Update on Wildlife Rabies Management in the United States

16th Meeting of Rabies Program Directors of the Americas
November 28-30, 2017
Antigua Guatemala

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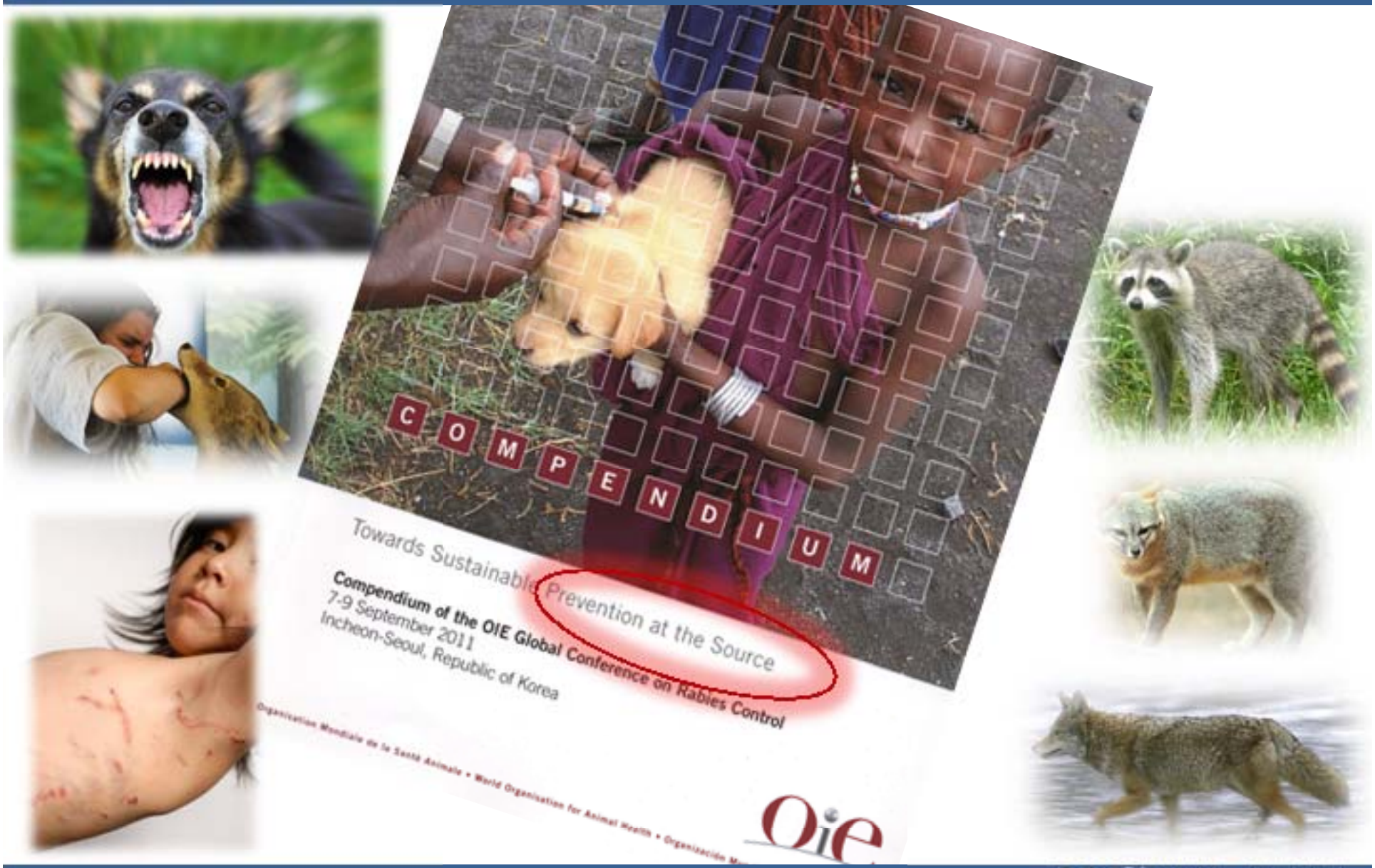
National Rabies Management Program
USDA, APHIS, Wildlife Services,
Concord, New Hampshire

Topics for Wildlife Rabies Management

- Background
- Raccoon Rabies Management
- Vampire Bat Surveillance
- Mongoose on Puerto Rico

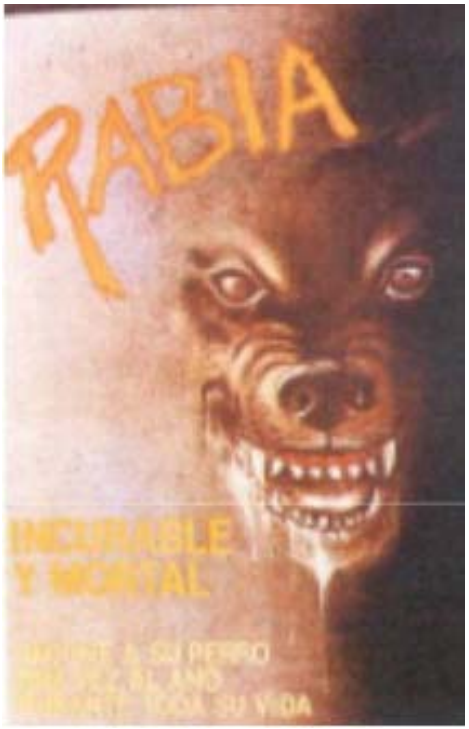
- Next Steps?

Goal of Managing Rabies at its Source

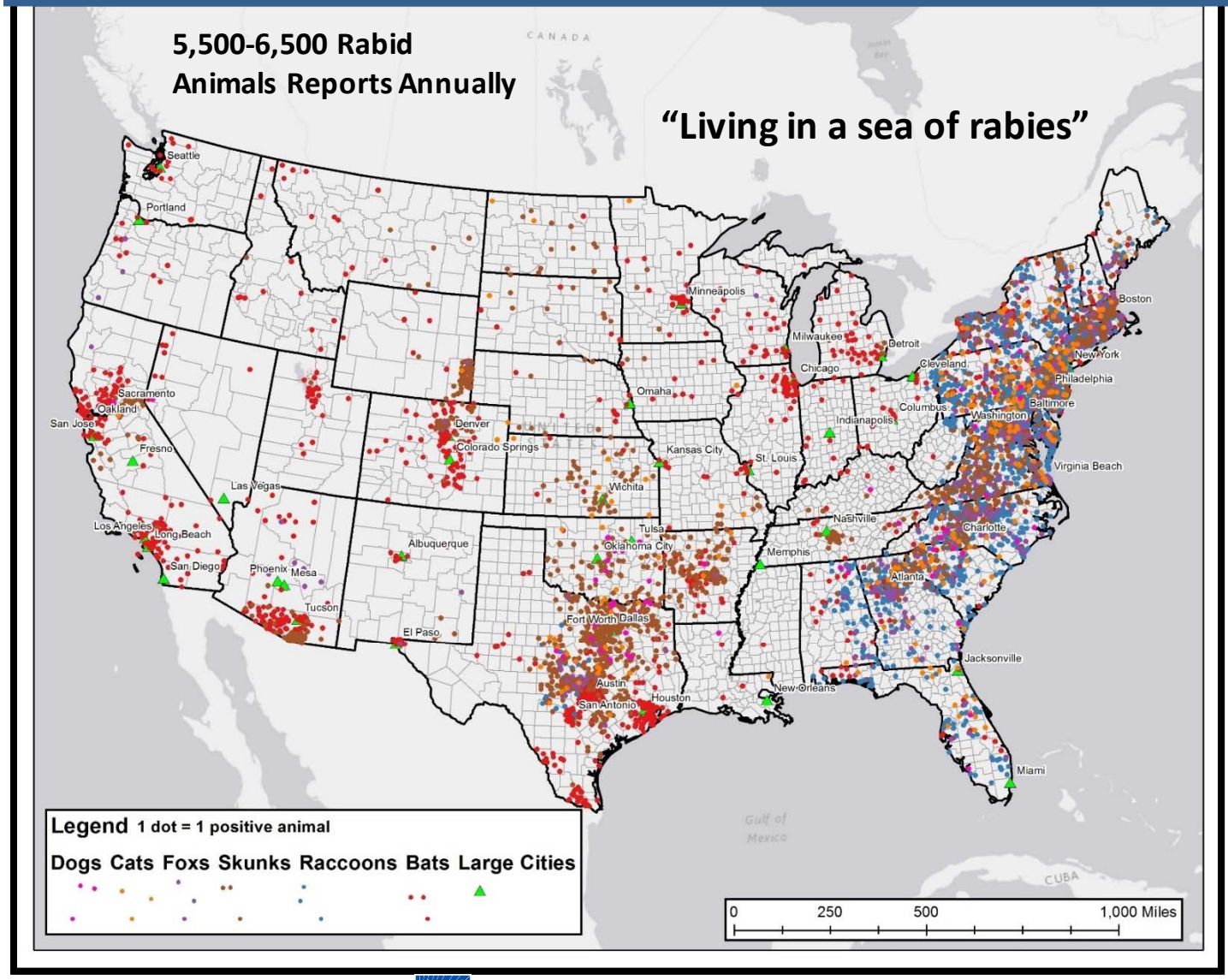


Canine Rabies Overshadows Wildlife Rabies

Canine Rabies has
Greater Impact on Public Health
…..But Wildlife Impacts Remain



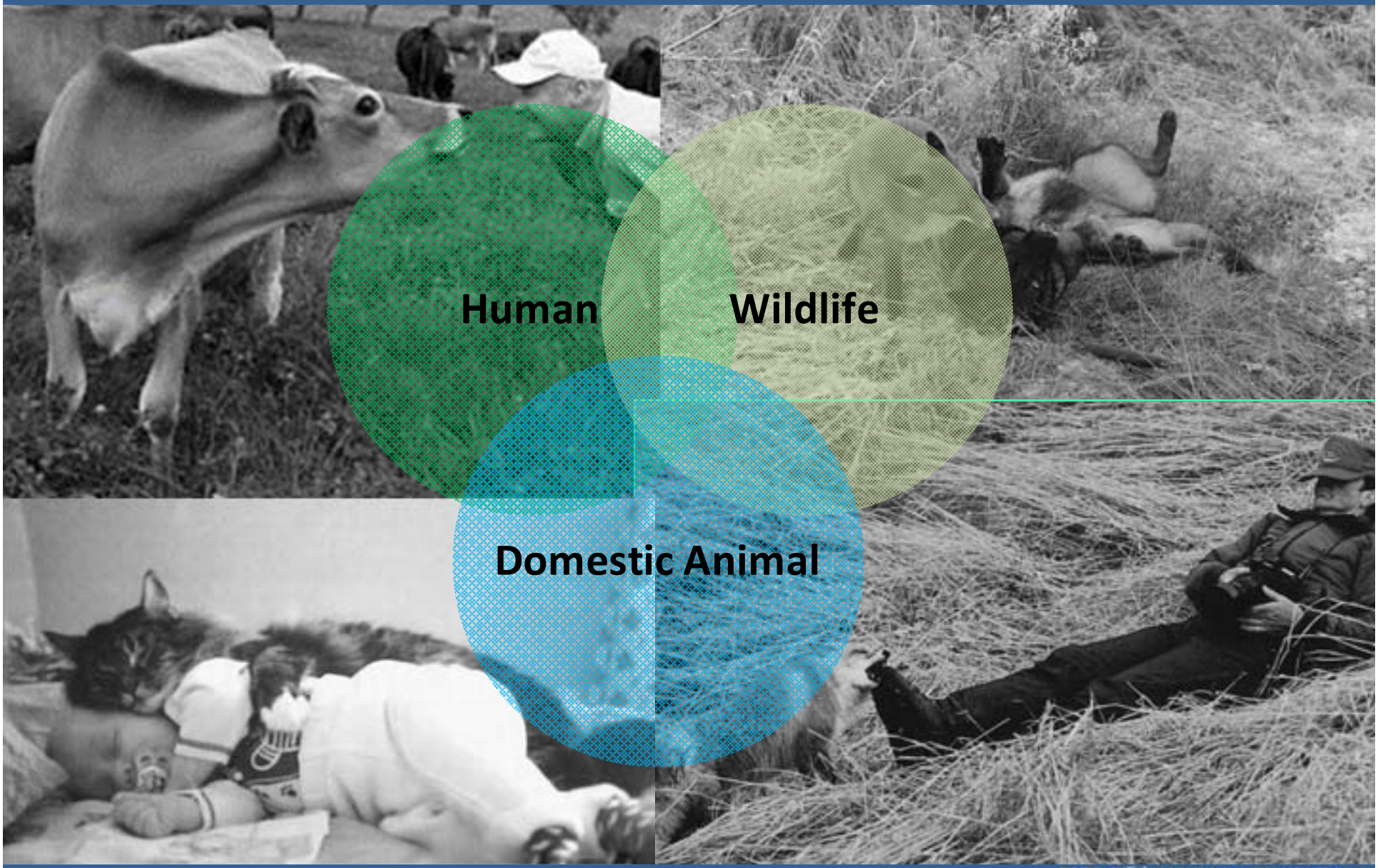
Positive Rabies Cases in U.S



[Source B. Monroe CDC/RITA 2016]

2015:
5,508: animal rabies
5,088 : wildlife (92.4%)

Management at: Human-Domestic Animal-Wildlife Interface



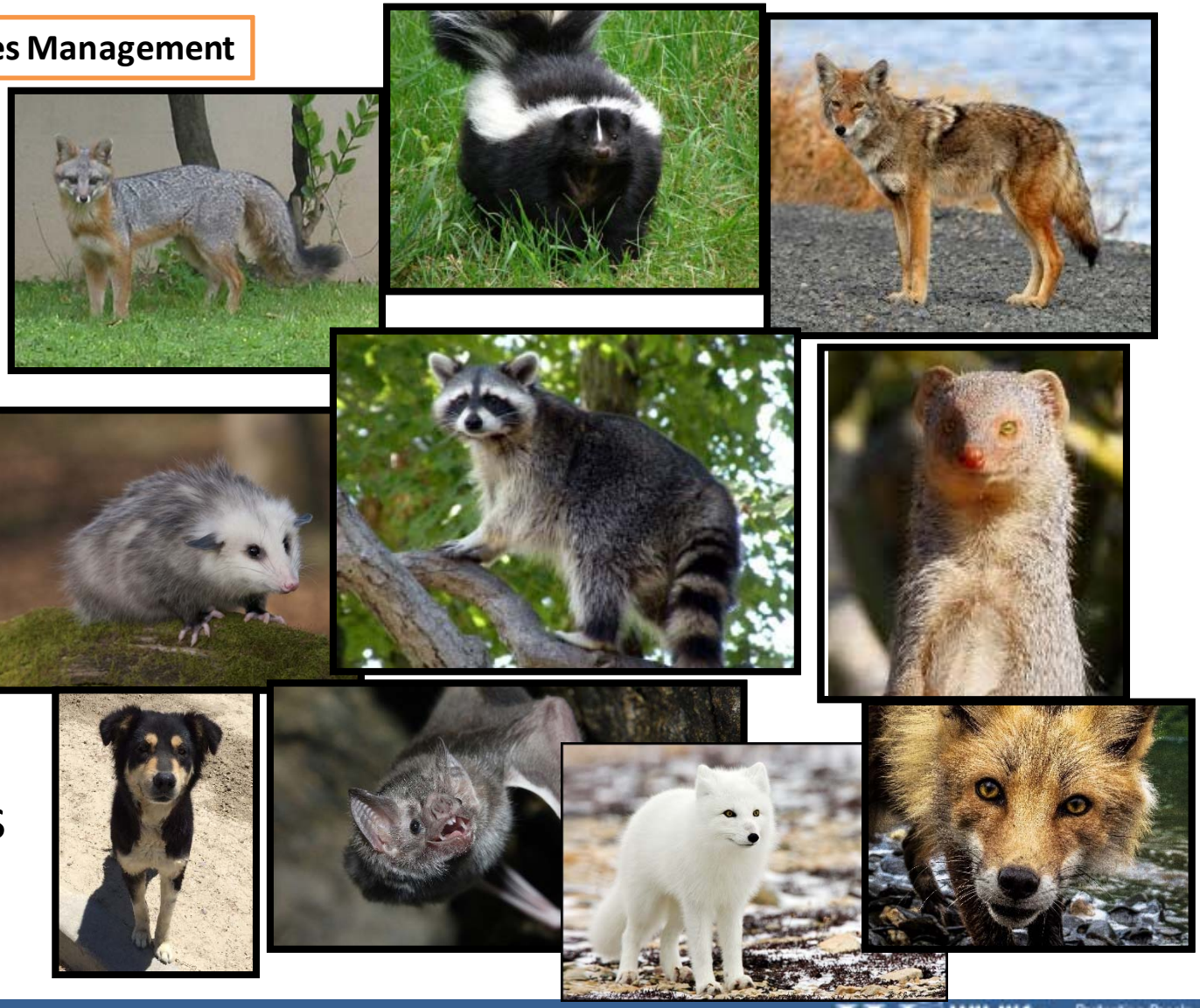
Current Management and Research Focus

"Managing Rabies at the Source in U.S."

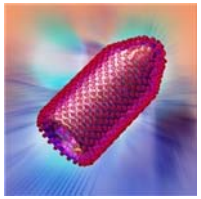
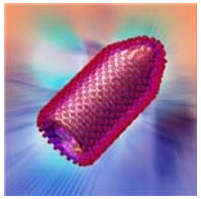
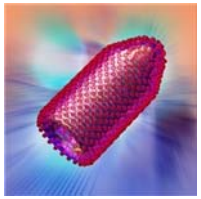
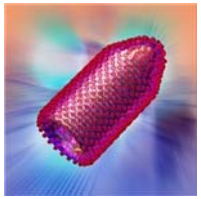
Focus of Terrestrial Rabies Management

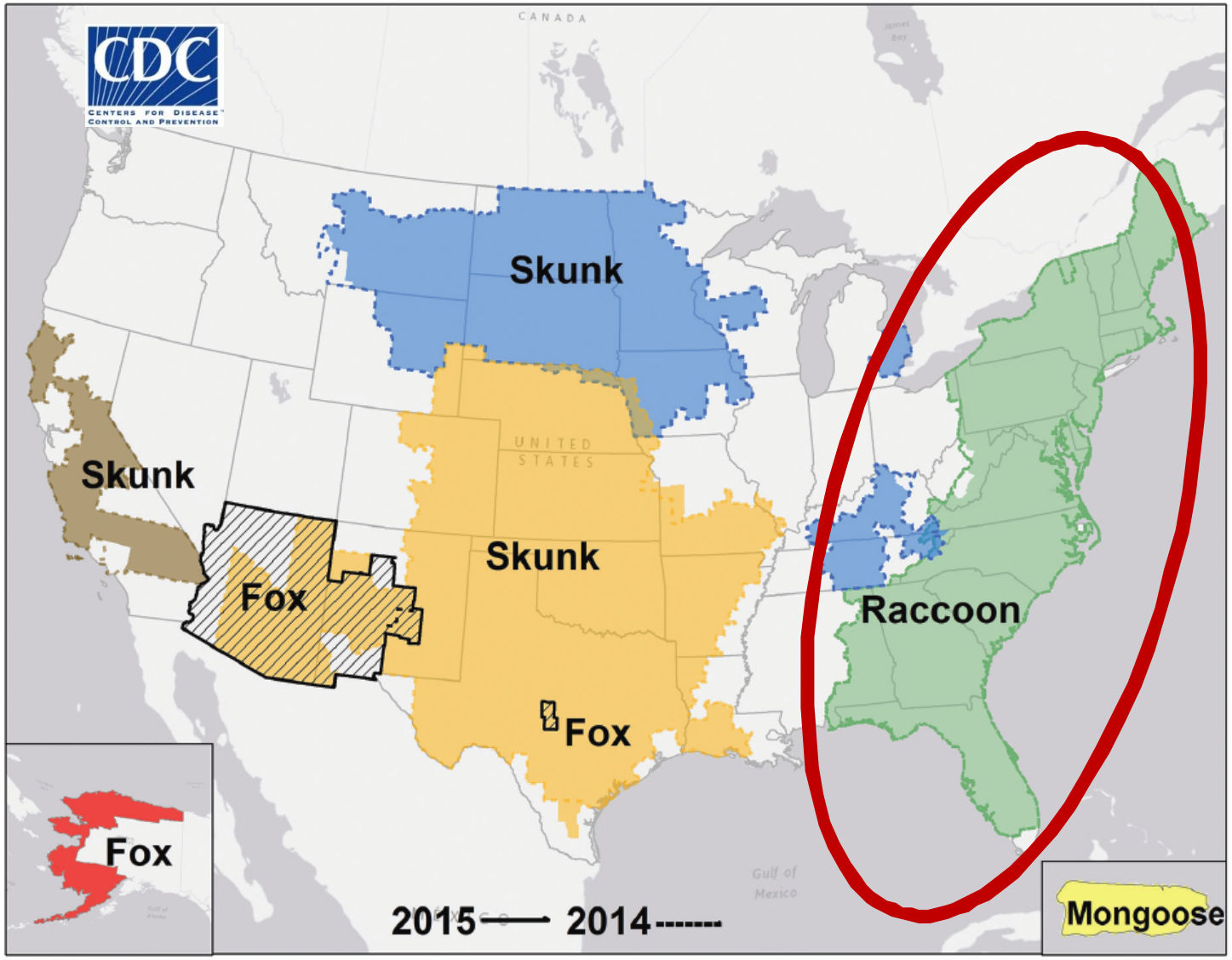
- Raccoons
- Skunks
- Coyotes
- Gray Fox
- Red Fox

- Artic Fox
- Opossum
- Mongoose
- Vampire bats
- (Feral Dogs)



Terrestrial Rabies Variants in the U.S. (2015)



Big Ideas, Big Goals

National Wildlife Rabies Management Goals

I. **Prevent the spread** of specific terrestrial rabies variants in the United States

II. **Eliminate** specific rabies variants at the local, regional, and national level

Operational Wildlife Rabies Management Since 1995

Cooperative and Coordinated

Key Program Components

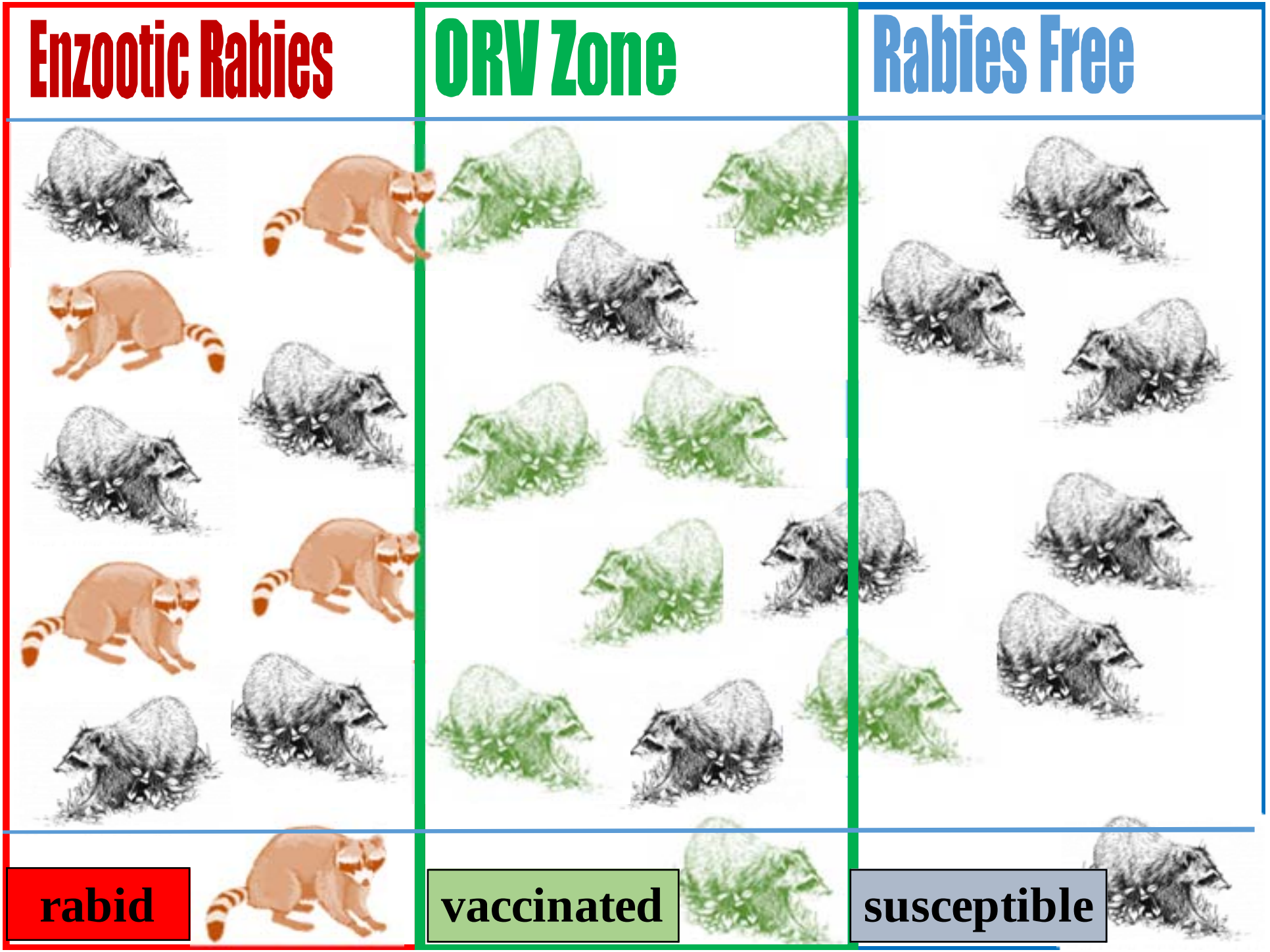
Wildlife Services
Protecting People
Protecting Agriculture
Protecting Wildlife

Oral Rabies Vaccines in the U.S. (2017)

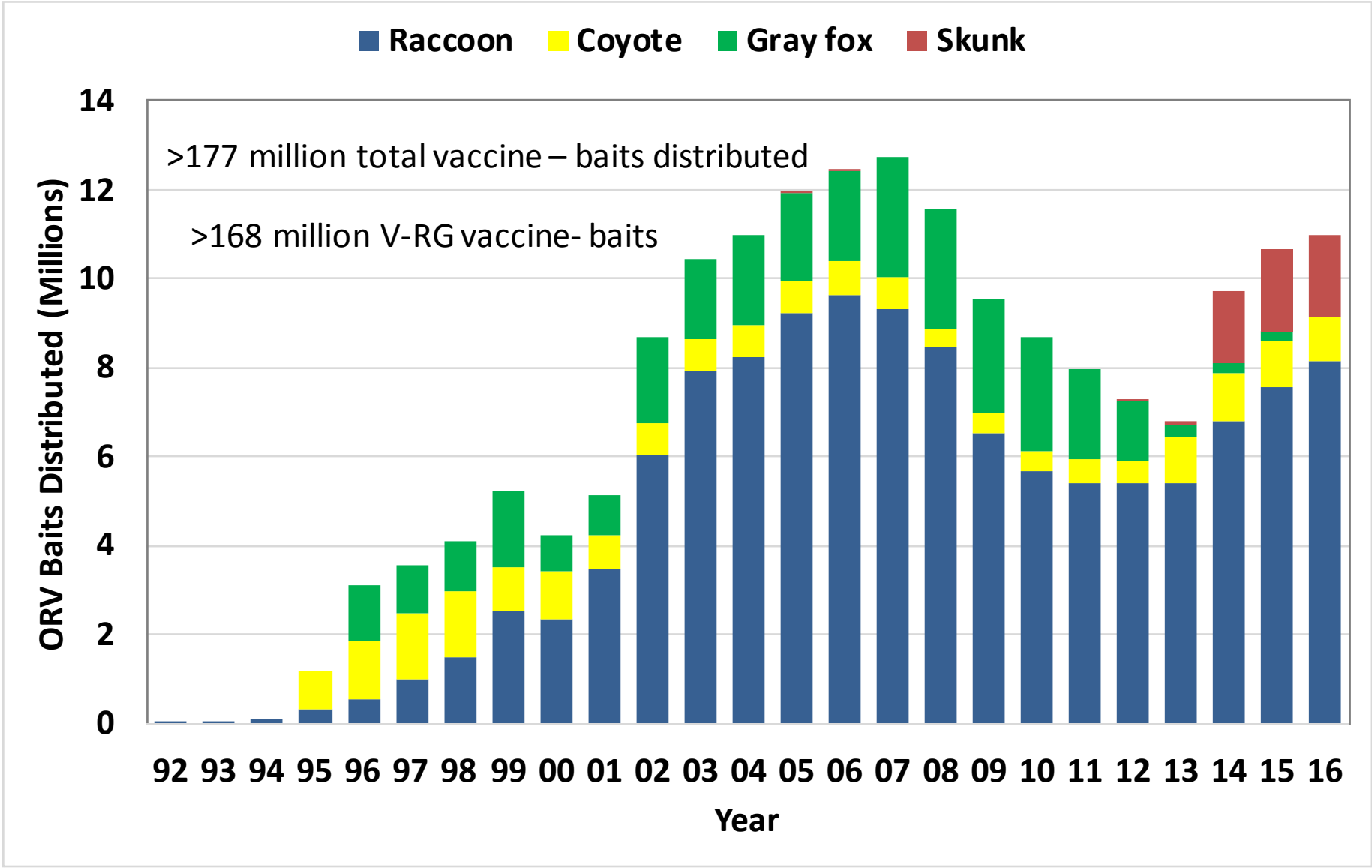
Artemis Technologies Inc.
ONRAB
(experiment use)
Recombinant –
Human adenovirus Type 5

Merial RABORAL V-RG®
Fish Meal Polymer
(FMP)

Merial RABORAL V-RG®
Coated Sachet
(CS)
Recombinant - Vaccinia

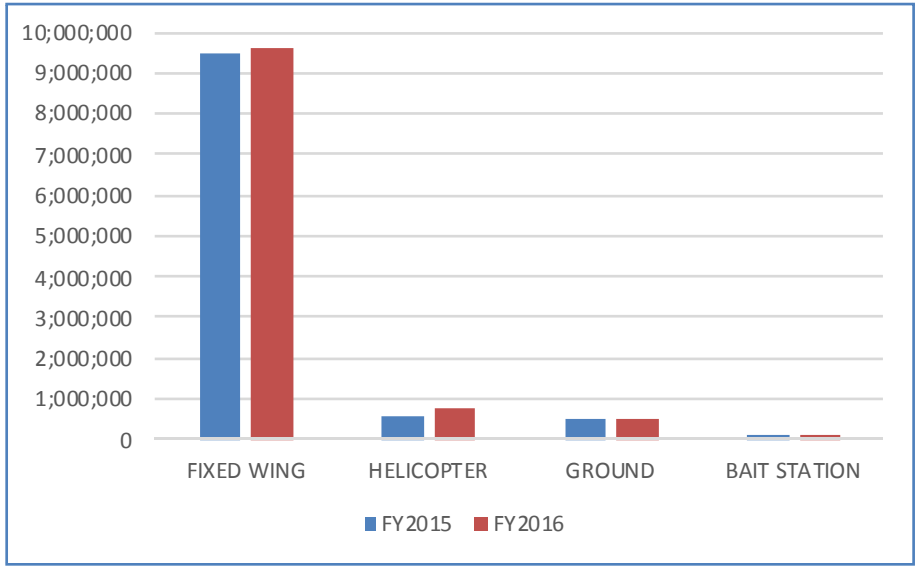

Enzootic Rabies
ORV Zone
Rabies Free
rabid
vaccinated
susceptible

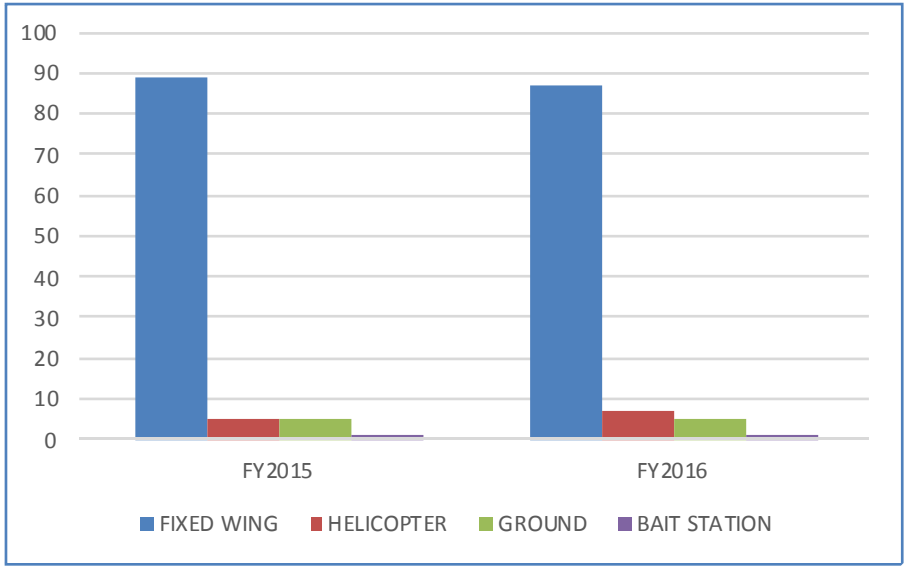
US ORV Distribution by Species Since 1992



ORV Distribution by Method

Bait Totals by Method	FY2015	% Total	FY2016	% Total
FIXED WING	9,504,050	89	9,622,725	87
HELICOPTER	556,144	5	777,257	7
GROUND	524,033	5	545,383	5
BAIT STATION	101,720	1	96,490	1





Strategies: Bait Density and Flight Line Spacing

- Bait Density = 37.5/75/150/300 baits per km2
- Flight Line Spacing = 750/500/250 meters
- Minimum ORV Zone width = 25 miles (40 km)

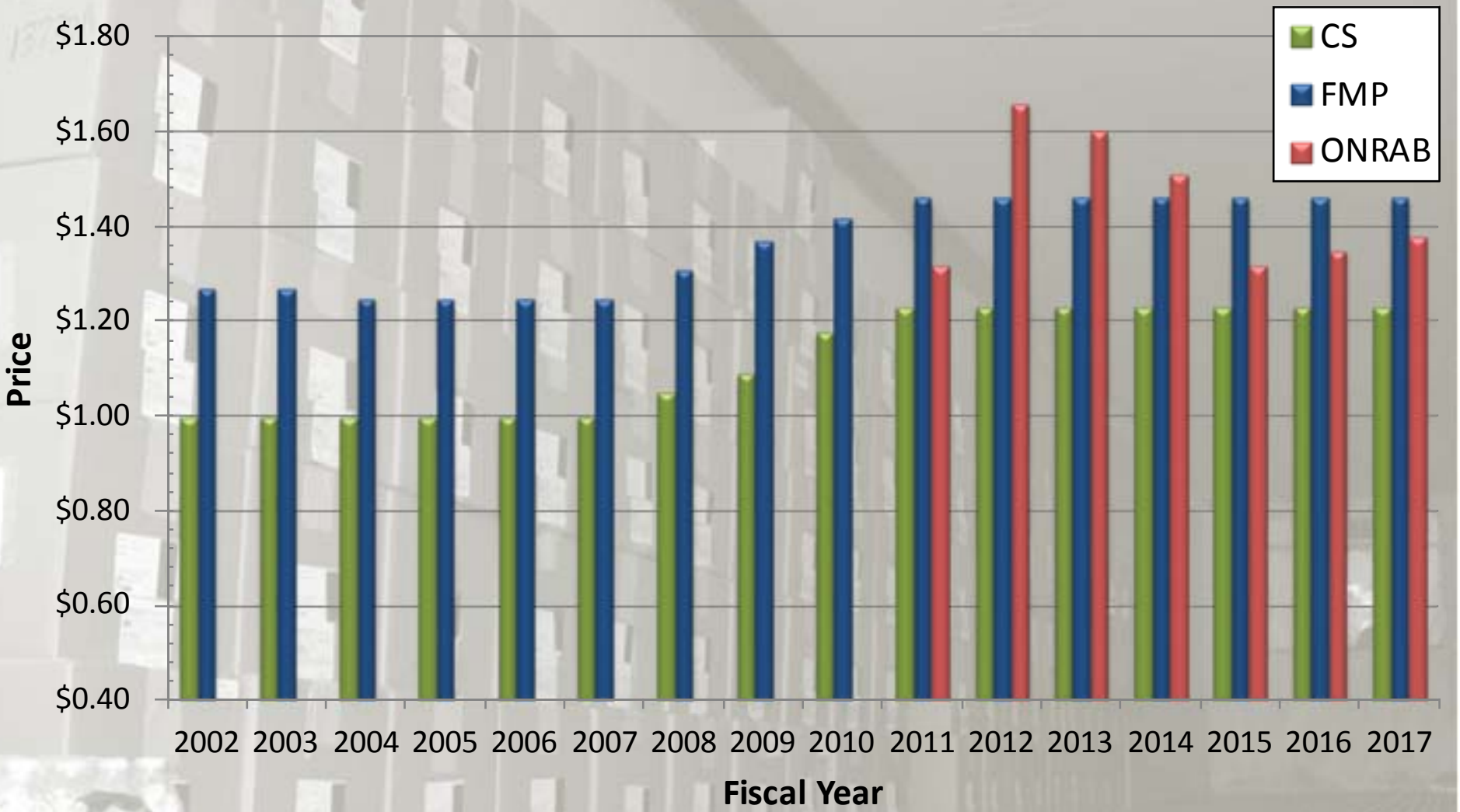
Bait density raccoons 75 – 150 baits/km^2

Bait density fox/coyote ~30 baits/km^2

Support from Congress and Tax Payers for ~ 20 Years

Focus on Efficiency, Effectiveness and Wise Use of Resources

Vaccine Bait Prices (2002-2017)



CS=$1.23; FMP=$1.46; ONRAB $1.40 USD

Wildlife Rabies Program Budgeting

Vaccine-Bait 50%

Air/Fuel 9%

WS State Programs 26%
(operations)

Coordinator's Account 8%

Cooperative Agreements 3%

NWRC 4%
(Research)

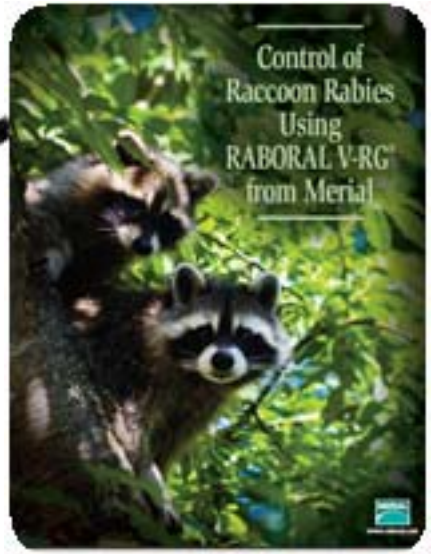
$28M

Management with Raboral V-RG® in U.S.

- Raboral V-RG® is the only licensed ORV in the U.S.
- **>170 million V-RG baits** distributed in U.S. since 1992
- Coordinated ORV with V-RG® has resulted in some major accomplishments in the U.S.

USDA

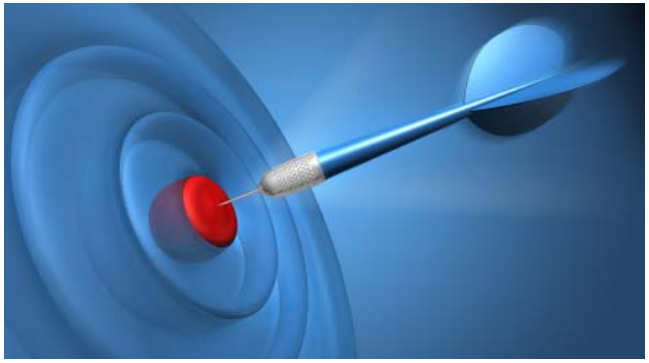
Boehringer Ingelheim

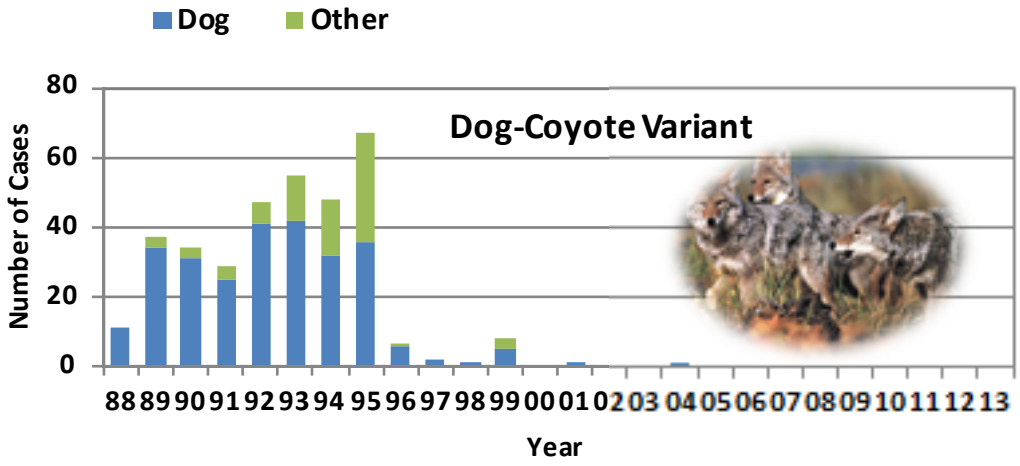


Wildlife Services

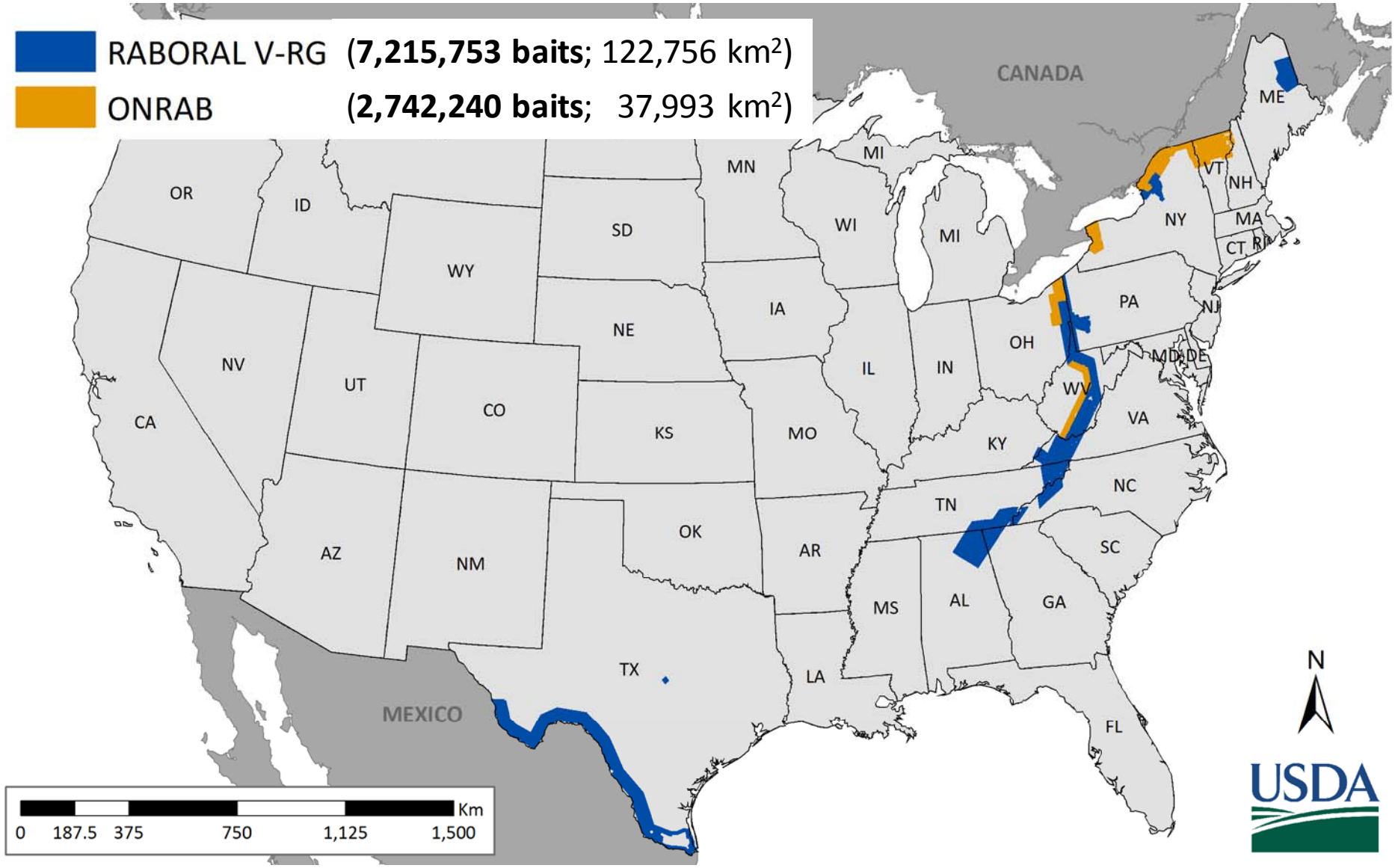
Cooperative Rabies Management Program Accomplishments

- No canine rabies in U.S. since 2004, declared free in 2007
- One gray fox rabies case in Texas since May 2009
- No appreciable spread of raccoon rabies to the West





2017 ORV Distribution in the US*



** Projected data for CY2017*

Wildlife Services
Protecting People
Protecting Agriculture
Protecting Wildlife

FY 2017 ORV Operations in the US

Baits Distributed: 10,420,249

Distance Flown: 385,000 km

Area baited: 161,098 km²

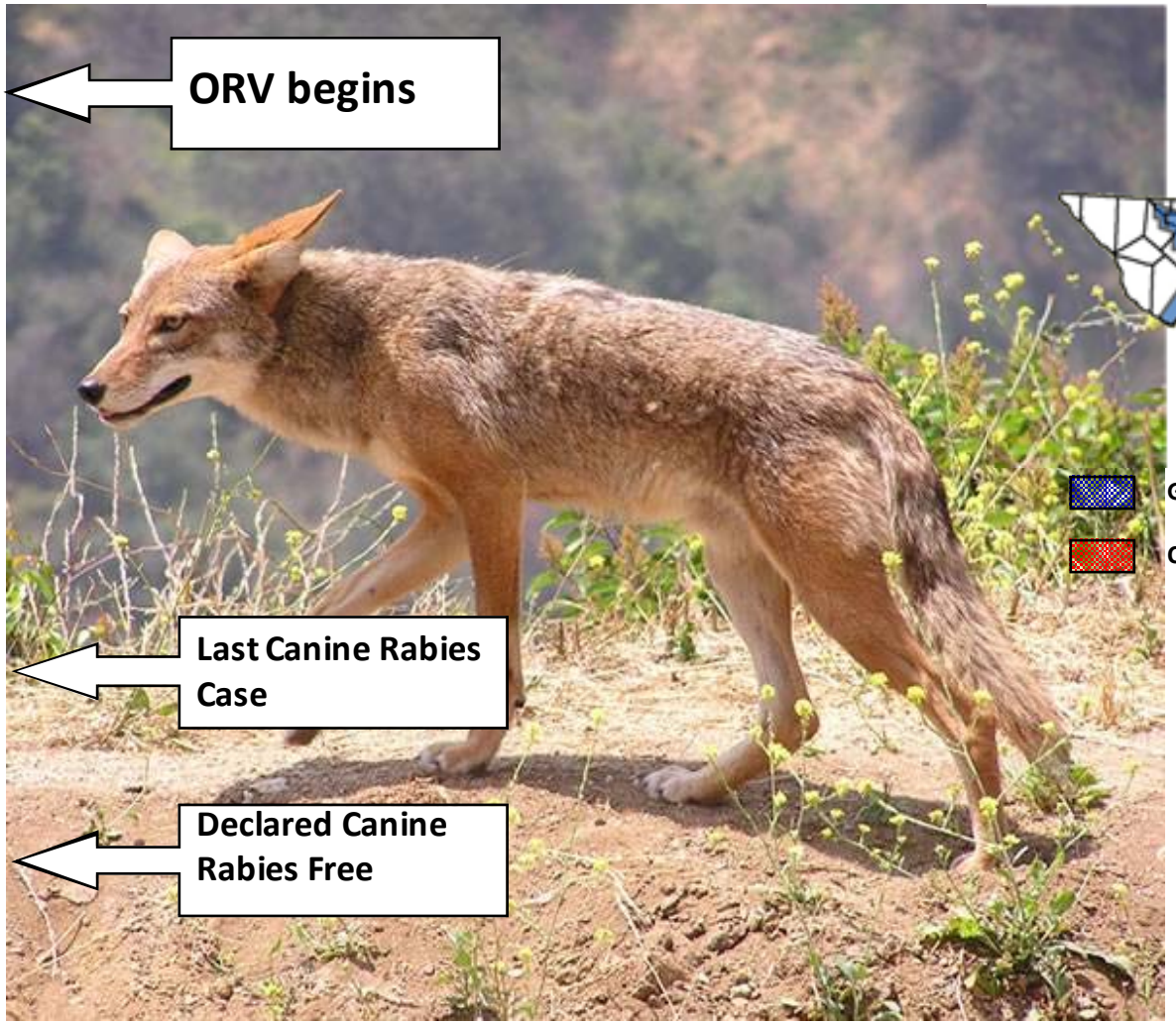
Hours of Flight: 2,000

Across 17 States

Canine Rabies in Coyotes
(South Texas)

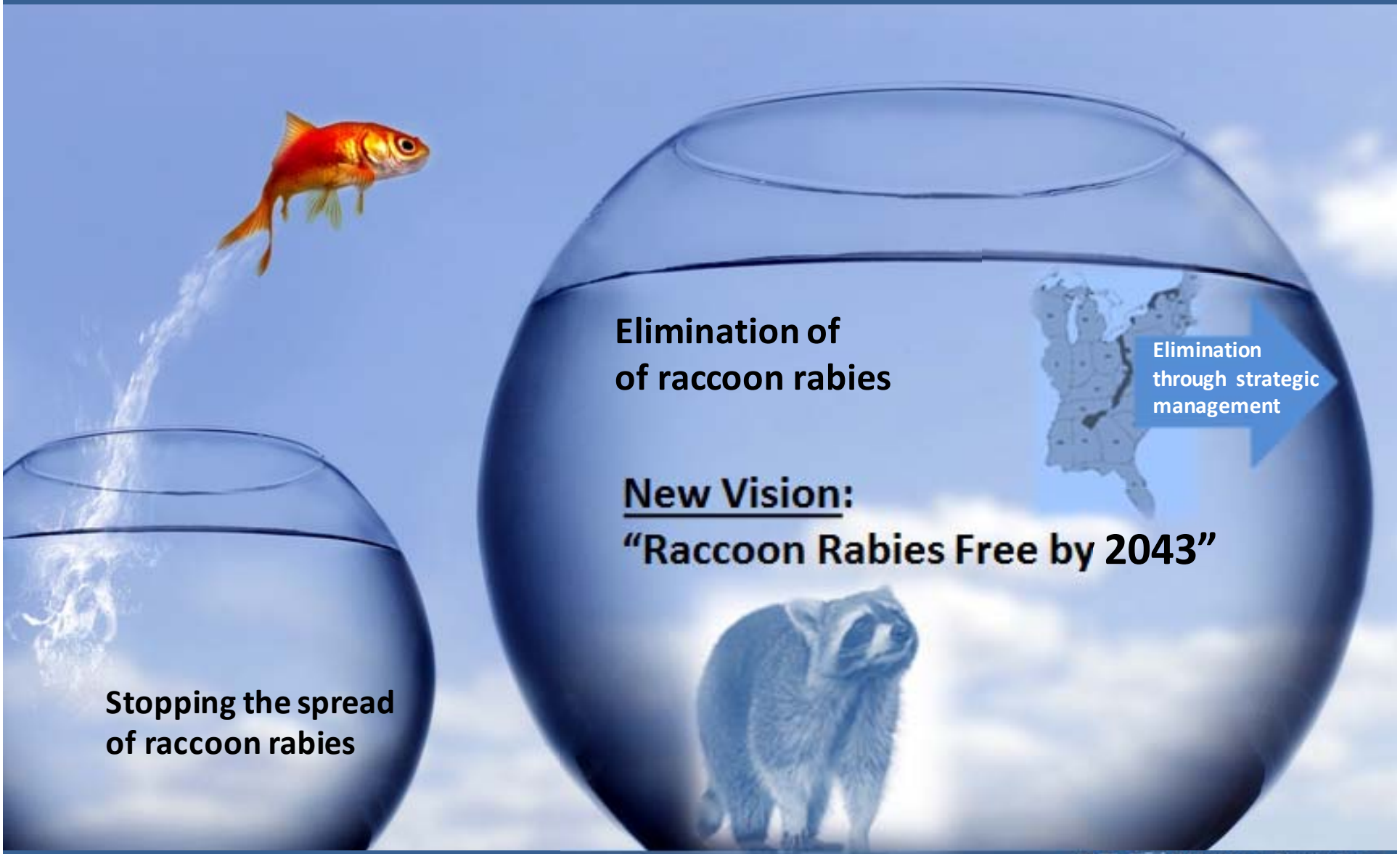
- Eliminated a second time in 2007 with ORV targeting coyotes

1994	166
1995	58
1996	21
1997	6
1998	5
1999	10
2000	0
2001	1
2002	0
2003	0
2004	1
2005	0
2006	0
2007	0
2008	0
2009-2017	0



Needs:
*Surveillance along border
*Contingency Plans

The Big Challenge…..

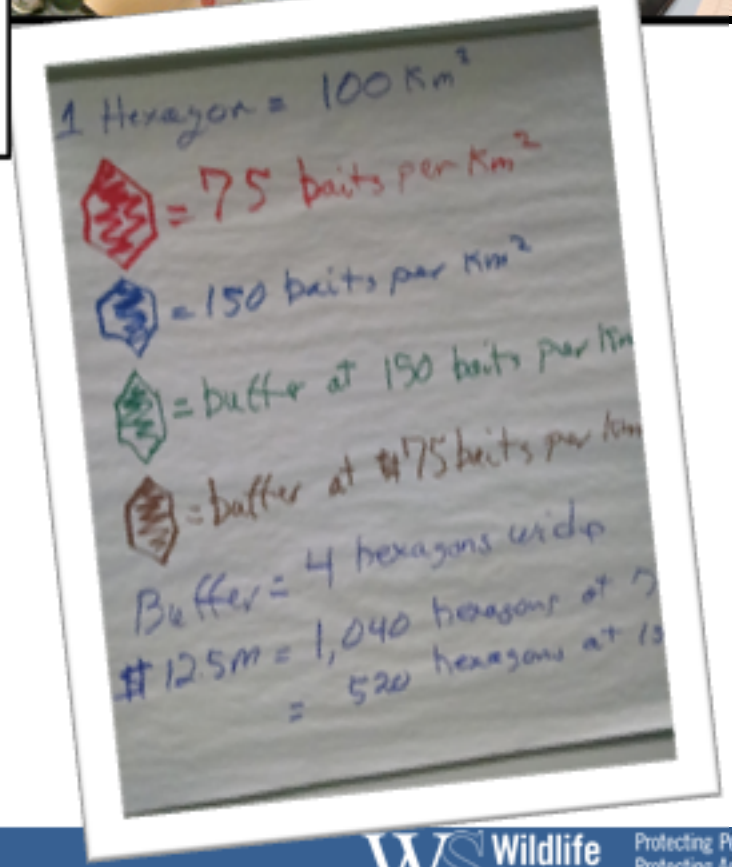


DELPHI II: Refinement of Elimination Strategies

30-year Planning Horizon

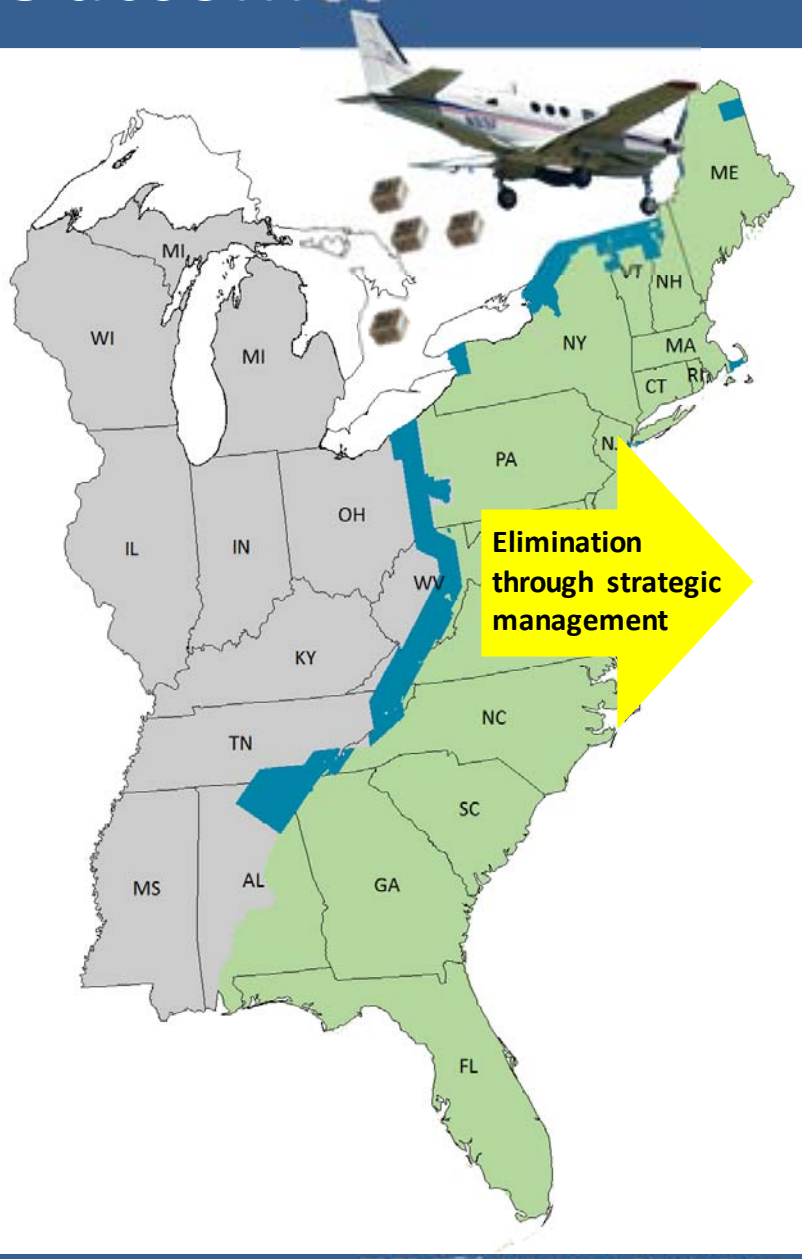
DELPHI II Meeting

March 9-11, 2016; Fort Collins, Colorado



Delphi II Targeted Outcomes

- Expert Opinion: Define landscape level **strategies for raccoon rabies variant elimination**
- Risk Models: Develop **risk models** to fully **evaluate the effectiveness** of potential strategies
- Economics: Apply results to **BioEcon and REMI** model to **estimate benefits and costs** associated with potential strategies

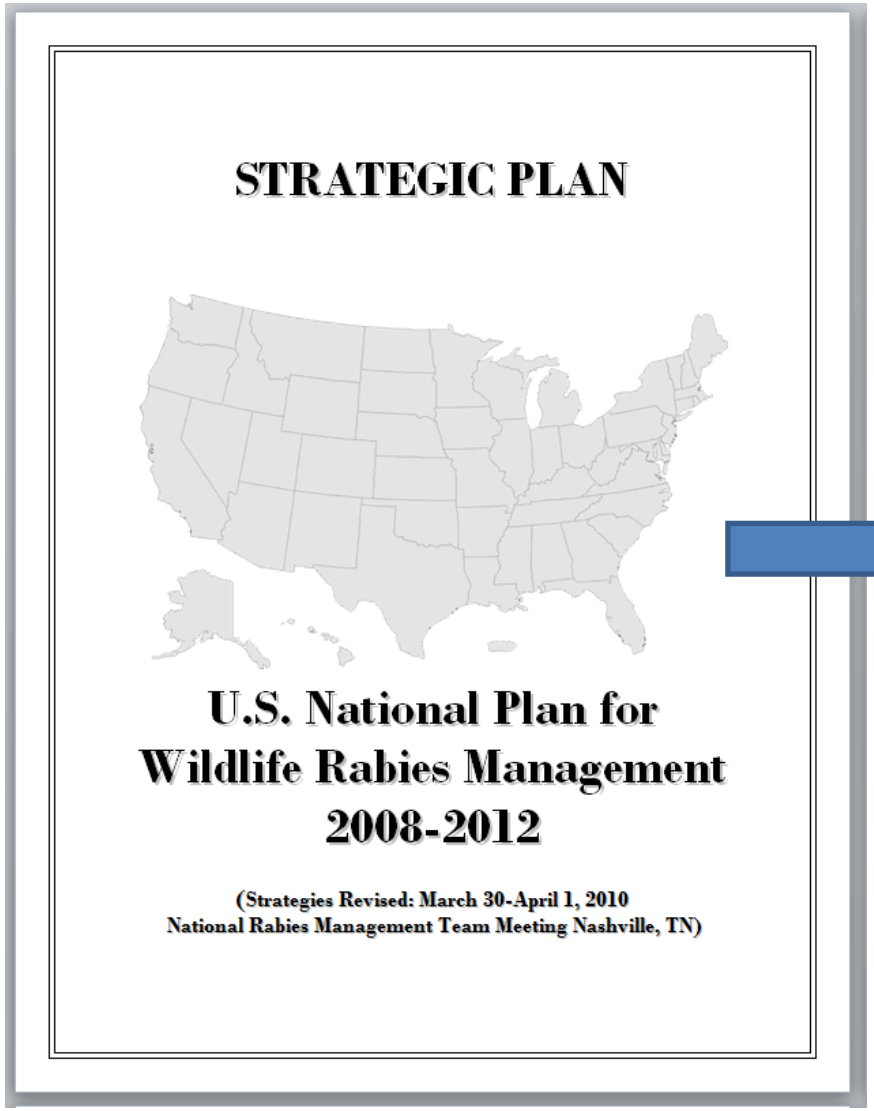


DELPHI II Raccoon Rabies Elimination

Diversity of Collaboration Essential

Global – North American – National – Regional – State – County - City - Town - Individuals

Strategic Planning = U.S. National Plan



The North American Rabies Management Plan

- ✓Information transfer
- ✓Surveillance and monitoring
- ✓Rabies control
- ✓Research

Large Scale, Intensive Program Monitoring

Key Program Metrics

Serology

- **RFFIT**: Rapid Fluorescent Focus Inhibition Test
  - **RVNA** as index to vaccine induced immunity
    - Direct measure of IgG

Rabies Cases

- **DFA:** Direct Fluorescent Antibody Test
- **dRIT:** Direct, Rapid Immunohistochemical Test

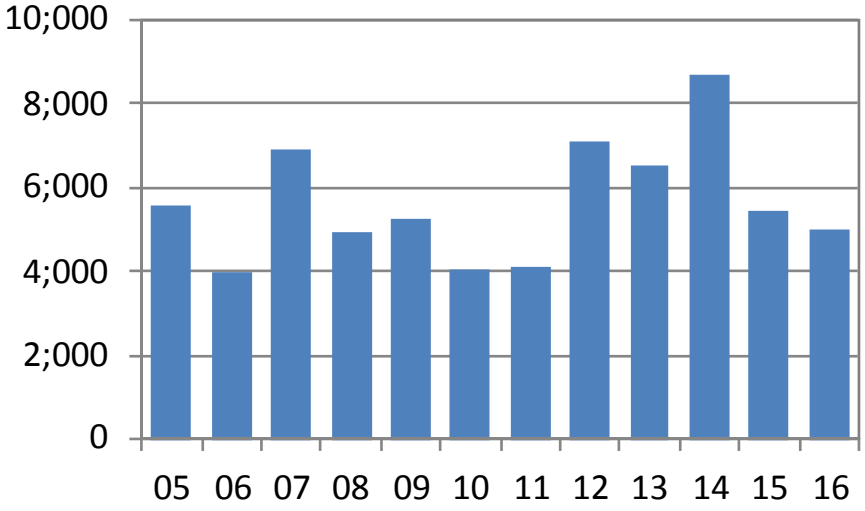
Program Metrics: Sampling (2005-2016)

Serology

Virus Neutralizing Antibodies

(blood samples)

Avg. >5,600

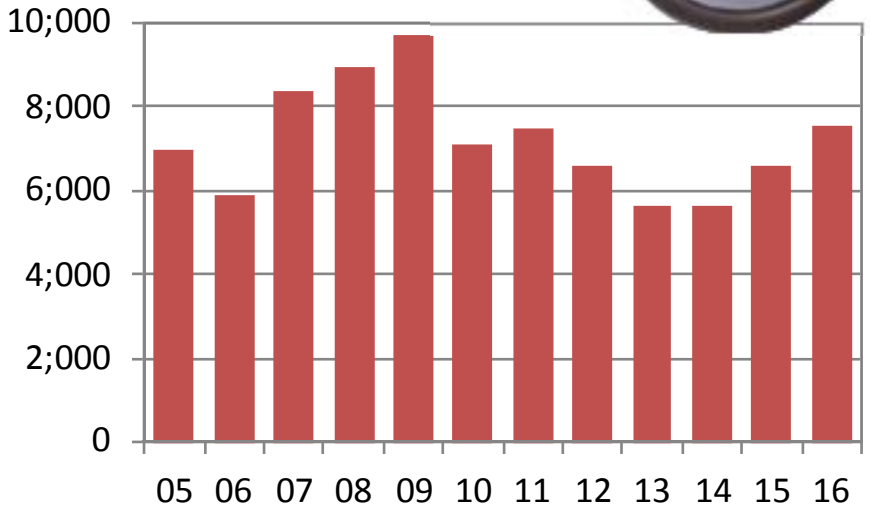


Surveillance

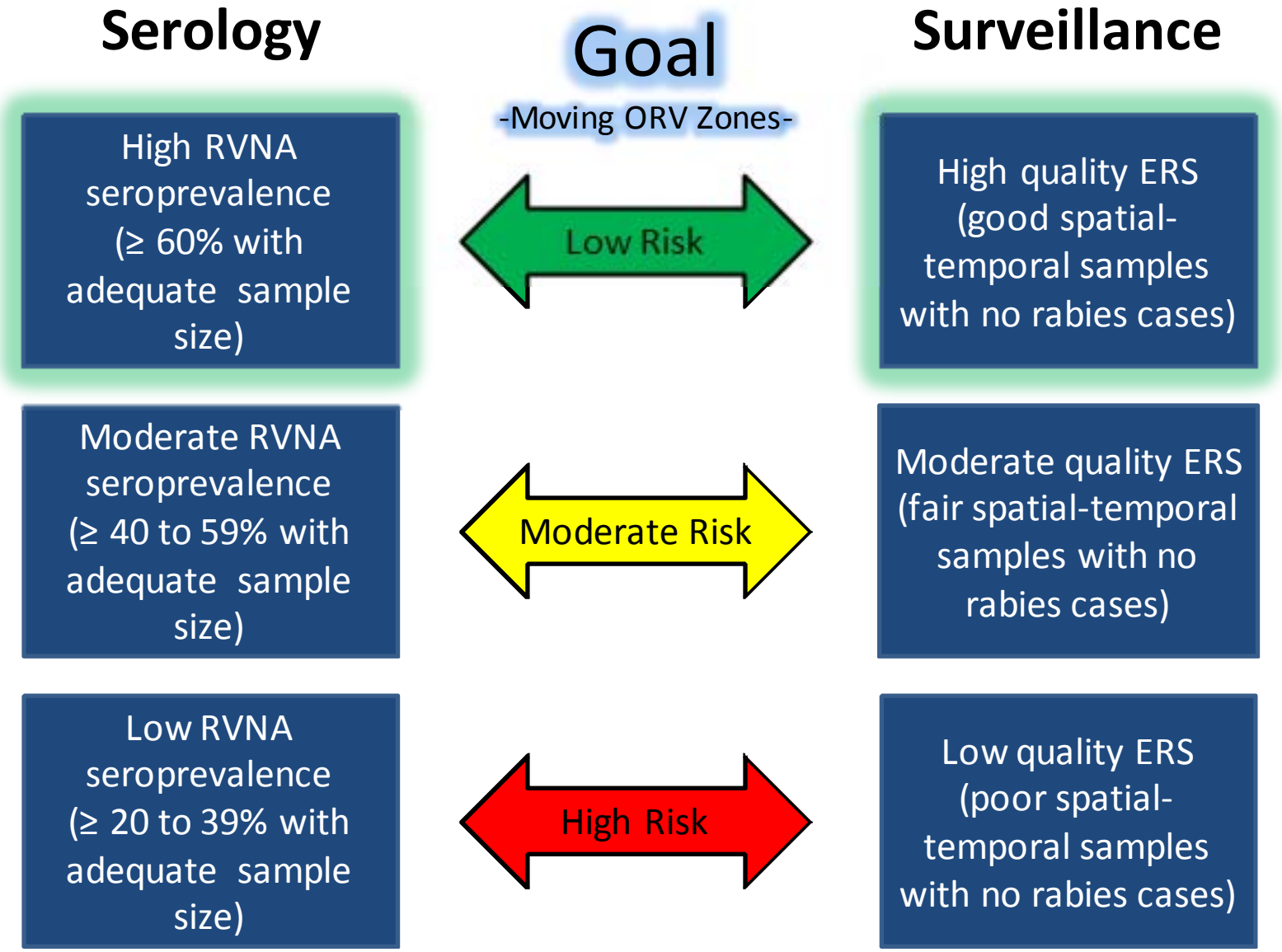
Virus Antigen Detection

(brainstem samples)

Avg. >7,200



Key Program Metrics ("Tower of Power")



Animals Handled* by NRMP 2006-2015

TARGETS

Species	Count
Bats	1,259
Bobcats	222
Coyotes	2,185
Foxes, arctic	256
Foxes, gray	1,381
Foxes, kit	13
Foxes, red	1,418
Mongooses, Indian	38
Raccoons	**151,717**
Skunks, hog-nosed	32
Skunks, hooded	398
Skunks, spotted	71
Skunks, striped	**14,039**
Total	**173,029**

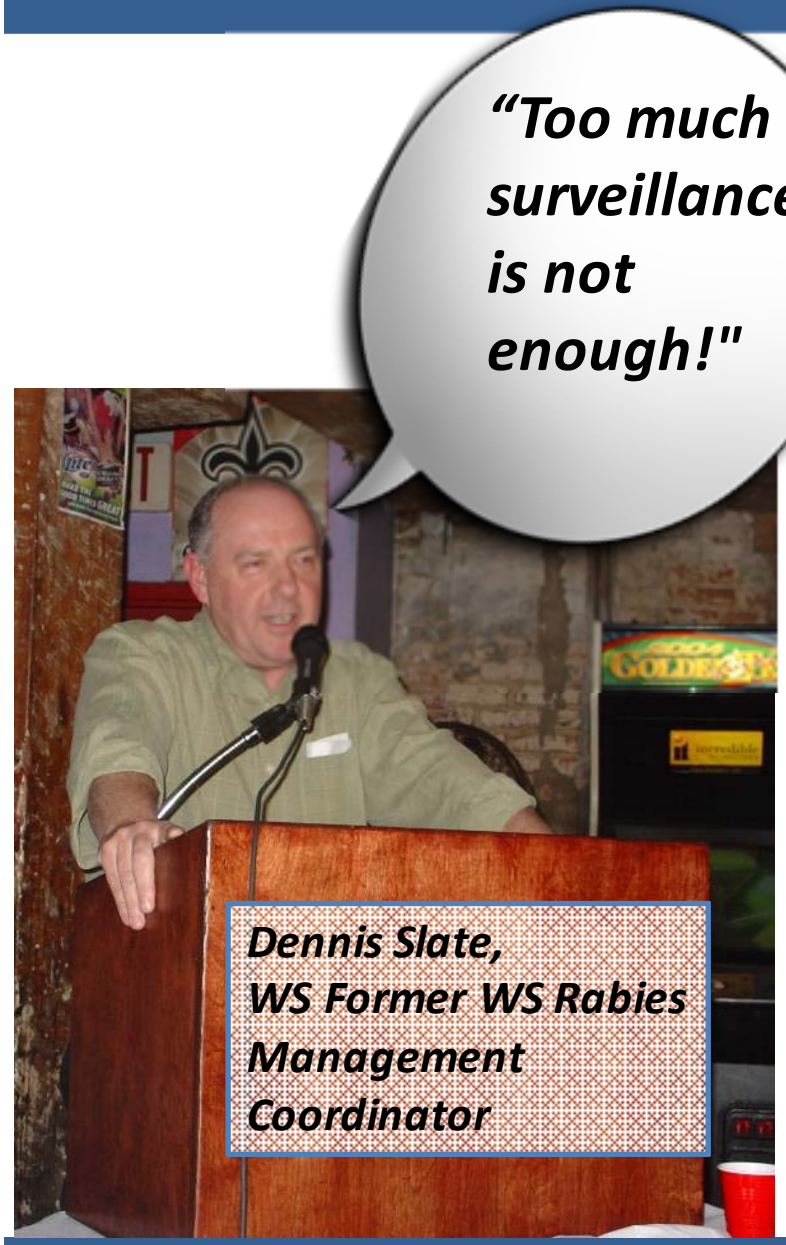
NONTARGETS

Species	Count
Alligators	4
Armadillos	92
Badgers	9
Bears (black & grizzly)	18
Beavers	33
Birds (28 different spp.)	120
Cats	3,426
Coatis	2
Deer/caribou/elk	20
Dogs	459
Ferrets	1
Fishers	266
Frogs/toads/snakes/turtles	184
Goats	6
Horses	1
Lions, mountain	4
Lynx	8
Martens, pine	17
Mice/voles/rats/squirrels/chipmunks	1,385
Minks	121
Moose	11
Muskrats	73
Opossums, virginia	16,846
Otters, river	44
Peccaries, collared (javelina)	24
Pocket gophers, Botta's	1
Porcupines	182
Rabbits/hares (6 spp.)	841
Ringtails	6
Sheep	3
Swine	2
Weasels	14
Wolverines	4
Wolves (gray/timber)	44
Woodchucks	1,723
Total	25,994

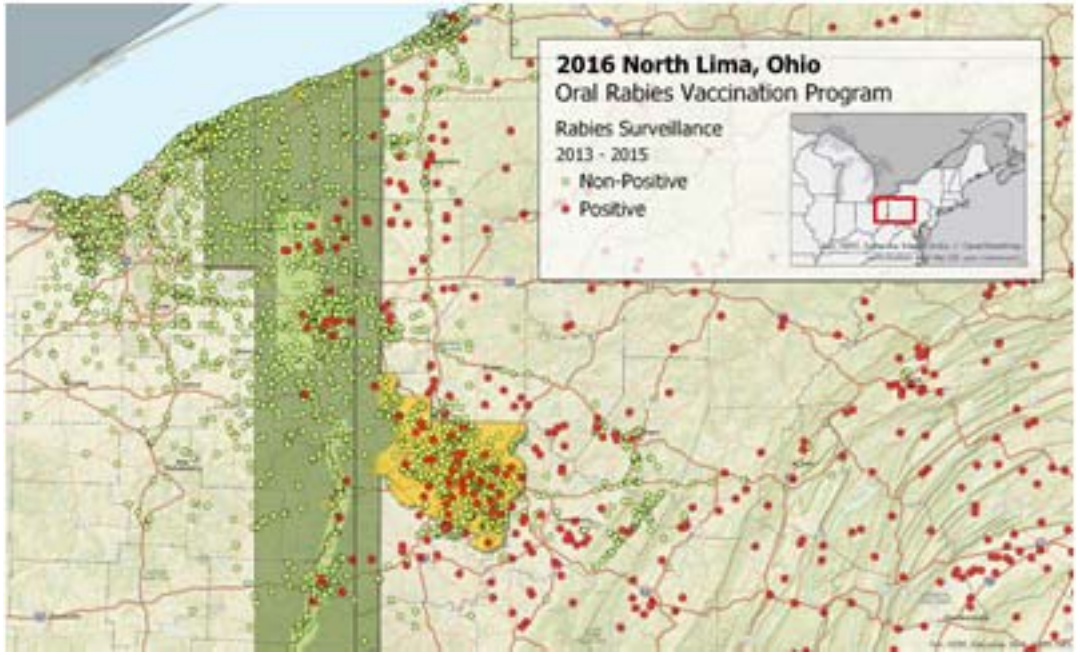
** Trapped and/or sampled*

Wildlife Services
Protecting People
Protecting Agriculture
Protecting Wildlife

Enhanced Rabies Surveillance Initiative (2015-)



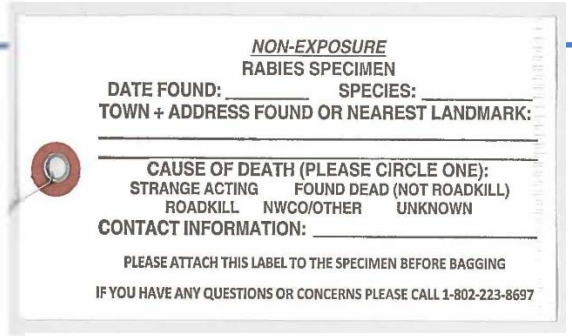
- ✓ high quality,
- ✓ spatial-temporally distributed sample
- ✓ *"Early detection, early response"*
- ✓ *Science-based decision making*

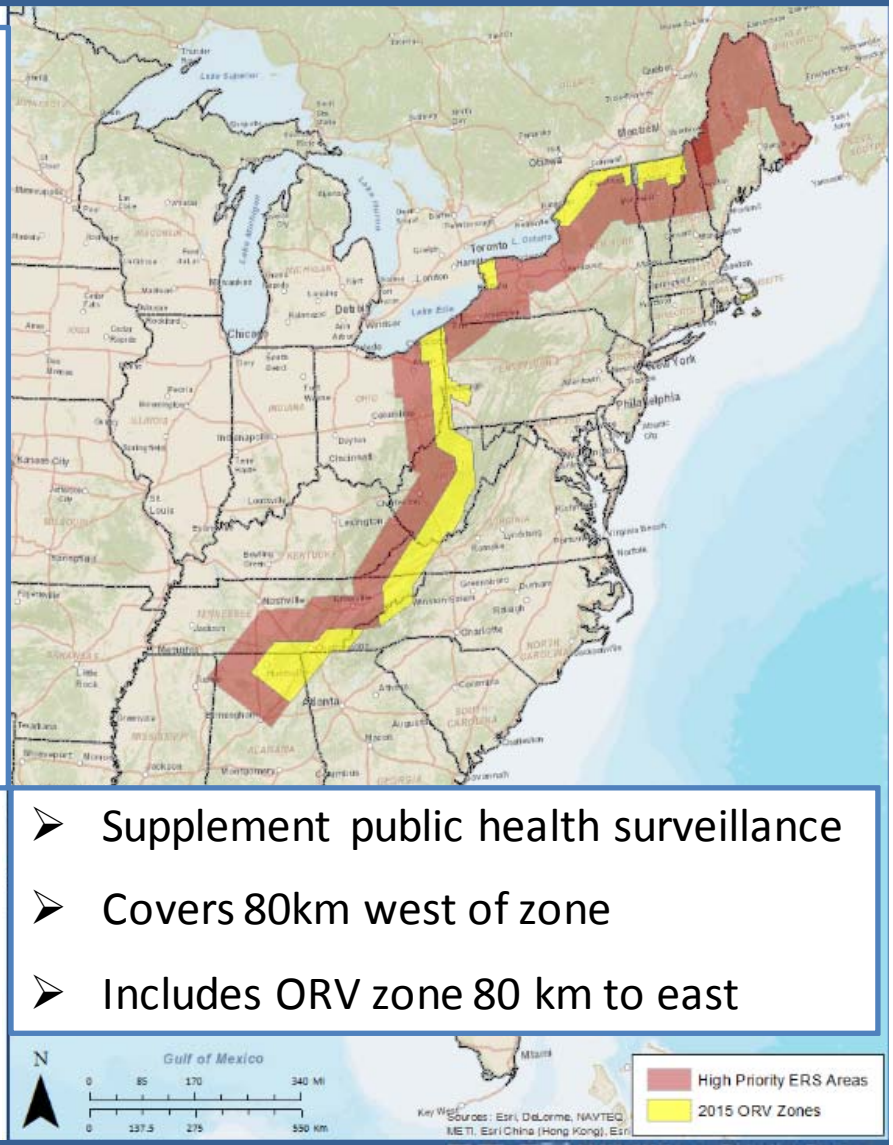


Another way? Enhanced Rabies Surveillance

No human or pet exposure history

- **Strange behaving animals**
- Animals with suspect lesions
- Animals removed – "hot rabies focus"
- Road kills/other dead animals
- Nuisance control or hunter harvested

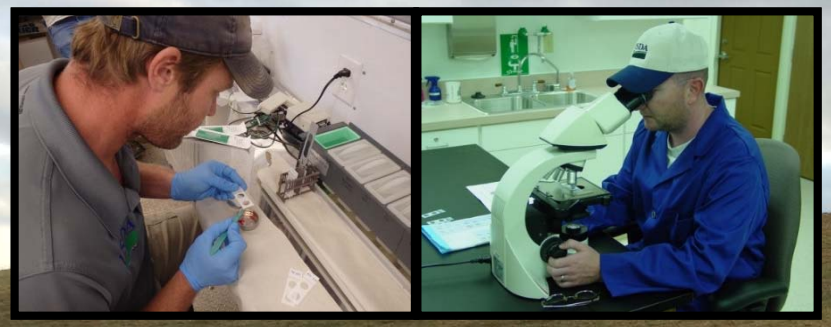




- Supplement public health surveillance
- Covers 80km west of zone
- Includes ORV zone 80 km to east

Wildlife Services
Protecting People
Protecting Agriculture
Protecting Wildlife

direct Rapid Immunohistochemical Test (dRIT)



Antigen Detection

dRIT
+

DFA
+

Collaboration:

- CDC
- Wistar Institute
- Lyssa LLC

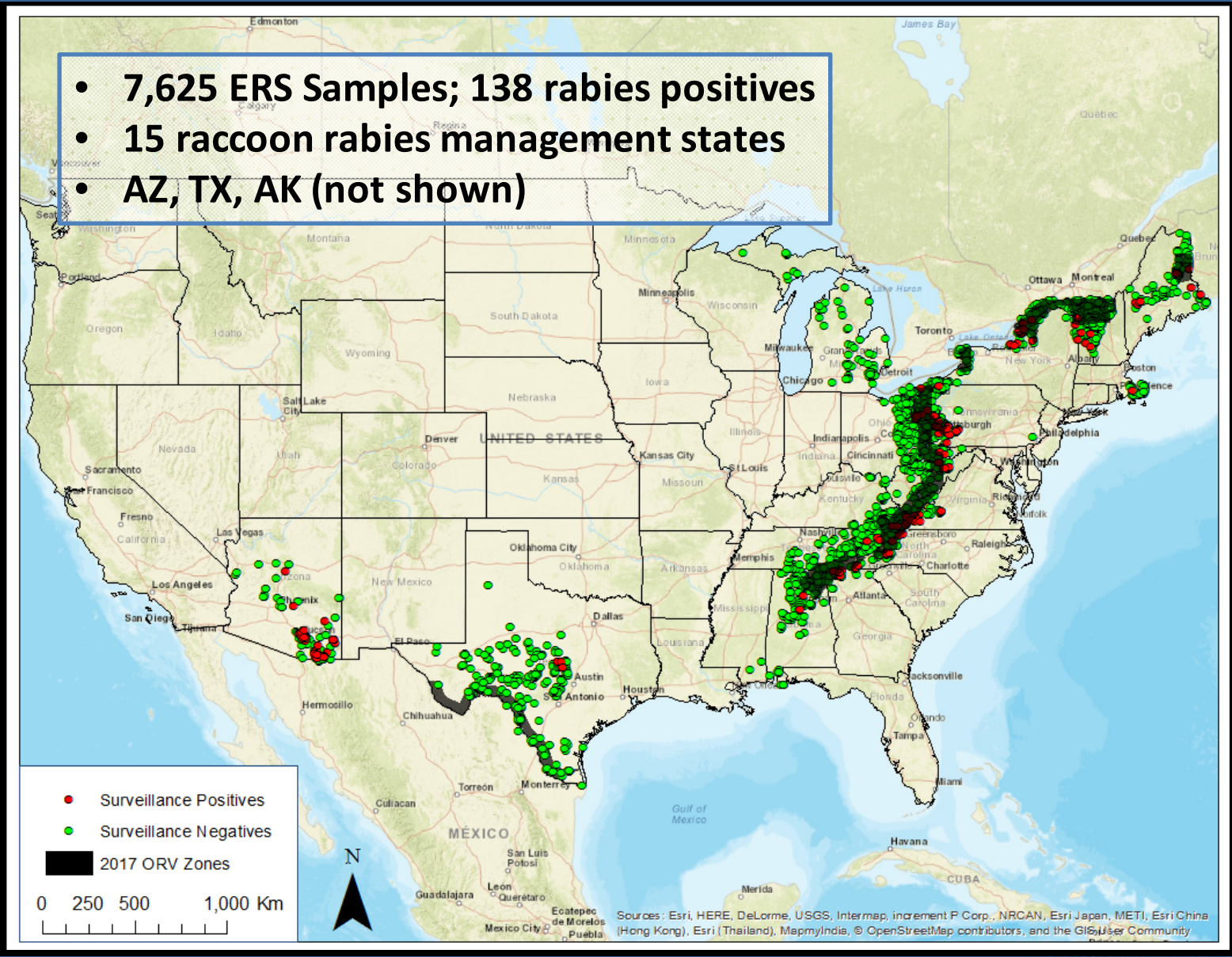
Enhanced Rabies Surveillance by USDA/WS (2005-2016)

Year	ERS Samples	dRIT Tested	Rabid by dRIT	Percent Rabid by dRIT
2005	3,788	2,848	59	2.10%
2006	6,930	6,072	109	1.80%
2007	9,959	8,136	157	1.90%
2008	10,999	8,790	142	1.60%
2009	12,256	10,534	160	1.50%
2010	9,231	7,294	145	2.00%
2011	9,492	7,574	141	1.90%
2012	7,783	6,605	117	1.80%
2013	6,774	5,485	142	2.60%
2014	7,068	5,799	104	1.90%
2015	7,346	6,222	94	1.90%
2016	8,387	6,603	136	2.10%
Total	**100,013**	**81,962**	**1,506**	**1.80%**

** Through 3/13/17*

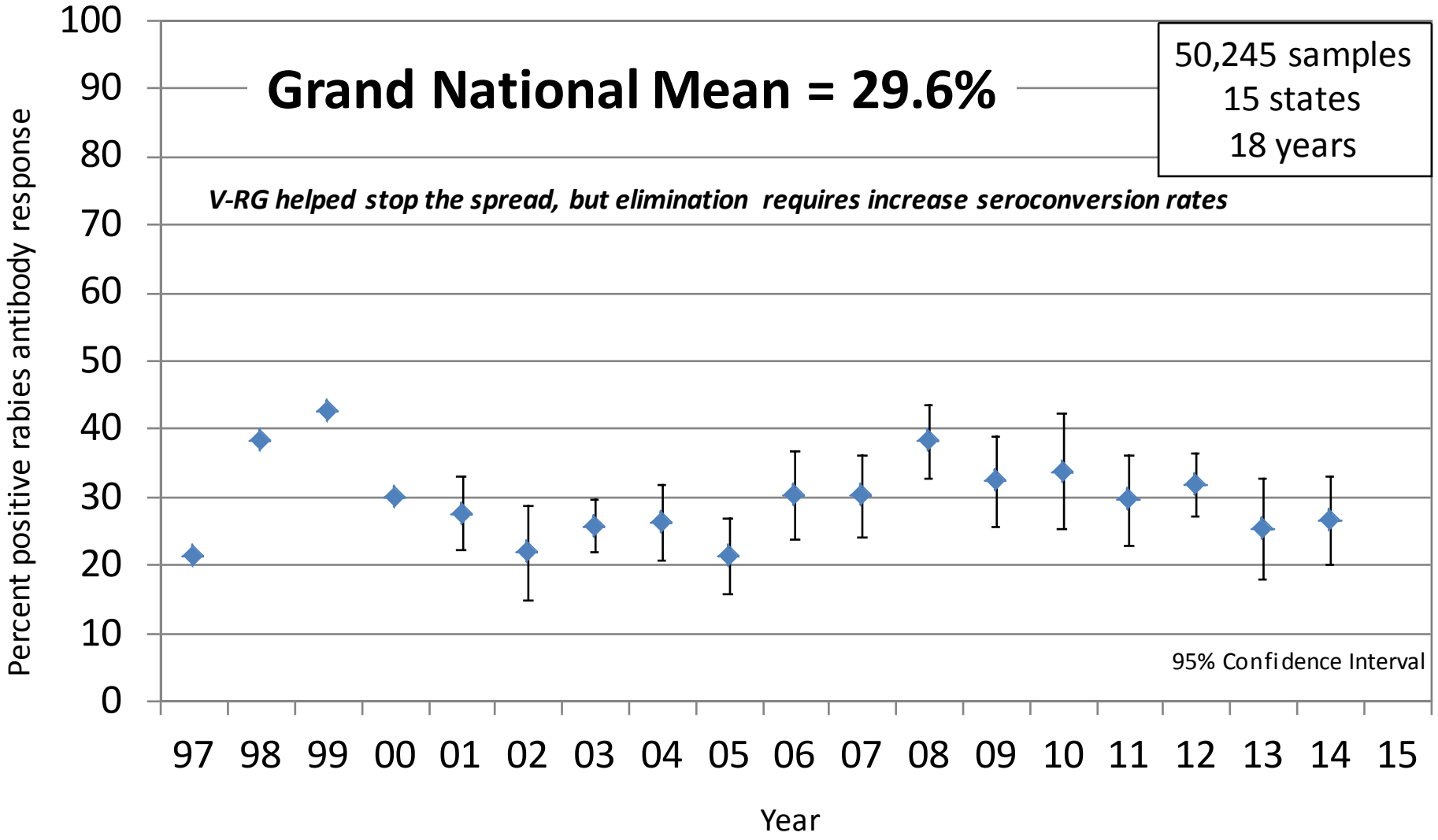
direct Rapid Immunohistochemical Test (dRIT)

2017 Enhanced Rabies Surveillance & ORV in the US



Models Suggest >60% Population Immunity Needed for Raccoon Rabies Elimination

Raccoon Response to V-RG (1997-2014)



% Positive rabies virus neutralizing antibodies at ≥0.05 IU/ml

Wildlife Services
Protecting People
Protecting Agriculture
Protecting Wildlife

V-RG works very well in Coyotes and Gray Fox

Coyote = 58% annual antibody response

Gray Fox = 71% annual antibody response

“Experiment Fearlessly”

Current and Candidate Vaccine-Baits

Vaccine	V-RG®	ONRAB	SAG2	SPN GASGAS "RABITECH M"
Recombinant	yes	yes	no, mod.-live	**yes, reverse genetics**
Vaccine Platform	vaccinia virus	human adeno virus	NA (rabies)	**rabies**
Lic. in U.S.	**yes**	**no***	**no**	**no**
Lic. Outside U.S.	yes	yes	yes	**no**
Interest in U.S.	yes	yes	yes	**yes**
Proprietor	**Merial**	**Artemis**	**Virbac**	**IDT**
Country	US	Canada	France	**Germany**

*used experimentally in U.S.

ONRAB (Artemis Technologies; Canada)

2011-2017 ONRAB Field Trial Summary

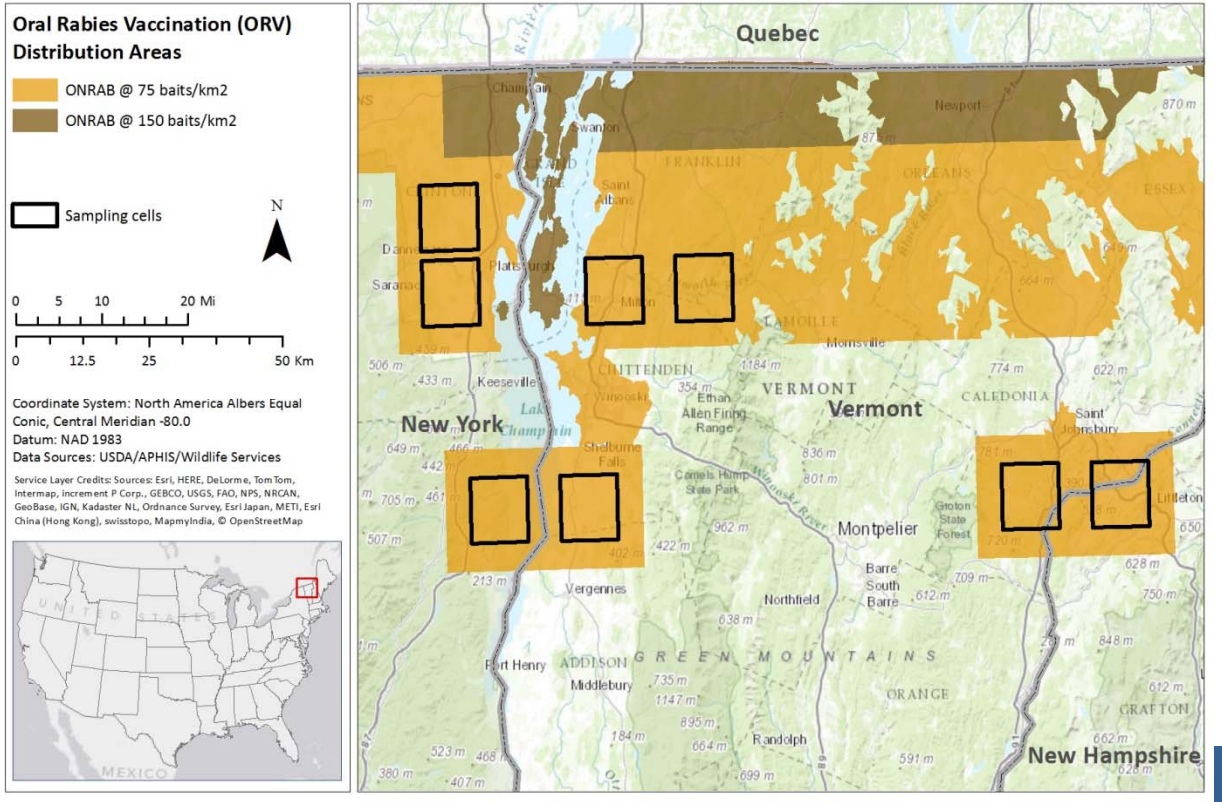
- ✓ **2011-2013 West Virginia:** ***Concluded***
- ✓ **2012-2014 NY/VT/NH:** ***Concluded***
- ✓ **2012-2014 Ohio:** ***Concluded***
- ✓ **2013-2015 NY – St. Lawrence:** ***Concluded***
- ✓ **2013-2015 NY – Niagara (Cornell):** ***Concluded***
- ✓ **2014-2016 West Virginia (skunks):** ***Concluded***
- ✓ **2015-2017 Vermont – Eastern:** ***Concluded***
- ✓ **2015-2017 Vermont – Burlington:** ***Concluded***

Additional Use

- ✓ 2015-2017 NY – Franklin Co. (contingency action)
- ✓ 2015-2017 Ohio (operational)
- ✓ 2016-2017 NY – Buffalo Area (Delauney analysis)
- ✓ 2017 Ohio – Stark Co. (contingency action)

2012-2014 NY/VT/NH ONRAB Trial

- ONRAB baiting at 75 baits/km^2 in an **ORV naïve rural area** to compare to WV (southern cells)
- ONRAB baiting at 75 baits/km^2 over an area **historically baited** at 75 baits/km^2 with **RABORAL V-RG®** (northern cells)

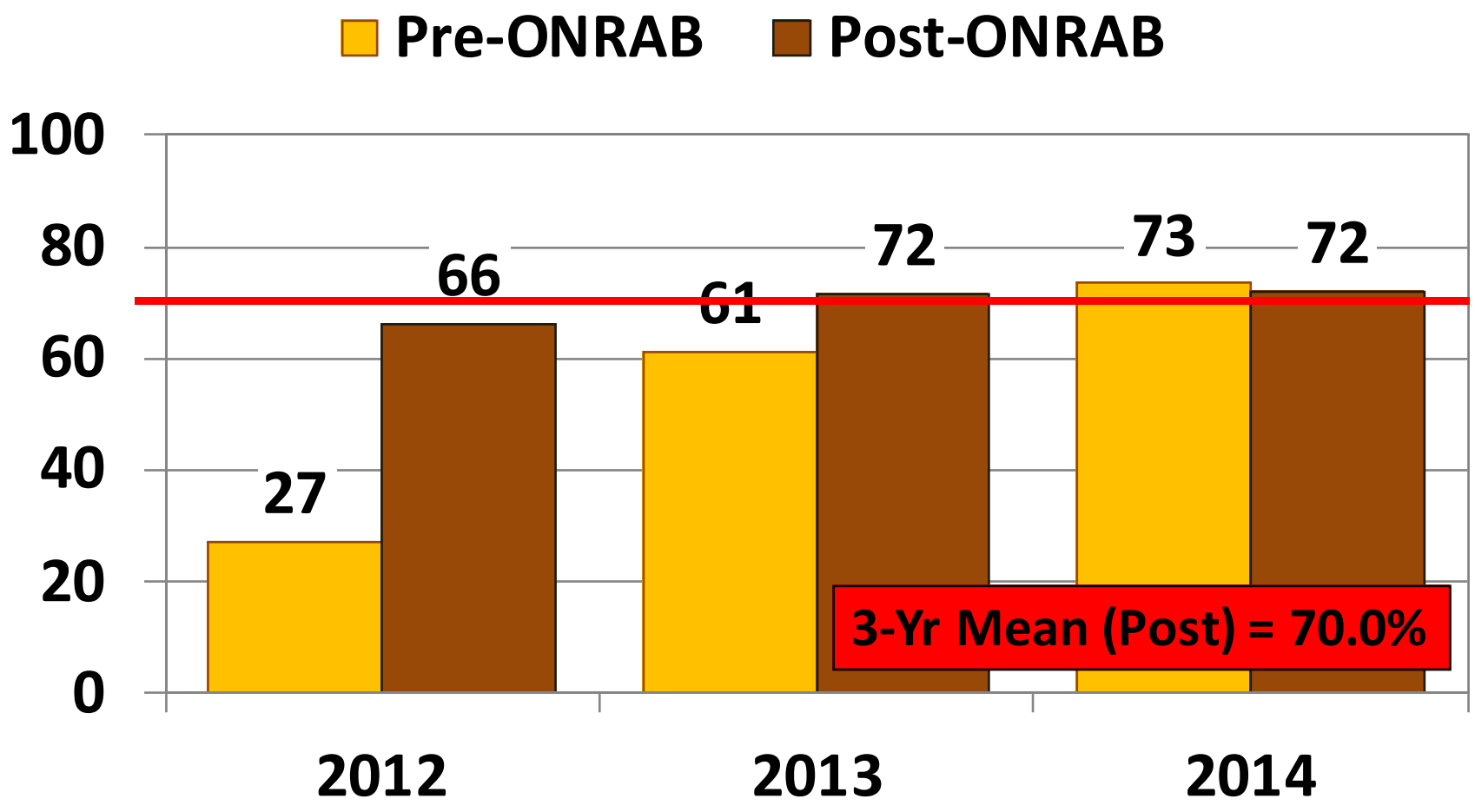


- **8 ONRAB sampling cells (132 km^2 each)**
- **150 traps/cell**
- **Sampling Pre and Post-ORV for 10 straight days**
- **Study areas = fixed-wing except villages (ground)**
- **750 m flight line spacing at 75 baits/km^2**

2012-2014 NY/VT/NH ONRAB Trial Summary

% RVNA in Raccoon Sera

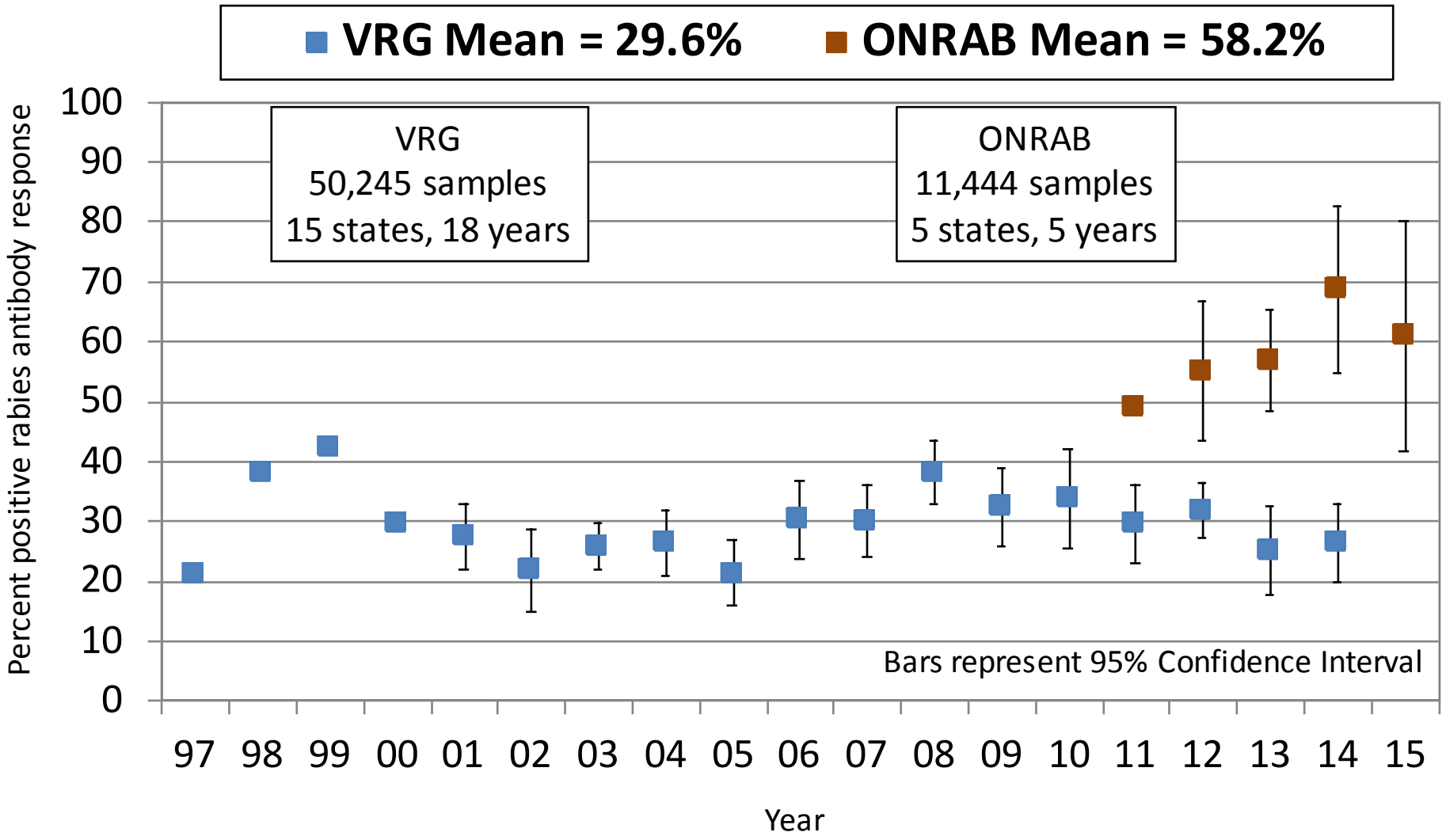
75 baits/km² – Rural



Wadsworth ≥0.0625 IU/ml represents RVNA positive

Wildlife Services
Protecting People
Protecting Agriculture
Protecting Wildlife

Raccoon Response to ORV (1997-2015)



% Positive rabies virus neutralizing antibodies at ≥0.05 IU/ml

Wildlife Services
Protecting People
Protecting Agriculture
Protecting Wildlife

A Way Forward, But Challenges Remain

Understanding Urban-Suburban Challenges

Urban Areas in U.S.
= **81% of human population**

Better Understanding Oral Rabies Vaccination in Skunks

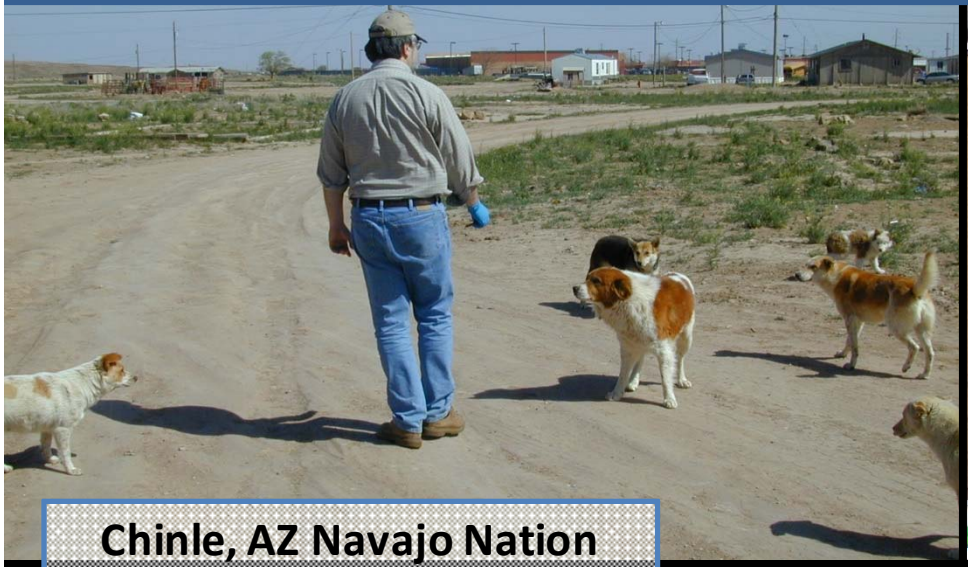
Intentional and Unintentional Translocation

- **Hundreds of thousands animals moved each year**
- Nuisance Wildlife Control Trappers?
- General Public?
- Rehabilitators?

Options for reducing translocation?

Vaccine - Bait Competition with Opossums?

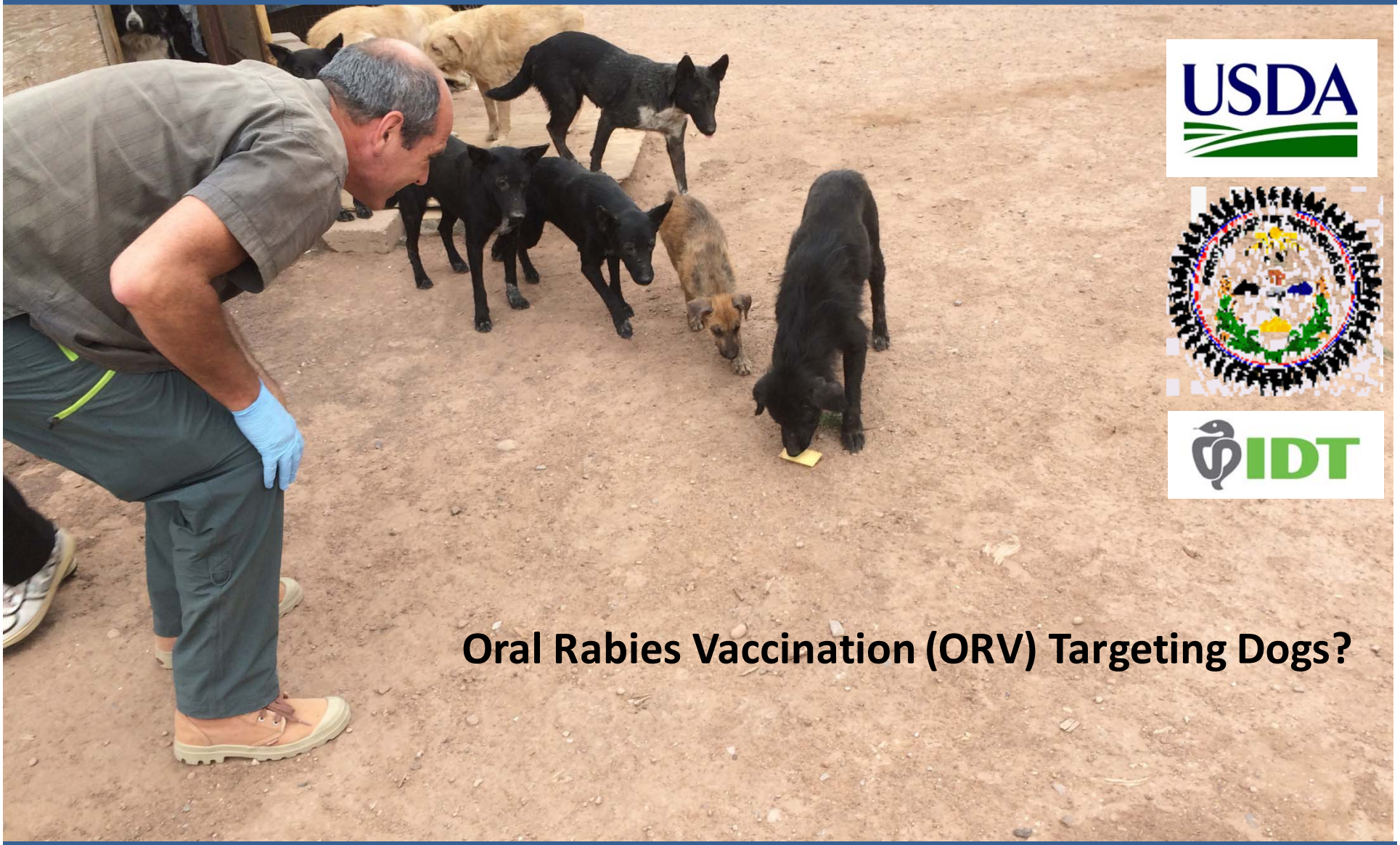
Bait Acceptability and Handling by Dogs Since 2005



Chinle, AZ Navajo Nation
April 18, 2005

Coated Sachets--Raboral V-RG®

Bait Acceptability and Handling by Dogs – Navajo Nation (USA) (2016)

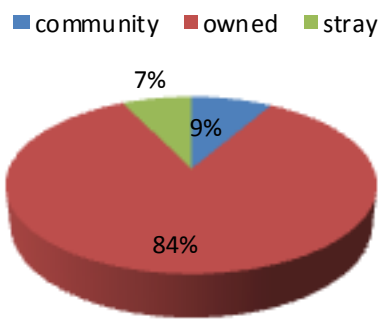


Oral Rabies Vaccination (ORV) Targeting Dogs?

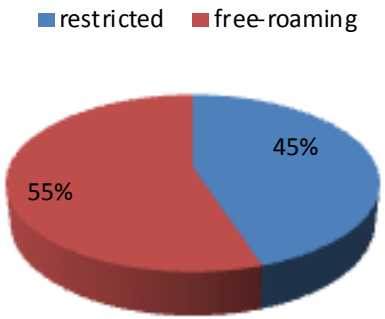
“Hand Out” Model

Understanding Characteristics of Dog Population

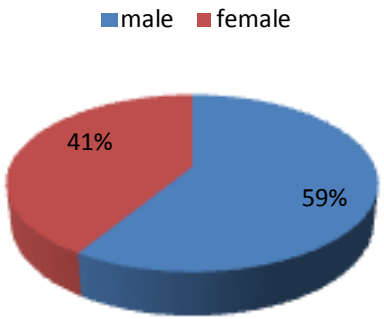
ownership



confinement

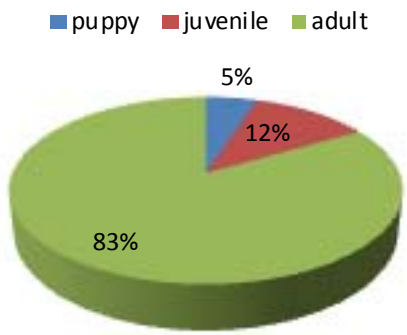


gender

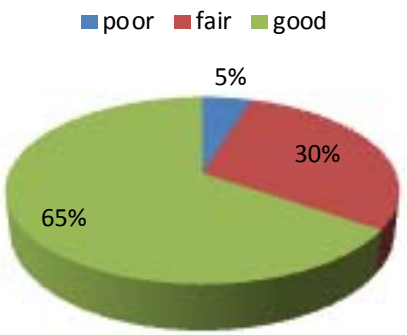


*unknowns not included

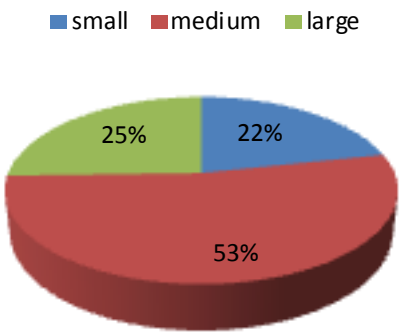
age



body condition



body size

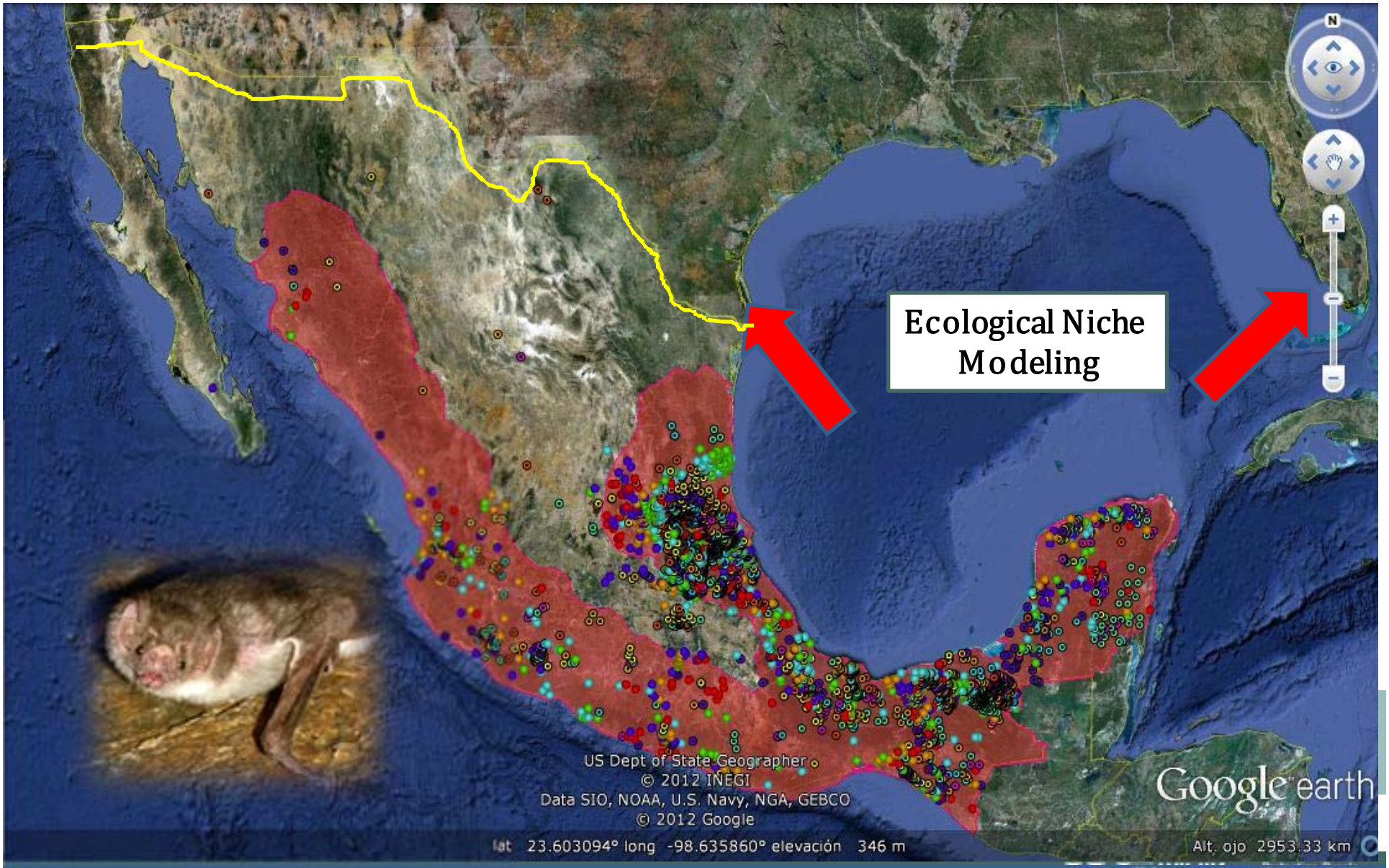


Bait Preference? Vaccine Field Effectiveness? Integrated Strategies

Vampire Bats in the U.S?

Current Range of the Vampire Bat (Desmodus rotundus)

Modeling to Predict Range Expansion of Vampire Bats



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Protecting Wildlife

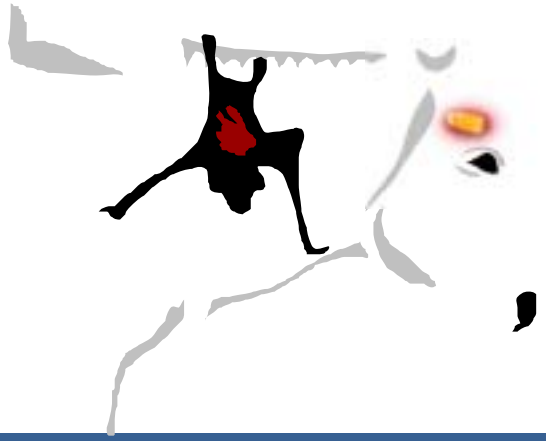
Most Recent Model

Hayes and Piaggio (2017)

- Modeling based on more than **7000 vampire bat** occurrence records. Five models map potential distribution along the Mexico-U.S. border **through 2070**
- Highest variable importance: **Minimum temp. of the coldest month**

✓ Two potential **future** routes for vampire bat **dispersal including TX and FL.**

✓ Models suggest **current suitable habitat** exist in extreme southern portions of **TX and southern FL.**



Cattle Surveys in Florida and Texas

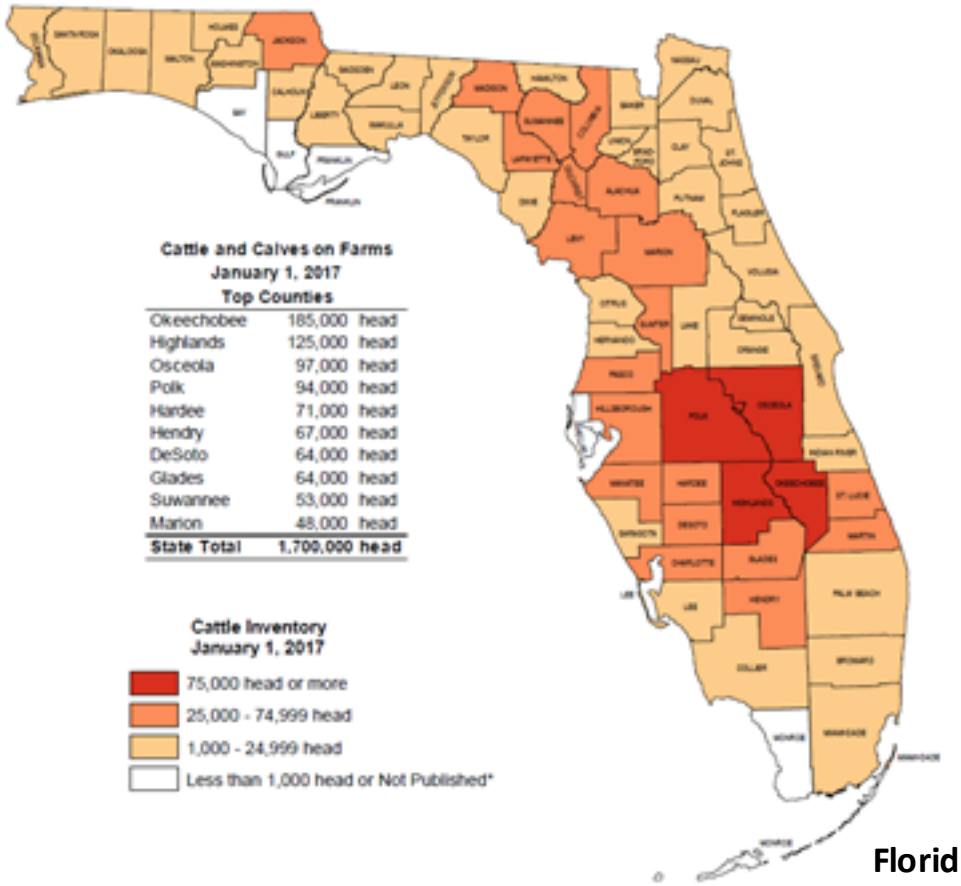
USDA, NASS
SOUTHERN REGION
355 East Hancock Ave, Suite 100
Athens, Georgia 30601
Phone: (706) 546-2236
E-mail: nassflosor@nass.usda.gov
Cooperating with Florida Department of Agriculture and Consumer Services

Florida County Estimates

Cattle 2016-2017

Released: May 2017

State Statistician: Mark Hudson



Cattle and Calves on Farms
January 1, 2017
Top Counties

Okeechobee	185,000 head
Highlands	125,000 head
Osceola	97,000 head
Polk	94,000 head
Hardee	71,000 head
Hendry	67,000 head
DeSoto	64,000 head
Glades	64,000 head
Suwannee	53,000 head
Marion	48,000 head
State Total	**1,700,000 head**

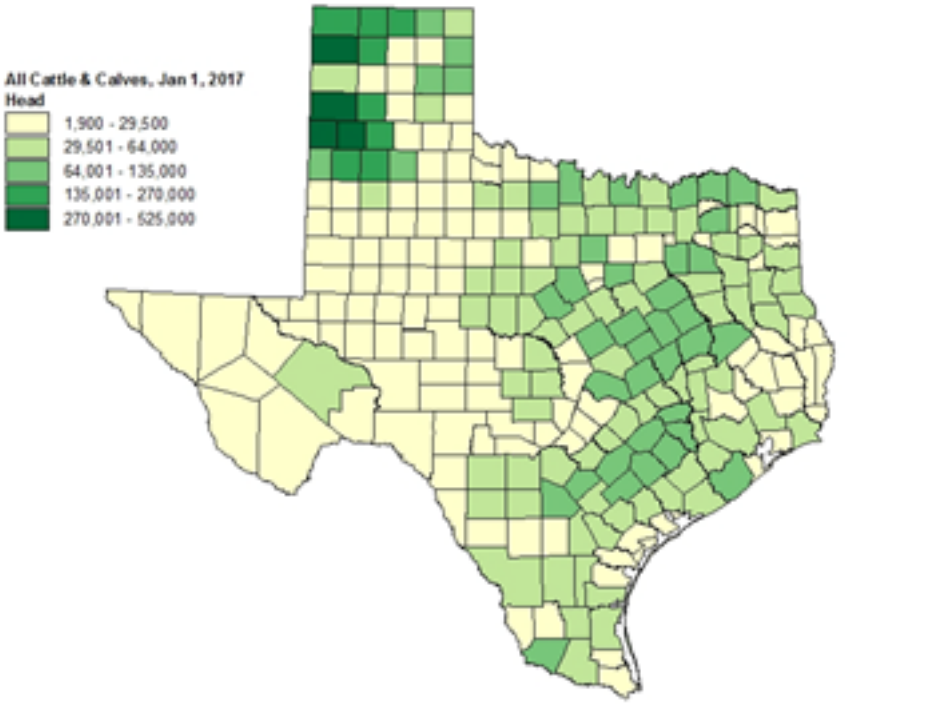
Cattle Inventory
January 1, 2017

- 75,000 head or more
- 25,000 - 74,999 head
- 1,000 - 24,999 head
- Less than 1,000 head or Not Published*

* Counties not published due to insufficient data or to avoid disclosure of individual operations.

USDA's National Agricultural Statistics Service
Southern Plains Regional Field Office *(and the Texas Field Office)*

County Estimate Map - Cattle

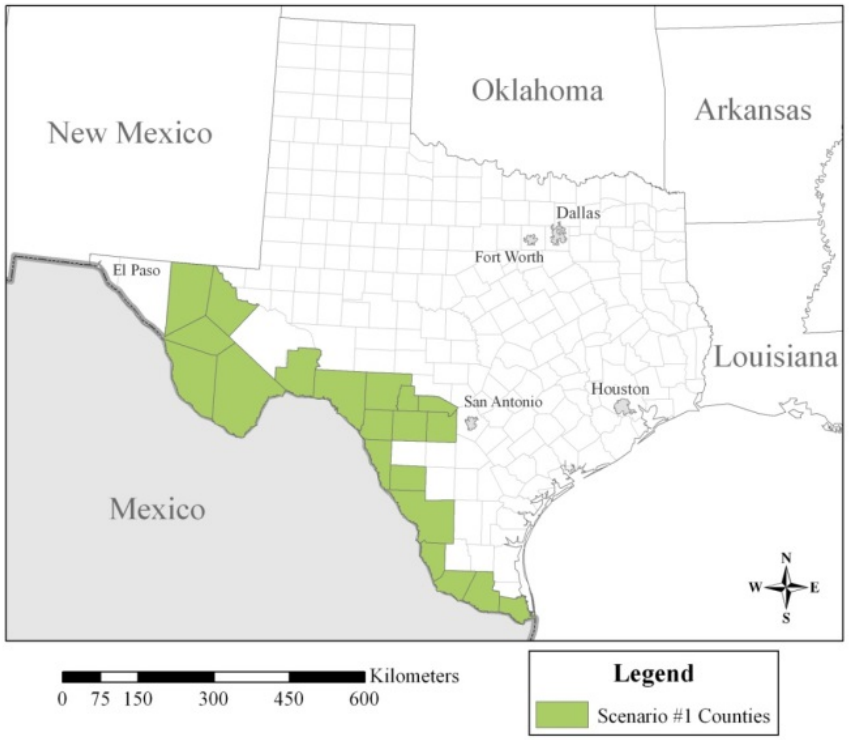


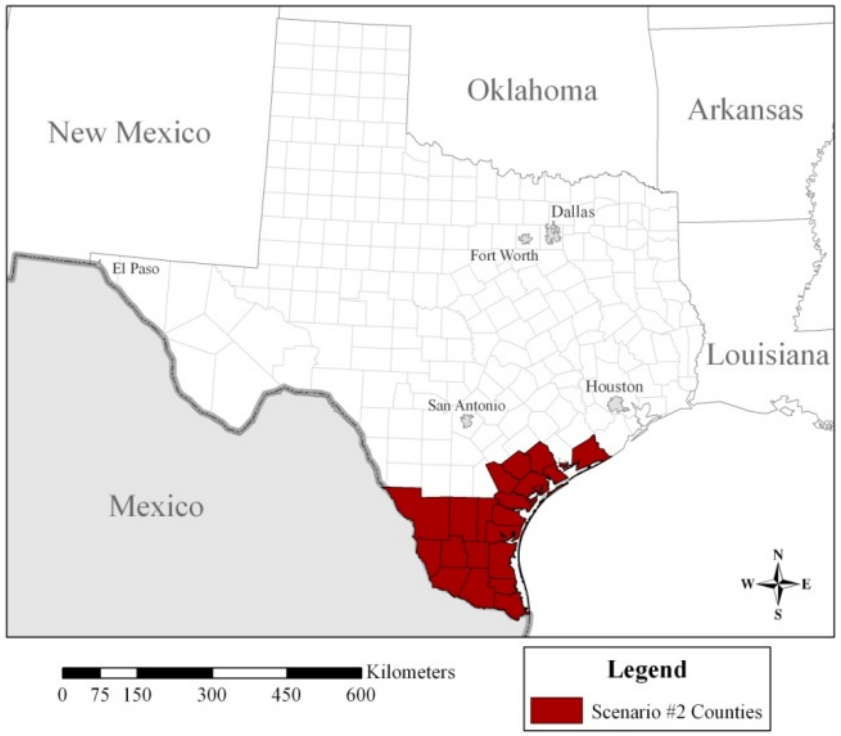
Last Modified: 09/15/2017

Texas 2017 Statewide Cattle Survey (as of January 1):
12,300,000

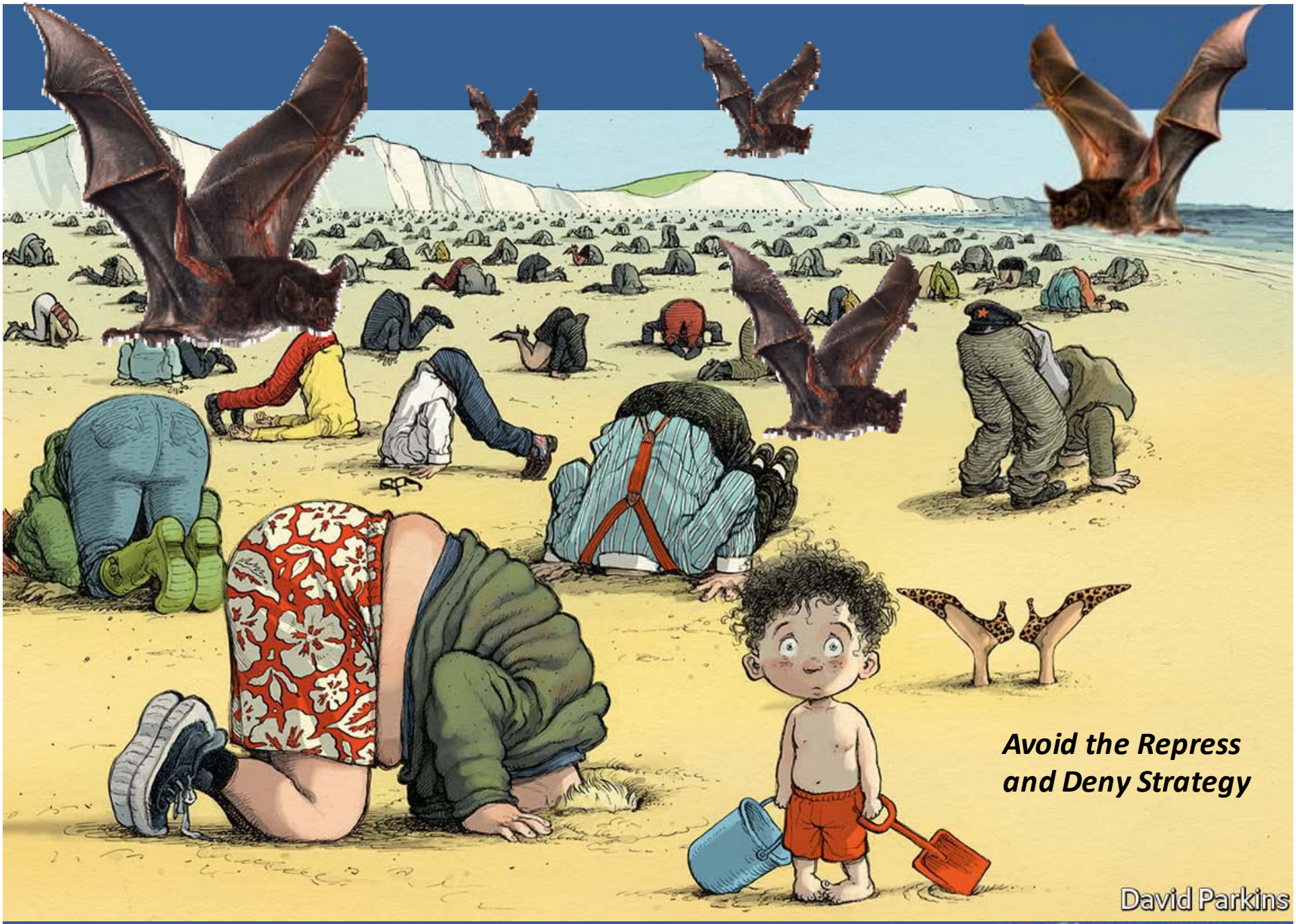
Florida 2017 Statewide Cattle Survey (as of January 1):
1,700,000

Economic Impact of Vampire Bats in the U.S

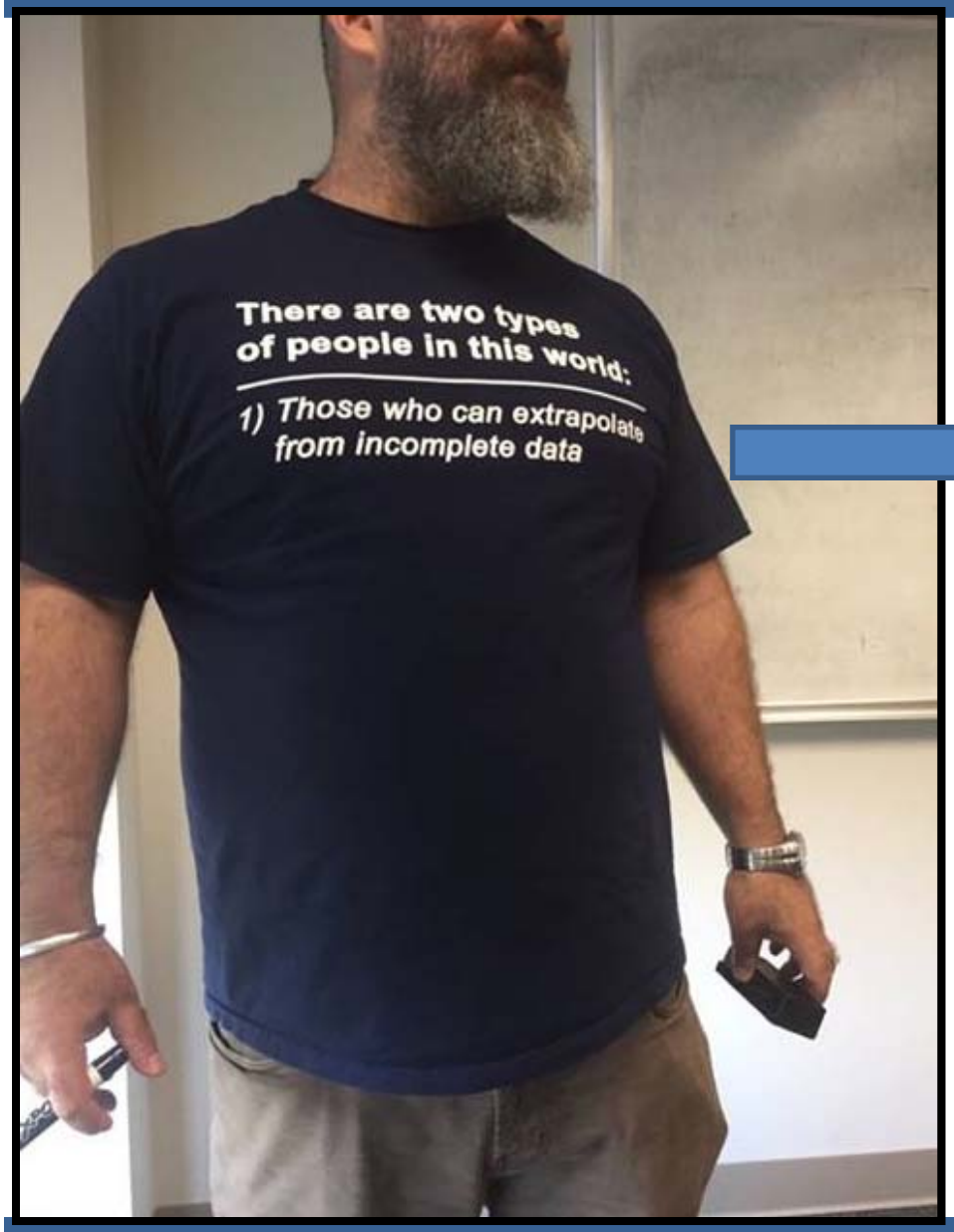




- An economic analysis by Anderson, Shwiff & Shwiff indicated a **total annual economic impact of $7.0 million to $9.2 million** under two different scenarios of US invasion



Begin the Discussion "Entrance Strategy?"



- **Introduction of Novel Wildlife Species**
- **Introduction of Novel Rabies Variant**

Opportunity

- Gather Relevant Available Information
- Conduct Enhanced Surveillance
- Cooperative Strategic Planning
- Coalition Building
- ID Jurisdictional Issues
- ID Potential Rabies Management Strategies

Enhanced Surveillance

*"**Surveillance*** is the systematic, continuous collection, analysis and interpretation of data and their dissemination to appropriate people in order that action be taken." (WHO 2013)

Enhanced Surveillance For Vampire Bats

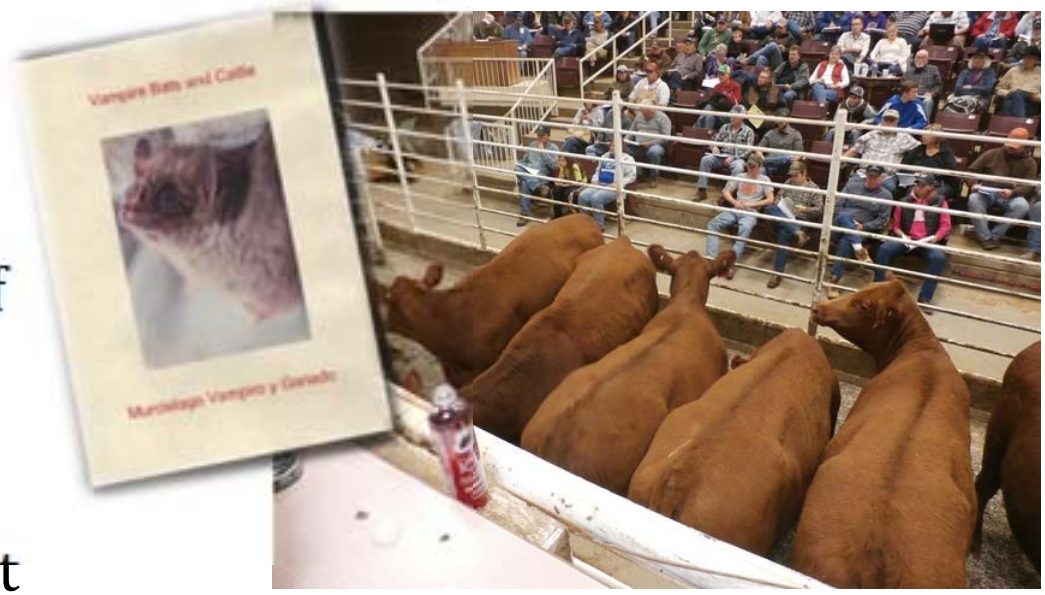
- USDA is monitoring for evidence of vampire bats in in areas predicted to have suitable habitat including south **Texas, Florida and Arizona.**

Vampire Bite Surveillance Targeting Cattle

Cattle Sales Barns TX, AZ, FL, Dairies in AZ, Feedlots FL

FY16-17 VBB Surveillance Accomplishments

- Conducted **561 surveys** examining **132,932** livestock at sales barns
- **Distributed 1,228 copies** of "Vampire Bats and Cattle" DVD
- No evidence of vampire bat bites were observed on any of the livestock examined



State FY2017	# Surveys	# Livestock Examined	# DVDs Distributed	# Collaborators
Arizona	144	34,546	10	5
Texas	200	14,868	340	17
Florida	47	46,251	2	2

Targeted Outreach (DVD) for Ranchers Along Border

Mike and Hunter Bodenchuk

Dr. Luis Lecuona

Vampire Bat Surveillance Training

Thanks to Our Colleagues in Mexico

- SAGARPA/SENASICA
- State Committees of Animal Health
  - ✓ Yucatan (2014-2015)
  - ✓ Hidalgo (2016)
  - ✓ Campeche (2017)

Moving Forward

- Significant wildlife management challenge
- Focus on managing the impact (Rabies!)
- Need to refine surveillance efforts (denominator!)
- **Communicate, Coordinate**, **Collaborate** and **Cooperate** across jurisdictions

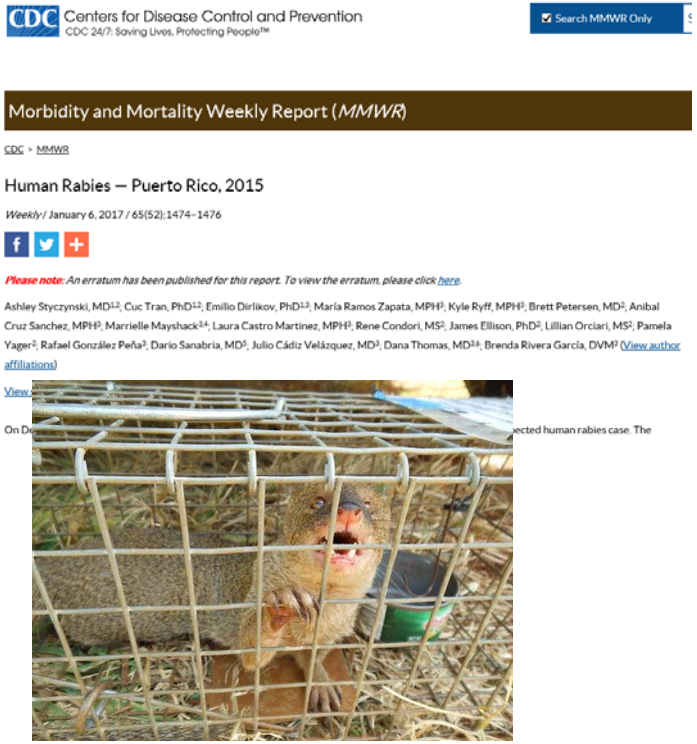
Mongoose Rabies in Puerto Rico

Puerto Rico ORV Baiting for Mongoose

Rabies Case and Public Health

- ~**6,000 annual animal bite** reports investigated by Puerto Rico Dept. of Health
- ~10% reported for rabies PEP
- Approximately **287 mongoose bite injuries**/year

- No compulsory vaccination of domestic/companion animals
- Human rabies case in 2015
  - mongoose bite
- No wildlife vaccination program



CDC Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™

Search MMWR Only

Morbidity and Mortality Weekly Report (*MMWR*)

CDC > MMWR

Human Rabies — Puerto Rico, 2015

Weekly / January 6, 2017 / 65(52);1474–1476

Please note: *An erratum has been published for this report. To view the erratum, please click here.*

Ashley Styczynski, MD[1,2]; Cuc Tran, PhD[1,2]; Emilio Dirlikov, PhD[1,3]; María Ramos Zapata, MPH[3]; Kyle Ryff, MPH[3]; Brett Petersen, MD[2]; Anibal Cruz Sanchez, MPH[3]; Marrielle Mayshack[3,4]; Laura Castro Martinez, MPH[3]; Rene Condori, MS[2]; James Ellison, PhD[2]; Lillian Orciari, MS[2]; Pamela Yager[2]; Rafael González Peña[3]; Dario Sanabria, MD[3]; Julio Cádiz Velázquez, MD[3]; Dana Thomas, MD[3,4]; Brenda Rivera García, DVM[3] (View author affiliations)

View

On De ected human rabies case. The

Research and Management on Puerto Rico

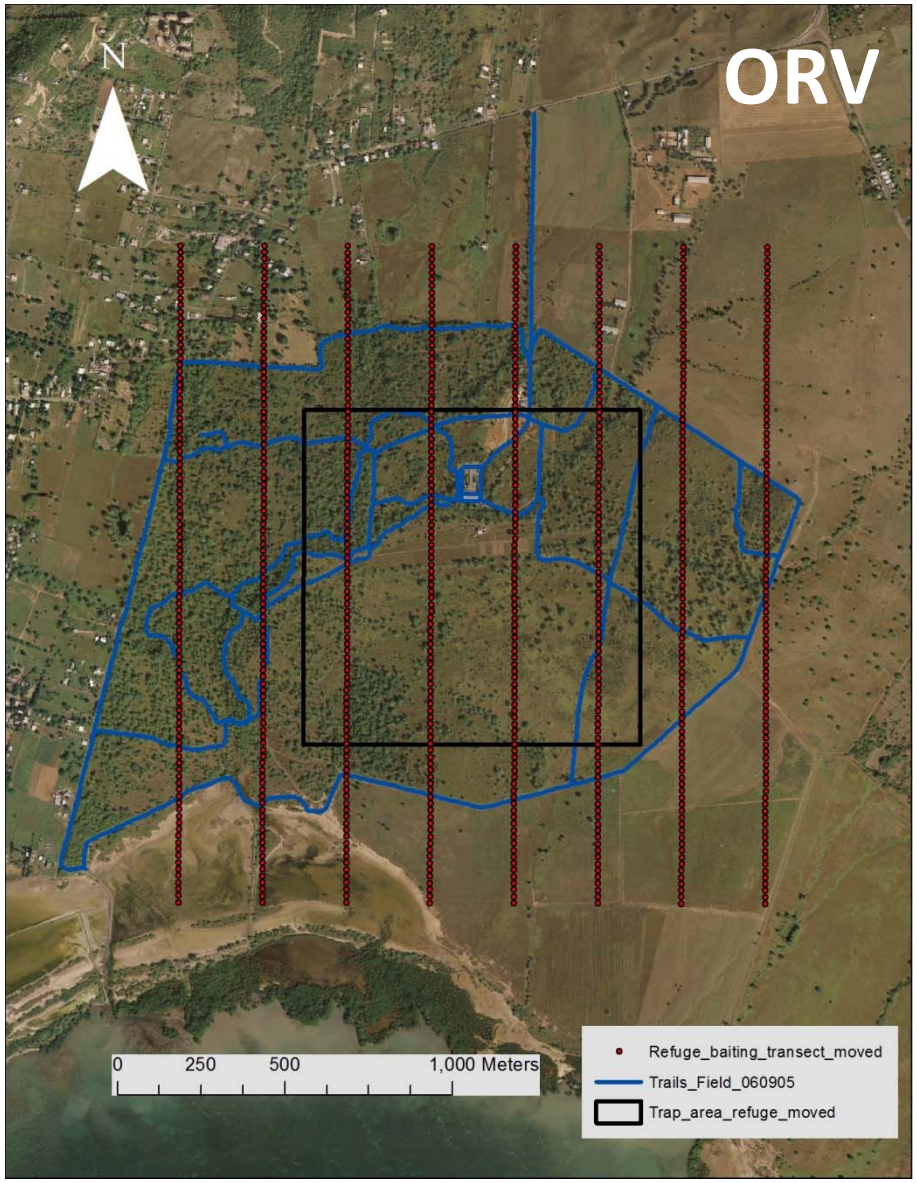
- Regular strategic planning and collaboration meetings
- Year-long Regulatory (NEPA) process (EA) to conduct a live-vaccine field trial in late 2018? (IDT Vaccine)
- NWRC Research on baits, non-targets (rats), biomarkers

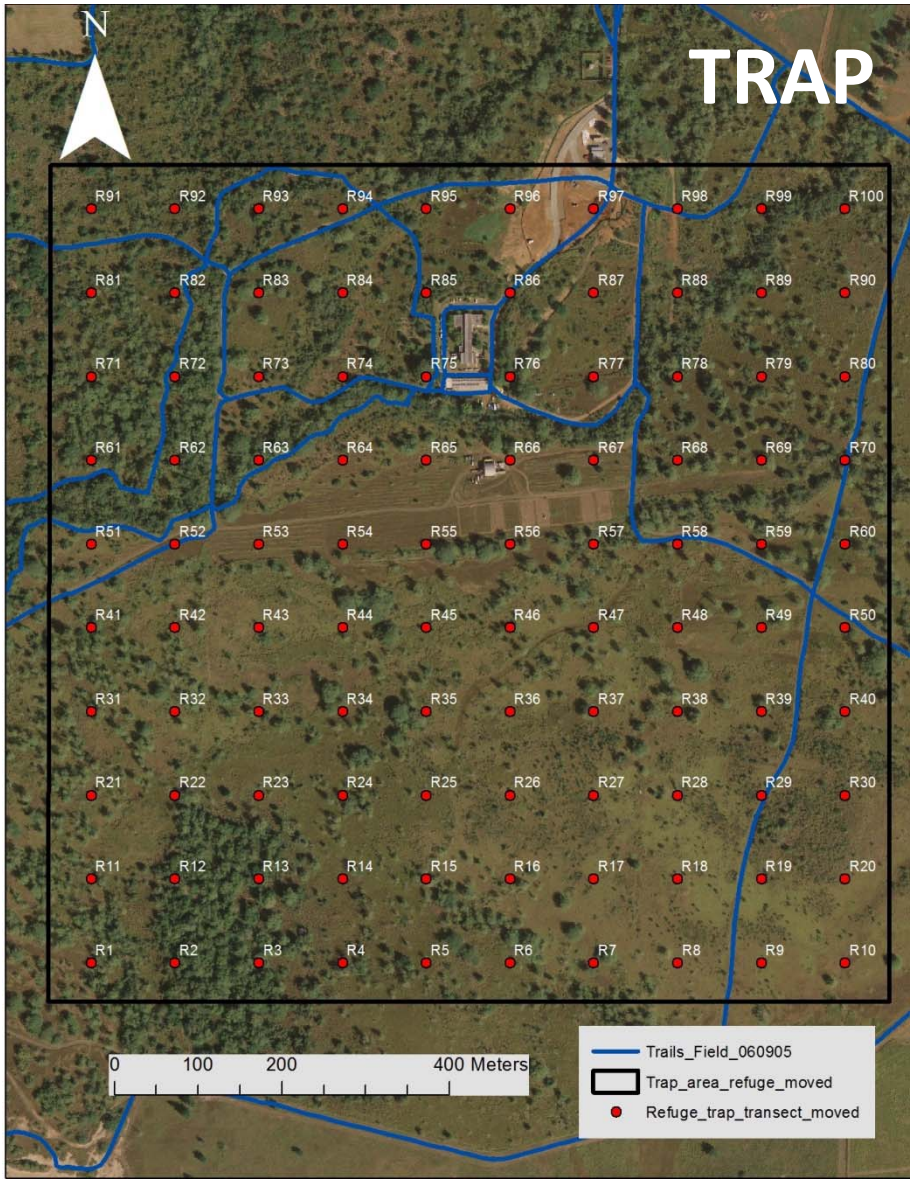
Placebo Bait Field Trial Targeting Mongoose

- First Placebo Bait Trial (September 28, 2016) (World Rabies Day!)
- Second Placebo Trial March 2017
- 3 Study Sites. 1 km^2 Plots (USFWS Cabo Rojo Refuge; Private land)
- Target density = 200 baits/km2
- Biomarker: Fall 2016: 2.8mg et-IPA/Spring 2017: 2.8 mg met-IPA
- Post bait trapping sample collection for 10 days
- Serology (IPA analysis) to evaluate bait uptake




Refuge ORV Bait and Trap Transects



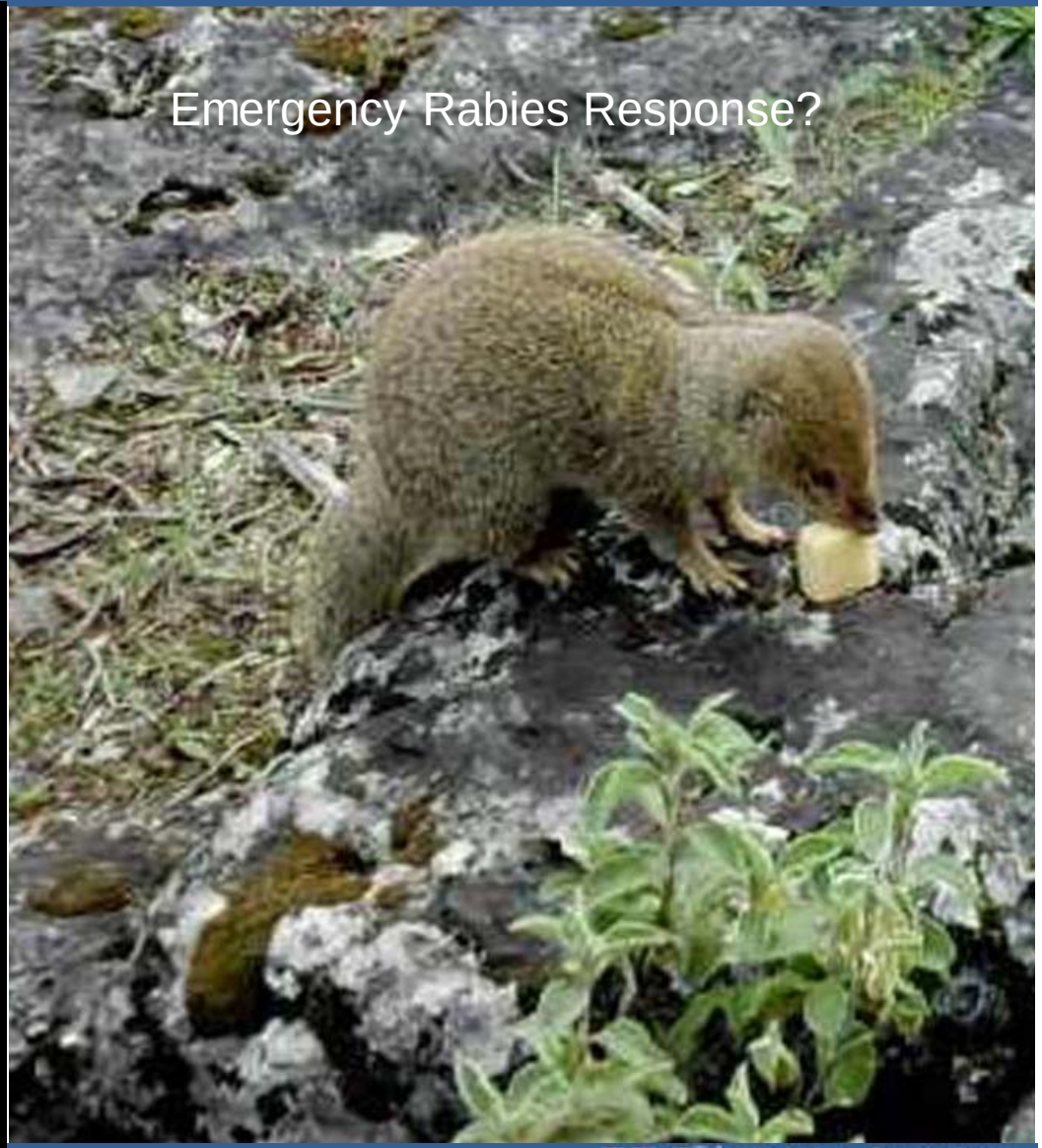


Results

Trial		# Sampled	# Positive	Proportion marked
Fall 2016	Ethyl-iophenoxic acid	87	55	63%
Spring 2017	Methyl-iophenoxic acid	123	84	68%
Pooled (accounting for recaptures)		180	134	74%

Future of Mongoose Rabies Management?

(Post Hurricane)



Before and After Hurricane Maria

Impact on mongoose and mongoose rabies?

Moving Forward?

- **29 islands** with mongoose populations; **4 with mongoose rabies**
  - Puerto Rico, Cuba, Grenada, Hispaniola
- Matter of time before **it spreads to other islands** putting more at risk.
- Potential spread of mongoose rabies to mainland sites in N. South America.

- Need **enhanced rabies surveillance** to:
  - better characterize scope
  - establish baseline (only on four islands?)

- Mongoose rabies is a **canine rabies virus lineage**.
  - and potential source to **re-infect dogs**.

- Been discussing this **key issue at REDIPRA** for a decade
  - white paper requested for REDIPRA by Fernando Leanes at last Antigua meeting
  - white paper provided at REDIPRA in 2009 Buenos Ares (Slate and Rupprecht)

Thoughts on a Surveillance and Potential Management Strategies?