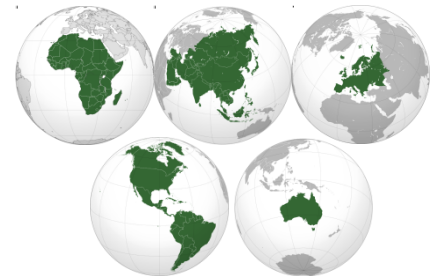


Wildlife Rabies Control - Latest Achievements and Challenges Ahead

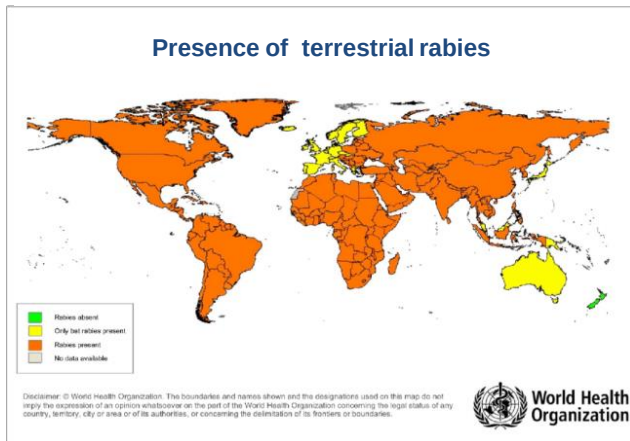


Thomas Müller
Conrad Freuling

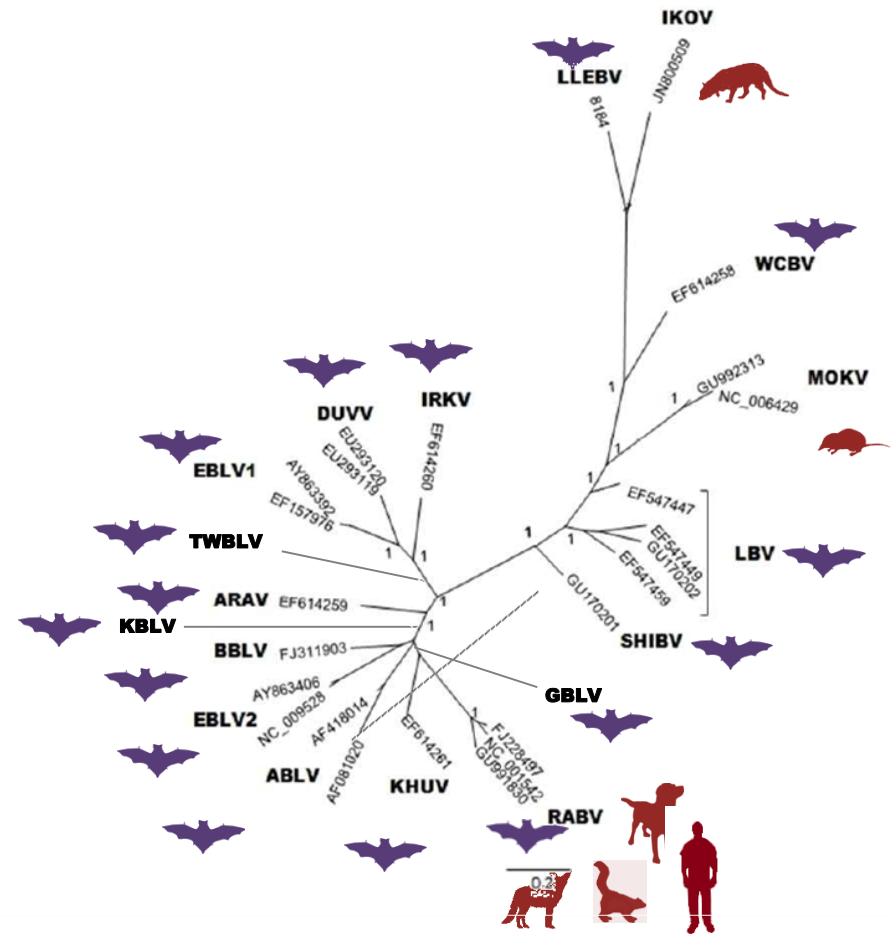
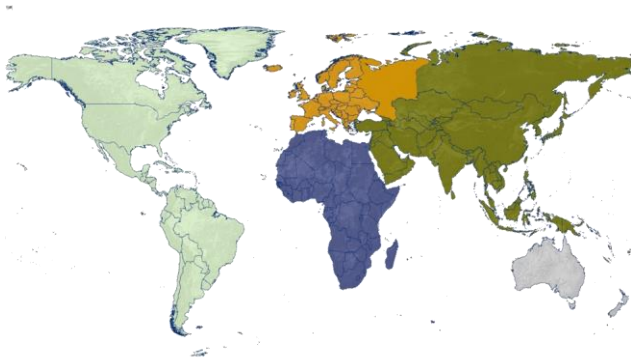
Introduction

Lyssaviruses

Rhabdoviridae – Mononegavirales



Bat lyssaviruses



Modified Aréchiga *et al.*, 2013

Terrestrial Rabies

Large Variety of Reservoir Species



FLI, 2015

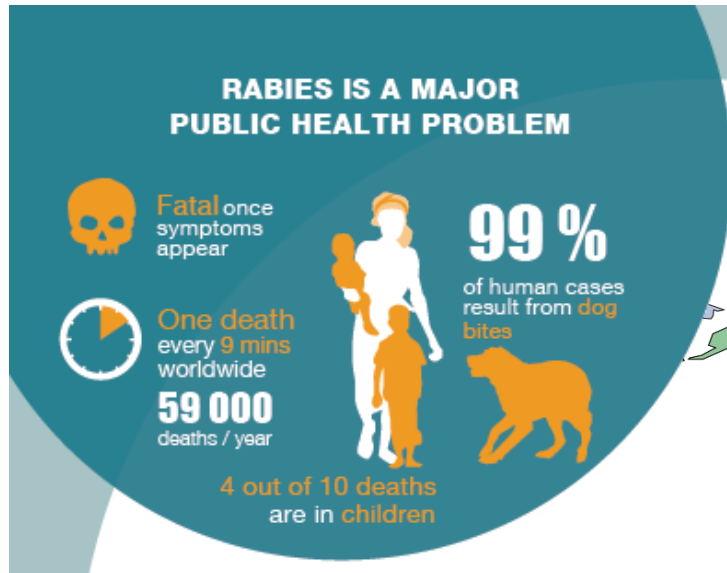
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Terrestrial Rabies

Dog-mediated (human) Rabies

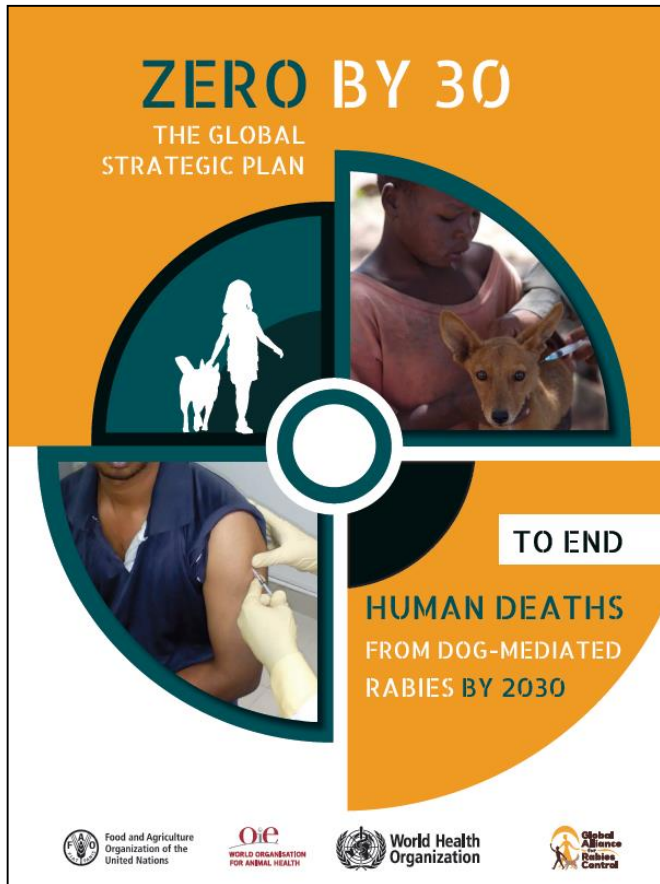


Heaviest incidence of human deaths falls on Africa and Asia.

-
- endemic dog-transmitted human rabies
 - endemic dog rabies
 - sporadic dog-transmitted rabies
 - controlled dog rabies
 - no dog rabies
 - no information

Terrestrial Rabies

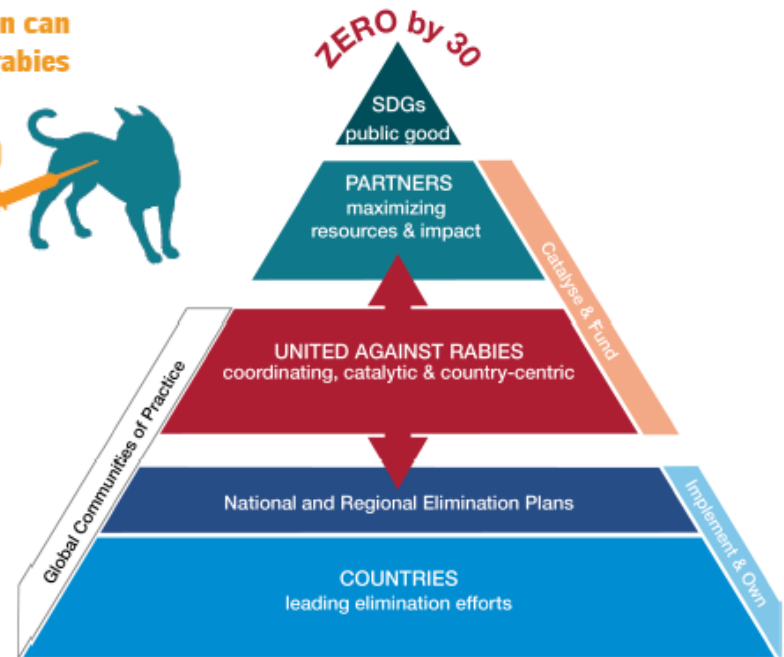
Dog-mediated (human) Rabies



THE UNITED AGAINST RABIES COLLABORATION

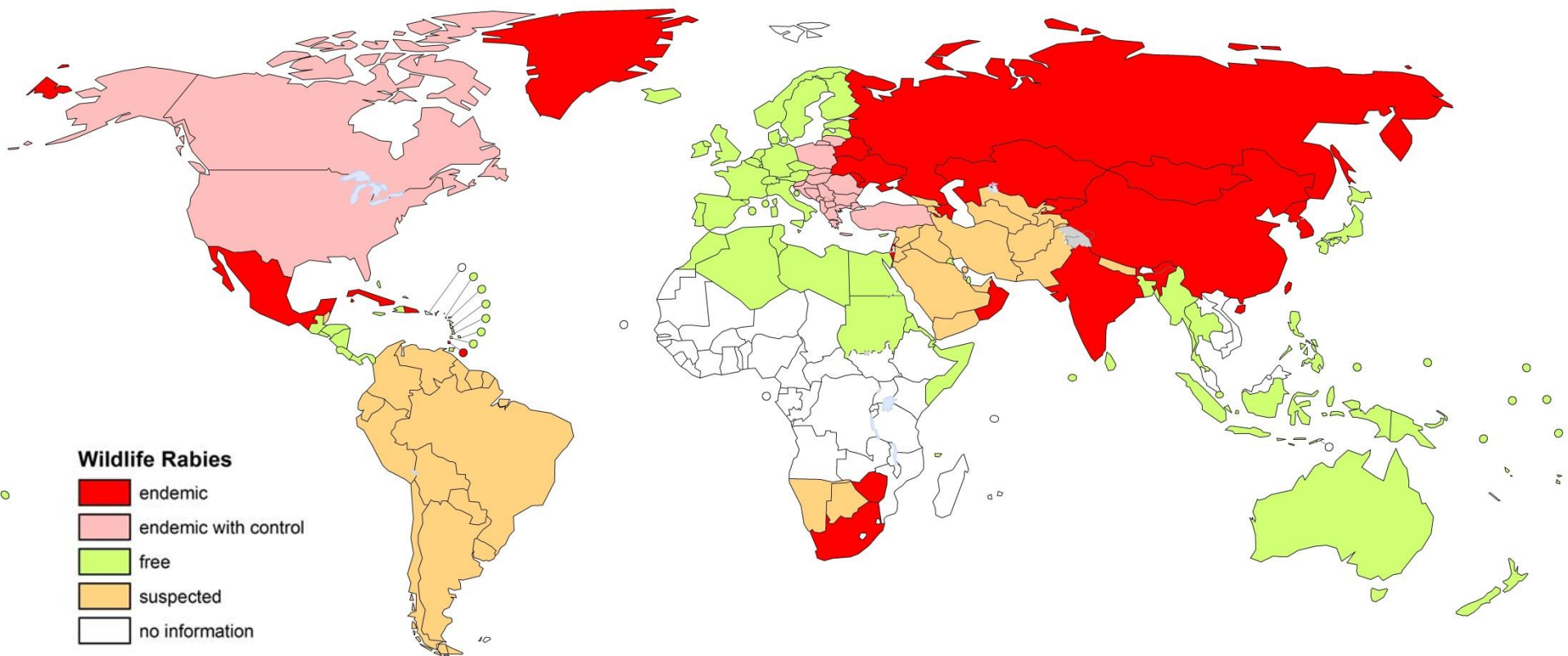
Dog vaccination can eliminate human rabies

Vaccinating **70%** of dogs in high-risk areas breaks rabies transmission cycle



Terrestrial Rabies

Occurrence of Wildlife-mediated Rabies



Source: WHO/FLI 2015

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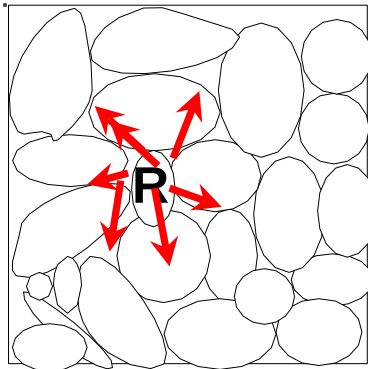
Bundesforschungsinstitut für Tiergesundheit
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Oral Rabies Vaccination of Wildlife

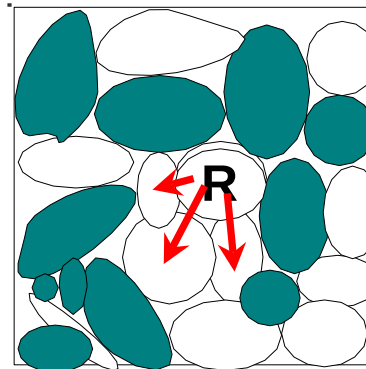
Only Solution



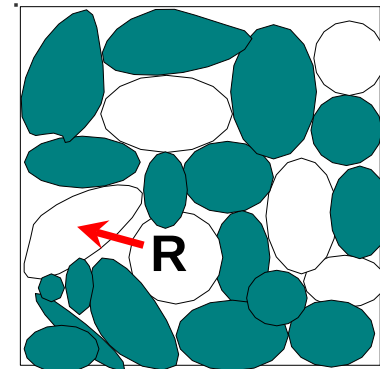
○ Susceptible



Immune barrier



● Protected



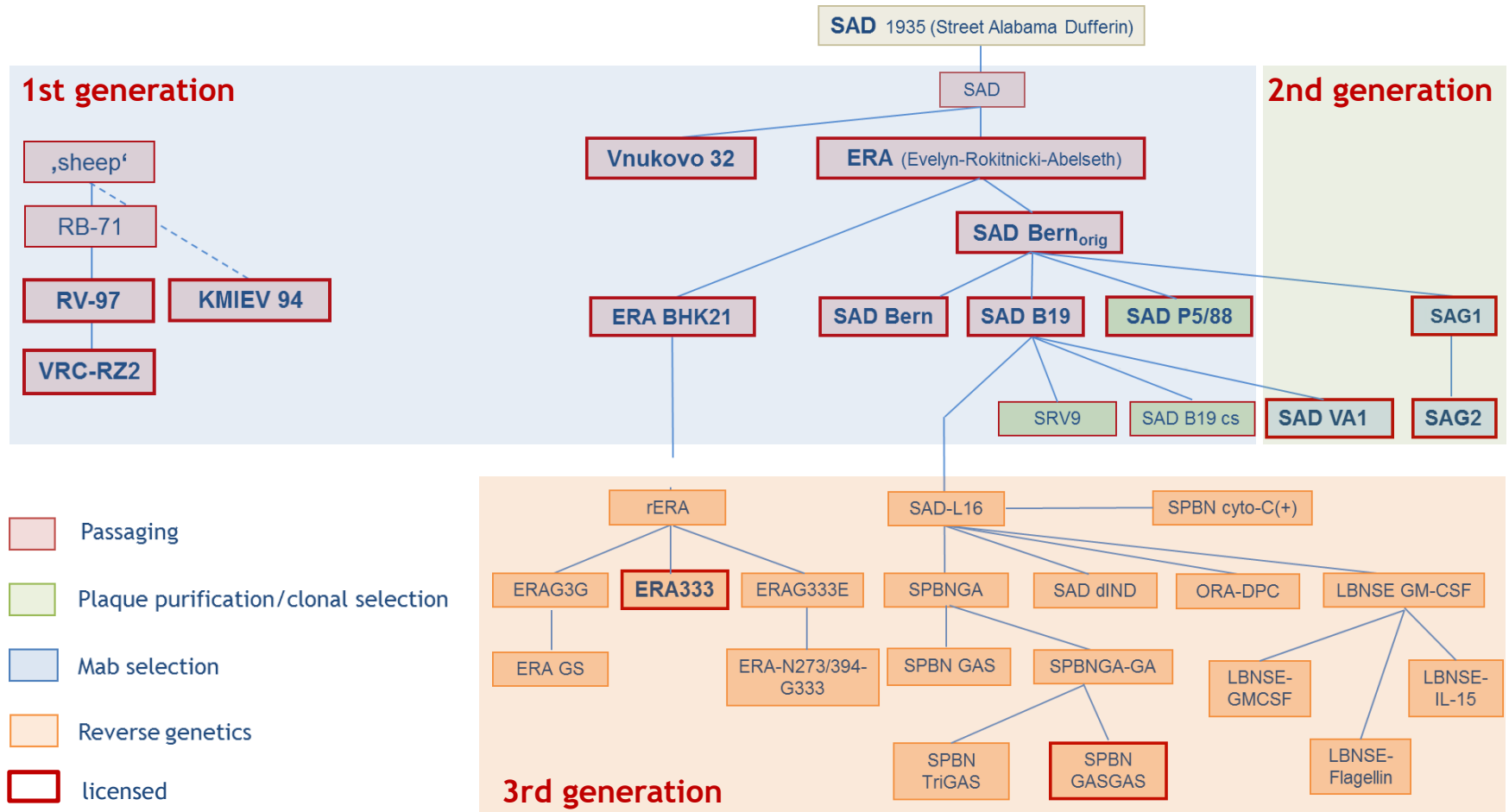
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Oral Rabies Vaccines

Attenuated Vaccines



Oral Rabies Vaccines

Recombinant Vaccines

Virus backbone	Name	Immunogenic component	Target species	Reference
HAdV (human adenovirus)	Ad-0910G, Ad-0910N	G-protein, N-protein	Dogs, wildlife	(Kim et al., 2017)
HAdV-5 (human adenovirus)	HAd5-G (AdRG1.3)	G-protein	Wildlife	Knowles et al. (2009)
CadV-2 (canine adenovirus)	CAV-2-E3Δ- RGP	G-protein	Wildlife	(Zhao et al., 2014)
RCN	RCN-G	G-protein	Bats, wildlife	(Stading et al., 2016)
Vaccinia (poxvirus)	VR-G	G-protein	Dogs, wildlife	(Kieny et al., 1984)
PIV5 (parainfluenza virus)	PIV5-G	G-protein	Bats, wildlife	(Huanq et al., 2015)

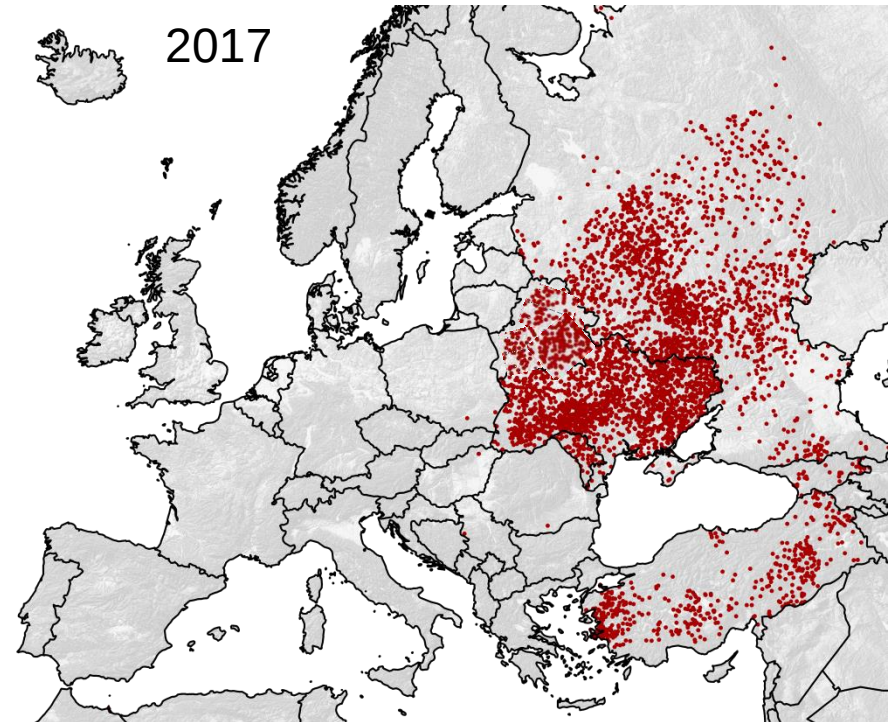
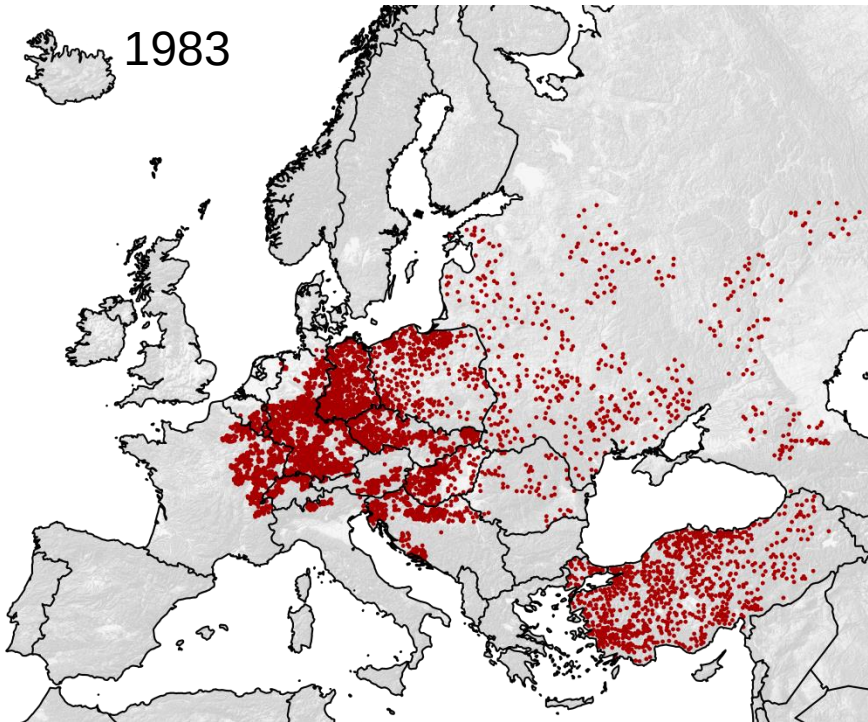
Wildlife Rabies Control

Latest Achievements

Success Stories

Europe (i)

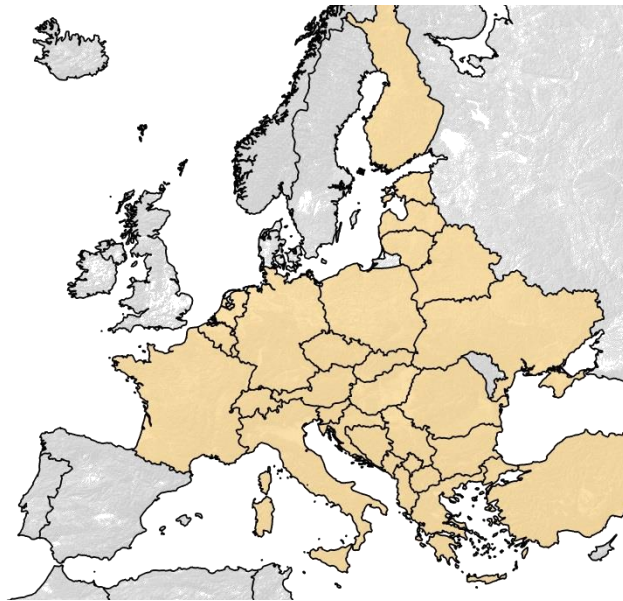
Elimination of fox rabies



Success Stories

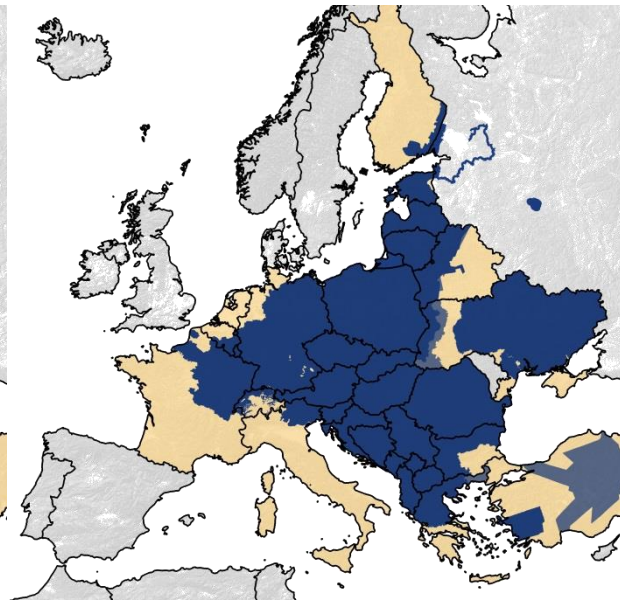
Europe (ii)

Elimination of Fox Rabies (1978-2018)



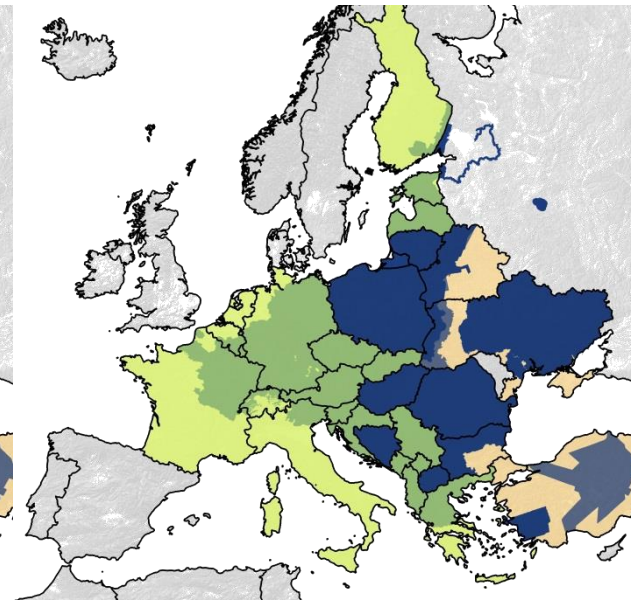
30 countries

ORV
implementation



Coherent area: 2.73 Mio km²
Cumulative area: 38.5 Mio km²

area ever
vaccinated



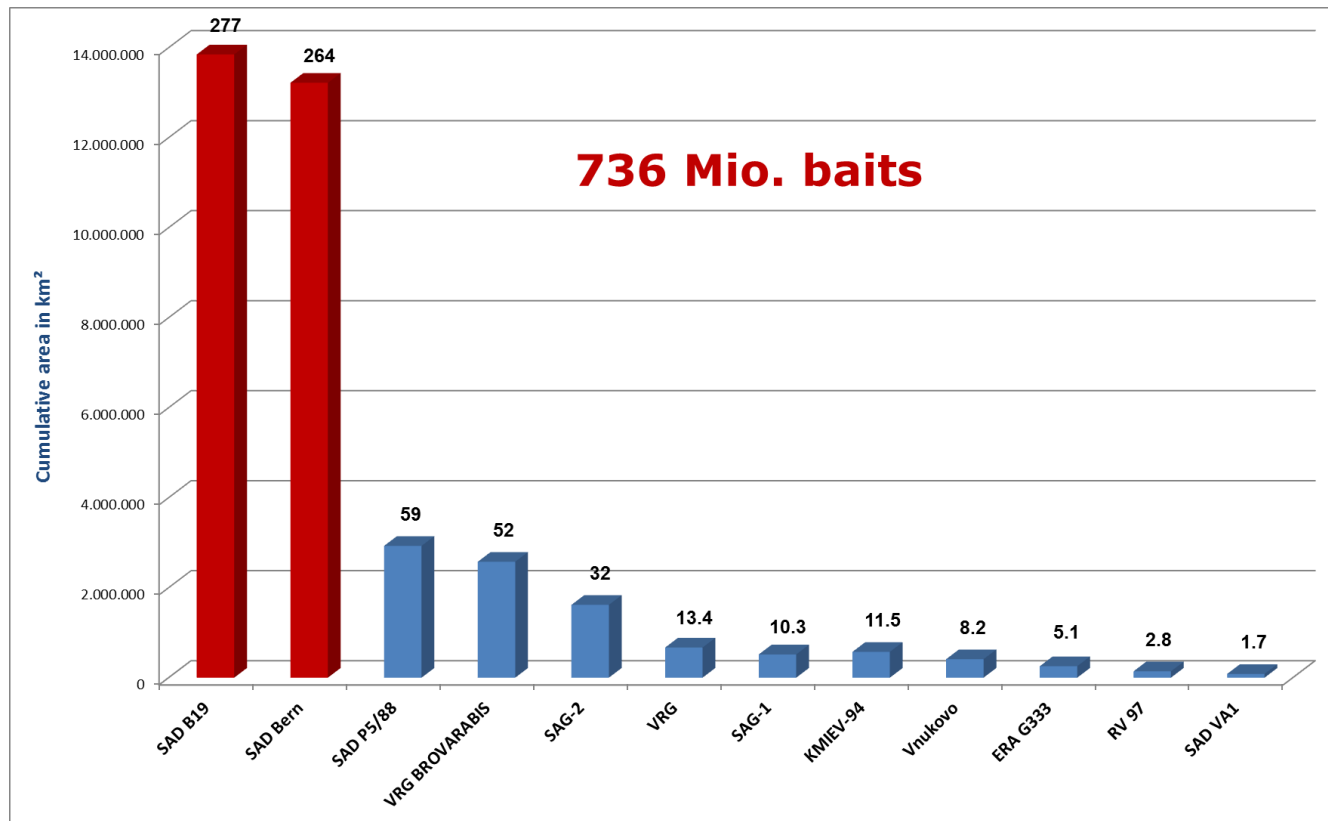
15 countries (by 2018)

rabies free
countries

Success Stories

Europe (ii)

N° of vaccine baits used (1978-2018)



Success Stories

North America (iii)



Reservoir Species Dependent Success

Elimination of Arctic Variant Rabies in Red Foxes, Metropolitan Toronto

R. C. Rosatte,* M. J. Power,†¹ D. Donovan,* J. C. Davies,* M. Allan,* P. Bachmann,* B. Stevenson,*
A. Wandeler,‡ and F. Muldoon‡

ELIMINATION OF RABIES FROM RED FOXES IN EASTERN ONTARIO

Charles D. MacInnes,^{1,12} Stephen M. Smith,² Rowland R. Tinline,³ Neil R. Ayers,⁴
Peter Bachmann,¹ David G. A. Ball,³ Laurie A. Calder,⁵ Sarah J. Crosgrey,⁶ Carolyn Fielding,⁷
Peggy Hauschildt,³ Janet M. Honig,³ David H. Johnston,⁸ Kenneth F. Lawson,⁹
Christopher P. Nunan,¹ Michael A. Pedde,¹ Bruce Pond,¹ Robert B. Stewart,¹⁰ and
Dennis R. Voigt¹¹



Evaluation of oral rabies vaccination programs for control of rabies epizootics in coyotes and gray foxes: 1995–2003

Thomas J. Sidwa, DVM; Pamela J. Wilson, MEd; Guy M. Moore, MS; Ernest H. Oertli, DVM, PhD, DACVPM;
Bradley N. Hicks, BS; Rodney E. Rohde, MS; David H. Johnston, BSc

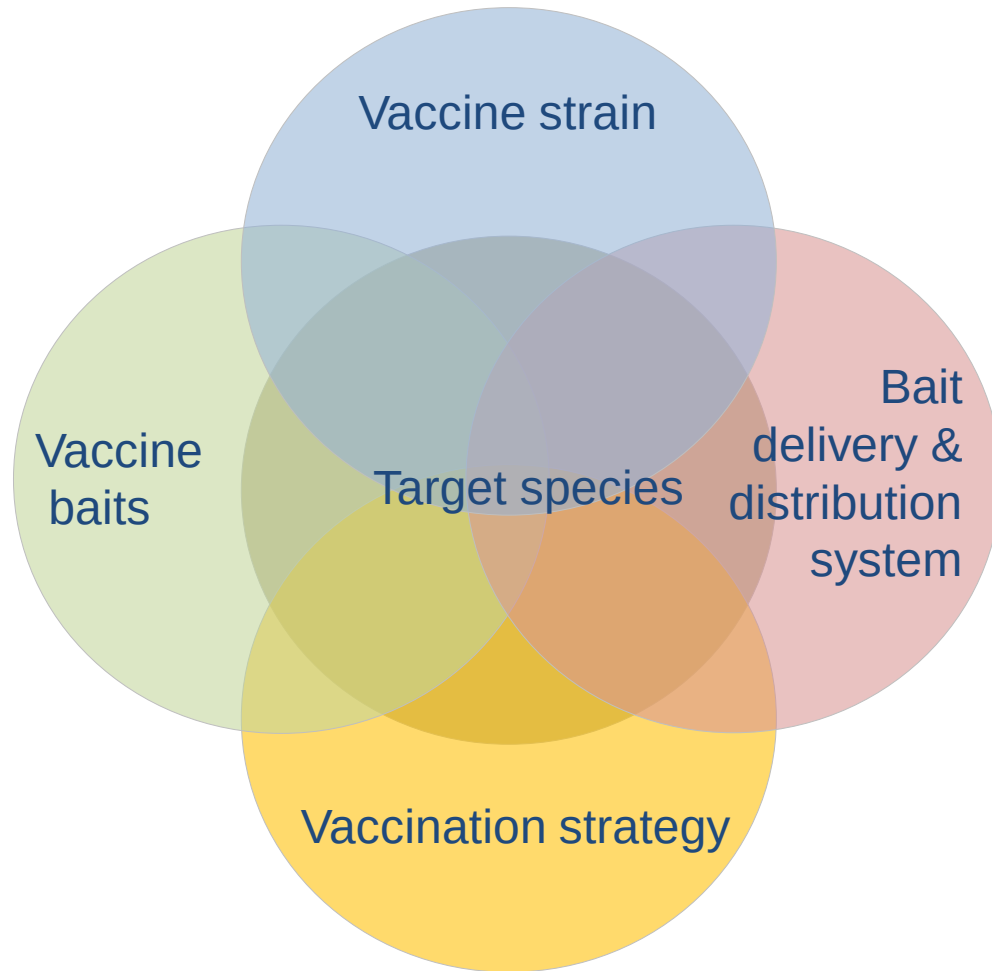


Wildlife Rabies Control

Challenges Ahead

Oral Rabies Vaccination of Wildlife

Pillars & Challenges

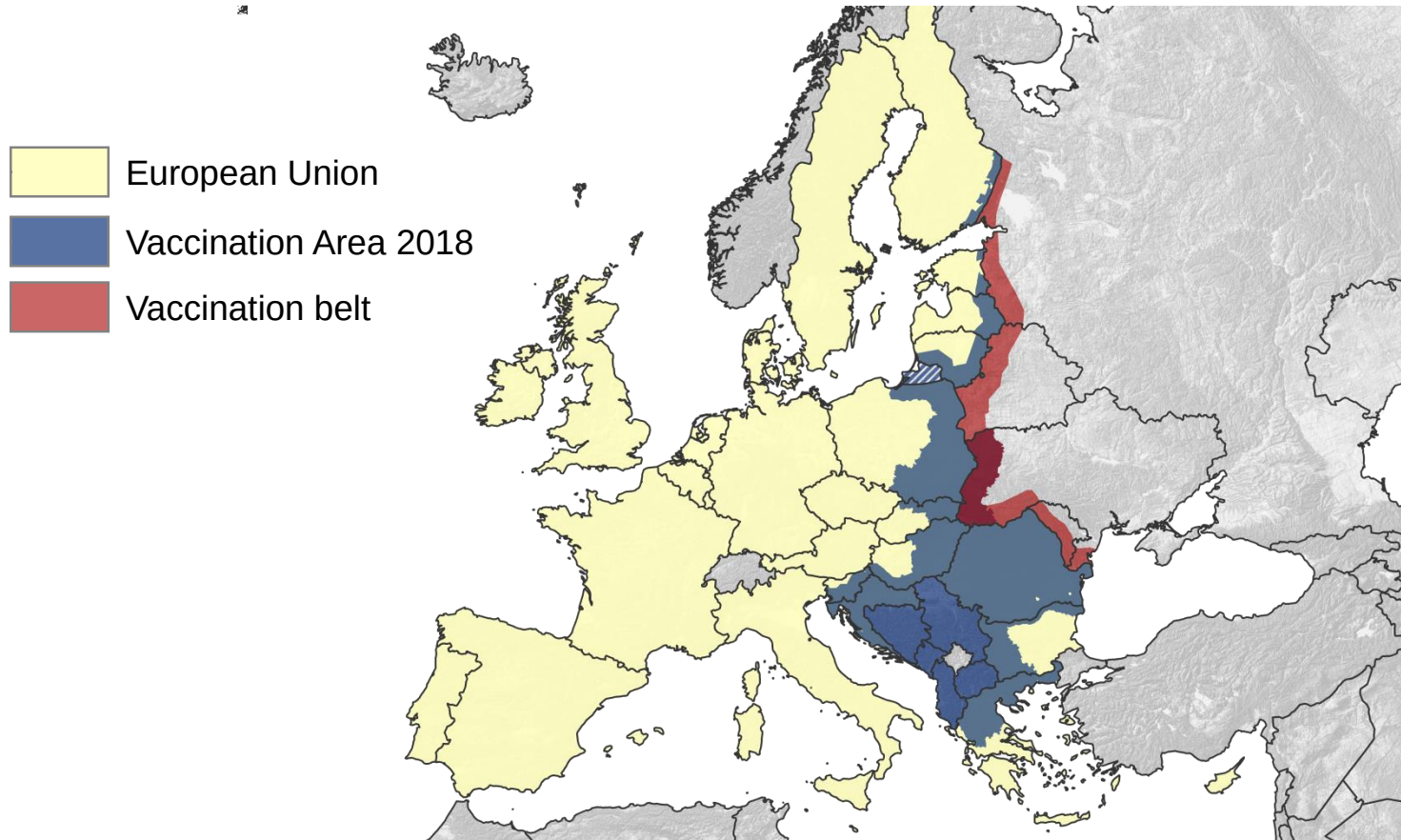




Challenges

Europe (i)

Maintenance of Freedom

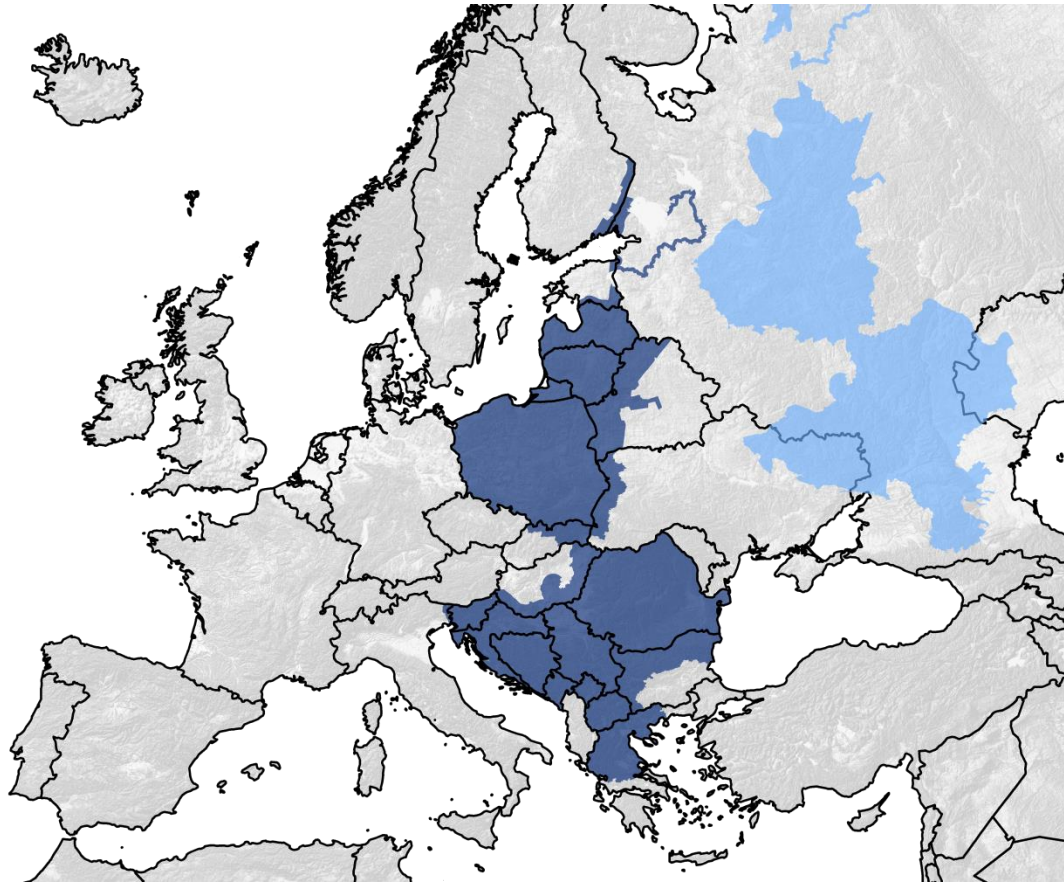




Challenges

Europe (ii)

ORV in Eastern Europe - financial & logistical overkill?



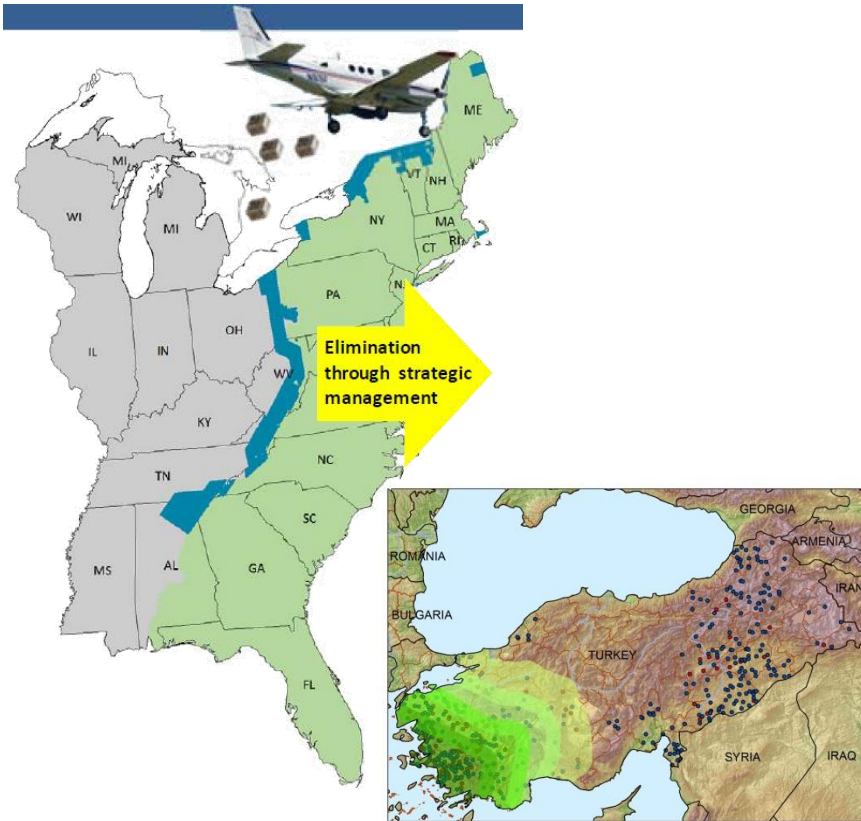
ORV 2013
1.22 Mio km²



Challenges

Europe - North America (iii)

Vaccination Strategy in Large Areas?



Alternative vaccination strategies:

- Territorial coverage
 - Gliding window vs. large scale
 - Minimum ORV area
- Vaccination intervals
- Natural barriers
- Bait densities
- Flight line spacing
- Cost-effectiveness



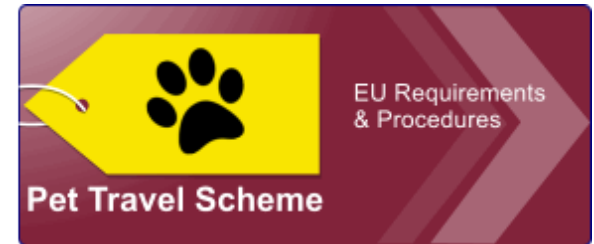
Challenges

Europe (iv)

Prevention of Re-introduction



- dog
- cat
- other



30 imported rabies cases
(1990 - 2018)

Rapid communications

IDENTIFICATION OF A RABID DOG IN FRANCE ILLEGALLY
INTRODUCED FROM MOROCCO

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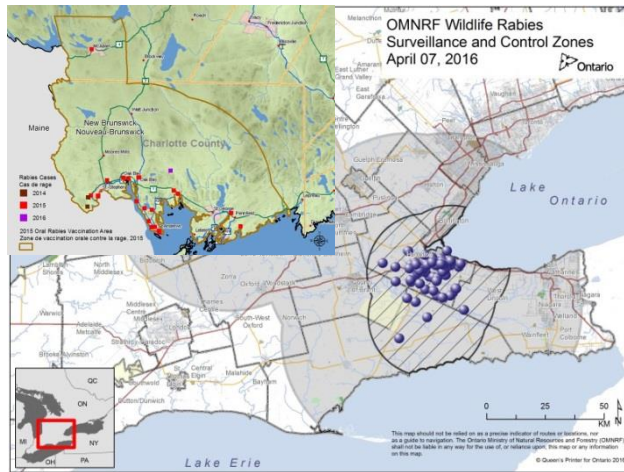


Challenges

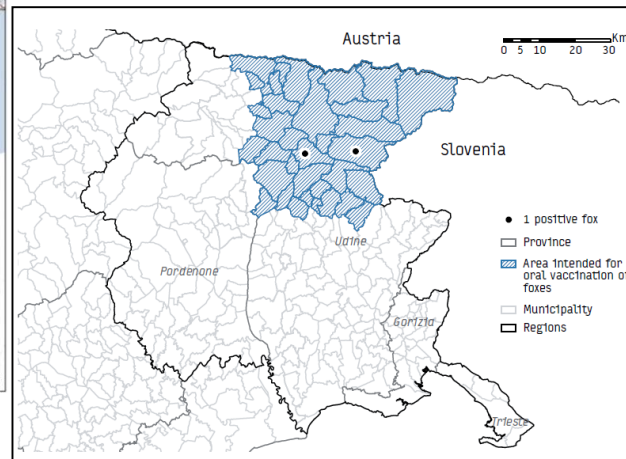
Europe (v)



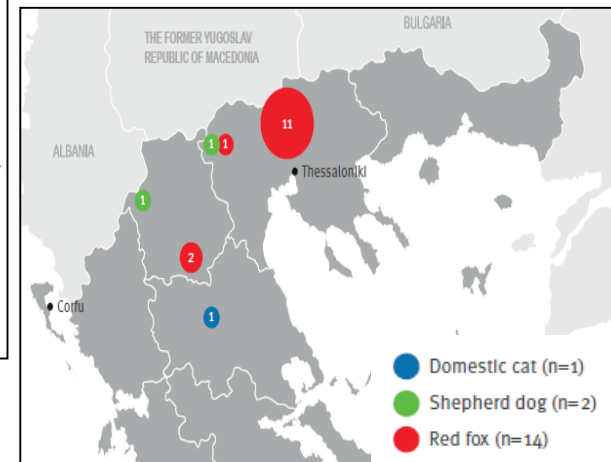
(Re)- Incursions into Rabies Free Areas



raccoon rabies -
Canada 2016



fox rabies -
Italy 2008



fox rabies -
Greece 2012

Source: Stevenson et al. (2016), Tsiodras et al. (2012), de Bendictes et al. (2008)

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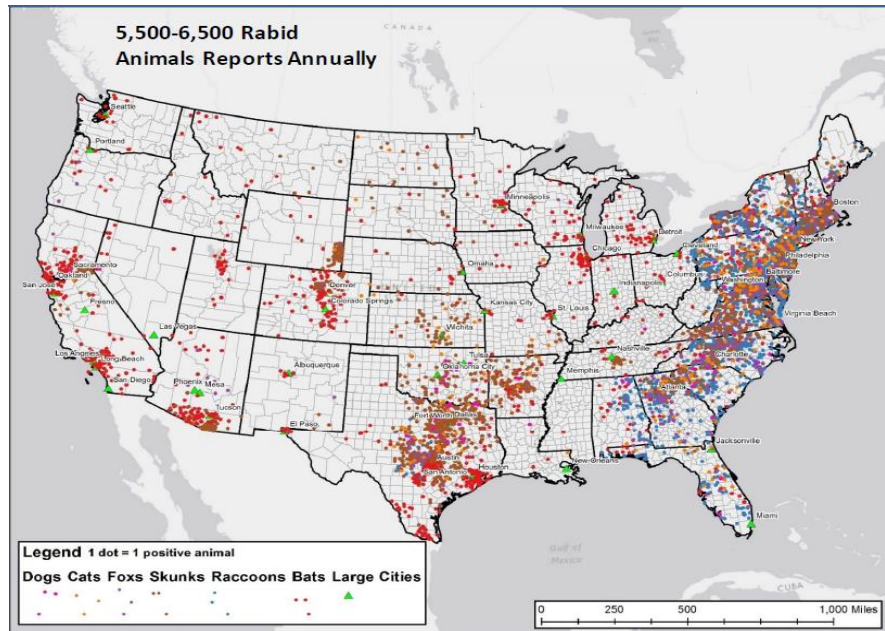
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Challenges

North America (vi)

Multi Reservoir Species



“Living in a sea of rabies”



Source: Richard Chipman, USDA Wildlife Services, REDIPRA 16 - Nov. 2017

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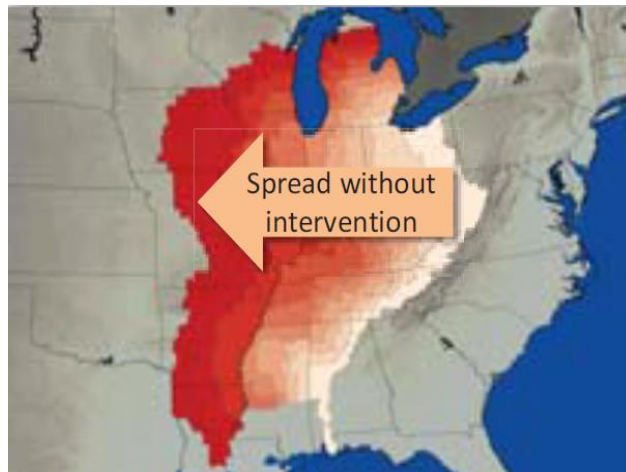
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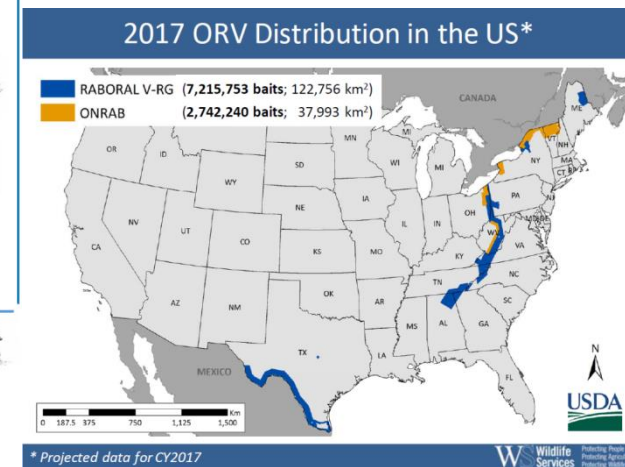
Challenges

North America (vii)

Containment rather than Elimination



Enzootic Rabies	ORV Zone	Rabies Free
    	    	    
rabid	vaccinated	susceptible

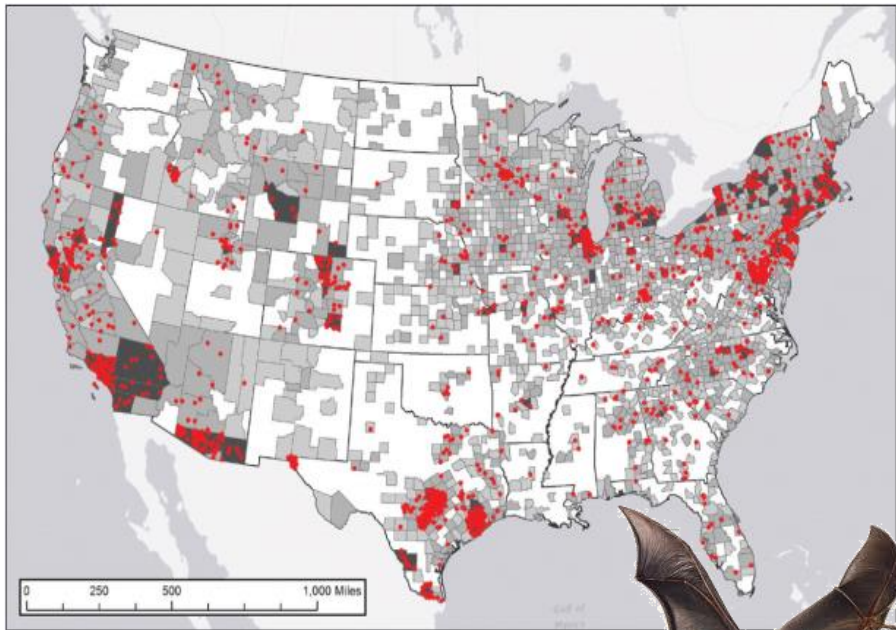


focus has been directed toward contingency actions to "hold-the-line"

Challenges

North America (viii)

Bat rabies - Spillovers



Challenges

North America (ix)



Bat rabies - Host Shift Events

➤ raccoon



- current raccoon endemic (Rupprecht et al., 2017)

➤ red fox



- Price Edward Island (Daoust et al., 1996)

➤ skunks



- Flagstaff, Arizona (Leslie et al., 2006)

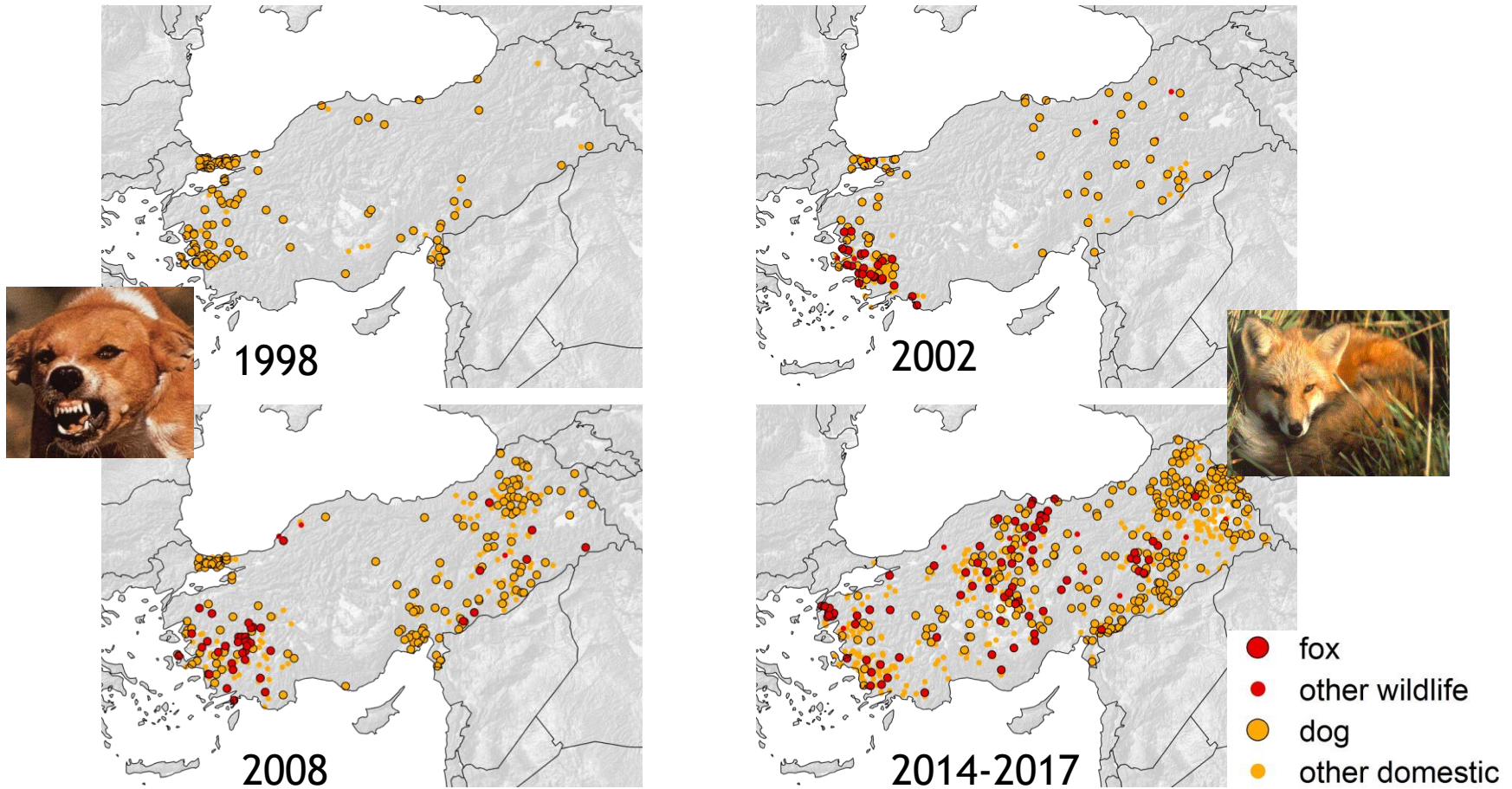




Challenges

Europe (x)

Host Shift Events - When Rabid Dogs Meet Wildlife



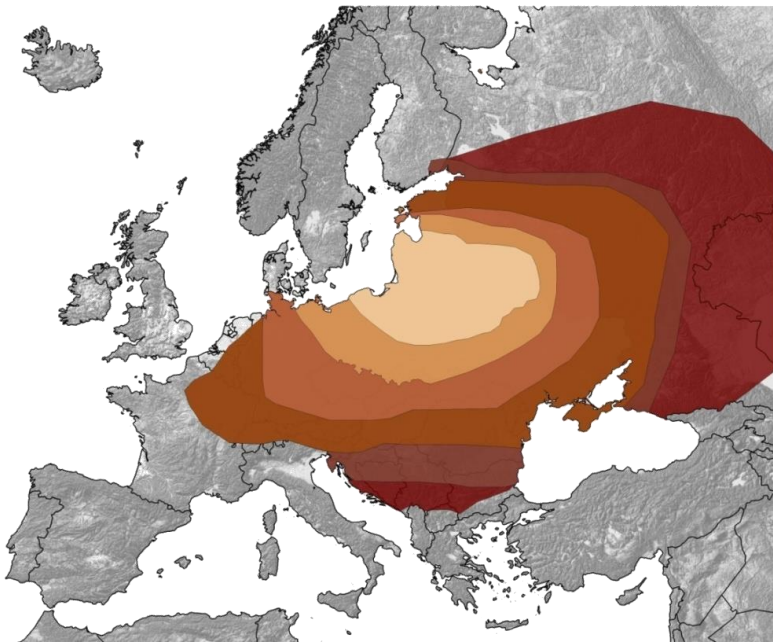


Challenges

Europe (xi)



Multi Reservoir Species?



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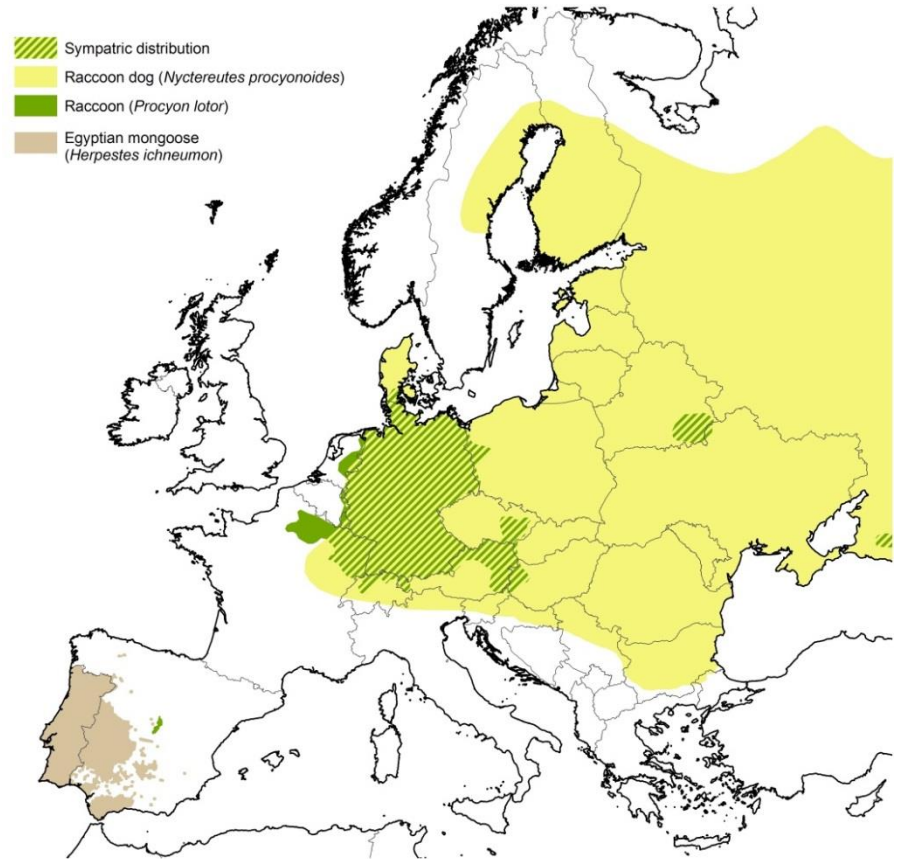
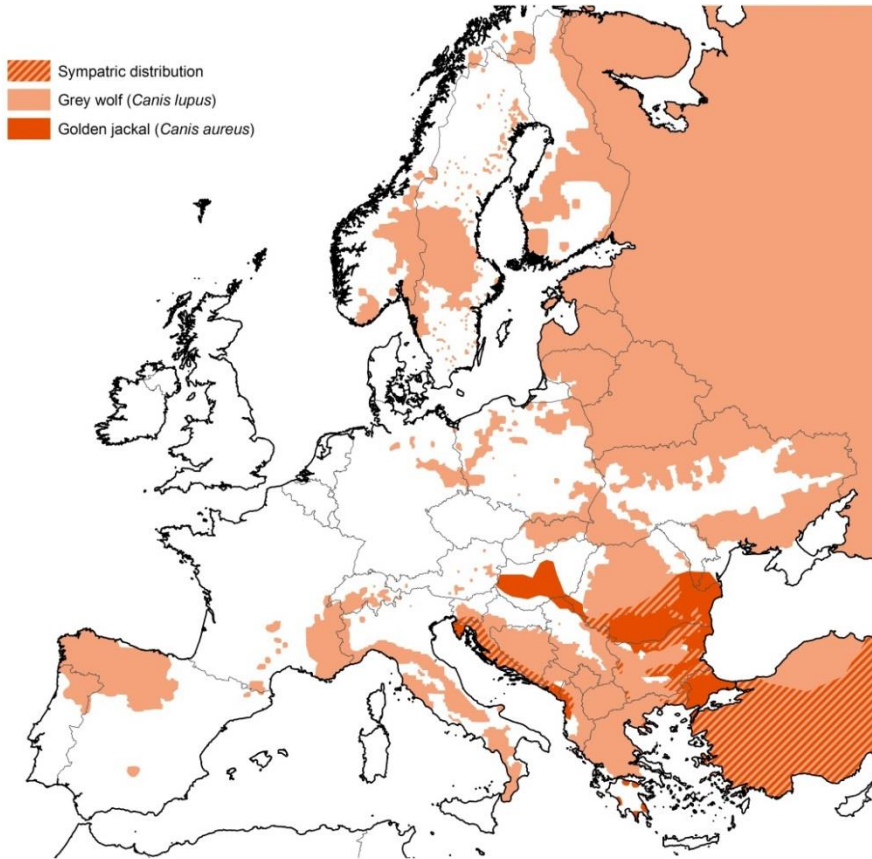
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Challenges

Europe (xii)

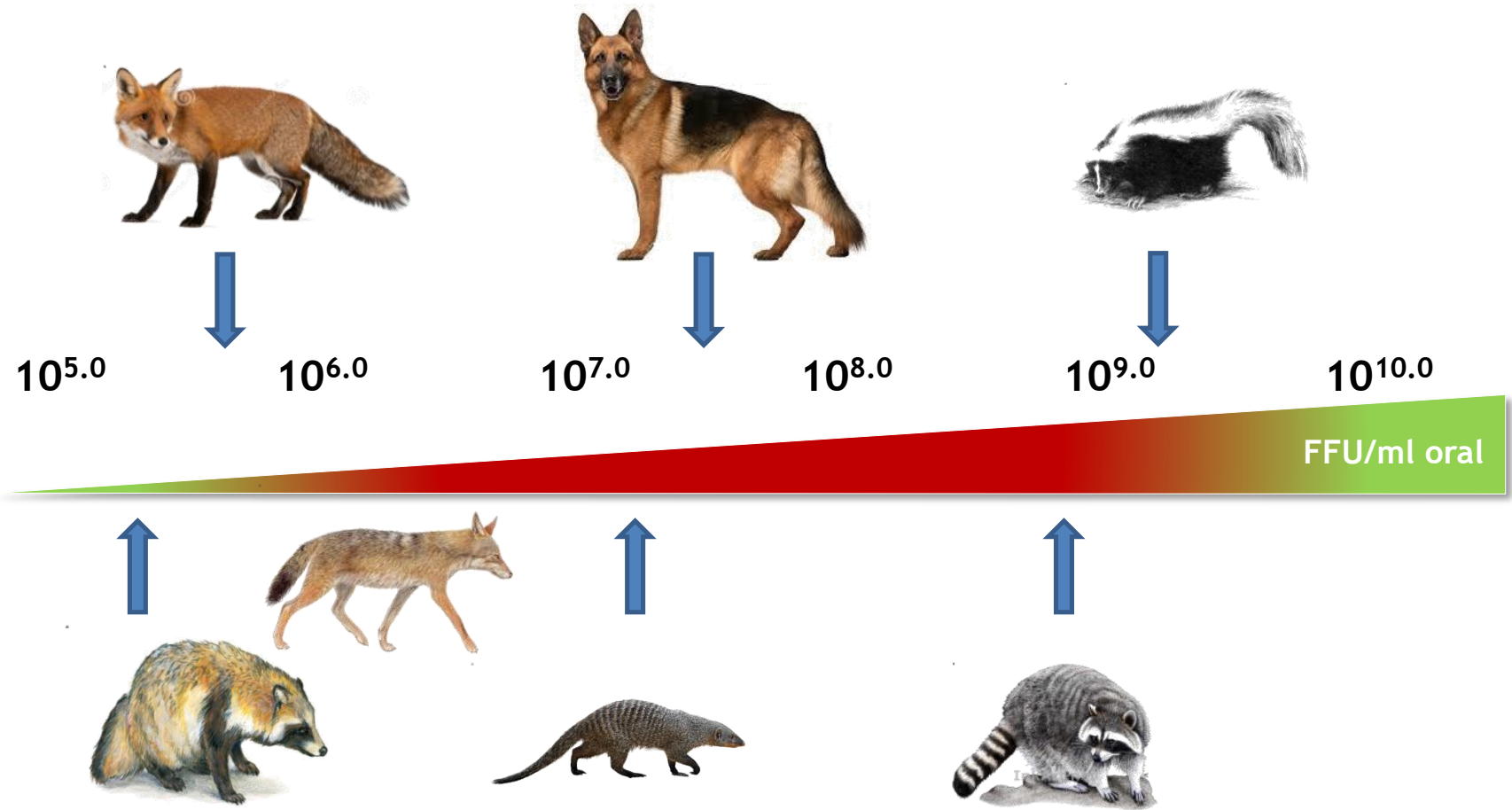
Multi Reservoir Species!



Challenges

General issues (xiii)

Minimum Effective Titre of Oral Rabies Vaccines



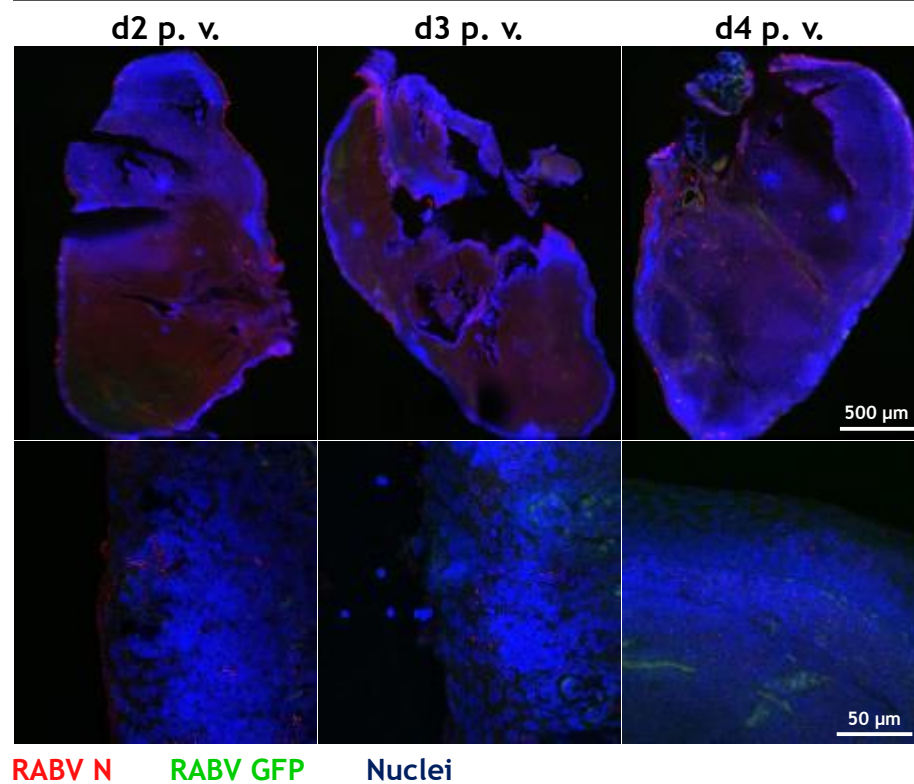
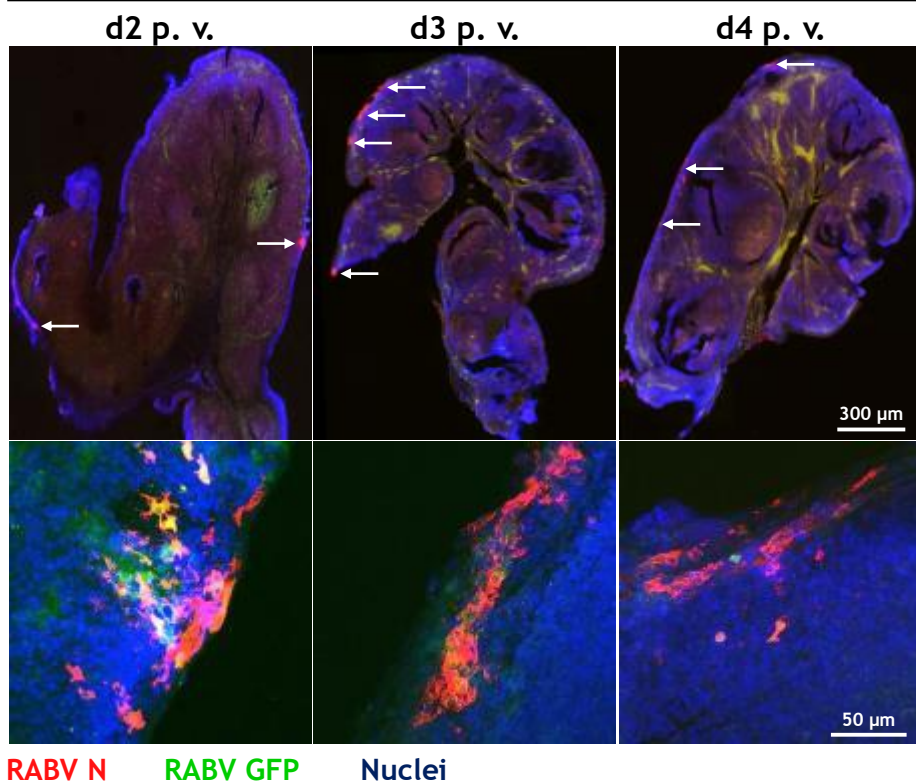
Challenges

General Issues (xiv)

Difference in Vaccine Uptake



Palatine Tonsil



Challenges

General Issues (xv)

Bait Development - No Bait fits all Species



fish meal polymer



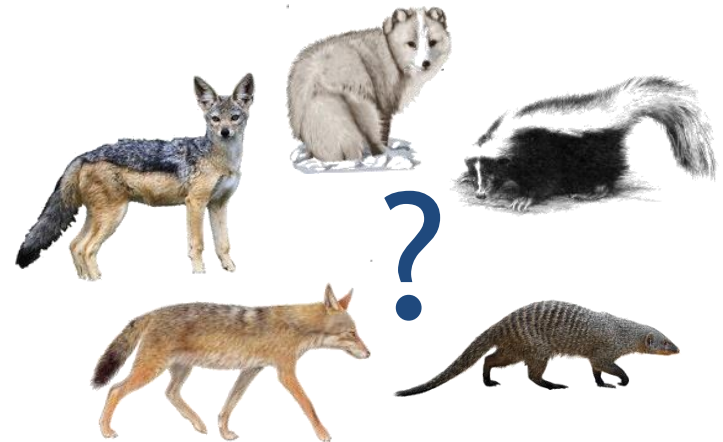
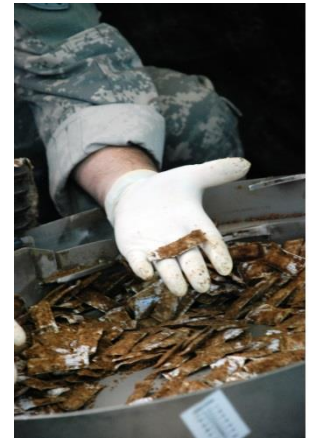
coated sachet



Challenges

General Issues (xvii)

Optimal Bait Distribution



Source: <http://news.cornell.edu/stories/2011/02/cornell-helps-get-long-island-raccoons-rabies-free> , courtesy Ad Vos

Challenges

Europe & North America (xviii)

Understanding Urban-Suburban Challenges



Fotos by Jens Scharon, reinholdkassen.wordpress, David Ascher/Flickr,
<http://www.arlington-tx.gov/animals/urban-wildlife/>, <http://dfwwildlife.org/skunk/>

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Conclusions

- Wildlife rabies cannot be eradicated(!)
- Elimination of rabies feasible for certain wild reservoir species
 - ORV is an effective tool to control rabies in those species
 - Will be a long, stony road and will take decades
- A multitude of challenges ahead & problems to be solved
 - Need for sustained political and financial support
 - Development of alternative, more potent or species-specific oral rabies vaccines
 - Need for more fundamental & applied research needed



Acknowledgements

Adriaan Vos, Steffen Ortmann



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Dennis Slate
(Rabies Management Program)



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Stefan Finke, Madlin Potratz,
Patrick Wysocki

