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Actual spreading and future evolution of alien population of Coypus (*Myocastor coypus*) in Campania region

Arianna Morena Belfiore*[1], Claudia Troiano[1], Maria Buglione[1], Simona Petrelli[1], Gabriele de Filippo[2] and Domenico Fulgione[1]

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***Correspondence:** arianna.m.belfiore@gmail.com

Affiliation:
[1] Department of Biology, University of Naples Federico II, Naples, Italy

[2] Istituto di Gestione della Fauna (IGF), Naples, Italy

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Abstract

This study has two main objectives: to define the presence of an alien species, the coypu (*Myocastor coypus*), in the Campania region and to develop a demographic projection in the absence of management plans. It was possible to highlight the areas in which the species is currently present on the territory and, once the biological and ecological aspects of it have been analysed, to observe whether favourable environmental conditions are present in the Campania region for its survival and proliferation. The results obtained from the environmental suitability model have effectively highlighted the presence of variables that can affect the survival of the species and that the synergy between these can lead to unexpected results. Therefore, to decipher the actual danger of the species it was necessary to develop a demographic projection to observe whether the latter may increase over time. The outcome highlighted an exponential increase in the population over time, thus highlighting the need to intervene in the short term to mitigate the negative impacts that the coypu already perpetuates on the environment.

Keywords: *Myocastor coypus*, Campania, population dynamics, suitable habitats, alien species

Riassunto

Questo studio ha due obiettivi principali: definire la presenza di una specie aliena, la nutria (*Myocastor coypus*), sul territorio campano e sviluppare una proiezione demografica in assenza di piani di gestione. È stato possibile evidenziare le zone in cui la specie è attualmente presente sul territorio e una volta analizzati gli aspetti biologici ed ecologici di essa, osservare se sul territorio campano sono presenti condizioni ambientali favorevoli per la sua sopravvivenza e proliferazione. I risultati ottenuti dal modello di idoneità ambientale hanno effettivamente messo in evidenza la presenza di variabili che possono condizionare la sopravvivenza della specie e che la sinergia tra queste può condurre a risultati inattesi. Dunque, per decifrare l'effettiva pericolosità della specie è stato necessario sviluppare una proiezione demografica in modo da osservare se quest'ultima possa aumentare nel tempo. L'esito ha evidenziato un aumento esponenziale della popolazione nel tempo mettendo quindi in luce il bisogno di intervenire nel breve periodo per mitigare gli impatti negativi che la nutria già perpetua nei confronti dell'ambiente.

Parole chiave: *Myocastor coypus*, Campania, dinamica di popolazione, habitat idonei, specie aliene

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Introduction

Alien species are represented by populations that are found outside their range of origin following voluntary or accidental action by humans (IUCN 2000; CBD 2002). They usually cause damage to the ecosystem and economic systems. In fact, the practical and normative sense, invasive alien species are those that threaten biodiversity and related ecosystem services (CBD 2000, 2002; IUCN 2000). Invasive alien species are second to habitat destruction in the causes of biodiversity loss (Wilson 2003).

The coypu (*Myocastor coypus* (Molina, 1782) is a rodent mammal native to South America, the only living species of the genus *Myocastor* and of the family *Myocastoridae*. it has spread to Europe, Asia and North America due to escapes and/or liberations from fur farms (Woods et al., 1992). This animal usually inhabits swamps, lake shores and slow streams, especially in areas where riparian vegetation is abundant (Greer 1966; Nowak 1991). Its sexual maturity is reached around 6 months of age; it does not have a specific reproductive period and has the possibility of reproducing all year round, as the factors influencing the reproductive potential of the coypu are the type and availability of food, weather conditions, predators and diseases. Litter size usually ranges from 3 to 6 cubs (Gosling 1981; Gosling & Backer 1981; Woods et al., 1992). The coypu is herbivorous; its diet consists largely of aquatic vegetation: stems, leaves, roots and even bark, but it occasionally also feeds on bivalve mollusks. (Woods et al., 1992).

In Italy, this species was introduced starting from the 1960s. It is present in almost all regions and many populations are in a phase of active expansion. The distribution of the coypus in Italy has had a strong increase in recent decades, passing from small, localized populations to two areas with an almost continuous distribution: one in Northern Italy, in the Po Valley and along the Adriatic coast down to Abruzzo, and the second along the Tyrrhenian coast of Liguria and Tuscany down to Campania. Along the middle Adriatic coast (Marche, Abruzzo), the lower Tyrrhenian coast and in Southern Italy and the islands, apparently isolated cores of smaller dimensions were present (Cochi & Riga 2001). In Italy, population densities ranging from 1 to 4 individuals per hectare have been detected (Vellatta & Ragni 1991; Reggiani et al., 1993). In Campania, the species was reported generally spotted, but also with connected population along the Sele-Tanagro river axis that crosses areas of high naturalistic interest.

The damage caused by this species through the excavation of the burrows along the banks and canals represents a threat to the hydraulic works and to water regulation and it can increase the risk of flooding. As for the impacts on the fauna, the coypu has a negative effect on several species of water birds that build floating nests and competes with the otter (*Lutra lutra*) for space. Food activity can lead to a strong contraction of the vegetation of wetlands and consequently to a strong decrease of many plant species, which in turn can negatively affect the natural dynamics of habitats (Bertolino & Cocchi 2018).

In our study we aim to:

- Analyze the coypu (*Myocastor coypus*) distribution of population in Campania region;
- Characterize the biotic and abiotic variables that make up the suitable habitat for this species;
- Model the demographic forecast for the next 20 years, considering that at present there are not management plans that can mitigate the impact of this animal.

Materials and Methods

Presence data collection

To identify the presence of coypus in the Campania region were carried out direct and indirect observations.

Direct sampling included the monitoring of specific areas of the Campania region, in the period 2020-2021 such as: Matese lake, Campolattaro lake, Picentino river, Volturno river, Sele river, Alento river, Tanagro river, Garigliano river, Sarno river, Calore river (BN), Calore river (SA), Bussento river (Fig.1).

Once a direct presence sign (observation of the animal) or indirect (slides, excretions and/or footprints) was identified, its location was recorded using a GPS device and recorded in a spreadsheet. As for the indirect field activity, this included the study of publications or reports through citizen size activities.

Environmental suitability modelling

The presence of coypus and arbitrariness environmental variables were used to develop a map of environmental suitability. We built a model of maximum entropy using software MaxEnt (Phillips et al., 2006; Phillips

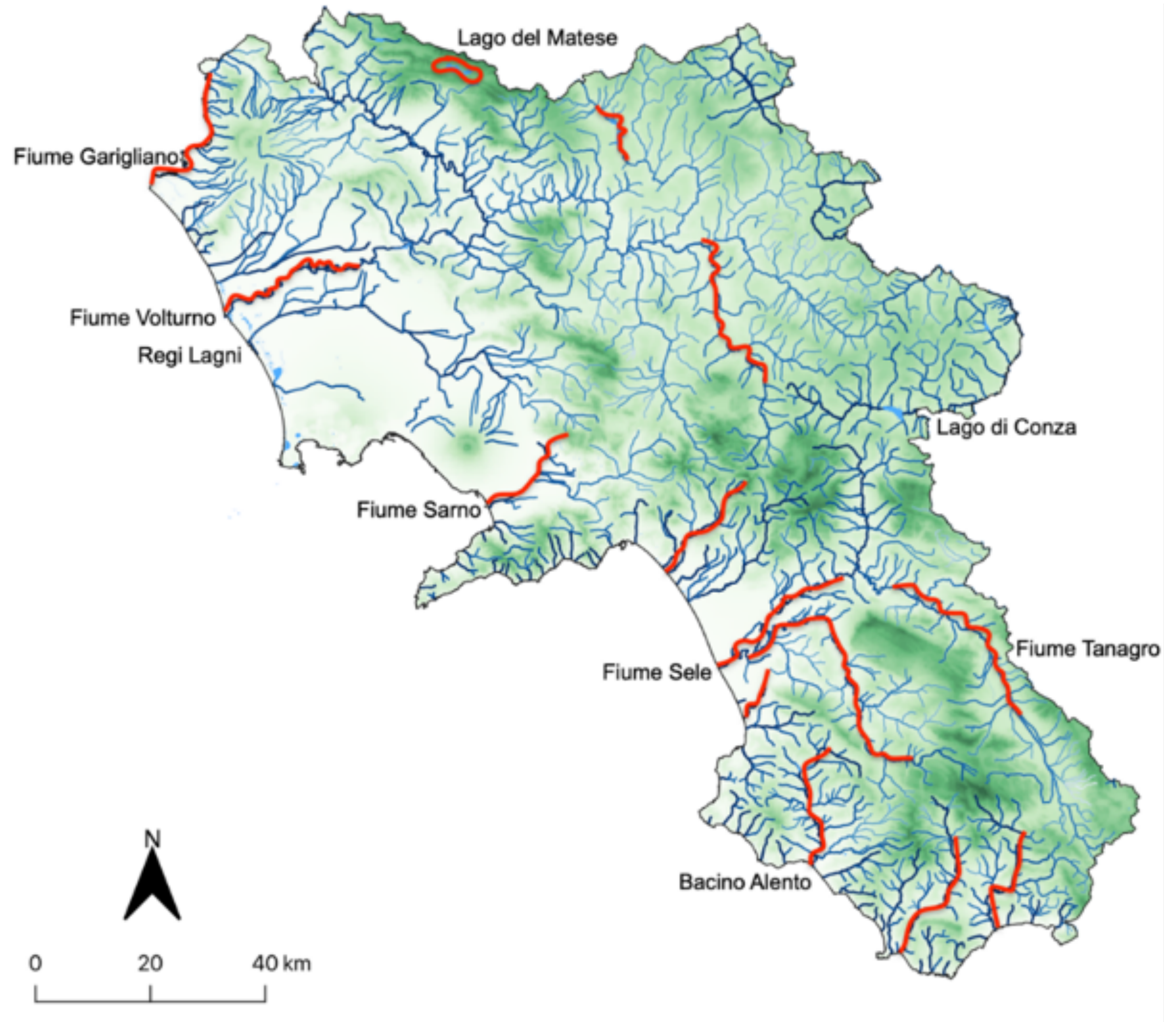

Figure 1: Sampling areas in Campania.

& Dudik 2008). It analyzes the relationship between environmental factors and the presence of species and is often used to predict the potential distribution of a species from presence-only data. It is possible to interpret MaxEnt predictions simply as environmental suitability indices, which could be useful for exploratory qualitative analyses, especially if sampling is not based on rigorous assumptions that allow the model output to be interpreted probabilistically (Merow et al., 2013).

To carry out this type of analysis, the work was follows three steps:

1. Assign UTM-WGS 84 33N coordinates to the presence signs.
2. Elaborate the environmental layers through QGis v.3.12.
3. Submit the coordinates file and the layers to the MaxEnt program.

In total, 73 occurrences were used to generate the model.

The variables chosen for the environmental suitability of *Myocastor coypus* are 13 (Tab. 1). Altitude, rivers, and roads and railways were obtained from the Campania Region Geoportal (https://sit2.regione.campania.it/ http://www.pcn.minambiente.it). All the other layers were generated from the Nature Charter system, available on the Superior Institute for Environmental Protection and Research (https://www.isprambiente.gov.it/).

Table 1: variables used for the environmental suitability of *Myocastor coypus*

Type	Name	Source
Geological		DTM Campania Region
	Altitude **Slope** **Exposition**	
Environmental		Nature Charter [ISPRA]
	Brackish environments	[COD.: 15.1; 15.5]
	Canals	[COD.: 89.2; 89.1]
	Reed	[COD.: 53.1; 53.6]
	Estuaries	[COD.: 13.2]
	Lakes	[COD.: 22.4]
	Beaches	[COD.: 4.12pm]
	Urban fabric	[COD.: 86.1]
	Riparian vegetation	[COD.: 44.12; 44.14; 44.513; 44.61; 44. D2cn]
	Rivers	Geoportal Campania Region
	Roads and railways	Geoportal Campania Region

The environmental layers were processed using the QGis v.3.12 software. Each layer corresponds to a type of variable chosen for the analyses. Environmental layers relative to specific site were chosen based on the ecological preferences of the species.

Altitude data, slope, and exposition were obtained as quantitative variables. Altitude was determined using the DTM model at 20 m, aspect and slope were calculated using the GDAL functions "Aspect" and "Slope" in QGIS 3.4.2. The remaining variables were rendered as continuous raster by considering the Euclidean distance from each feature, using the GDAL function Proximity (raster distance), and considering geographical units. All layers were rendered as raster maps with a resolution of 100 x 100 m.

In Maxent v. 3.4 models were generated using default settings. A regularization parameter of 1.0 was used, the maximum number of iterations was set at 500 and a jackknife procedure was used to assess variable importance. To estimate model performance, the average test AUC (the area under the receiver operating characteristic curve) was considered, through fivefold cross-validation (Swets 1988).

Demographic forecast for the next 20 years

Population Viability Analysis (PVA) is a species-specific risk assessment method frequently used in conservation biology. Each PVA is developed individually for a target population or species and, consequently, each PVA is unique (Sanderson 2006). PVA is also used to identify factors driving population dynamics (Manlik et al., 2018). The current PVA has become a quantitative analysis of the probability of persistence of a population subjected to a set of assumptions and circumstances (Lacy et al., 2015).

The PVA of the *Myocastor coypus* population was made using the VORTEX 10.1.6.0 software (Lacy et al., 2015). VORTEX is based on an individual-based model, in which a virtual representation of each individual animal is created and its fate is followed in each year of its life, keeping track of sex, age and grade of kinship. The simulations are performed as a series of events describing the life cycle of a diploid organism (Miller & Lacy 2005). The analysis is based on Monte Carlo simulations (Lacy 1993; Lacy et al., 2015). The software models demographic processes as discrete and sequential events and with probabilistic results. Random processes (gene transmission, number of offspring produced by each female, natural disasters, etc.) generating fluctuations in population demographics will influence their fate (Miller & Lacy 2005).

For each year, the specific mortality rates for each age group are calculated as well as the fertility of individuals who acquire sexual maturity. Inbreeding depression, on the other hand, is expressed as a decrease in the survival of newborns. Based on the parameters entered, which must be as faithful as possible to the biology of the studied population, the statistical results of the simulations are returned with reference to the population growth rate, the probability of extinction and the average

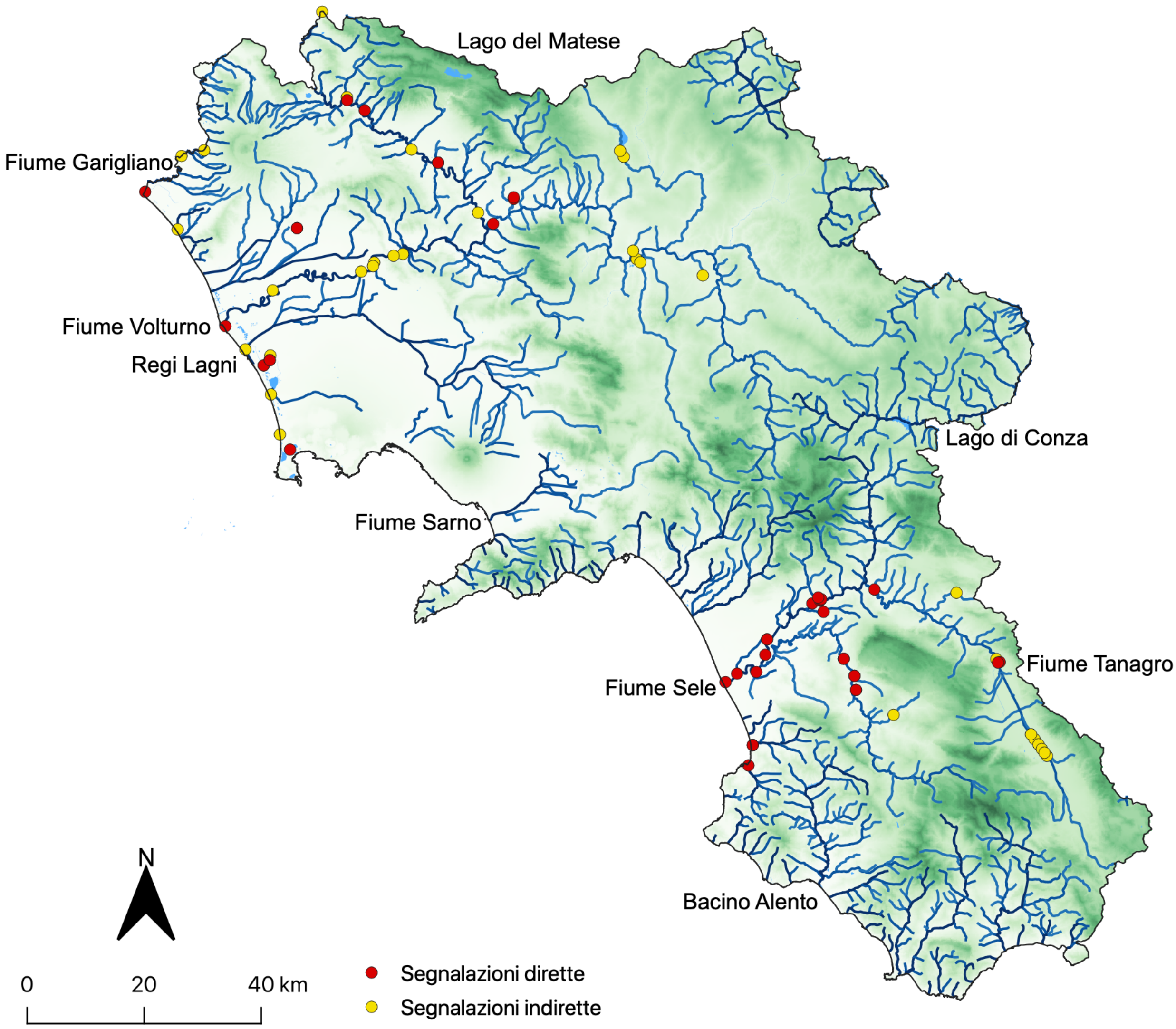

Figure 2: Signs of presence of *Myocastor coypus.*

Table 2: The scenarios used for the simulation in VORTEX.

Parameter	Value	Reference
Reproductive system	polygamy	Guichon et al., 2003
Inbreeding depression (no. of lethal equivalents)	6,29	Setting Default (Lacy et al., 2015)
Life span (years)	6	HGAR*
Male fertile interval (days)	130**	HGAR*
Female fertile interval (days)	130**	HGAR*
Maximum number of cubs per year	3	HGAR*
Sex ratio at birth as % of males	50	Pagnoni & Santolini, 2011
% of fertile females	67	Iori et al., 2013Cocchi & Riga, 2008: Guichón et al., 2003
Number of young per female	6	HGAR*
Fatalities rate (%) 0-1 years	50%	Carter et al., 1999
Fatalities rate (%) >1 years	20%	Carter et al., 1999
Abundance of the initial population (n° individuals)	150***	This study
Carrying capacity (n° individuals)	1490	This study
Female sexual maturity (days)	152**	HGAR*
Male sexual maturity (days)	152**	HGAR*
Number of iterations	1000	Operator's choice
Number of years (timesteps)	20	Operator's choice

*https://genomics.senescence.info/species/entry.php?species=Myocastor_coypus
**Compared to the literature data we have set the fertility interval and sexual maturity to 1 year to be more conservative and have a more reality-aware estimate also because coypu is located outside its original range and may have expanded the time of sexual maturation.
***Considering that there are 73 points of presence reported and that the average Italian density of coypu is= 2.0Individuals/1ha (Vellata & Ragni, 1991; Reggiani et al., 1993) an initial population of 150 individuals has been hypothesized.

time of extinction, considering the user-defined time interval (Lacy et al., 2015). Since the increase or decline of a population is strongly influenced by random events, the interactions of the same data can produce different results (Lacy 1993). The scenarios used for the simulation in VORTEX are based on a 20-year projection, on data collected during this research project and on bibliographic data known for the species (Tab. 2).

Results

Presence data collection

The direct field activities led to the identification of 38 signaling points, while the indirect activities (i.e., those deriving from citizen size) led to the identification of 35 signaling points for a total of 73 points of presence.

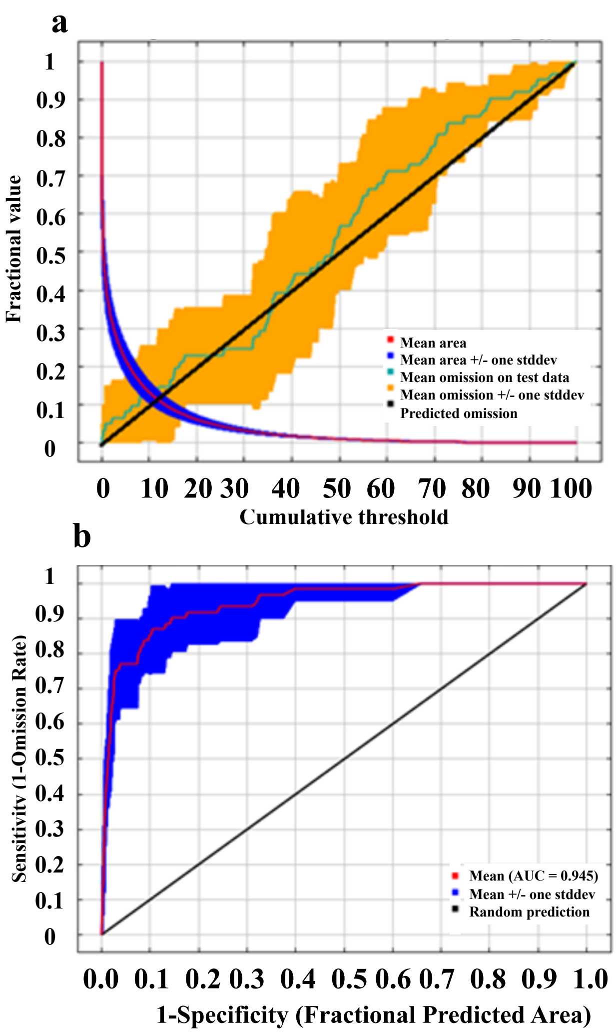

Figure 3: a) Average Omission and Predicted area and b) Average Sensitivity vs.1 Specificity for *Myocastor coypus*.

In the map (Fig. 2) we can see the direct signaling points in red and the indirect ones in yellow. Considering that there are 73 reporting points and that the Italian average is = 2.0individuals / 1ha (Vellatta & Ragni 1991; Reggiani et al., 1993), the initial assumed population is 150 individuals.

Environmental suitability modeling

The signs of the presence of the coypus collected from the different sources represented the data base for the elaboration of the spatial model of environmental suitability on the presence of the species relating to the 13 variables (3 geological and 13 environmental) taken into consideration.

The relationship between the environmental suitability values predicted for coypus and the proportion of selected presences (Phillips et al., 2006), indicates that the model approximates the real data quite well, given that the trend of the omission rate on the testing dataset (green line) is close to the predicted omission line (Fig. 3a).

The receiver operating characteristic (ROC) curve indicates the performance of the model. The value of the area under the ROC curve, the AUC (area under the curve), is equal to 0.945 ± 0.042 (SD). The obtained values indicate that the model is very efficient (Manel et al., 2001) and therefore the relative predictions can be considered reliable (Fig. 3b).

The weight of the ecogeographic variables is measured based on their contribution through the Percent contribution and Permutation importance measures (Tab.3).

It is clear, from the calculations of the percentage contribution, that the slope variable ('Slope') contributes to defining most of the environmental suitability of the species.

A separate comments must be made on the "Altitude" variable, as this seems to have a small percentage contribution, but also

Table 3: The weight of the ecogeographic variables. Con. %, Contribution (%); Per.imp., Permutation importance.

Variable	Con. %	Per.imp.
Slope	32.9	49.7
Rivers	22.9	11.2
Riparian vegetation	20	5.3
Reed	12.7	2.3
Canals	2.1	13
Altitude	2.1	10.3
Lakes	1.8	4.7
Roads and railways	1.7	1.7
Estuaries	1.5	0.1
Brackish environments	1.5	1
Exposition	0.3	0.1
Urban fabric	0.3	0.3
Beaches	0.1	0.4

observing the data on the importance of permutation, it still plays a certain weight in the analysis of the model; the same goes for the distance from the reeds.
The variables that, on the other hand, generally play a scarcely relevant role in the model are: distance from lakes, estuaries, brackish environments, beaches and the distance from the road and rail network, urban fabric and exposure.
The MaxEnt software also returns graphs in logistic format ("response curves") that illustrate how each variable affects the forecasts of environmental suitability. Each graph relates to each single covariant and two types are observed: a) the first graph

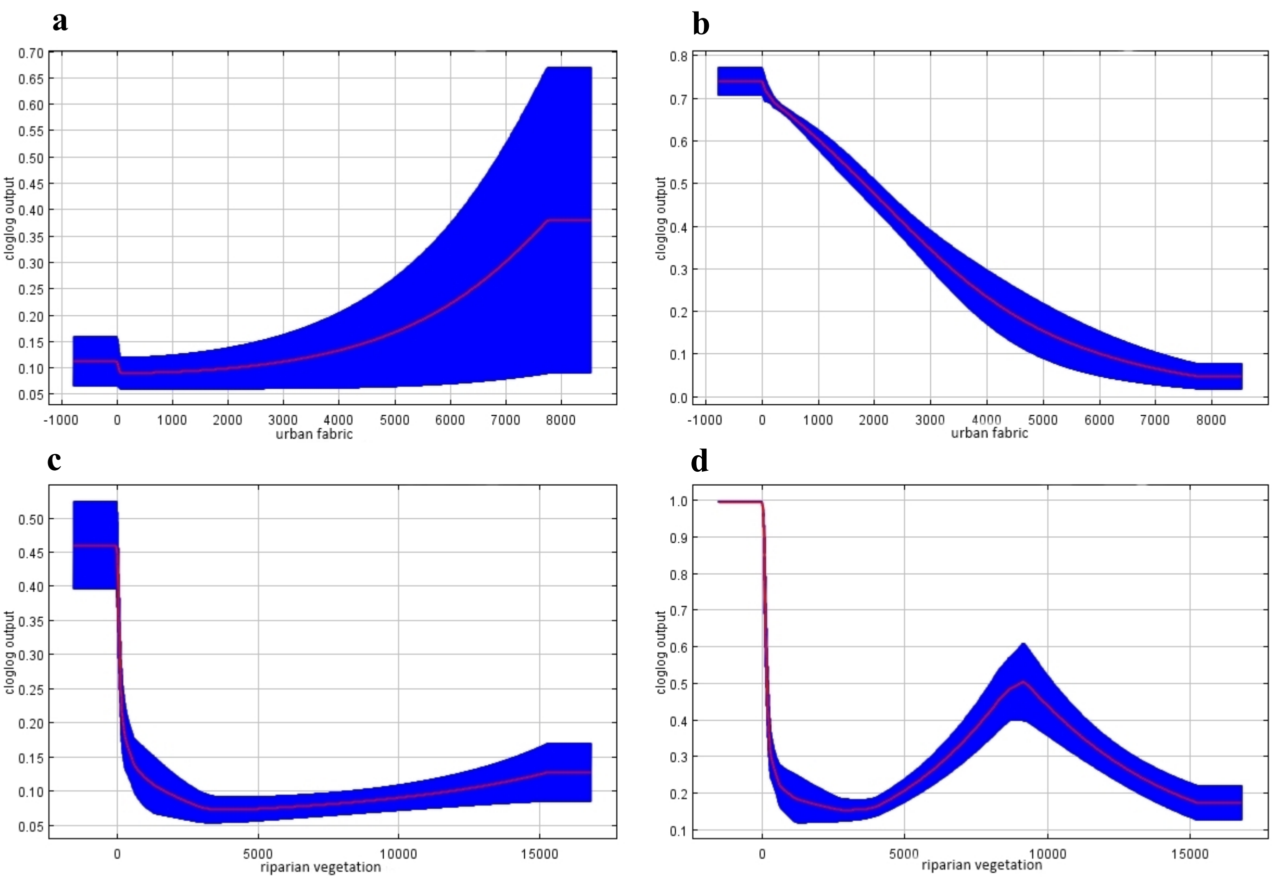

Figure 4: Average values of environmental suitability in response to a) distance from urban fabric, considering the other variables at their average value; b) distance from urban fabric as a single isolated variable; c) distance from riparian vegetation, considering the other variables at their average value; d) distance from riparian vegetation as a single isolated variable.

shows the average values of environmental suitability obtained by keeping the average value of all the other variables constant, except for the target variable and letting the value of the target variable only; b) the second graph shows the completion of the model by varying only the indicated environmental variable and excluding all the other variables (Phillips et al., 2006). The curves explain the response of each variable on the mean of 5 replicates (in red) ± the standard deviation (in blue).

It is particularly interesting to observe the evolution of the variables 'urban fabric' (Fig. 4a and b) and 'riparian vegetation' (Fig.4c and d). It is assumed that the discrepancy we have for the distance from the urban fabric (Fig. 4a and b) is because an intrinsic distinction must be made between the urbanized fabric and anthropization. In the first case we are talking about those areas in which man carries out most of his activities (e.g., homes, offices, schools, universities, etc.) in which the coypus, in Campania, tends not to colonize for what is the habitat

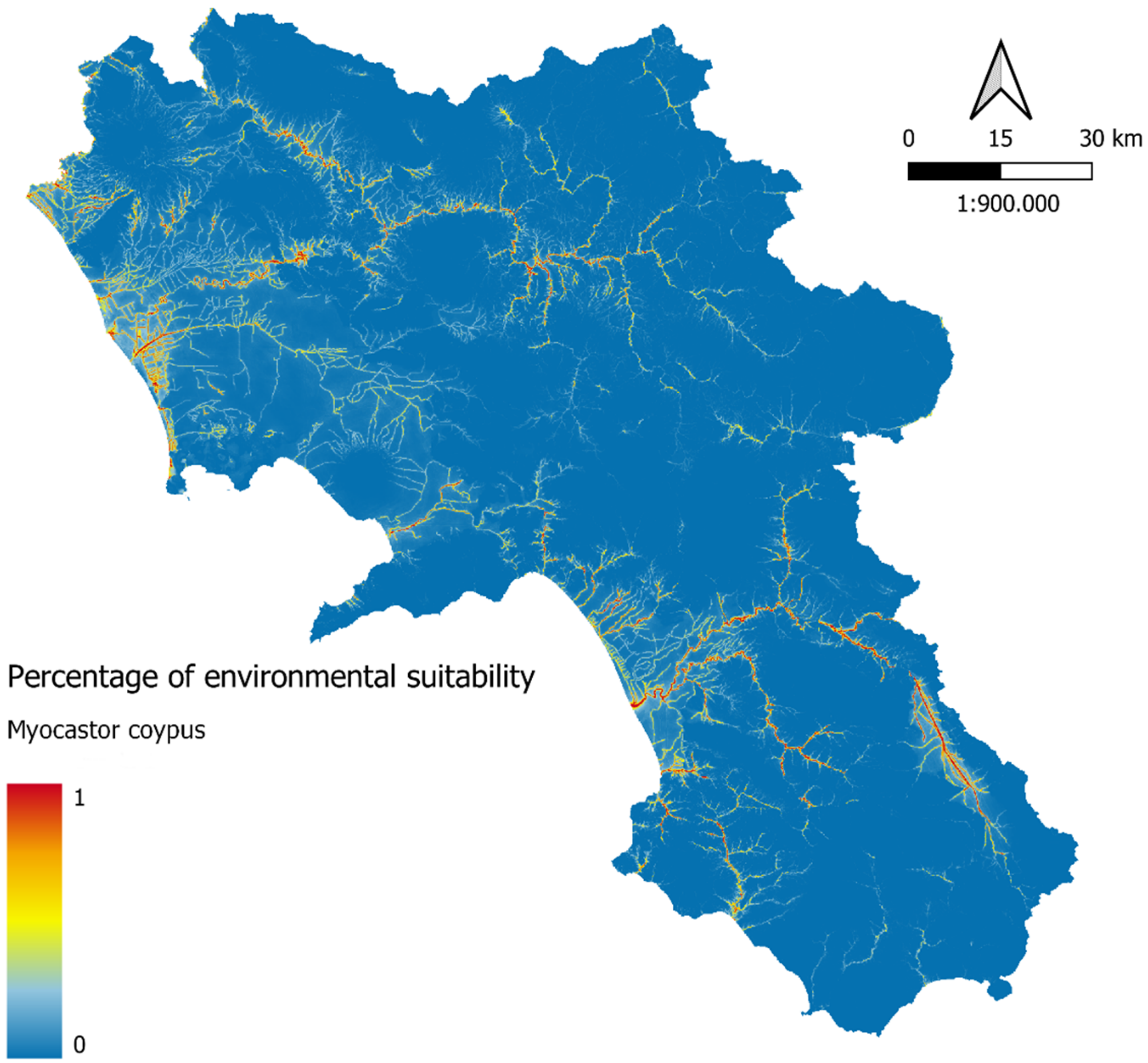

Figure 5: Environmental suitability map for *Myocastor coypus*.

Table 4: Demographic parameters derived from the VORTEX simulation.

nRuns	det-r	stoch-r	SD(r)	PE	N-extant
1000	0,1636	0,1348	0,1924	0,0000	1247,18

fragmentation (e.g., inability to find food due to building cementation). In the case of anthropization, reference is made to those areas where, although man acts, he does not particularly disturb the suitable habitat. Instead, as regards the distance from riparian vegetation, the fact that the suitability is greater both when one is close to and at a medium distance from this variable (Fig. 4c and d) is explained by studying the ecology of the species. In fact, the coypus does not prefer only riparian woods (e.g., forest composed so much of willow grove, poplar grove, etc.) but prefers those environments in which we have a riparian forest interrupted by a clearing and then by a hygrophilous forest, which leaves the possibility of formations of ecological corridors.

The result generated by the MaxEnt software given to the interaction between the ecogeographic variables and the signaling points returns the environmental suitability map of the coypus (Fig. 5).

Demographic forecast for the next 20 years

The result of the demographic projection of the coypu in Campania over the next 20 years without any control plan shows a probability of survival of 100% and therefore a zero probability of extinction (Fig. 6a) and an increasing trend (Fig.6b) of the population which at the end of the simulation is made up of 1247 individuals (Tab. 4).

Discussion

This research has highlighted how the monitoring of this species has been little followed over the years, so much so that at the time of the direct censuses the initial population present in the area was unknown. Based on the observable results in the distribution chart (Fig. 2), it was thus possible

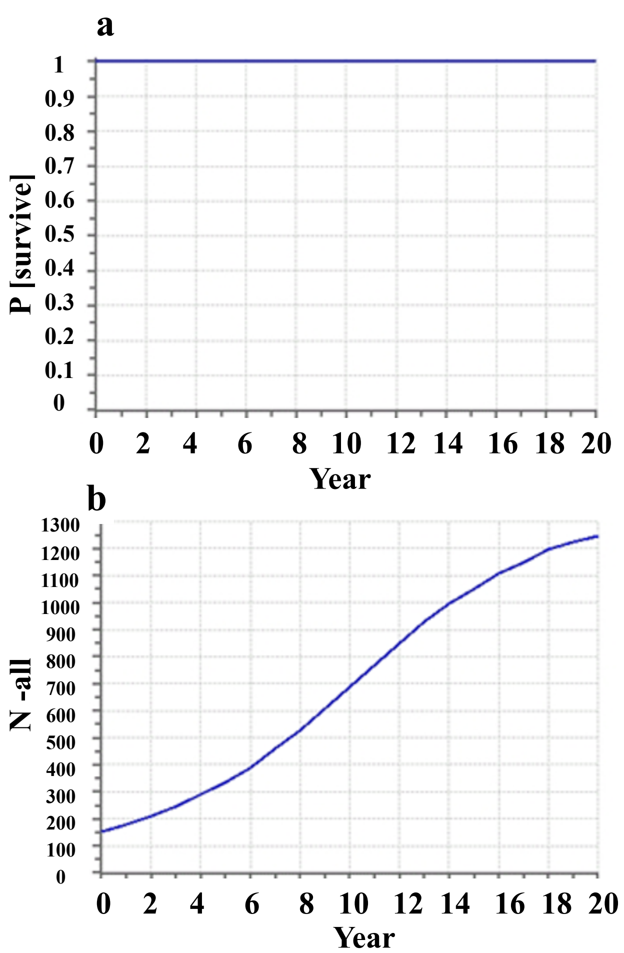

Figure 6: a) Probability of permanence of *Myocastor coypus* population and b) Final result of population growth in 20 years after 1000 iterations.

to estimate a current population of 150 individuals.

One of the main objectives of this study, in addition to knowing the current population, was also to understand if in Campania there is indeed to worry about a real expansion of the species and if there is therefore a need for adequate management plans. To do this, it was necessary to understand if there is the suitable habitat for coypus in the area and this analysis was made possible thanks to the elaboration of the environmental suitability modelling using the MaxEnt software. As can be seen from the results obtained, in Campania there are different levels of environmental suitability and the areas of highest environmental suitability are identified along the rivers (Fig.5, in red). This result brings to light important evidence, first of all in Campania there are biotic and abiotic elements necessary for the survival and expansion of this species and, in addition, the areas with the highest environmental suitability are also identifiable as ecological corridors that allow displacement of individuals from one area of the territory to another, so as to create different sub-populations.

Consequently, once this result has been obtained and knowing what are the negative effects that an alien species can produce on the territory, in our opinion it was necessary to predict a future evolution of the population in the absence of management plans by developing a population viability analysis, which analyses population dynamics taking into consideration various factors (e.g., ecology of the species, reproductive strategy, bearing capacity of the territory, etc.). The result highlighted that in the absence of disturbances, apart from the intrinsic ones already taken into consideration such as environmental variability or predation, which here in Campania seems to be perpetuated by the wolf (*Canis lupus*), the species tends to grow in 20 years of simulation (Fig. 6b) until reaching a final population of 1247 individuals (Tab. 4) thus having a population increase of 730% compared to the initial one.

In the face of what this research has highlighted, it is strongly recommended to intervene in the short term to mitigate the negative impacts that the coypu now has on the territory, mainly: disruption of the embankments and disturbance towards other animal species such as: aquatic birds that nest near riparian vegetation or its competition for space with the otter (*Lutra lutra*).

Author contributions

Conceptualization: A.M.B and D.F.; Data curation: A.M.B, D.F, C.T., G.d.F; Formal analysis: A.M.B; C.T.; M.B., S.P. Investigation: A.M.B; D.F., C.T.; M.B., S.P. G.d.F. Methodology: A.M.B; D.F., C.T.; M.B., S.P. G.d.F. Project Administration: D.F.; Resources: D.F.; Writing – original draft: A.M.B; D.F., C.T.; M.B., S.P. G.d.F.; Writing – final draft preparation: A.M.B; D.F., C.T.; M.B., S.P. G.d.F.

References

Bertolino S., Cocchi R. (2018). Piano di gestione nazionale della Nutria ISPRA.

Carter J., Foote A. L. and Lori A. Johnson-Randall. (1999). Modeling the effects of nutria (*Myocastor coypus)* on wetland loss. The Society of Wetland Scientists. Vol. 19, No. 1, March 1999, pp. 209-219

CBD Secretariat. (2000). Decision V/8. Alien species that threaten ecosystems, habitats or species. UNEP/CBD/COP/

5/8. Secretariat of the Convention on Biological Diversity, Nairobi, Kenya

CBD Secretariat. (2002). Decision VI/23: Alien species that threaten ecosystems, habitats and species. Document UNEP/CBD/COP/6/23. Secretariat of the Convention on Biological Diversity Montreal, Canada

Cocchi R. & Riga F. (2008) Control of a coypu *Myocastor coypus* population in northern Italy and management implications, Italian Journal of Zoology, 75:1, 37-42, DOI: 10.1080/11250000701690350

Gosling L. M. (1981). Climatic determinants of spring littering by feral coypus, *Myocastor Coypus*. Journal of Zoology 195:281-288.

Gosling L. M. and Baker S. J. (1981). Coypu (*Myocastor coypus*) potential longevity. Journal of Zoology 197:285-312.

Greer J. K. (1966). Mammals of Malleco Province Chile. Publications of the Museum, Michigan State University Biological Series 3:49-152.

Guichon M.L., Borgnia M., Righi-Fernàndez C., Cassini G.H., Cassini M.H. (2003). Social Behavior and Group Formation in the Coypu (*Myocastor coypus*) in the Argentinean Pampas. Journal of Mammalogy 84(1):254-262.

Iori R., Gunji Y., Hishinuma M., Nagano M., Takada T. & Higaki S. (2013). Reproductive biology of the coypu, *Myocastor coypus* (Rodentia: *Myocastoridae*) in western Japan. ZOOLOGIA 30 (2): 130–134.

IUCN-The World Conservation Union. (2000). Species Survival Commission (SSC). Guidelines for the prevention of biodiversity loss caused by alien invasive species prepared by the SSC Invasive Species Specialist Group. Approved by the 51st Meeting of the IUCN Council, Gland Switzerland, February 2000.

Lacy R.C. (1993). What is Population (and Habitat) Viability Analysis? Primate Conservation 14/15: 27-33.

Lacy R.C., P.S. Miller, K. Traylor-Holzer (2015). Vortex 10 User's Manual. 15 April 2015 update. IUCN SSC Conservation Breeding Specialist Group, and Chicago Zoological Society, Apple Valley, Minnesota, USA.

Manlik O., Lacy R.C., Sherwin W.B. (2018). Applicability and limitations of sensitivity analyses for wildlife management. Journal of Applied Ecology. 55 (3): 1430–1440. doi: 10.1111/1365-2664.13044

Merow, C., Smith M.J., Silander J.A. 2013. Practical guide to MaxEnt for modeling species' distributions: what it does, and why inputs and settings matter. Ecography 36: 1058–1069 doi: 10.1111/j.1600-0587.2013.07872.x.

Miller P.S., Lacy R.C. (2005). VORTEX: A Stochastic Simulation of the Extinction Process. Version 9.50 User's Manual. Apple Valley, MN: Conservation Breeding Specialist Group (SSC/IUCN).

Nowak R. M. (1991). Walker's Mammals of the World. Johns Hopkins university Press, London.

Pagnoni G.A., Santolini R. (2011) Struttura di popolazione di nutria (*Myocastor coypus*) in un'area agricola della Pianura Padana Orientale. Studi Trent. Sci. Nat., 88 (2011): 45-52

Phillips S.J., Anderson R.P., Schapire R.E. (2006). Maximum entropy modelling of species geographic distribution. Ecological Modelling 190: 231-259 doi:10.1016/j.ecolmodel.2005.03.026.

Phillips, S.J., Dudík M. 2008. Modelling of species distributions with Maxent: new extensions and a comprehensive evaluation. Ecography 31:161-175 doi: 10.1111/j.0906-7590.2008.5203.x.

QGIS Development Team. QGIS Geographic Information System. Open Source

Geospatial Foundation Project, 2019, http://qgis.org.
Reggiani G., Boitani L., D'Antoni S., De Stefano R. (1993). Biology and control of the coypu in the Mediterranean area. Suppl. Ric. Biol. Selvaggina, XXI: 67-100.
Sanderson E.W. (2006) How many animals do we want to save? The many ways of setting population target levels for conservation. BioScience 56: 911-922, (p. 913).
Swets, J.A., Measuring the accuracy of diagnostic systems, *Science*, 1988, vol. 240, no. 4857, pp. 1285–1293.
Vellata F., Ragni B. (1991). La popolazione di Nutria (*Myocastor copyus*) del Lago Transimeno. Consistensa, struttura e controllo numerico. Suppl. Ric. Biol. Selvaggina, XIX: 311-326.
Wilson E.O. (2003). The future of life. Vintage Books, New York, U.S.A., 256 pp.
Woods C. A., Contreras L., Willner-Chapman G., Whidden H. P. (1992). *Myocastor coypus*. Mammalian Species 398:1-8.

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