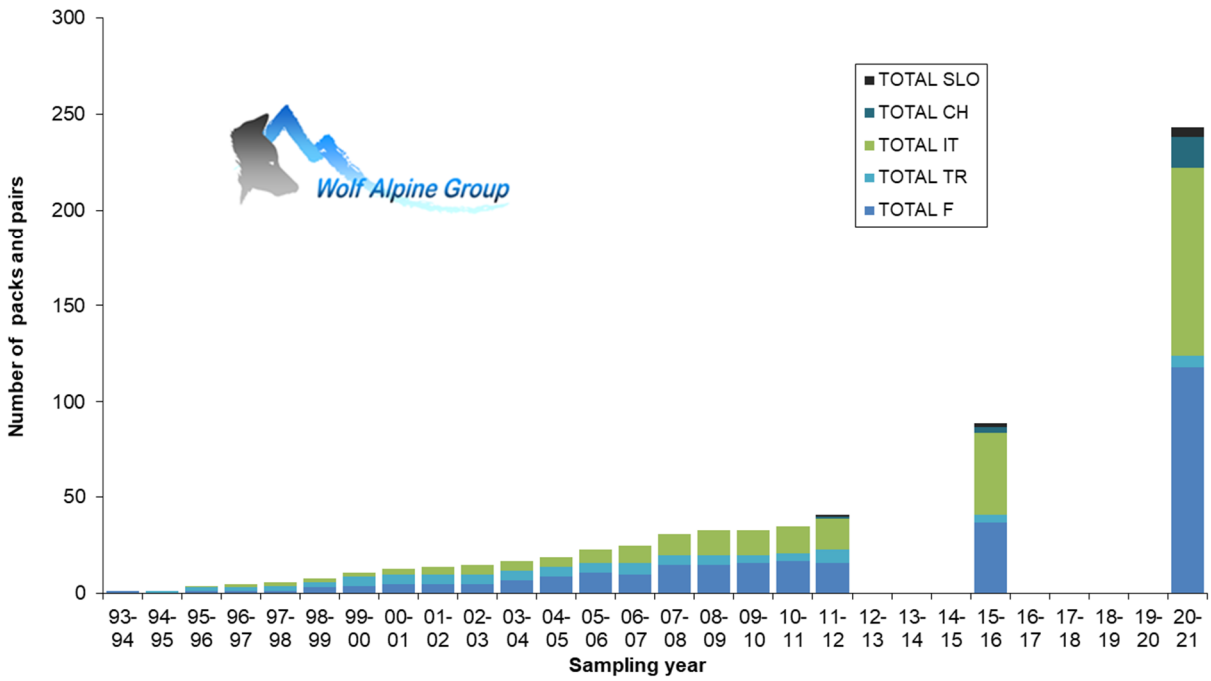

Figure 3. Temporal trend of the number of wolf packs and pairs across the Alpine range. F: France; IT: Italy, CH: Switzerland; SLO: Slovenia, TR: transboundary.

The previous population status was assessed in 2015-2016 (WAG, 2018), when we recorded 65 wolf packs and 12 pairs over the Alps, with the great majority of them located in the Western part between Italy and France (Figure 3). In particular, in Italy we documented 27 packs, 8 pairs; in France 31 packs, 3 pairs; in Switzerland 1 pack, 1 pair; and in Slovenia 2 packs. Moreover, we could document one transboundary pack between Switzerland and Italy and 3 between Italy and France.

In 2020-2021, we documented a total of 206 packs and 37 new pairs, for a total of 243 reproductive units. The western part of the Alps is almost entirely occupied and has the highest pack density over the Alpine range, in particular in its south western part (Figure 1). The wolf Alpine population has further expanded to the Central-Eastern part. At the same time, the Dinaric population has also expanded northward, while the population has increased in density in the Western part of the Alps of Italy and France. In those areas wolves have reached hills and expanded beyond the Alpine chain (Figure 1). A positive trend of the number of wolf packs is documented over the years showing a greater increment in 2020-2021, with the major contribution to the increase given by France and Italy (Figure 3). Considering only the Alpine area within each country, we documented 82 packs and 16 pairs in Italy; 107 packs and 11 pairs in France; 8 packs and 8 pairs in Switzerland and 5 packs in Slovenia. Moreover, we could document 2 transboundary reproductive units (1 pack and 1 pair) between Switzerland and Italy, 2 between Italy and France, 1 pack between France and Switzerland, and 1 between Italy and Slovenia (Figure 1). The map evidences the international dimension of the wolf Alpine population and justifies the need for a continued coordinated approach to wolf monitoring in the 7 Alpine countries.

4.3 Detection of wolf-dog hybrids

Hybridization between wild species and their domestic counterparts may represent a major threat to natural populations (Allendorf et al., 2001). However, the high genetic similarity between the hybridising taxa makes the detection of hybrids difficult and may hinder attempts to assess the impact of hybridization in conservation biology. Hybridization between wolves and free-ranging dogs has occurred in several recent cases of wolf recolonization of human-dominated areas, it is of increasing concern to conservationists in Europe and has been addressed in many research programmes (e.g., Vila and Wayne 1999; Galaverni et al. 2017; Kusak et al. 2018; Pilot et al. 2018). Reducing the population of free-ranging dogs and preventing wolf-dog mating encounters (Salvatori et al. 2020) is therefore an important priority of wolf management and conservation in the Alps.

A consistent and efficient management requires a reliable identification of wolf-dog hybrids and backcrosses when a first generation hybrid mates with an individual from one of the parent groups. Genetic methods are required to detect hybridization as morphological identification of hybrids and backcrosses is difficult and usually unreliable (e.g., Galaverni et al. 2017). New genetic processes based on single nucleotide polymorphism (SNP) markers have been recently developed to distinguish wolves, dogs, and their first two generations of hybrids (Harmoinen et al. 2021). Thanks to the geneticist collaborations and WAG facilitations in the framework of the LIFE WolfAlps EU project, these genetic sets of markers have been tested with data from across Europe. A large sampling properly designed is on the course in order to apply a standard estimate of the phenomenon all across Europe with a unified approach. Hence, the discussion on having a standardised unified approach to quantify hybridization is under process, and will be one of the main topics of discussion in the next WAG workshops, in order to incorporate the identification of hybrid packs into our monitoring assessments or quantify other indexes of hybridization at the population level among countries. For now in Figure 1 and 2 it is possible that hybrids are detected within the wolf population estimate.

Although the detection of wolf-dog hybrids (WDH) is not the main aim of the monitoring programs in every Alpine country, the regular and systematic monitoring involving genetic analyses and camera traps makes the detection of first generation (F1) WDH very likely, at least in the core areas where the monitoring is particularly intense. Where camera traps are applied regularly also phenotypically deviating backcrosses are likely to be detected. Wolf-dog admixture have been reported for many countries in Europe at low percentage of usually 0% to 10% event occurrences when considering first or recent generation crossbreeds respectively (Harmoinen et al. 2021; Salvatori et al. 2019). In particular, in the monitoring year 2020-2021, for the first time wolf-dog hybrids were detected in 2 packs in the Alpine regions in Italy out of 103 reproductive units documented (Marucco et al. 2022b), which are currently under management actions to control potential reproductions, and in one pack in Slovenia which has been partially culled (Potocnik et al. 2022). Information on hybridization detection in France is documented in the "Le suivi génétique des loup en 2018" and show at least 2 cross breeds during the last 10 years producing F1 offspring (Duchamp and Queney, 2019). So, we think it will be extremely important to monitor the occurrence of hybrids in the Alps in a standardised manner in the future, since it is a new emerging issue, and that the issue could be incorporated in the framework of the existing international monitoring programs.

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