Long-term Management Plan

for the

Wolverine

(*Gulo gulo gulo*)

European Endangered Species Programme (EEP)

EEP coordinator

Leif Blomqvist

Population Biologists

Elmar Fienieg and Kristin Leus, EAZA Executive Office

16 March 2017

EEP Executive Summary

Wolverine (*Gulo gulo gulo*)

As of 1 November 2016, the Wolverine EEP population consists of 116 individuals (59.55.2) at 45 institutions (See *Ex situ* status and Census below for specifics). The Wolverine EEP only includes the nominate form of Wolverine (*Gulo g. gulo*) and excludes the North American subspecies (*Gulo. g. luscus*). The wolverine is assessed as Vulnerable on the European level (IUCN, Landa 2007).

The role of the Wolverine EEP is to

- Serve as a backup population, in case the wild population declines dramatically. Such dramatic declines can be caused by hunting pressures and emerging diseases, where the latter is expected to increase due to climate change. Wolverine populations are known to recover slowly from population declines.
- Use veterinary expertise and data gathered on biology and natural history present in the *ex situ* community to inform in situ conservation actions when necessary.
- Raise awareness and educate the public about a taxonomically unique and ecologically important European species. The species is the largest mustelid in the world and one of the four European large carnivores. When displayed properly, it is easy to educate visitors about its ecologic characteristics, such as eating frozen carcasses, surviving in a harsh environment, saving their food by keeping it frozen in the ground or hidden in trees, breeding in winter and the ability to walk on the snow with their large feet enabling them to hunt much larger prey species, such as reindeer.

Conclusions for the EEP Population:

- Population growth is expected to stabilise in the coming ten years at 150 individuals, which means a lower growth rate will be required than in the last years. At the same time, with the increase in population size, the number of breeding pairs has increased as well. The EEP will therefore have to restrict reproduction of several pairs to avoid a higher growth rate than the EEP can handle.
- Genetic diversity in the population is currently slightly lower than 90% and without new founders the EEP will not be able to meet its genetic goal of maintaining 90% genetic diversity over 100 years. The EEP therefore plans to import two founders every five years by taking in cubs from the wild that would otherwise be culled by the authorities as a means of controlling some areas of high abundance of wolverine in the wild.
- Eleven individuals in the EEP will receive transfer recommendations. To reach the desired birth rate of the population in 2018, 22 breeding pairs are recommended out of a maximum of 36. These breeding pairs have been selected based on, among others, logistics, expected breeding success, behaviour and mean kinship. While the EEP strives for underrepresented pairs to reproduce relatively more offspring, also overrepresented pairs may receive a breeding recommendation in the future because the EEP believes that breeding and rearing cubs is an important enrichment item for females.
- This population will be re-evaluated annually by the Wolverine EEP Coordinator and Species Committee.

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Acknowledgements

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EEP Coordinator: Leif Blomqvist (Nordens Ark Foundation)
Eva Andersson (Nordens Ark Foundation)
Emily Boyes (Cotswold Wildlife park)
Jamie Craig (Cotswold Wildlife park)
Thomas Lind (Kolmarden Wildlife park)
Kristin Leus, Population biologist (EAZA Executive office)
Katharina Herrmann, Executive coordinator (EAZA Executive office)
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Prioritised Actions

Actions for current institutional holders of Wolverine

- Follow the (non-)breeding and transfer recommendations made in this document.
- Communicate to the Veterinary advisor (Emily Boyes) and EGZAC (contraception@chesterzoo.org) if you have any experience with contraception in wolverine.

Actions for EEP Species Committee and EEP coordinator

- Investigate whether keeping cubs with their parents until the age of two years does not lead to any problems and inhibits breeding of the pair. One or a few institutions need to be identified where this can be tried out (**Action EEP Coordinator).** Note that this should be an institution with good knowledge of wolverines that can separate the cubs from a pair quickly when needed.

- Inform the wider EAZA community on how certain challenges with keeping wolverine, such as stereotypic behaviour, suitable climate zones, aggressiveness and parasites, are either myths or can be tackled relatively easy, through:
    - communication in Zooquaria (**Action Jamie Craig and Emily Boyes**).
    - a presentation at the EAZA annual conference (**Action Jamie Craig**).
    - the Small Carnivore Facebook page (**Action Eva Andersson**).

- Inform all holders on precautions to take when transferring wolverines (i.e. strong enough crates) through a short story in the Small carnivore TAG newsletter **(Action EEP Coordinator and Thomas Lind**).

- Investigate and review the enclosures of all EEP participants as a first step to work towards having no stereotypic behaviour in any institution (**Action EEP Coordinator**).
    - Share the enclosure information obtained through the Parasite survey (**Action Emily Boyes**).
    - To avoid sending another survey to institutions, determine what can be learned from the ZooChat database (**Action student supervised by Eva Andersson**).

- Contact any Conservation organisations or projects that work on the *in situ* conservation of wolverine to ask if there are opportunities for them to benefit from the experience of the EEP (**Action Tomas Lind and/or EEP Coordinator**).

- Formalise the non-EAZA EEP participation of European institutions HANSTEDT, NIKOLAEV (Candidate for Membership), NOVOSIBRK (Candidate for Membership), OSIJEK and VOLKEL, AZA institutions COLUMBUS, DETROIT, MINNESOTA, BILLINGS and ST FELICI and the North-American non-AZA institutions ANCHORAGE and BIG GAME (**Action EEP coordinator**)

Action for population biologists

- Investigate the difference in fecundity between breeding pairs without cubs and with cubs still in the same enclosure (**Action Elmar Fienieg**)

Population Status
Wolverine (*Gulo gulo gulo*)

In situ status

The Wolverine EEP only includes the nominate form of wolverine (*Gulo g. gulo*) and excludes the North American subspecies (*Gulo g. luscus*). According to IUCN (Landa 2007), the wolverine is assessed as Vulnerable on the European level. The reason for this is that both European populations are very small, with the Fennoscandian and Karelian populations consisting of 750 and 450 individuals respectively. Also, overharvesting and decline in prey populations have caused sharp declines in the Russian part of the Karelian population, which as a population is assessed as Endangered. The main threat of the Fennoscandian populations is that there is legal and illegal hunting due to conflict with holders of livestock.

Ex situ status

The total Wolverine population consists of 116 individuals, of which 59 males, 55 females and two of unknown sex. These are held at 46 institutions, of which 34 are EAZA institutions, two are approved non-EAZA participants (BARDU and NAMSKOGAN), five are AZA institutions and five other are non-EAZA EEP participants that are not yet formalised: HANSTEDT, NIKOLAEV (Candidate for Membership), NOVOSIBRK (Candidate for Membership), OSIJEK and VOLKEL. The AZA institutions that participate in the EEP, but are not yet formalised are: ANCHORAGE, COLUMBUS, BIG GAME, DETROIT, MINNESOTA, BILLINGS and ST FELICI. Six old individuals were excluded from genetic analysis because they are post-reproductive (<u>Appendix B</u>).

Institutional holdings

Table 1. Current institutional holdings of Wolverine in the EEP population as of 10 October 2016 (before any transfers recommended in this document).

Mnemonic	Location	Males	Females	Unknown sex	Total	Membership
AHTARI	Zoo Ahtari (Ähtärin Eläinpuisto Oy)	1	1	0	2	EAZA
ANCHORAGE	Alaska Zoo	1	1	0	2	Non-AZA
BARDU	Polar Park	0	0	0	0	Non-EAZA
BIG GAME	Alaska Wildlife Conservation Center	1	1	0	2	Non-AZA
BORAS	Boras Djurpark Zoo	1	1	0	2	EAZA
BRNO	Brno Zoo	2	1	0	3	EAZA
BUDAPEST	Budapest Zool.& Botanical Garden	1	1	0	2	EAZA
BURFORD	Cotswold Wildlife Park and Gardens	1	2	0	3	EAZA
CALVIAC	Reserve Zoologique de Calviac	1	1	0	2	EAZA
CEZALIER	Parc Animalier d'Auvergne	1	1	0	2	EAZA
CHOMUTOV	Zoopark Chomutov	0	1	0	1	EAZA
COLUMBUS	Columbus Zoo and Aquarium	1	1	0	2	AZA
COULANGE	Parc Zoologique d'Amneville	0	0	0	0	EAZA
DETROIT	Detroit Zoological Society	0	0	0	0	AZA
DUISBURG	Zoo Duisburg AG	1	1	0	2	EAZA
EBERSWALD	Tierpark Eberswalde	1	1	0	2	EAZA
HANSTEDT	Wildpark Lüneburger Heide	2	0	0	2	Non-EAZA
HANSURLES	Reserve d'Animaux Sauvage	1	1	0	2	EAZA
HELSINKI	Helsinki Zoo	1	1	0	2	EAZA
HERBERSTN	Tierwelt Herberstein	1	1	0	2	EAZA
HLUBOKA	Zoologicka Zahrada Ohrada	1	1	0	2	EAZA
HUNBSTRND	Nordens Ark	3	2	0	5	EAZA
JARVZOO	Järvzoo	4	2	0	6	EAZA
KERKRADE	GaiaZoo	1	1	0	2	EAZA
KINGUSSIE	Highland Wildlife Park	1	1	2	4	EAZA
KOLMARDEN	Kolmardens Djurpark AB	1	2	0	3	EAZA
KRISTIANS	Kristiansand Dyrepark ASA	1	1	0	2	EAZA
LUND	Skanes Djurpark	2	2	0	4	EAZA
LYCKSELE	Lycksele Djurpark/Zoo	2	1	0	3	EAZA
MINNESOTA	Minnesota Zoological Garden	1	1	0	2	AZA
BILLINGS	ZooMontana	0	0	0	0	AZA
MOSCOW	Moscow Zoological Park	3	5	0	8	EAZA
MUNICH	Münchener Tierpark Hellabrunn	1	1	0	2	EAZA
NAMSKOGAN	Namsskogans Familiepark	1	0	0	1	Non-EAZA
NIKOLAEV	Nikolaev Zoo of Nikolaev-City Council	1	1	0	2	Non-EAZA
NOVOSIBRK	Novosibirsk Zoological Park	2	3	0	5	Non-EAZA
OPOLE	Ogrod Zoologiczny Opole	1	1	0	2	EAZA
ORSA	Orsa Rovdjurspark	1	1	0	2	EAZA
OSIJEK	Zoo Osijek	2	0	0	2	Non-EAZA
OSNABRUCK	Zoo Osnabrück	1	2	0	3	EAZA
PARIS ZOO	Parc Zoologique de Paris (MNHN)	1	1	0	2	EAZA
RANUA	Ranua Wildlife Park	1	2	0	3	EAZA
SALZBURG	Salzburg Zoo Hellbrunn	1	1	0	2	EAZA
ST FELICI	Zoo Sauvage de St-Félicien	1	1	0	2	AZA
STE CROIX	Parc animalier de Sainte-Croix	1	1	0	2	EAZA
STOCKHOLM	Skansen Foundation, Zool. Dept.	1	1	0	2	EAZA
SZEGED	Szeged Zoo	1	1	0	2	EAZA
USTI	Usti nad Labem Zoo	1	1	0	2	EAZA
WHIPSNADE	ZSL Whipsnade Zoo	1	1	0	2	EAZA
VOLKEL	Ziezoo	2	0	0	2	Non-EAZA
	Total:	59	55	2	116	

Demographic summary

Census

The first record of Wolverine in captivity was in HELSINKI in 1958. Even though the first captive breeding occurred already in 1967, in BORAS, there was little captive breeding success until 1982. Due to an increase in captive births and a decrease in litter mortality since 1982, the population started growing (Figure 1). After a need arose to manage the population and to acquire knowledge on husbandry, the Wolverine EEP was established in 1994. The population has continued growing and because of a steady increase in participating institutions (Figure 3) breeding restrictions to avoid space issues have not been needed in the past.

Table 2 Demographic status of the EEP, current to 10 October 2016.

	Population size (N)*1	Institutions*2	Excluded*3	N after exclusions*4	T*5
EAZA institutions	44.46.2 (92)	34	1.4.0 (5)	43.41.2 (87)	-
Non-EAZA, non-AZA institutions	10.4.0 (14)	7	0.1.0 (1)	10.3.0 (13)	-
AZA	5.5.0 (10)	5	0.0.0 (0)	5.5.0 (10)	-
EEP	59.55.2 (116)	46	1.5.0 (6)	58.50.2 (110)	7.1

*1 Current population size shown as Males.Females.Unknown Sex (Total). *2 Institutions currently holding individuals. *3 Individuals excluded from the potentially breeding population because they are guaranteed to not breed anymore (Appendix B). *4 Potentially breeding population. *5Generation time in years.

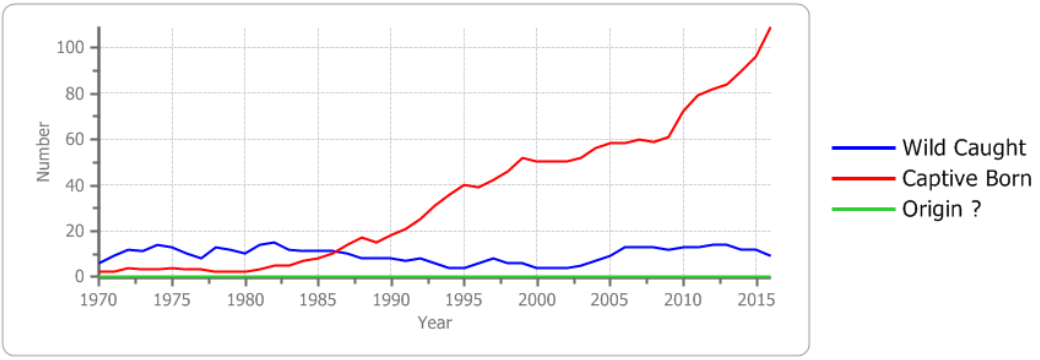

Figure 1: Census, by origin, for the entire Wolverine EEP since 1970.

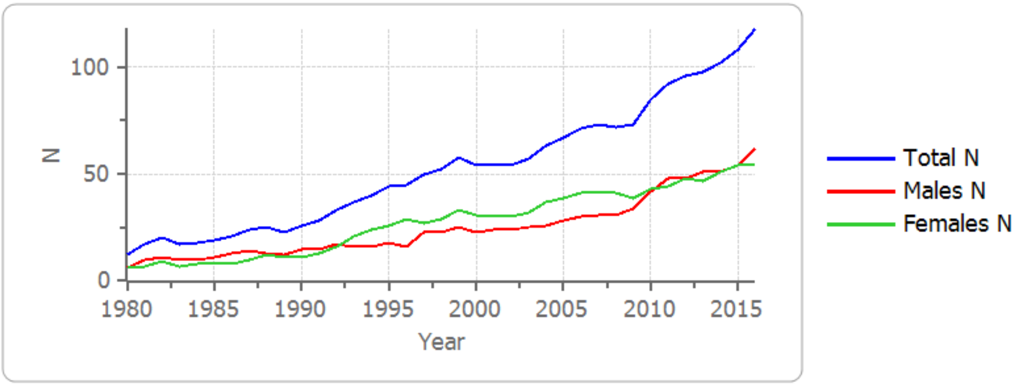

Figure 2: Census, by sex, for the entire Wolverine EEP since 1980.

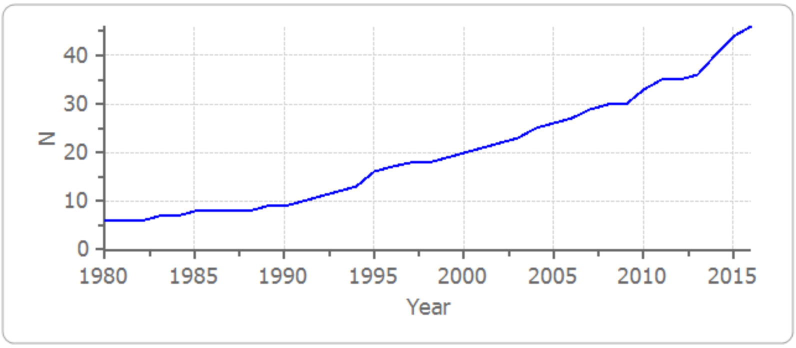

Figure 3: Number of institutions holding the Wolverine EEP population since 1980.

Age distribution

This population is not large with 116 individuals and therefore not entirely demographic stable. Thus, the age distribution has some poorly populated age classes and is not perfectly pyramid shaped. Nevertheless, the population has an even sex ratio and a reasonable number of young individuals and of individuals in breeding age.

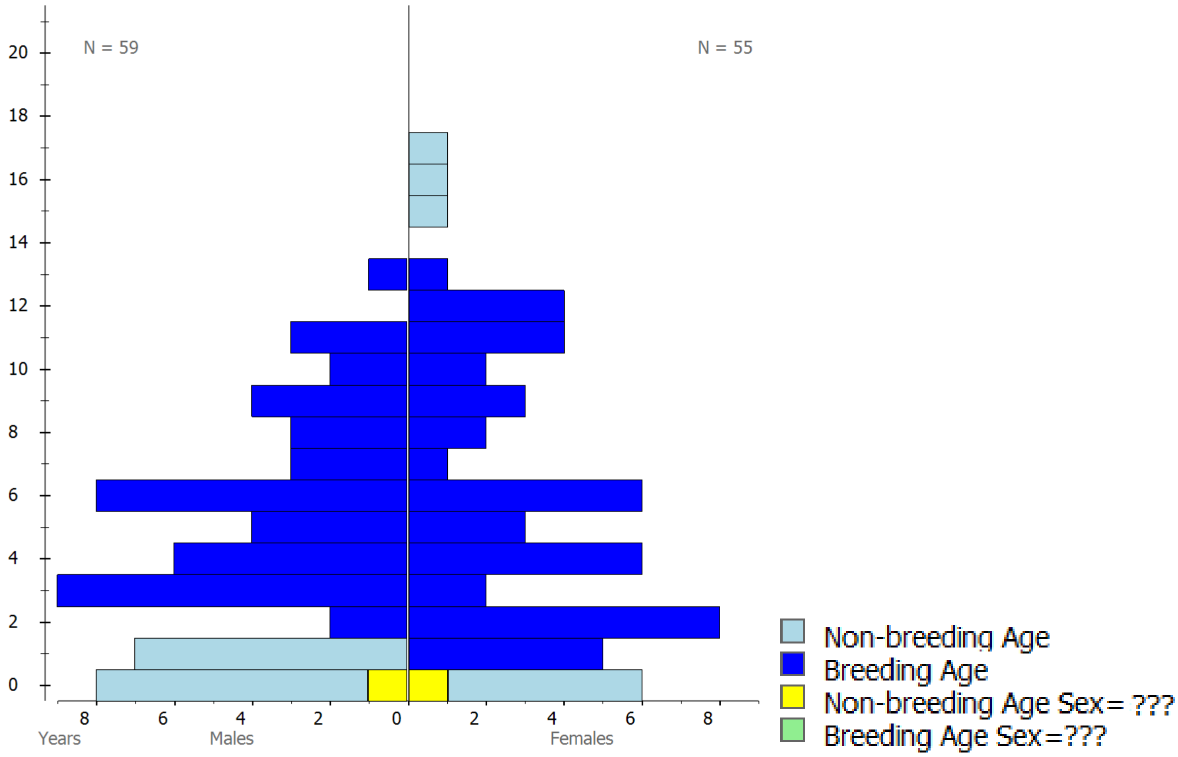

Figure 4: Age distribution of the current Wolverine EEP population.

Births and deaths

Table 3. Annual births and deaths in the Wolverine EEP in the last five years.

Year	2012	2013	2014	2015	2016
Births	15	14	10	16	16
Deaths	13	12	5	10	8
Number of births per year needed to maintain the population at the current size*$_1$					9
How do the recent annual births compare to the births needed to maintain the population size?					
Nine births per year are expected to be necessary to maintain population size based on projections. This is considerably lower than the average of 14 births per year in the last five years. A continuation of this birth rate into the future is thus expected to cause the population to grow considerably.					

*$_1$ Note that births in this population are highly seasonal (N=285), with the great majority of births occurring in February (78%), with virtually no births before January and after March. Therefore, for projections "Birth Flow" in PMx settings was changed from "Continuous" to "Pulse".

Fecundity and Mortality

Wolverines are of reproductive age from the age of two years. Fecundity seemingly increases over their lifetime until the age of 12 years for males and the age of 10 years for females, after which fecundity quickly decreases. Litter sizes range from one to four cubs, with an average of 2.2 cubs per litter.

Based on 197 births, 25% of males and females will die before they reach the age of one year, with mortality being particularly high in the first four months of life. After the first year, mortality rates are low until the age of 10 years. For individuals above the age of 10 years, the chance to die sharply increases. The exact mortality and fecundity rates can be found in Appendix C.

Seasonality

Wolverine are highly seasonal (N=239), with the earliest recorded birth on 21 January and the latest births recorded on 13 March.

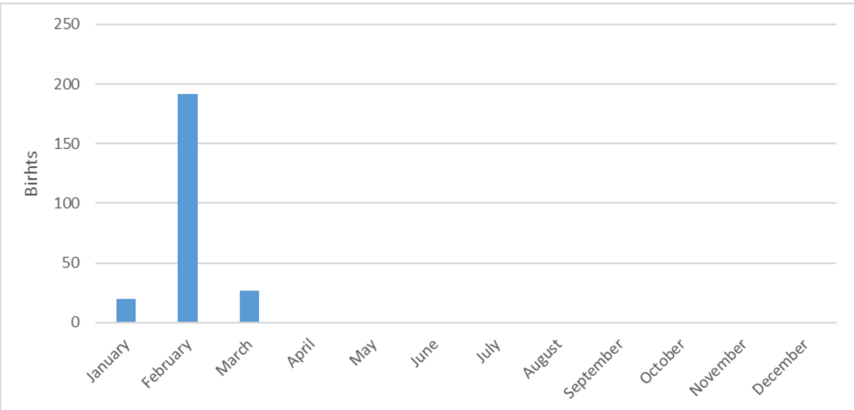

Figure 5: Seasonality of births in the Wolverine EEP, based on 239 births with a known birth date during 1 January 1994 to 10 October 2016. Months are presented on the x-axis and number of births on the y-axis.

Genetic Summary

*Table 4 Genetic status of the Wolverine EEP population*1*

	Current	Potential
Founders	18	1
Founder genome equivalents (FGE)	4.8	12.5
Genetic diversity (GD)	89.6%	96.0%
Population mean kinship (MK)	0.10	
Mean inbreeding (F)	0.07	
Pedigree known before assumptions and exclusions	100%	
Pedigree known after assumptions and exclusions	100%	
Effective population size/census size ratio (Ne / N)	0.29	

Projections*2	
Years to 90% Gene Diversity	-*3
Years to 10% Loss from Current Gene Diversity (89.6% GD)	74
Gene Diversity at 100 Years from present	76.5%
Gene Diversity at 100 Years from present if two sibling founders are added every five years*4	91.7

*1 Six individuals were excluded from this genetic analysis due to old age (Appendix B).

*2 Based on projections in PMx using the following variables, generation time (T)= 7.1 years, (Ne/N)= 0.30, lambda (λ)= 1.0581 and target population size= 150) were used for projections.

*3 Gene diversity currently already lower than 90%.

*4 Based on projections in PMx using the following variables, generation time (T)= 7.1 years, (Ne/N)= 0.30, lambda (λ)= 1.0581 and target population size= 150), adding two founders each 5 years with FGE per founder set on 0.30 to correct for siblingship, starting in 5 years and stopping in 100 years).

Because 100% of the ancestry of the captive born population can be traced back to 18 wild caught founders, the genetic population parameters of this population can be accurately calculated. Note that two of these 18 founders are full siblings, which has been corrected for in genetic analysis. Additionally, there are two wild born individuals in the population that have not yet reproduced, of which one is already post-reproductive (#347 at NIKOLAEV).

Not all genetic material of the 18 founders of the population is retained in the population founders are genetically not equally represented in the population. Thus, the genetic diversity in the population is slightly less than that of five unrelated founders (FGE=4.8), capturing 89.6% of the gene diversity of the wild population. By breeding with individuals with a mean kinship lower than the population's average, it is possible to increase gene diversity in the population. By pairing individuals with similar mean kinship, it remains possible to increase the representation of underrepresented lineages, and thus gene diversity, in the next generation as well. The maximum gene diversity that can be achieved in the population, without exchange with other populations, is 96.3%. Do note that in practice, this theoretical maximum is difficult or even impossible to achieve.

Roles, goals and reproductive strategy

The role of the Wolverine EEP is to

- Serve as a backup population, in case the wild population declines dramatically. Such dramatic declines can be caused by hunting pressures and emerging diseases, where the latter is expected to increase due to climate change. Wolverine populations are known to recover slowly from population declines.
- Use veterinary expertise and data on biology and natural history present in the *ex situ* community to inform in situ conservation actions when necessary.
- Raise awareness and educate the public about a taxonomically unique and ecologically important European species. The species is the largest mustelid in the world and one of the four European large carnivores. When displayed properly, it is easy to educate visitors about its ecologic characteristics, such as eating frozen carcasses, surviving in a harsh environment, saving their food by keeping it frozen in the ground or hidden in trees, breeding in winter and the ability to walk on the snow with their large feet enabling them to hunt much larger prey species, such as reindeer.

Target population size and reproductive planning

The available institutional space for the Wolverine EEP is expected to stabilise at 150 individuals in ten years, with 130 individuals in Europe and 20 in North America. Considering the current population size of 116 individuals, around 12 to 13 kits should be born annually (or six to seven litters) in the coming years to reach this goal. There have been no breeding restrictions in the last five years and this has led to the birth of 14 kits (seven litters) per year on average. With a growth in the population size, also the number of breeding pairs in the population has increased and an increase in birth rate is expected if there are no breeding restrictions. To avoid the population growing too fast, breeding of some pairs will be restricted. Breeding restrictions are given to genetically over-represented individuals to immediately increase genetic diversity. While only genetically valuable pairs are encouraged to reproduce in 2018, from 2019 onwards, some overrepresented pairs may also receive breeding recommendations because the EEP acknowledges the welfare benefits of allowing pairs to reproduce and raise offspring, albeit fewer than genetically valuable pairs.

Decreasing the birth rate

There are several management strategies available to implement a non-breeding recommendation. One strategy is separating the male and female during the breeding season, in May and June. Another is to use contraception. For guidelines on the use of contraception, see Appendix G. Alternatively, institutions can breed and cull the entire litter or part of the litter in discussion with the EEP Coordinator.

The EEP is currently investigating whether the reproductive rate can also be decreased by keeping cubs for a longer period with their parents. The fact that several pairs reproduced in 2017 despite the presence of cubs, illustrates that this method does not guarantee the prevention of reproduction. Also, it is still unclear until which age offspring can be kept with their parents without causing problems.

Genetic goal

The EEP's genetic goal is to maintain at least 90% genetic diversity of the wild population over 100 years, because this level is generally seen as a fair compromise between incurring an acceptably small level of inbreeding and loss of genetic diversity on the one hand, and being able to achieve this with a smaller population size on the other hand (Soulé et al.1986). Unfortunately, the current level of genetic

diversity (GD) retained in the living descendant population is already lower than this (GD= 89.6% GD). But also in case all individuals in the population would have been currently unrelated (GD= 99.6%), gene diversity would still drop below 90% in 68 years.
To achieve its genetic target, the EEP will not only breed by mean kinship to minimise the loss of gene diversity, but also periodically add new founders. Wild born cubs that would otherwise be culled in Sweden to control some areas of high abundance of wolverine in the wild, are sometimes donated to the Swedish zoo association and as such end up in EAZA member zoos. This is ideally kept to a minimum however, because there is a financial cost associated with obtaining them. The EEP aims to obtain two wild born siblings once every five years, resulting in a retention of 91.7% genetic diversity over 100 years. Note that to maintain 90% gene diversity over 100 years, it will be required to continue these founder imports for at least the coming 85 years.

Cooperation with AZA

All AZA institutions that have received *G. g. gulo* will be treated similarly as all other participants of the EEP. Because transfer costs between North America and Europe are considerably higher than intra-regional transfers, transfers between the regions will of course be kept to a minimum. The EEP therefore aims to build up a genetically diverse group of individuals in North-America. An additional reason to do so is that there is a chance that it will become more difficult to transfer wolverines to North-America due to changing laws in the USA.

Conclusions for Wolverine

- The EEP population has grown considerably in recent years and this has not yet caused any space-problems. Population growth is expected to stabilise in the coming ten years at 150 individuals, which means a lower growth rate will be required. At the same time, with the increase in population size, the number of breeding pairs has increased as well. The EEP will therefore have to restrict reproduction of several pairs to avoid a higher growth rate than the EEP can handle.
- Genetic diversity in the population is currently slightly lower than 90% and without new founders the EEP will not be able to meet its genetic goal of maintaining 90% genetic diversity over 100 years. The EEP therefore plans to import a wild caught sibling pair every five years by taking in cubs from the wild that would otherwise be culled by the authorities as a method of controlling some areas of high abundance of wolverine in the wild.
- Eleven individuals in the EEP will receive transfer recommendations. To reach the desired birth rate of the population in 2018, 22 breeding pairs are recommended out of a maximum of 36. While the EEP strives for underrepresented pairs to reproduce relatively more offspring, also some overrepresented pairs may receive a breeding recommendation in the future because the EEP believes that this brings welfare benefits for the pair.
- This population will be re-evaluated annually by the Wolverine EEP Coordinator and Species Committee.

Institutional Breeding Recommendations

These recommendations are for the **mating season in 2017, with births occurring in 2018**. For a few pairs, it is already known that they will receive a breeding recommendation for the mating season of 2018, with births occurring in 2019, but generally, new breeding recommendations will be issued for the next mating season. Please postpone transfer recommendations until after February for reproductively mature females. Note that for pairs with a non-breeding recommendation, instead of avoiding reproduction through separating the pair during the breeding season or using contraception recommended by EGZAC (See Appendix G), it is also possible to apply a breed and cull strategy.

AHTARI

Ahtari, Finland

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
260	205002	F	12	Hold		DoNotBreed		
428	216049	M	0	Hold		DoNotBreed		

ANCHORAGE

Alaska Zoo

Anchorage, United States

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
391	2016-21	M	3	Hold		Breed	405	Good genetic pair.
405	2015-23	F	2	Hold		Breed	391	

BARDU

Polar Park

Troms, Norway

Animals planned to be received by this institution

ID	LocalID	Sex	Age	Current Location	Breeding	With	RecNotes
422	JZM15016	M	1	JARVZOO	DoNotBreed		
423	JZM15017	M	1	JARVZOO	DoNotBreed		

BIG GAME

Alaska Wildlife Conservation Center

Portage Glacier, United States

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
393	KASPER	M	3	Hold		DoNotBreed		Please postpone breeding until 2019 (mating in 2018)
407	KAYLA	F	2	Hold		DoNotBreed		

BILLINGS

ZooMontana

Billings, USA

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
429	M17002	F	0	hold		DoNotBreed		Too young to breed. Please postpone breeding until 2019 (mating in 2018).

Animals to be received by this institution

ID	LocalID	Sex	Age	Current location	Breeding	With	RecNotes
425	216004	M	0	HUNBSTRND	DoNotBreed		Too young to breed. Please postpone breeding until 2019 (mating in 2018).

BORAS

Boras Djurpark Zoo

Boras, Sweden

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
421	RJ0035	F	1	SendTo	LYCKSELE	DoNotBreed		Companion for male #353 at LYCKSELE
281	RJ0028	M	10	Hold		Breed	343	Important genetic pair.

Animals planned to be received by this institution

ID	LocalID	Sex	Age	Current Location	Breeding	With	RecNotes
343	THELMA	F	6	LYCKSELE	Breed	281	Good genetic pair with 281.

BRNO

Brno Zoo and Environmental Education Center

Brno, Czech Republic

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
313	ROE001	M	8	Hold		DoNotBreed		Please postpone breeding until 2019 (mating in 2018).
334	ROE002	F	6	Hold		DoNotBreed		
442	ROE004	U	0	Hold		DoNotBreed		
443	ROE005	U	0	Hold		DoNotBreed		
444	ROE006	U	0	Hold		DoNotBreed		

BUDAPEST

Budapest Zool.& Botanical Garden

Budapest, Hungary

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
373	301089	M	4	Hold		DoNotBreed		Please postpone breeding until 2019 (mating in 2018).
402	301093	F	2	Hold		DoNotBreed		

BURFORD

Cotswold Wildlife Park and Gardens

Burford, United Kingdom

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
306	MM1324	F	8	Hold		Breed	318	Good genetic pair.
318	MM1405	M	7	Hold		Breed	306	
418	M1953	F	1	SendTo	ST FELICI	Breed		

CALVIAC

Reserve Zoologique de Calviac

Calviac-en-Perigord, France

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
299	204001	F	9	Hold		DoNotBreed		Do not mate in 2017 or 2018. This pair may receive a breeding recommendation again in the future.
394	2015GG05	M	3	Hold		DoNotBreed		
445	2017GG01	U	0	Hold		DoNotBreed		
446	2017GG02	U	0	Hold		DoNotBreed		
447	2017GG03	U	0	Hold		DoNotBreed		
448	2017GG04	U	0	Hold		DoNotBreed		

CEZALIER

Parc Animalier d'Auvergne

Ardes-sur-couze, France

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
369	C646	F	4	Hold		DoNotBreed		Please postpone breeding until 2019 (mating in 2018).
382	C370	M	3	Hold		DoNotBreed		

CHOMUTOV

Podkrusnohorski Zoopark Chomutov

Chomutov, Czech Republic

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
256	ROS003	F	13	Hold		DoNotBreed		

COLUMBUS

Columbus Zoo and Aquarium

Powell, United States

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
381	214123	F	3	Hold		DoNotBreed		Please postpone breeding until 2019 (mating in 2018).
383	214037	M	3	Hold		DoNotBreed		

COULANGE

Parc Zoologique d'Amnéville

Amnéville, France

Animals to be received by this institution

ID	LocalID	Sex	Age	Disposition	New location	Breeding	With	RecNotes
430	GG1	M	0	Hold		DoNotBreed		

DUISBURG

Zoo Duisburg AG

Duisburg, Germany

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
236	4212	F	16	Hold		DoNotBreed		
295	5606	M	9	Hold		DoNotBreed		

DETROIT

Detroit zoo

Royal Oak, USA

Animals to be received by this institution

ID	LocalID	Sex	Age	Current location	Breeding	With	RecNotes
439	YAROSLAV	M	0		DoNotBreed		

EBERSWALD

Tierpark Eberswalde

Eberswalde, Germany

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
312	KONRAD	M	8	Hold		DoNotBreed		This pair may receive a breeding recommendation again in the future.
346	346	F	6	Hold		DoNotBreed		

HANSTEDT

Wildpark Luneburger Heide

Hanstedt-Nindorf, Germany

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
367	KATKA	M	4	Hold		DoNotBreed		
368	KAMPPI	M	4	Hold		DoNotBreed		

HANSURLES

Reserve d'Animaux Sauvage

Han-sur-Lesse, Belgium

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
400	GR42	M	2	Hold		Breed	404	Good genetic pair.
404	GR41	F	2	Hold		Breed	400	
TBC	TBC	U	0	Hold		DoNotBreed		Litter of unknown size

HELSINKI

Helsinki Zoo

Helsinki, Finland

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
389	214029	M	3	Hold		DoNotBreed		
403	215003	F	2	Hold	TBC	DoNotBreed		

HERBERSTN

Tierwelt Herberstein

Buchberg, Austria

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
414	101732	F	1	Hold		Breed	420	Genetically good pair.
420	101731	M	1	Hold		Breed	414	

HLUBOKA

Zoologicka Zahrada Ohrada

Hluboka nad Vltavou, Czech Republic

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
365	M4100001	F	4	Hold		Breed	374	Good genetic pair.
374	M4200002	M	4	Hold		Breed	365	

HUNBSTRND

Nordens Ark								
Hunnebostrand, Sweden								
ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
273	205009	M	11	Hold		Breed	285	Good genetic pair.
285	206072	F	10	Hold		Breed	273	
290	208002	F	9	Hold		DoNotBreed		Please postpone breeding with this pair until 2019 (mating in 2018). There is a possibility that #356 will go on breeding loan to STOCKHOLM for female #282.
356	211009	M	5	Hold		DoNotBreed		
425	216004	M	0	SendTo	BILLINGS	DoNotBreed		
TBC	TBC	U	0	Hold		DoNotBreed		Two litters. One of size unknown and one of at least two kits.
TBC	TBC	U	0	Hold		DoNotBreed		

JARVZOO

Jarvzoo								
Jarvso, Sweden								
ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
278	JZM06009	F	11	Hold		Breed	291	Important genetic pair.
291	JZM08001	M	9	Hold		Breed	278	
293	JZM07005	M	9	Hold		DoNotBreed		This pair may receive a breeding recommendation again in the future.
345	FROSSA	F	6	Hold		DoNotBreed		
422	JZM15016	M	1	SendTo	BARDU	DoNotBreed		
423	JZM15017	M	1	SendTo	BARDU	DoNotBreed		

KERKRADE

GaiaZoo, Kerkrade								
Kerkrade, Netherlands								
ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
378	M12146	F	4	Hold		DoNotBreed		Please postpone breeding until 2019 (mating in 2018).
419	M15078	M	1	Hold		DoNotBreed		

KINGUSSIE

Highland Wildlife Park								
Kingussie, United Kingdom								
ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
267	5669	M	11	Hold		Breed	401	OK genetic pair. It is understood that due to the high age of the male, breeding may not be successful.
401	5831	F	2	Hold		Breed	267	
434	5926	U	0	Hold		DoNotBreed		Please determine the sex of these individuals to facilitate a future transfer recommendation.
435	5927	U	0	Hold		DoNotBreed		

KOLMARDEN

Kolmardens Djurpark AB								
Kolmarden, Sweden								
ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
319	11121	M	7	Hold		Breed	324	Good genetic pair.
324	10812	F	7	Hold		Breed	319	
433	12926	F	0	SendTo	LYCKSELE	Breed	348	Important genetic pair.

KRISTIANS

Kristiansand Dyrepark ASA								
Kristiansand, Norway								
ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
275	GULGG006	F	11	Hold		DoNotBreed		
329	GULGG015	M	6	Hold		DoNotBreed		

LUND

Skanes Djurpark Resort AB								
Hoor, Sweden								
ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
274	LUNA	M	11	Hold		DoNotBreed		
294	DINA	F	9	Hold		DoNotBreed		
439	YAROSLAV	M	0	SendTo	DETROIT	DoNotBreed		
440	YARA	F	0	SendTo	NAMSKOGAN	DoNotBreed		

LYCKSELE

Lycksele Djurpark/Zoo								
Lycksele, Sweden								
ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
343	THELMA	F	6	SendTo	BORAS	Breed	281	Good genetic pair with 281.
348	348	M	5	Hold		Breed	433	Important genetic pair with 433. The chance to reproduce in 2018 seems low due to the young age of the female.
353	LUDDE	M	5	Hold		DoNotBreed		

Animals to be received by this institution

ID	LocalID	Sex	Age	Current location	Breeding	With	RecNotes
421	RJ0035	F	1	BORAS	DoNotBreed		Companion for male #353. Currently this pair does not receive a breeding recommendation.
433	12926	F	0	KOLMARDEN	Breed	348	Important genetic pair. The chance to reproduce in 2018 seems low due to the young age of the female.

MINNESOTA

Minnesota Zoological Garden								
Apple Valley, United States								
ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
387	13729	F	3	Hold		Breed	390	Good genetic pair.
390	13728	M	3	Hold		Breed	387	

MOSCOW

Moscow Zoological Park

Moskovskaya oblast, Russian Federation

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
231	200541	F	17	Hold		DoNotBreed		
263	40874	F	12	Hold		Breed	331	Important genetic pair, even though it is unlikely that this female will reproduce again due to her age.
331	100022	M	6	Hold		Breed	263	
264	40875	F	12	Hold		Breed	332	It is understood that these individuals are related and thus not an ideal pair. However, the female is very unlikely to reproduce again due to her age. In the unlikely event that she does still manage to reproduce it is still beneficial for the population because the female is genetically very valuable.
332	100023	M	6	Hold		Breed	264	
336	100067	M	6	Hold		Breed	380	Important genetic pair.
380	120693	F	4	Hold		Breed	336	
424	150597	F	1	Hold		DoNotBreed		

MUNICH

Munchener Tierpark Hellabrunn

Munchen / Munich, Germany

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
360	083009	F	5	Hold		DoNotBreed		This pair may receive a breeding recommendation again in the future.
364	083010	M	4	Hold		DoNotBreed		

NAMSKOGAN

Namsskogans Familiepark

Trones, Norway

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
325	NIILA	M	6	Hold		DoNotBreed		

Animals to be received by this institution

ID	LocalID	Sex	Age	Current location	Breeding	With	RecNotes
440	YARA	F	0	LUND	DoNotBreed		

NIKOLAEV

Nikolaev Zoo of Nikolaev-City Council

Nikolaev, Ukraine

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
347	403055	F	15	Hold		DoNotBreed		
371	414048	M	4	Hold		DoNotBreed		

NOVOSIBRK

Novosibirsk Zoological Park

Novosibirsk, Russian Federation

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
328	123026	M	6	Hold		DoNotBreed		Please postpone breeding with this pair (328/338) until 2019 (mating in 2018).
338	123025	F	6	Hold		DoNotBreed		
372	123028	F	4	Hold		DoNotBreed		
437	123033	M	0	SendTo	ST FELICI	Breed	418	
438	123034	F	0	TBC		DoNotBreed		The EEP is currently waiting for additional information to come in before giving a final recommendation.

OPOLE

Ogrod Zoologiczny Opole

Opole, Poland

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
330	M11064	M	6	Hold		Breed	349	Genetically important female, but overrepresented male. Recommended to breed anyway.
349	M12076	F	5	Hold		Breed	330	

ORSA

Orsa Rovdjurspark

Orsa, Sweden

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
305	WV2	M	8	Hold		DoNotBreed		This pair may receive a breeding recommendation again in the future.
399	WV4	F	2	Hold		DoNotBreed		

OSIJEK

Zoo Osijek/UNIKOMza Komun Gospodarstvo

Osijek, Croatia

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
416	GG01	M	1	Hold		DoNotBreed		
417	GG02	M	1	Hold		DoNotBreed		

OSNABRUCK

Zoo Osnabruck

Osnabruck, Germany

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
344	2780	M	6	Hold		Breed	358	Good genetic pair
358	3015	F	5	Hold		Breed	344	
436	3836	F	0	SendTo	WHIPSNADE	DoNotBreed		
TBC	TBC	U	0	Hold		DoNotBreed		Possibly, litter of four.
TBC	TBC	U	0	Hold		DoNotBreed		
TBC	TBC	U	0	Hold		DoNotBreed		

PARIS ZOO

Parc Zoologique de Paris (MNHN)								
Paris, France								
ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
366	ZB4070	F	4	Hold		Breed	385	Good genetic pair.
385	ZB4055	M	3	Hold		Breed	366	

RANUA

Ranua Wildlife Park								
Ranua, Finland								
ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
279	206038	F	11	Hold		DoNotBreed		Do not breed in 2018. Maybe this pair will receive a breeding recommendation for 2019 (mating in 2018).
296	211002	M	9	Hold		DoNotBreed		

SALZBURG

Salzburg Zoo Hellbrunn								
Anif, Austria								
ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
317	S1050	F	8	Hold		DoNotBreed		
406	S2085	M	2	Hold		DoNotBreed		

ST FELICI

Zoo Sauvage de St-Felicien

St-Felicien, Canada

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
395	B14086	M	3	Hold		DoNotBreed		Please postpone breeding until 2019 (mating in 2018).
398	B14104	F	2	Hold		DoNotBreed		

Animals to be received by this institution

ID	LocalID	Sex	Age	Current location	Breeding	With	RecNotes
418	M1953	F	1	BURFORD	Breed	437	
437	123033	M	0	NOVOSIBRK	Breed	418	

STE CROIX

Parc Animalier de Sainte Croix

Rhodes, Moselle

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
411	1643	F	1	Hold		Breed	412	Good genetic pair.
412	1642	M	1	Hold		Breed	411	

STOCKHOLM

Skansen Foundation, Zool. Dept.

Stockholm, Sweden

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
252	941335	M	13	Hold		DoNotBreed		Continue the discussion with the EEP coordinator about the option of culling this individual.
282	941520	F	10	Hold		Breed	TBC	Possibly will receive a breeding-visit from male of KOLMARDEN or HUNBSTRND, depending on the births in February-March 2017.

SZEGED

Szeged Zoo

Szeged, Hungary

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
283	2246	M	10	Hold		DoNotBreed		This pair may receive a breeding recommendation again in the future.
340	2746	F	6	Hold		DoNotBreed		

USTI

Usti nad Labem Zoo

Usti nad Labem, Czech Republic

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
266	UL0575	F	11	Hold		Breed	357	Important genetic pair. It is understood that it is unlikely for this female to reproduce successfully at this age.
357	UL1998	M	5	Hold		Breed	266	

VOLKEL

ZieZoo

Delft, Netherlands

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
431	Z1045	M	0	Hold		DoNotBreed		
432	Z1046	M	0	Hold		DoNotBreed		

WHIPSNADE

ZSL Whipsnade Zoo

Dunstable, United Kingdom

ID	LocalID	Sex	Age	Disposition	New Location	Breeding	With	RecNotes
323	4059	M	7	Hold		DoNotBreed		Please do not breed with this pair in 2018 (Do not mate in 2017).

Animals to be received by this institution

ID	LocalID	Sex	Age	Current location	Breeding	With	RecNotes
436	3836	F	0	OSNABRUCK	DoNotBreed		Please do not breed with this pair in 2018 (Do not mate in 2017).

Appendix A
Summary of Data Exports

Export for both demographic and Genetic analysis

PMx Project: Wolv21994D(ImprovedCurrentness)
Created: 2016-11-22 by PMx version 1.3.20160708
File: C:\PMxProjects\Wolv21994D(ImprovedCurrentness).pmxproj

Primary data file
Data File Name: EXCHANGE.CSV
GULO input file for pmx
Scientific name: GULO GULO GULO
Common name: WOLVERINE
Exported on: 22/11/2016 09:07:22
Software version: Sparks 1.66
Scope: European regional
Current to: 1/11/2016
Compiled by: Leif Blomqvist, Nordens Ark, leif.blomqvist@nordensark.se
Filter conditions in effect:
Dates: 01/01/1994 <= 15/11/2016
Association: \Sparks\EAZA.fed + BARDU, SPRINGE, NAMSKOGAN, HANSTEDT, NIKOLAEV, NOVOSIBRK, OSIJEK, VOLKEL, ANCHORAGE, COLUMBUS, BIG GAME, DETROIT, MINNESOTA, MONTANA and ST FELICI.

Locations data file
Data File Name: location.txt

Demographic input files
Census1 file: PMXCENS.CSV

Appendix B
Animals Excluded from Genetic Analysis

ID	Location	House name	Sex	Reason for exclusion
231	MOSCOW	Agnetha	F	Old age
236	DUISBURG	Ronja	F	Old age
252	STOCKHOLM	Untamo	M	Old age
256	CHOMUTOV		F	Old age
260	AHTARI	Roosa	F	Old age
347	NIKOLAEV	Plotinka	F	Old age

Appendix C
Life Tables
- For EEP population

Export dates used for these life tables are from 1 January 1994 to 15 November 2016. Note that the reported mortality and fecundity rates are always a result of a combination of the biology of the species and historical management and that especially data on older ages becomes less reliable due to a smaller sample size.

Males				
Age	Qx	Lx	Mx	Sample size
0	25%	100%	0.00	100.5
1	5%	75%	0.00	84
2	4%	72%	0.10	73.8
3	2%	71%	0.13	70
4	3%	69%	0.07	62.3
5	2%	66%	0.26	55.1
6	4%	64%	0.34	49.8
7	0%	61%	0.23	43.5
8	5%	58%	0.23	42
9	5%	58%	0.38	36.9
10	0%	53%	0.32	32.7
11	14%	50%	0.25	28.3
12	13%	45%	0.52	22.8
13	4%	36%	0.09	22.2
14	24%	23%	0.20	18.6
15	38%	19%	0.09	13
16	55%	16%	0.00	7.6
17	43%	12%	0.00	4
18	60%	7%	0.00	2.2
19	100%	7%	0.00	0
20	100%	0%	0.00	0
21	100%	0%	0.00	0

Females				
Age	Qx	Lx	Mx	Sample size
0	25%	100%	0.00	96.5
1	4%	75%	0.01	95.9
2	1%	72%	0.07	85.6
3	3%	71%	0.12	79.1
4	4%	69%	0.21	73.7
5	3%	66%	0.17	64.1
6	5%	64%	0.32	61.1
7	5%	61%	0.22	55.5
8	0%	58%	0.25	52.7
9	8%	58%	0.30	50.6
10	7%	53%	0.27	44.6
11	10%	50%	0.14	39
12	20%	45%	0.04	30.4
13	36%	36%	0.03	20.7
14	18%	23%	0.00	13.3
15	13%	19%	0.00	11.3
16	26%	16%	0.00	9.6
17	43%	12%	0.00	5.9
18	0%	7%	0.00	3
19	100%	7%	0.00	0
20	100%	0%	0.00	0
21	100%	0%	0.00	0

Appendix D
Ordered Mean Kinship list

Population mean kinship (MK)= 0.10

Legend

Very Underrepresented
Underrepresented
Neutral
Overrepresented
Very overrepresented

Males				Females			
ID	MK	Age	Location	ID	MK	Age	Location
281	0.02	10	BORAS	343	0.00	6	LYCKSELE
391	0.07	3	ANCHORAGE	380	0.00	4	MOSCOW
422	0.07	1	JARVZOO	278	0.01	11	JARVZOO
423	0.07	1	JARVZOO	282	0.02	10	STOCKHOLM
385	0.07	3	PARIS ZOO	285	0.04	10	HUNBSTRND
348	0.07	5	LYCKSELE	263	0.04	12	MOSCOW
412	0.07	1	STE CROIX	264	0.05	12	MOSCOW
357	0.08	5	USTI	387	0.07	3	MINNESOTA
356	0.08	5	HUNBSTRND	340	0.07	6	SZEGED
318	0.08	7	BURFORD	349	0.07	5	OPOLE
319	0.08	7	KOLMARDEN	414	0.07	1	HERBERSTN
323	0.09	7	WHIPSNADE	358	0.08	5	OSNABRUCK
382	0.09	3	CEZALIER	401	0.09	2	KINGUSSIE
383	0.09	3	COLUMBUS	411	0.09	1	STE CROIX
400	0.09	2	HANSURLES	433	0.09	0	KOLMARDEN
389	0.09	3	HELSINKI	372	0.09	4	NOVOSIBRK
390	0.09	3	MINNESOTA	324	0.09	7	KOLMARDEN
431	0.09	0	VOLKEL	338	0.09	6	NOVOSIBRK
432	0.09	0	VOLKEL	365	0.09	4	HLUBOKA
336	0.09	6	MOSCOW	366	0.09	4	PARIS ZOO
371	0.09	4	NIKOLAEV	418	0.09	1	BURFORD
419	0.09	1	KERKRADE	424	0.10	1	MOSCOW
420	0.09	1	HERBERSTN	334	0.10	6	BRNO
296	0.09	9	RANUA	306	0.10	8	BURFORD
364	0.09	4	MUNICH	404	0.10	2	HANSURLES
416	0.09	1	OSIJEK	405	0.10	2	ANCHORAGE
417	0.09	1	OSIJEK	438	0.10	0	NOVOSIBRK
295	0.09	9	DUISBURG	436	0.10	0	OSNABRUCK
373	0.10	4	BUDAPEST	345	0.11	6	JARVZOO
374	0.10	4	HLUBOKA	346	0.11	6	EBERSWALD
331	0.10	6	MOSCOW	378	0.11	4	KERKRADE

Males			
ID	MK	Age	Location
332	0.10	6	MOSCOW
425	0.10	0	HUNBSTRND
437	0.10	0	NOVOSIBRK
328	0.11	6	NOVOSIBRK
344	0.11	6	OSNABRUCK
267	0.11	11	KINGUSSIE
291	0.12	9	JARVZOO
428	0.12	0	AHTARI
430	0.13	0	BRNO
330	0.13	6	OPOLE
305	0.13	8	ORSA
325	0.13	6	NAMSKOGAN
367	0.13	4	HANSTEDT
368	0.13	4	HANSTEDT
329	0.14	6	KRISTIANS
293	0.14	9	JARVZOO
273	0.14	11	HUNBSTRND
393	0.14	3	BIG GAME
394	0.14	3	CALVIAC
395	0.14	3	ST FELICI
274	0.14	11	LUND
283	0.14	10	SZEGED
353	0.14	5	LYCKSELE
406	0.14	2	SALZBURG
439	0.14	0	LUND
312	0.15	8	EBERSWALD
313	0.15	8	BRNO

Females			
ID	MK	Age	Location
266	0.11	11	USTI
398	0.12	2	ST FELICI
399	0.12	2	ORSA
429	0.12	0	BILLINGS
290	0.12	9	HUNBSTRND
369	0.13	4	CEZALIER
402	0.13	2	BUDAPEST
403	0.13	2	HELSINKI
279	0.14	11	RANUA
294	0.14	9	LUND
421	0.14	1	BORAS
360	0.14	5	MUNICH
407	0.14	2	BIG GAME
440	0.14	0	LUND
299	0.14	9	CALVIAC
275	0.15	11	KRISTIANS
381	0.15	3	COLUMBUS
317	0.15	8	SALZBURG

Appendix E
Resources

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Appendix F
Definitions

Demographic Terms

Age Distribution – A two-way classification showing the numbers or percentages of individuals in various age and sex classes.

Ex, Life Expectancy – Average years of further life for an animal in age class x.

Lambda (λ) or Population Growth Rate – The proportional change in population size from one year to the next. Lambda can be based on life-table calculations (the expected lambda) or from observed changes in population size from year to year. A lambda of 1.11 means a 11% per year increase; lambda of .97 means a 3% decline in size per year.

lx, Age-Specific Survivorship – The probability that a new individual (e.g., age 0) is alive at the *beginning* of age *x*. Alternatively, the proportion of individuals which survive from birth to the beginning of a specific age class.
Mx, Fecundity – The average number of same-sexed young born to animals in that age class. Because SPARKS is typically using relatively small sample sizes, SPARKS calculates Mx as 1/2 the average number of young born to animals in that age class. This provides a somewhat less "noisy" estimate of Mx, though it does not allow for unusual sex ratios. The fecundity rates provide information on the age of first, last, and maximum reproduction.

Px, Age-Specific Survival – The probability that an individual of age *x* survives one time period; is conditional on an individual being alive at the beginning of the time period. Alternatively, the proportion of individuals which survive from the beginning of one age class to the next.

Qx, Mortality – Probability that an individual of age *x* dies during time period. Qx = 1-Px

Risk (Qx or Mx) – The number of individuals that have lived during an age class. The number at risk is used to calculate Mx and Qx by dividing the number of births and deaths that occurred during an age class by the number of animals at risk of dying and reproducing during that age class.
The proportion of individuals that die during an age class. It is calculated from the number of animals that die during an age class divided by the number of animals that were alive at the beginning of the age class (i.e.-"at risk").

Vx, **Reproductive Value** – The expected number of offspring produced this year and in future years by an animal of age

Genetic Terms

Allele Retention – The probability that a gene present in a founder individual exists in the living, descendant population.

Current Gene Diversity (GD) -- The proportional gene diversity (as a proportion of the source population) is the probability that two alleles from the same locus sampled at random from the population will not be identical by descent. Gene diversity is calculated from allele frequencies, and is the heterozygosity expected in progeny produced by random mating, and if the population were in Hardy-Weinberg equilibrium.

Effective Population Size (Inbreeding N_e) -- The size of a randomly mating population of constant size with equal sex ratio and a Poisson distribution of family sizes that would (a) result in the same mean rate of inbreeding as that observed in the population, or (b) would result in the same rate of random change in gene frequencies (genetic drift) as observed in the population. These two definitions are identical only if the population is demographically stable (because the rate of inbreeding depends on the distribution of alleles in the parental generation, whereas the rate of gene frequency drift is measured in the current generation).

FOKE, First Order Kin Equivalents – The number of first-order kin (siblings or offspring) that would contain the number of copies of an individuals alleles (identical by descent) as are present in the captive-born population. Thus an offspring or sib contributes 1 to FOKE; each grand-offspring contributes 1/2 to FOKE; each cousin contributes 1/4 to FOKE. FOKE = 4*N*MK, in which N is the number of living animals in the captive population.

Founder – An individual obtained from a source population (often the wild) that has no known relationship to any individuals in the derived population (except for its own descendants).

Founder Contribution -- Number of copies of a founder's genome that are present in the living descendants. Each offspring contributes 0.5, each grand-offspring contributes 0.25, etc.

Founder Genome Equivalents (FGE) – The number wild-caught individuals (founders) that would produce the same amount of gene diversity as does the population under study. The gene diversity of a population is 1 - 1 / (2 * FGE).

Founder Genome Surviving – The sum of allelic retentions of the individual founders (i.e., the product of the mean allelic retention and the number of founders).

Founder Representation -- Proportion of the genes in the living, descendant population that are derived from that founder. I.e., proportional Founder Contribution.

GU, Genome Uniqueness – Probability that an allele sampled at random from an individual is not present, identical by descent, in any other living individual in the population. GU-all is the genome uniqueness relative to the entire population. GU-Desc is the genome uniqueness relative to the living non-founder, descendants.

Inbreeding Coefficient (F) -- Probability that the two alleles at a genetic locus are identical by descent from an ancestor common to both parents. The mean inbreeding coefficient of a population will be the proportional decrease in observed heterozygosity relative to the expected heterozygosity of the founder population.

Kinship Value (KV) – The weighted mean kinship of an animal, with the weights being the reproductive values of each of the kin. The mean kinship value of a population predicts the loss of gene diversity expected in the subsequent generation if all animals were to mate randomly and all were to produce the numbers of offspring expected for animals of their age.

Mean Generation Time (T) – The average time elapsing from reproduction in one generation to the time the next generation reproduces. Also, the average age at which a female (or male) produces offspring. It is not the age of first reproduction. Males and females often have different generation times.

Mean Kinship (MK) – The mean kinship coefficient between an animal and all animals (including itself) in the living, captive-born population. The mean kinship of a population is equal to the proportional loss of gene diversity of the descendant (captive-born) population relative to the founders and is also the mean inbreeding coefficient of progeny produced by random mating. Mean kinship is also the reciprocal of two times the founder genome equivalents: MK = 1 / (2 * FGE). MK = 1 - GD.

Percent Known – Percent of an animal's genome that is traceable to known Founders. Thus, if an animal has an UNK sire, the % Known = 50. If it has an UNK grandparent, % Known = 75.

Prob Lost – Probability that a random allele from the individual will be lost from the population in the next generation, because neither this individual nor any of its relatives pass on the allele to an offspring. Assumes that each individual will produce a number of future offspring equal to its reproductive value, Vx.

Appendix G

Contraception Use and Guidelines for Wolverines

Date: November 2016
Compiled by: Veronica Cowl
Reviewed by: Yedra Feltrer MSc MRCVS

Females:
Deslorelin acetate (Suprelorin) Subcutaneous implant- 1-2x 4.7mg implants depending on size and weight for a minimum duration of 6 months and 1-2x 9.4mg for a minimum duration of 12 months. Duration of efficacy can show individual variation. To suppress the initial stimulation phase supplement the first bout with additional contraception such as oral megestrol acetate pills (Ovarid) daily, 7 days before and 8 days after implantation. In seasonal breeders, treatment should be given more than 2 months prior to the expected breeding season. In wolverine, we would recommend placing the implants in early spring. Deslorelin is designed to be fully reversible; however there are no records of reversal in our database. Removal of implant to aid reversibility is recommended. General side effects include increased appetite and weight gain.

Leuprolide acetate (Lupron®): Subcutaneous or intramuscular injection – Although it is believed that Lupron should work in Bush Dogs, there are no cases of Lupron being used in this species in the database therefore efficacy, dose and reversibility have not been established. Therefore EGZAC is in no position to recommend or discourage its use.

Available in various formulations lasting from 1 to 6 months, duration of efficacy can show individual variation. In seasonal breeders, treatment should be given more than 2 months prior to the expected breeding season. Males can remain fertile for two or more month following first being injected and the initial stimulation phase may come with an increase in aggression or sexual interest, it is therefore recommended that the sexes are separated for this period. A side effect of using Lupron is suppression of secondary sexual characteristics.

Males:
Deslorelin (Suprelorin): Subcutaneous implant- 1-2x 4.7mg implants depending on size and weight for **aminimum** duration of 6 months and 1-2x 9.4mg implants for a **minimum** duration of 12 months. Duration of efficacy can show individual variation. There is an initial stimulation phase after treatment which unfortunately cannot be suppressed in males. In seasonal breeders, treatment should be given more than 2 months prior to the expected breeding season. Deslorelin is designed to be fully reversible, but there are no cases of this available on the database. Removal of implant to aid reversibility is recommended. General side effects include feminisation of males. Males may loss muscle and overall weight, becoming the size (weight) of females.

Leuprolide acetate (Lupron®): Subcutaneous or intramuscular injection – Although it is believed that Lupron should work in Bush Dogs, there are no cases of Lupron being used in this species in the database therefore efficacy, dose and reversibility have not been established. Therefore EGZAC is in no position to recommend or discourage its use.

Available in various formulations lasting from 1 to 6 months, duration of efficacy can show individual variation. In seasonal breeders, treatment should be given more than 2 months prior to the expected breeding season. Males can remain fertile for two or more month following first being injected and the initial stimulation phase may come with an increase in aggression or sexual interest, it is therefore recommended that the sexes are separated for this period. A side effect of using Lupron is suppression of secondary sexual characteristics.

We would highly encourage any institutions planning on using contraception in their animals to assess the safety and efficacy of the product with behavioural, hormonal, and reproductive tract monitoring. For more information on this, please do not hesitate in contacting us.

We also have product information sheets available on our website which will tell you more about the mechanism of action etc. of each of the recommended products above.

Appendix H Directory of EEP Participants

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