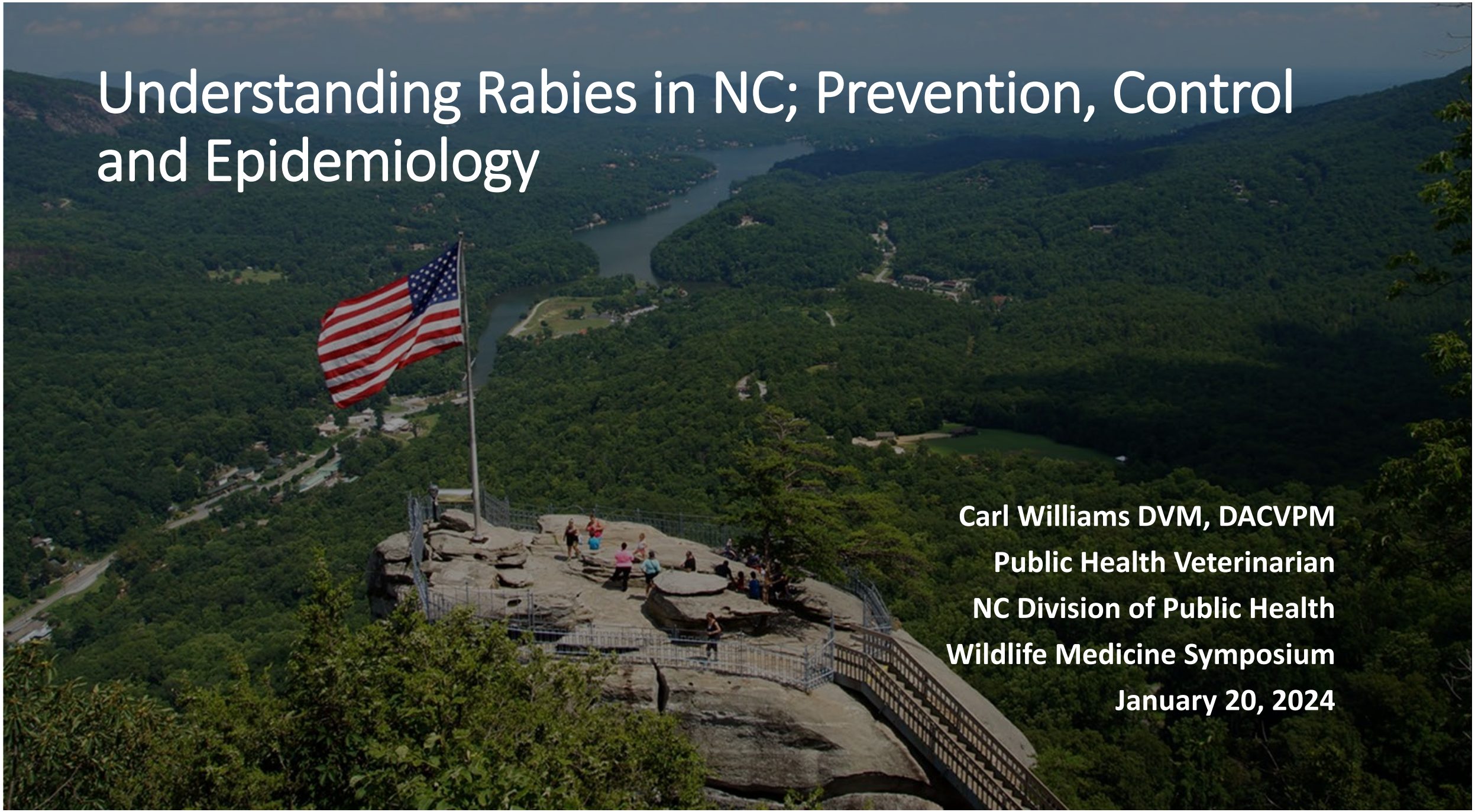
Understanding Rabies in NC; Prevention, Control and Epidemiology



Carl Williams DVM, DACVPM
Public Health Veterinarian
NC Division of Public Health
Wildlife Medicine Symposium
January 20, 2024

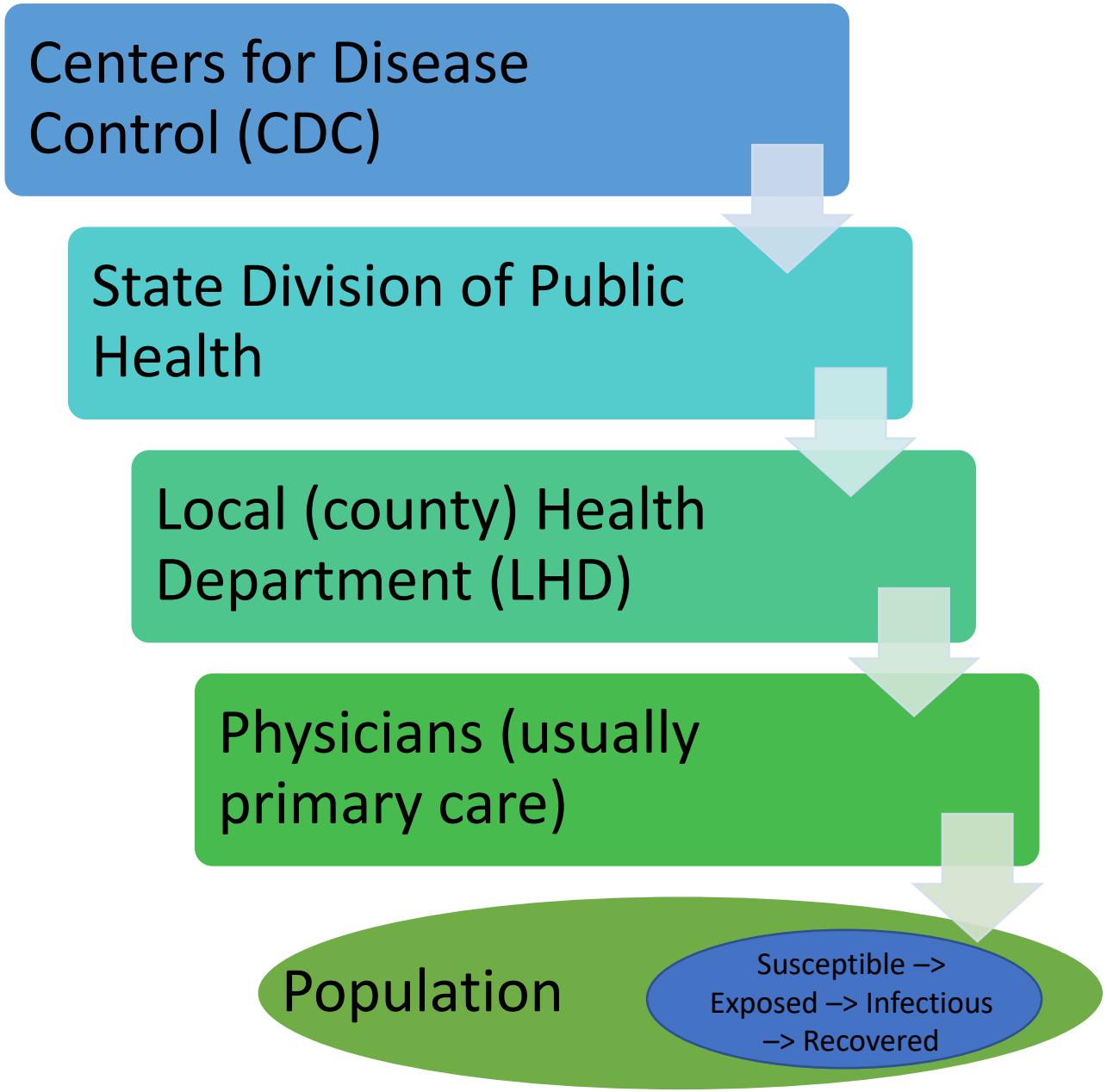
Overview

- Structure of Public Health in North Carolina
- Public Health Law
- Rabies virus and disease
- Rabies surveillance
- Prevention of rabies

Public Health Infrastructure

CDC and State DOHs must cooperate and have limited powers (although rarely tested)

Tremendous responsibility falls on MDs/Primary Health Care Providers



Public Health Mission in NC

- 130A-1.1. Mission and essential services.
  - The General Assembly recognizes that unified purpose and direction of the public health system is necessary to ensure that all citizens in the State have equal access to essential public health services.
  - The General Assembly declares that the mission of the public health system is to promote and contribute to the highest level of health possible for the people of North Carolina by:

- Preventing health risks and disease;
- Identifying and reducing health risks in the community;
- Detecting, investigating, and preventing the spread of disease;
- Promoting healthy lifestyles;
- Promoting a safe and healthful environment;
- Promoting the availability and accessibility of quality health care services through the private sector; and
- Providing quality health care services when not otherwise available

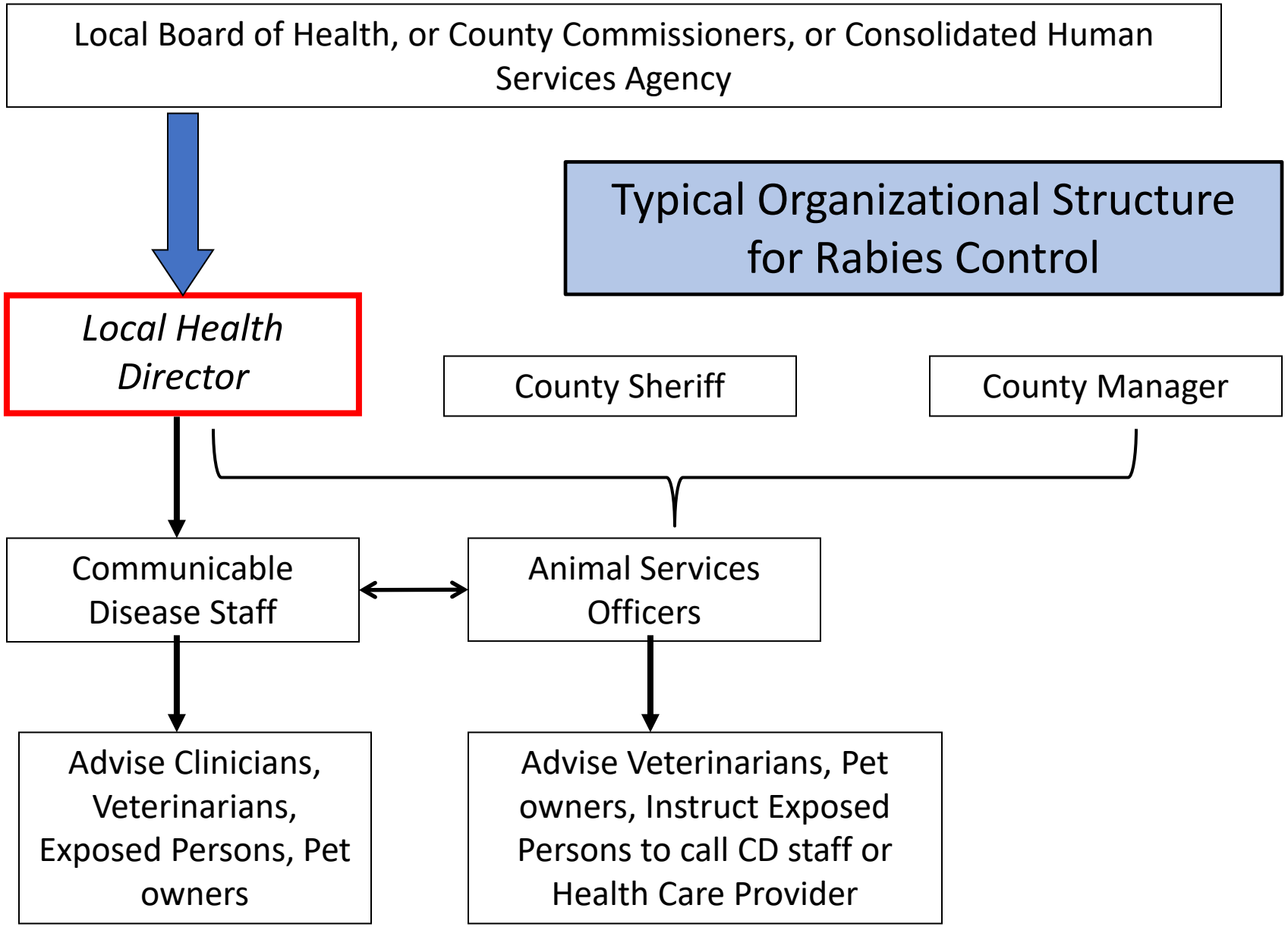
Reportable Diseases

- ~ 80 Reportable Conditions in NC:
  - High consequence or fatal:
    - Rabies, Anthrax, Elevated blood lead levels
  - Spread quickly:
    - Measles, Pertussis
  - May become established without intervention
    - Malaria, Zika
  - May be spread through common food supply
    - E. coli O157:H7, Salmonellosis
- Health Care Providers and Laboratories responsible

Public Health Authority in NC

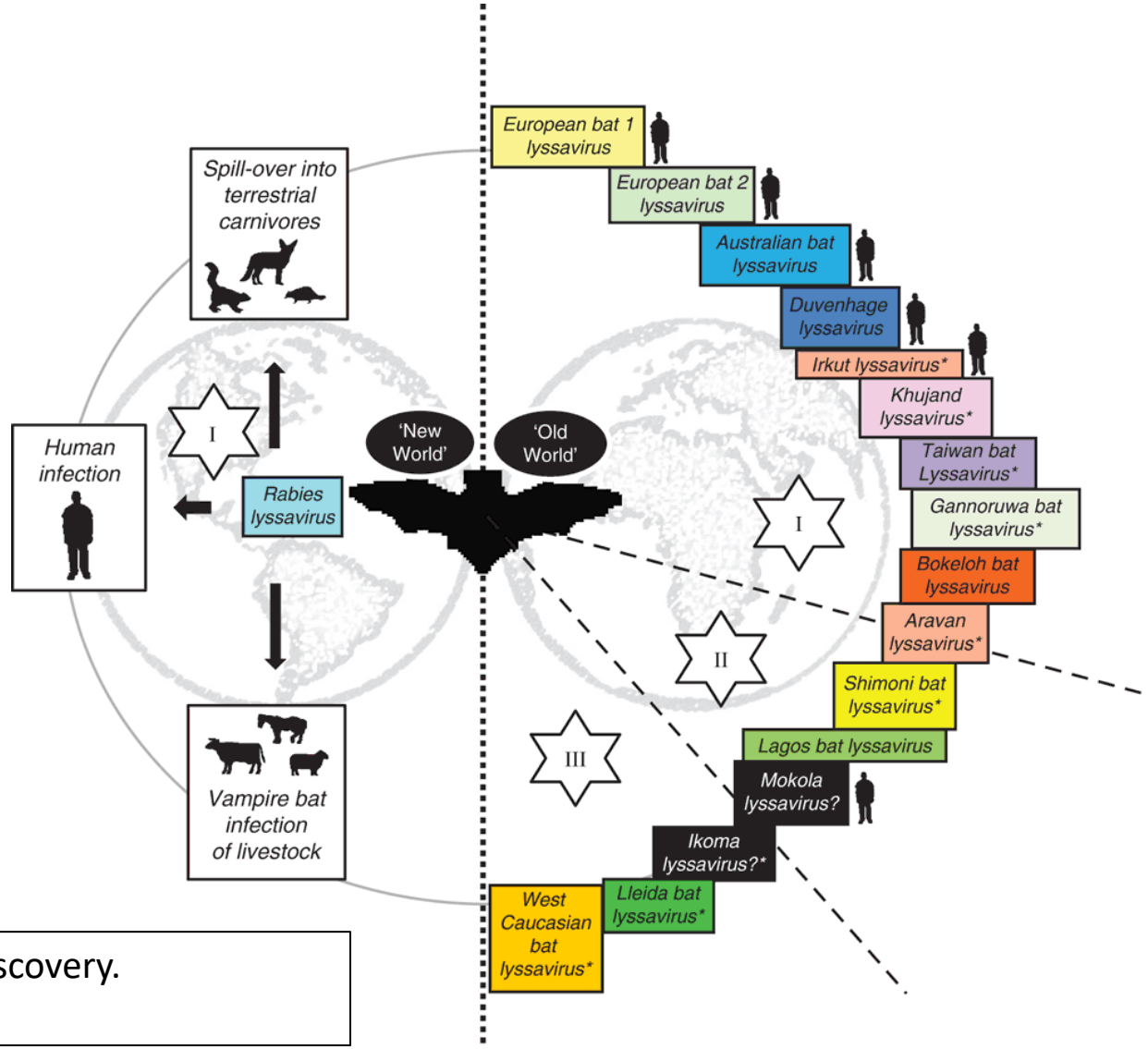
- NCGS 130A-41 Powers and duties of local health director:
  - To investigate the causes of infectious, communicable and other diseases;
  - To exercise quarantine authority and isolation authority pursuant to G.S. 130A-145;
  - To examine, investigate and control rabies pursuant to Part 6 of Article 6 of this Chapter;
- The LHD may delegate (some) responsibility to Animal Control (AC) agencies
  - There must be written agreements (MOA) between agencies specifically delineating responsibility
  - AC officers **must** defer human rabies risk assessments to local CD nurses

Typical Organizational Structure for Rabies Control



Rabies: What's in a Name?

- Rabies is an acute encephalitis or meningoencephalitis due to a lyssavirus infection.
- The etiological agents of rabies encephalitis belong to the
  - Mononegavirales order,
  - Rhabdoviridae family
  - Lyssavirus genus
  - Multiple species (17 on image)
- Only one species, classic rabies virus, is present in North America

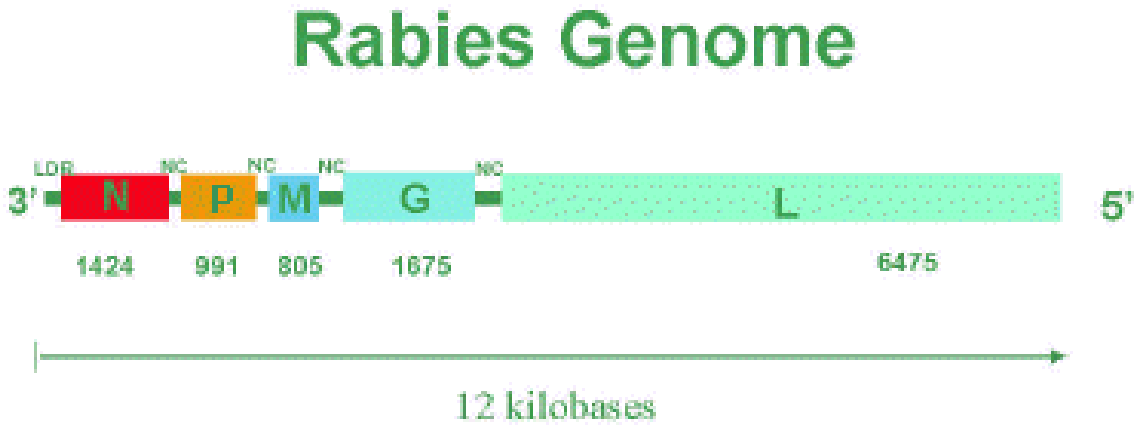


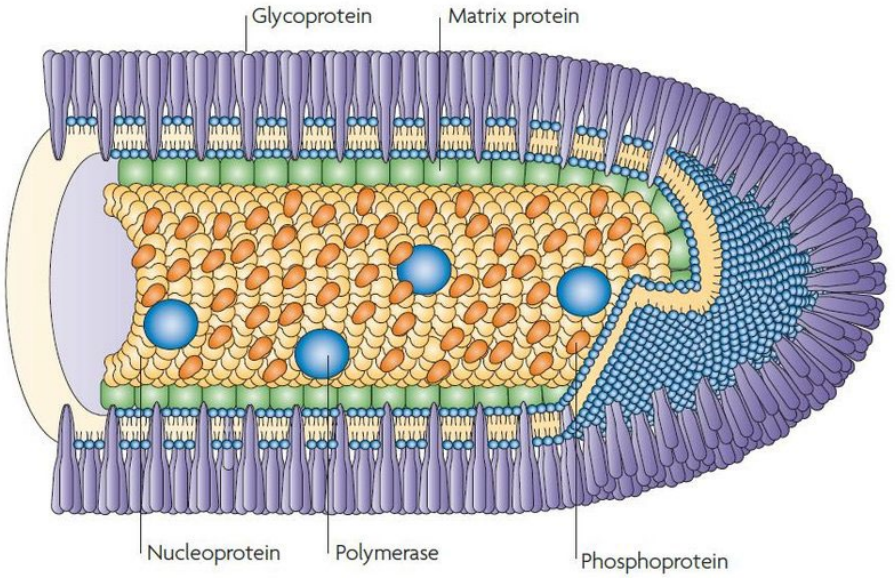
Banyard, Fooks. The impact of novel lyssavirus discovery. Microbiology Australia. Feb 2017. pp. 17-21.

Rabies Virus Genome

- The rabies virus genome is single-stranded, antisense, nonsegmented, RNA of approximately 12 kb.

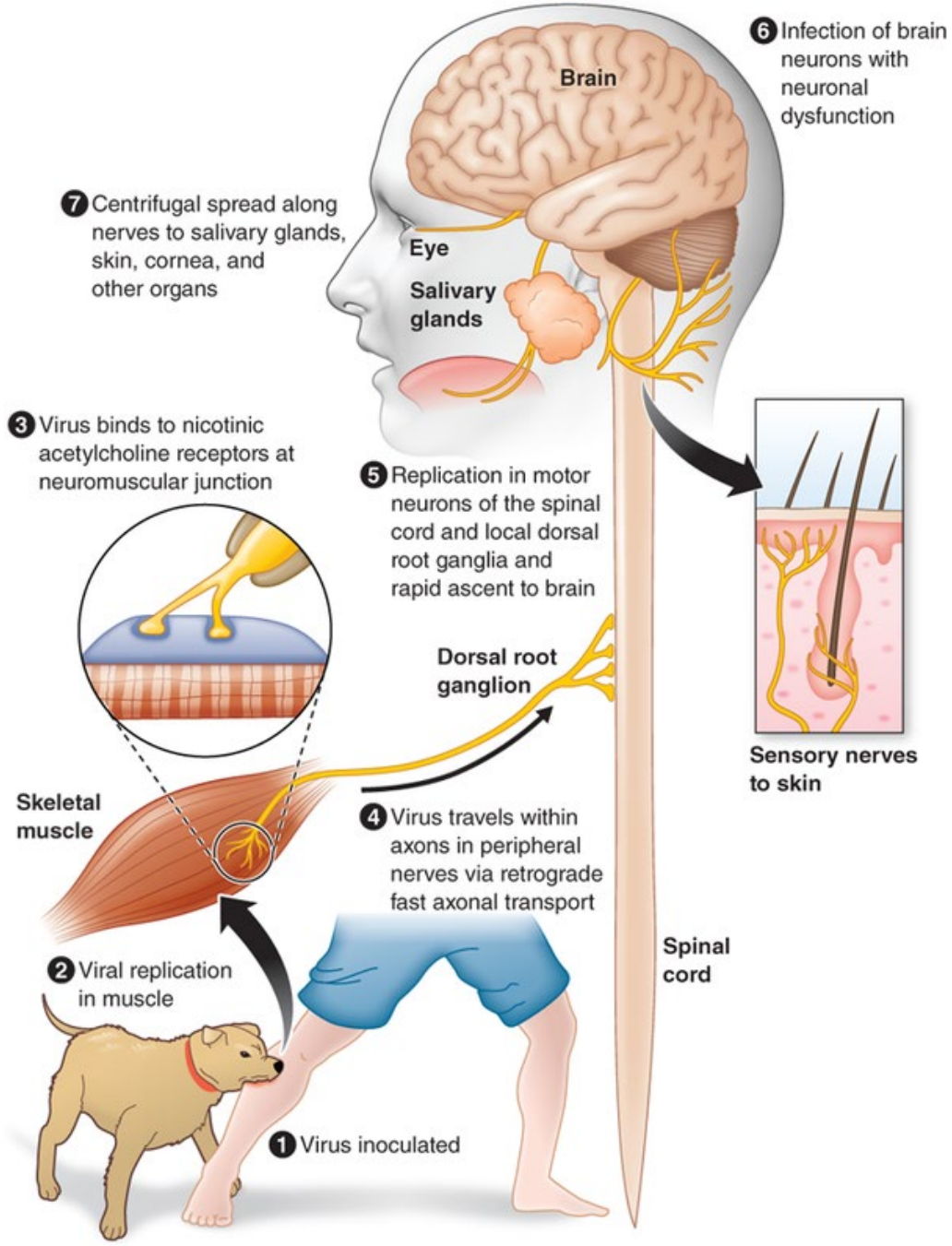
- There is a leader-sequence (LDR) of approximately 50 nucleotides, followed by N, P, M, G, and L genes.





Rabies Pathogenesis

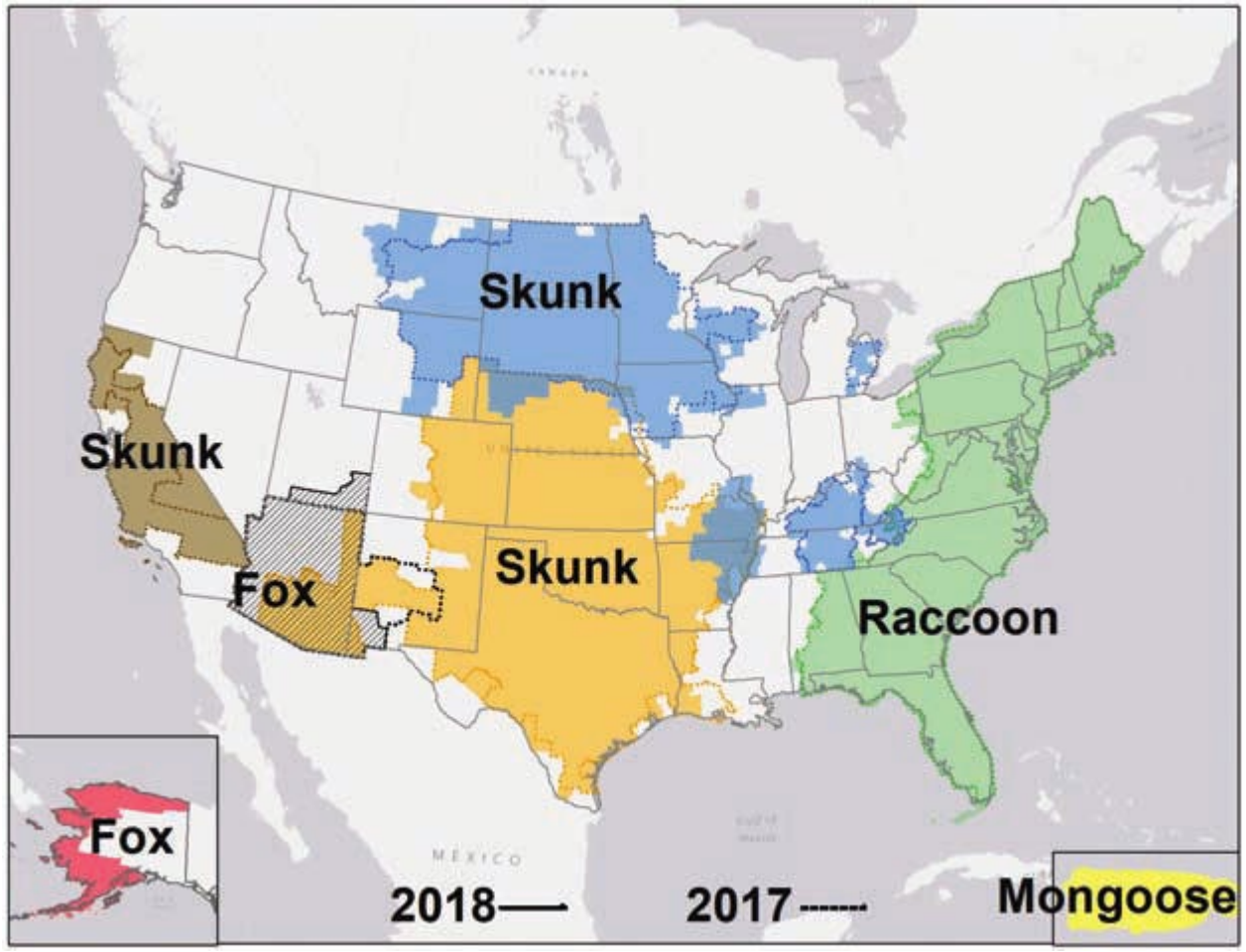
- Bite
  - Any penetration of the skin by teeth constitutes exposure
  - It is assumed that all bite exposures result in contamination of the wound with saliva



Rabies in Animals in the United States

- In North America many unique, host adapted, strains of Rabies Lyssavirus exist
  - Eastern raccoon,
  - Texas grey fox,
  - North central skunk,
  - Arctic fox,
  - *etc*.
  - Bats (all states except HI)

Ma, et. al. Rabies surveillance in the United States during 2018. JAVMA | JAN 15, 2020 | VOL 256 | NO. 2



www.avma.org

1,403 Raccoons

1,400 Bats

846 Skunks

338 Foxes

288 Cats

37 Dogs

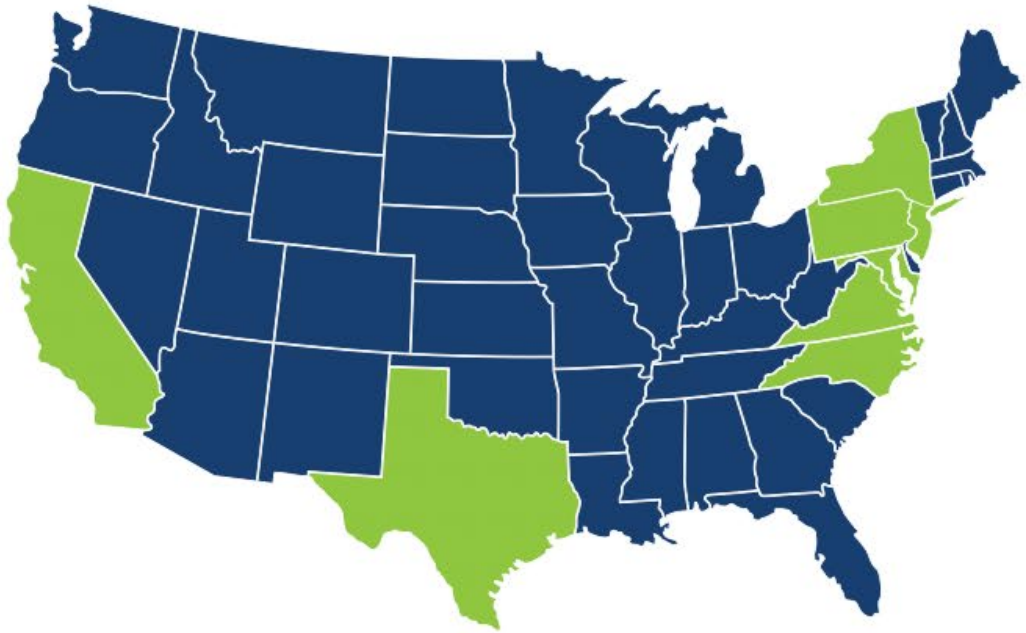
43 Cattle

In 2020, rabid animals in the U.S. totaled

4,479

A **DECREASE** from 4,690 in 2019 by

4.5%



RABIES IN THE U.S. 2020

Almost 3/5 of all animal rabies cases in 2020 were found in 8 states:

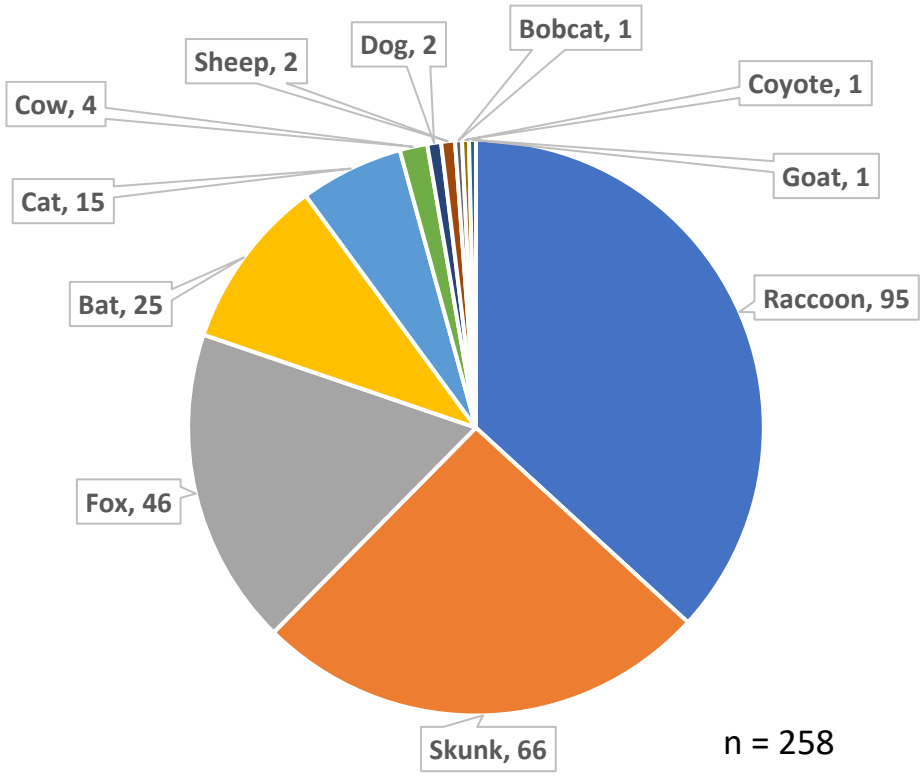
TX PA VA NY
NC NJ MD CA

North Carolina Surveillance Indications for Rabies Testing

- NC State Laboratory for Public Health is the only lab in the state that tests animals for rabies
  - Specimen – brain tissue
- High risk wildlife that have exposed a person or domestic animal
- Cats, dogs or ferrets that cannot undergo a 10-day confinement (§ 130A-199 requires testing)
  - Showing signs of rabies
  - Too ill
  - Too vicious
- Veterinarian requests testing for diagnostic purposes – domestic animal
- Submit head of animal/whole bat

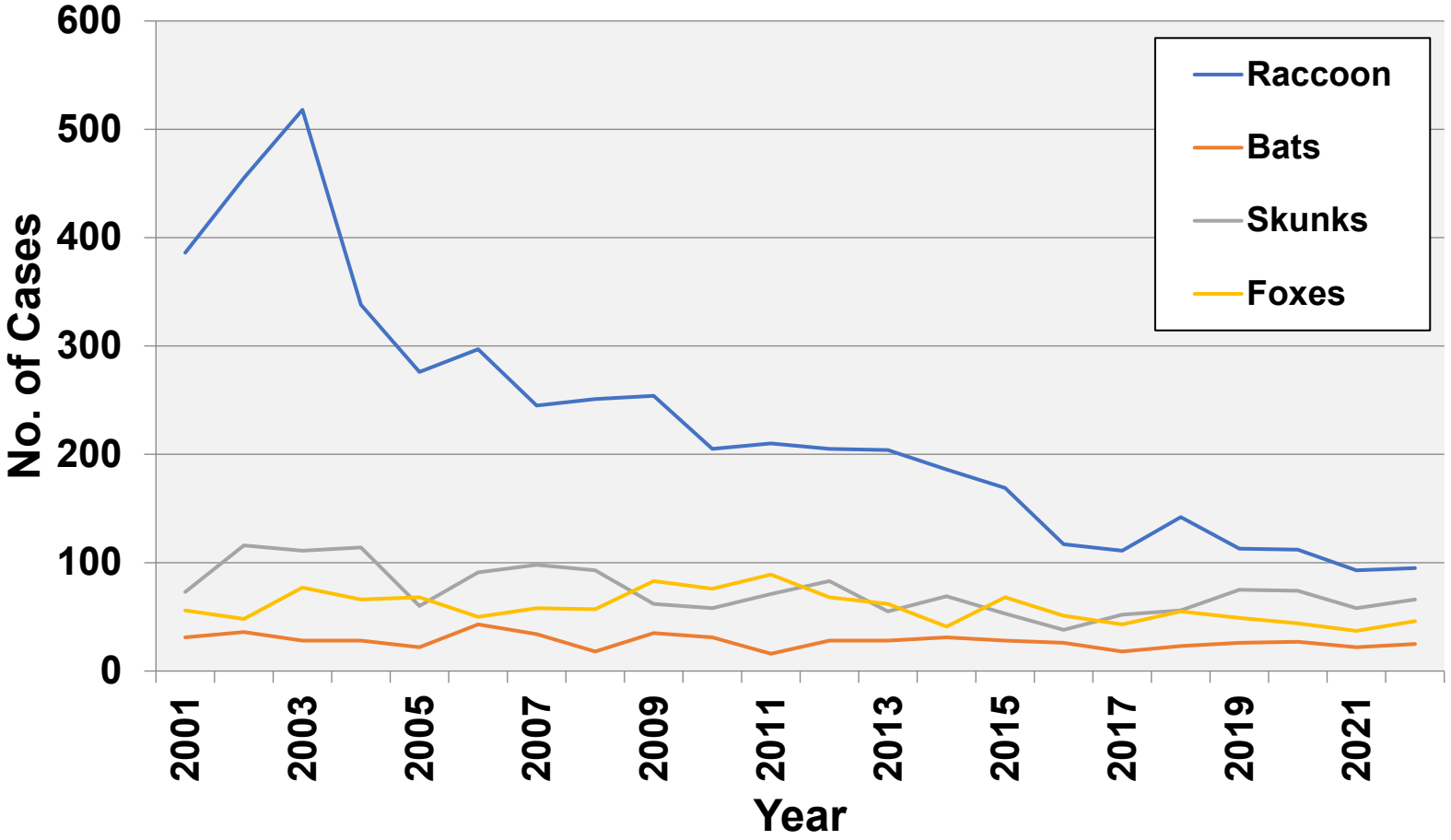
Rabies Positive Mammals and Percent Positivity by Species, North Carolina, 2022

ANIMAL	# pos	# tested	% pos
Raccoon	95	319	29.6%
Skunk	66	82	80.5%
Fox	46	90	51.1%
Bat	25	1016	2.5%
Cat	15	779	1.9%
Cow	4	62	6.5%
Dog	2	744	0.3%
Sheep	2	25	8.0%
Coyote	1	10	10.0%
Bobcat	1	1	100.0%
Goat	1	78	1.3%

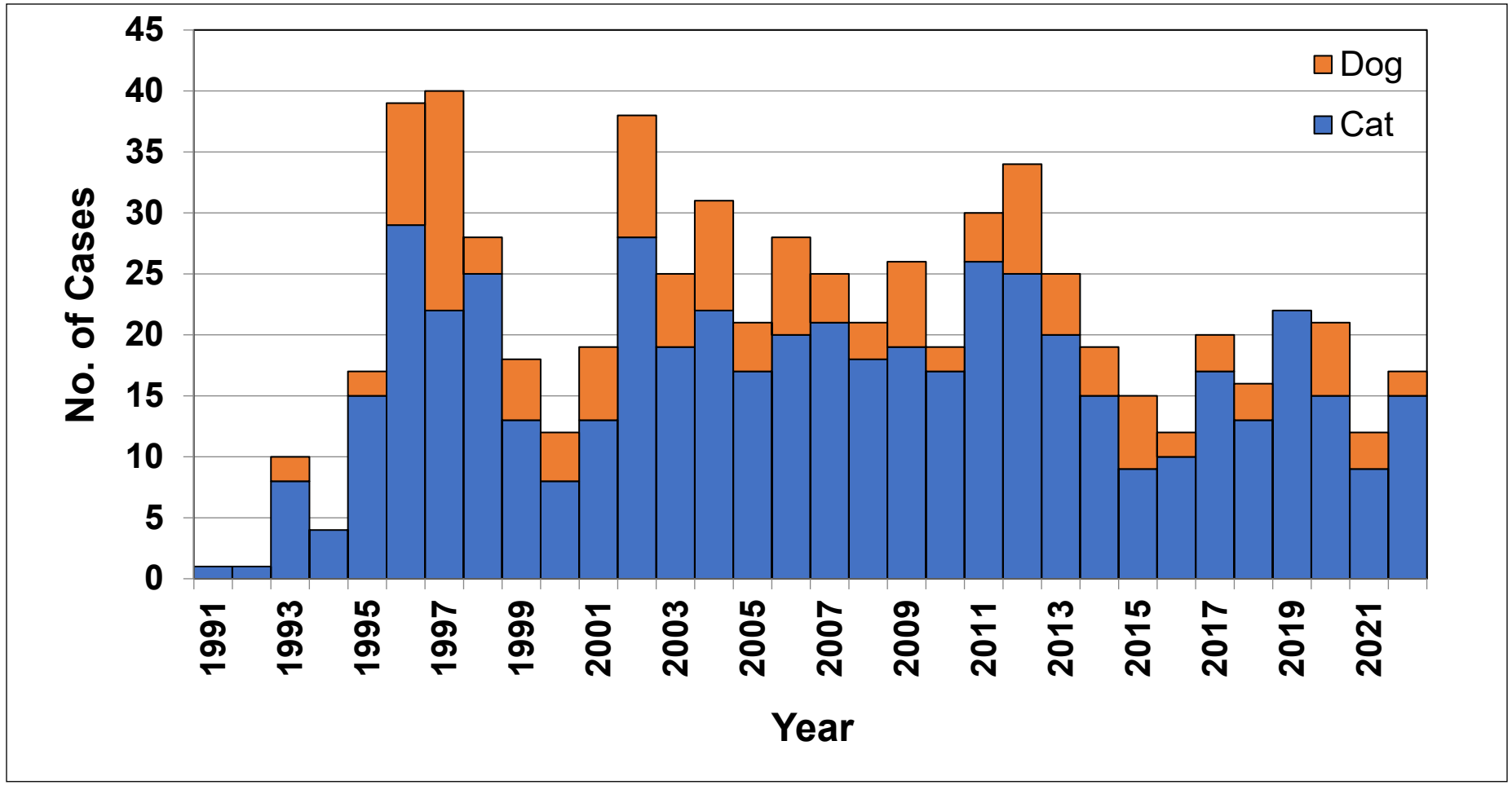


Source: N.C. State Laboratory of Public Health
Data Accessed Jan 2023

Rabies North Carolina: Number of Positive Wild Mammals by Species by Year, North Carolina, 2001 – 2022 (n = 8,504)

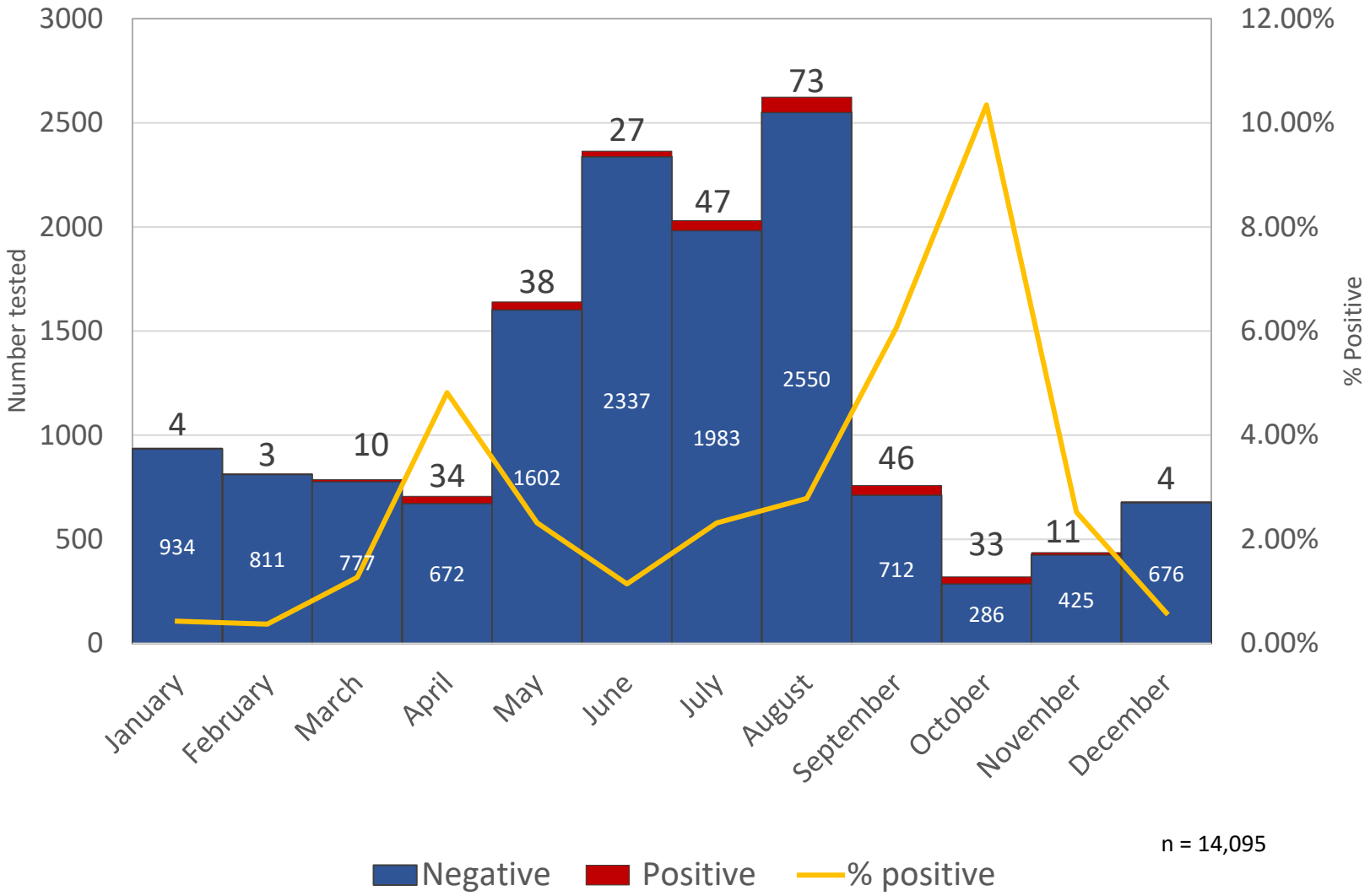


Rabies Positive Dogs and Cats, North Carolina, 1991 – 2022 (n = 666)



NC State Laboratory of Public Health
Data Accessed Jan 2023

Bats - Rabies Results by Month - NC 2010 - 2022



NC State Laboratory of Public Health
Data Accessed Jan 2023

Estimated Burden of Human Rabies in the World

- Human mortality from rabies is estimated to be 55,000 deaths per year
- Mostly in Africa and Asia
- Due to uncontrolled canine rabies
  - Weekly Epidemiological Record **No. 49/50**, **2007**, **82**, 425–436
  - **http://www.who.int/wer**

Burden of Rabies in the US

- Estimated 40,000 – 50,000 post-exposure prophylaxis treatments (cost > $3000 each)
- ~$245 - $510 million annually
  - Vaccination of companion animals
  - Diagnostic testing
  - Post- and pre-exposure prophylaxis

  (doesn't include associated healthcare costs, animal control, lost time from work)

https://www.cdc.gov/rabies/index.html

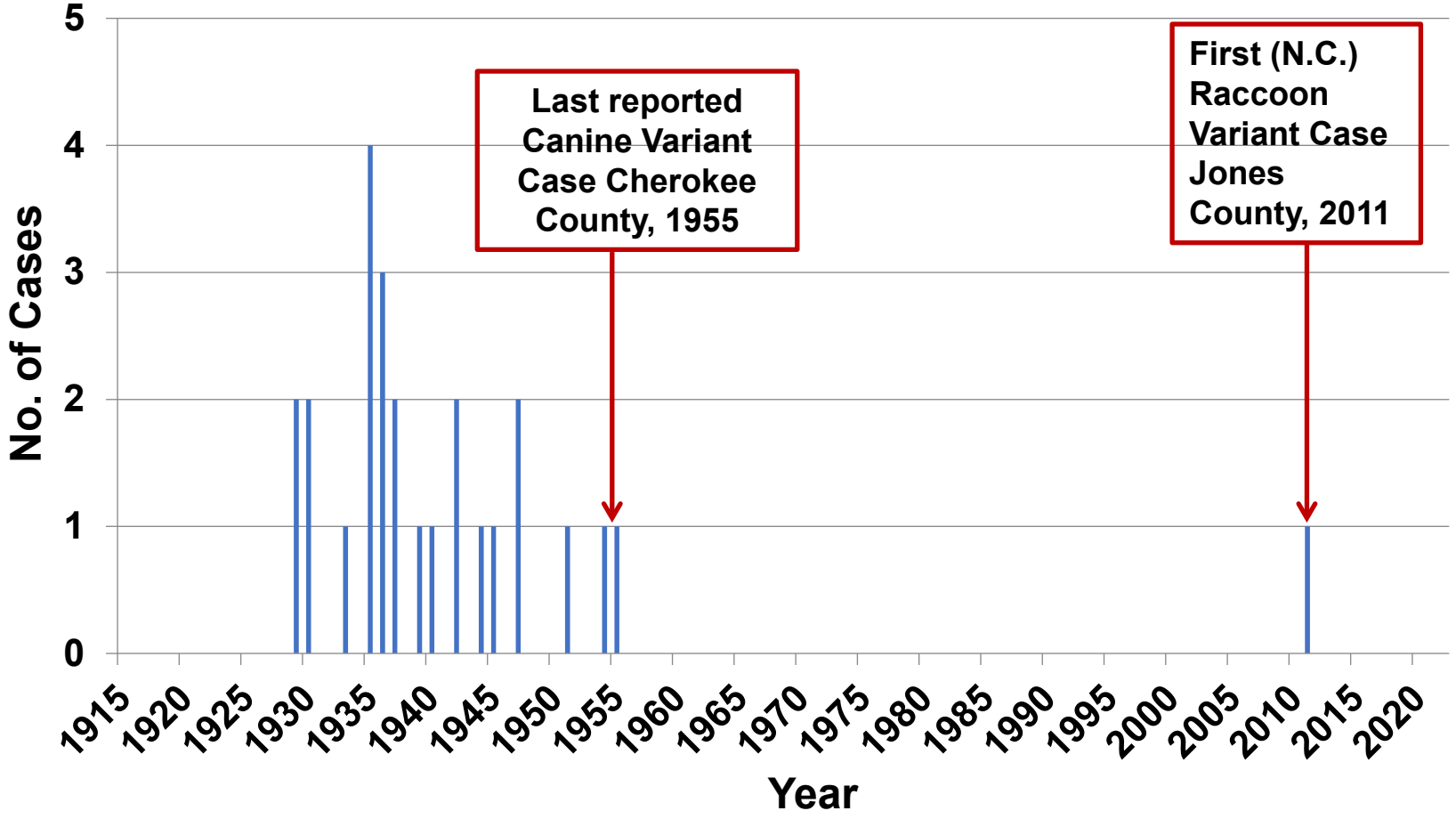
Human Rabies in the US: 2008-2022

30 cases

- 17 due to bat variant
  - 6 reported bite
  - 7 reported contact
  - 4 had unknown exposures
- 9 canine variant
  - exposure outside US
  - 1 mongoose – Puerto Rico
- 3 raccoon variant
  - one exposed in NC, one transplant recipient
- 1 unknown exposure and variant

Sources: https://www.cdc.gov/rabies/location/usa/surveillance/human_rabies.html
https://avmajournals.avma.org/view/journals/javma/aop/javma.23.02.0081/javma.23.02.0081.xml

Human Rabies Reported Cases North Carolina, 1929 - 2022 (n = 26)



NC Department of Health and Human Resources
Reported Communicable Diseases, Data Accessed Jan 2023

Rabies Prevention

Vaccination Laws

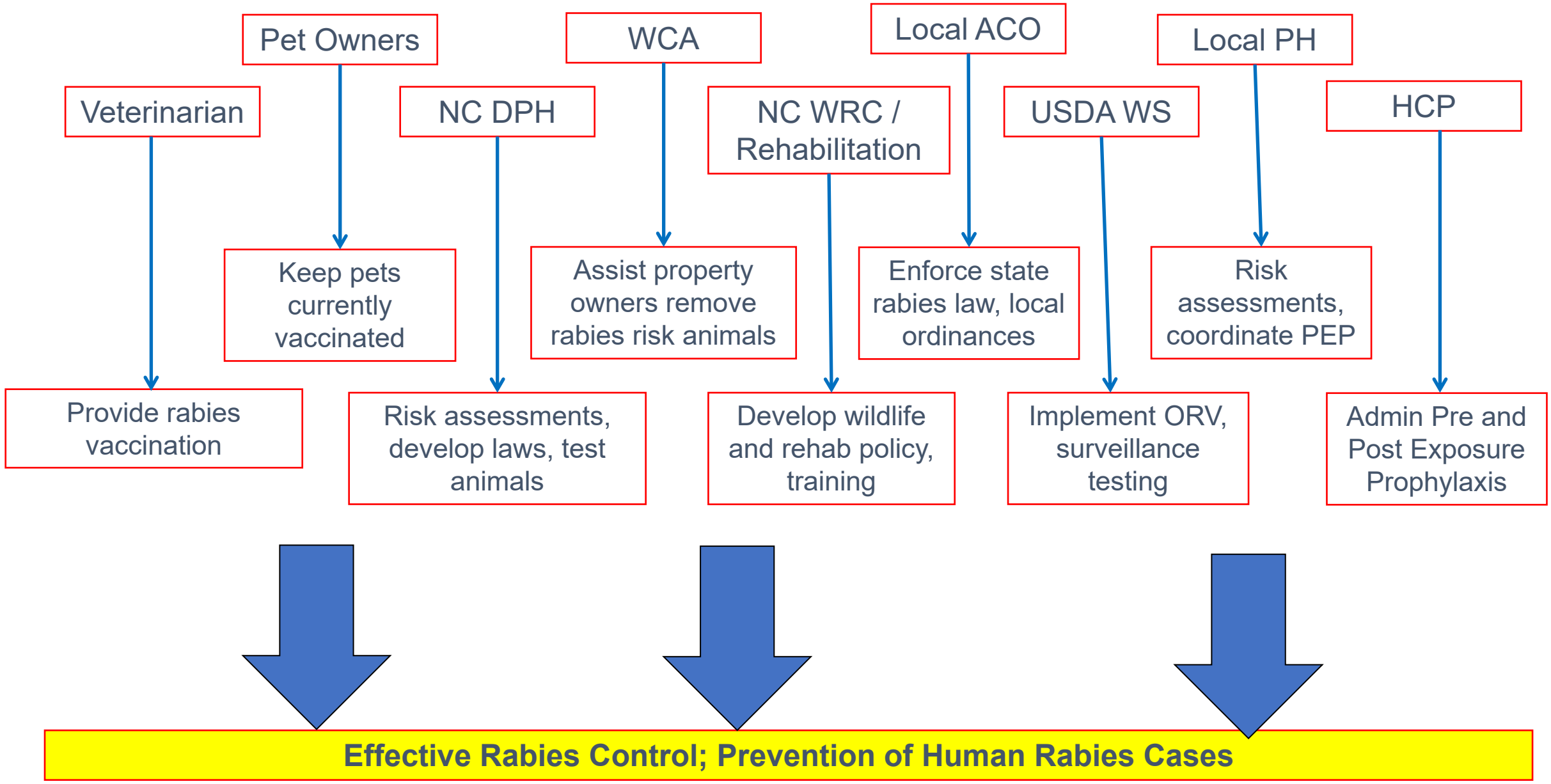
- **NCGS 130A-185. Vaccination of all dogs, cats and ferrets**
- **(a) The owner of every dog and cat over four months of age shall have the animal vaccinated against rabies.** The time or times of vaccination shall be established by the Commission. Rabies vaccine shall be administered only by a licensed veterinarian or by a certified rabies vaccinator.
- We learned from Old Yeller and Atticus

Prevention – Laws and Guidance

- Animals
  - Compendium of Animal Rabies and Control, 2016
    - National Association of State Public Health Veterinarians
    - Incorporated into our statute: 130A-197 Management of dogs, cats and ferrets exposed to rabies.
    - Used as guidance for other species

    http://www.nasphv.org/Documents/NASPHVRabiesCompendium.pdf
- Humans
  - Advisory Committee on Immunization Practices (ACIP)
    - Human Rabies Prevention—United States, 2008
    - Use of a Reduced (4-Dose) Vaccine Schedule for Postexposure Prophylaxis to Prevent Human Rabies, 2010
    - Use of a Modified Preexposure Prophylaxis Vaccination Schedule to Prevent Human Rabies: Recommendations of the Advisory Committee on Immunization Practices — United States, 2022

    https://www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/rabies.html


Pet Owners
WCA
Local ACO
Local PH
Veterinarian
NC DPH
NC WRC / Rehabilitation
USDA WS
HCP
Keep pets currently vaccinated
Assist property owners remove rabies risk animals
Enforce state rabies law, local ordinances
Risk assessments, coordinate PEP
Provide rabies vaccination
Risk assessments, develop laws, test animals
Develop wildlife and rehab policy, training
Implement ORV, surveillance testing
Admin Pre and Post Exposure Prophylaxis
Effective Rabies Control; Prevention of Human Rabies Cases

Response to Animal Bites

- Wound care
- Antibiotic therapy
- Tetanus Booster or TIG administration[1]
  - Many immigrants not adequately vaccinated against tetanus, thorough history needed
- Rabies specific risk assessment
  - Most dog/cat bites do not require rabies PEP
  - Bites from RVS often require PEP initiation

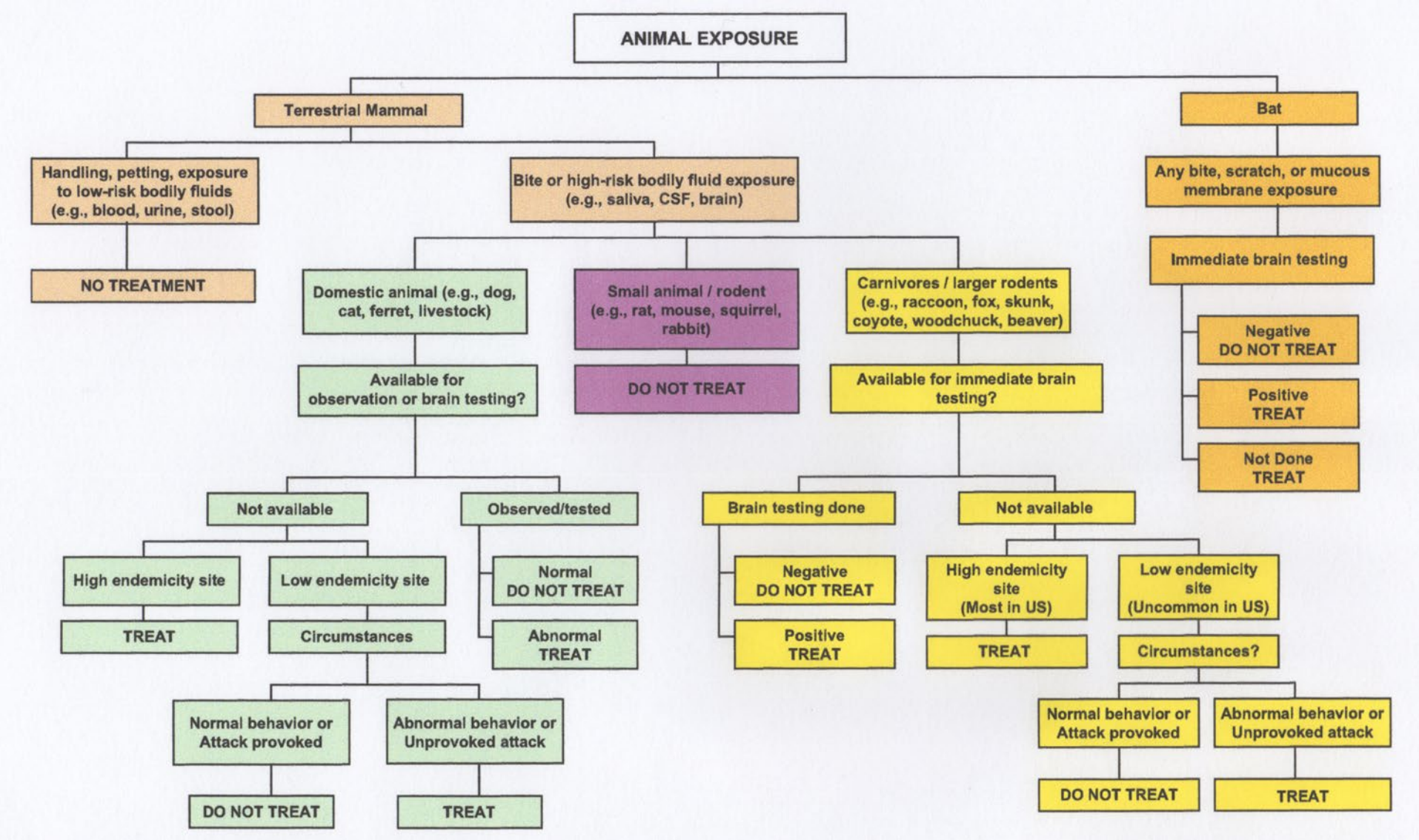
[1] Talan DA, Abrahamian FM, Moran GJ, et al. Tetanus immunity and physician compliance with tetanus prophylaxis practices among emergency department patients presenting with wounds. *Ann Emerg Med*. 2004;43:305-314.

Rabies exposures

- Saliva or brain/nervous system tissue are only infectious materials
  - Blood, urine, feces ≠ infectious
  - Rabies virus becomes non-infectious when it dries out or is exposed to sunlight
- Route of transmission
  - Bite
  - Non bite: infectious material into open wound or onto mucous membranes, theoretically scratches
    - Rare but has been documented
    - Petting, contact with non-infectious materials ≠ exposure

Rabies exposures

- Exposing animal high-risk or low risk?
  - High:
    - raccoon, skunk, fox, coyote, bobcat, beaver, groundhog (other large carnivores)
  - Low:
    - small rodents (squirrel, mouse, rat, mole, hamster, guinea pig), rabbits
  - Low risk acting aggressively/neurologic→high risk



Moran, et. al. Antimicrobial Prophylaxis for Wounds and Procedures in the Emergency Department. Infect Dis Clin N Am 22 (2008) 117–143

Basis for 10-day Confinement - Cats

- 86 cats experimentally infected with rabies virus
- 26 died from rabies
- 23 had detectable rabies virus in saliva
- Range of viral shedding extended from 1 day prior to symptom onset to 7 days after symptom onset
- Most cats died 5 – 6 days after symptom onset

Vaughn, et. al. Excretion of Street Rabies Virus in Saliva of Cats. JAMA, Vol. 184 No. 9, 1963. pp.705-708

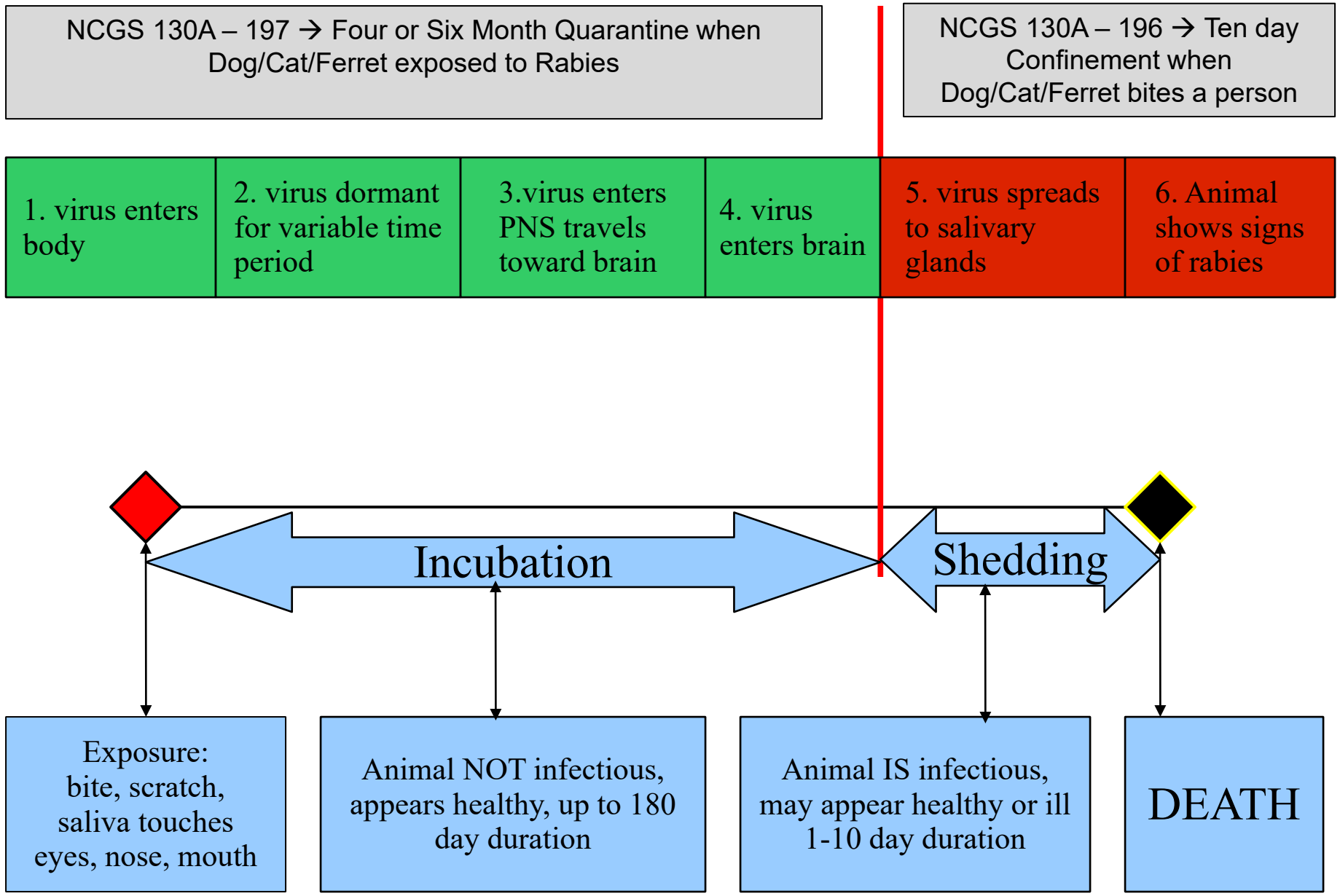
Basis for 10-day Confinement - Dogs

- 117 dogs experimentally infected with rabies virus
- 54 died from rabies
- 25 had detectable rabies virus in saliva
- Range of viral shedding extended from 3 days prior to symptom onset to 7 days after symptom onset
- Most dogs died 3 – 4 days after symptom onset

Vaughn, et. al. Excretion of Street Rabies Virus in Saliva of Dogs. JAMA, Vol. 193 No. 5, 1965. pp.113-115

Confinement for other species that bite

- Ferrets – 10 days, similar data as for dogs/cats
- Livestock – 15 days, as long as healthy and no history of being exposed to a rabies vector species
- All other species - no appropriate confinement


NCGS 130A – 197 → Four or Six Month Quarantine when Dog/Cat/Ferret exposed to Rabies
NCGS 130A – 196 → Ten day Confinement when Dog/Cat/Ferret bites a person
1. virus enters body
2. virus dormant for variable time period
3.virus enters PNS travels toward brain
4. virus enters brain
5. virus spreads to salivary glands
6. Animal shows signs of rabies
Incubation
Shedding
Exposure: bite, scratch, saliva touches eyes, nose, mouth
Animal NOT infectious, appears healthy, up to 180 day duration
Animal IS infectious, may appear healthy or ill 1-10 day duration
DEATH

Rabies Control Measure Summary

Control Measure	Use	Authority
Countywide Rabies Program	Examine, investigate and control rabies	130A-41
10 Day Confinement	When a dog/cat/ferret bites a person	130A-196
15 Day Confinement	When livestock bites a person	State policy developed with NCDA&CS in communication with CDC
45 Day Observation	When a rabies vaccinated dog/cat/ferret has been exposed to rabies	130A-197 / NASPHV Compendium
4 Month Quarantine	When a dog/cat not currently vaccinated against rabies has been exposed to rabies	130A-197 / NASPHV Compendium
6 Month Quarantine	When a ferret not currently vaccinated against rabies has been exposed to rabies	130A-197 / NASPHV Compendium
Test	When a dog/cat/ferret in a 10 day confinement dies	130A-199
Test	Other animals tested at the discretion of the SPHV	130A-198

Humans - Pre-exposure Vaccination

Recommended for

- Veterinarians and staff
- Laboratory workers – rabies diagnostic labs or research labs
- Animal control officers
- Wildlife workers
- Travelers to rabies endemic countries; at risk

Updates to the ACIP recommendations to prevent human rabies, 2022

- A 2-dose PrEP schedule has replaced the 3-dose PrEP schedule to protect for up to 3 years. Options for maintaining protection beyond 3 years are also described.
- Risk categories have been redefined into 5 risk groups.
- The minimum acceptable laboratory value (antibody titer) used to determine whether rabies vaccine booster doses are needed was revised and standardized.
- Many people for whom serial titers were recommended every 2 years now require only a one-time titer (and booster if below a certain level) OR a one-time booster.
- Clinical guidance for administering PrEP to people with weakened immune systems has been outlined and includes recommendations to confirm that the vaccine was effective.

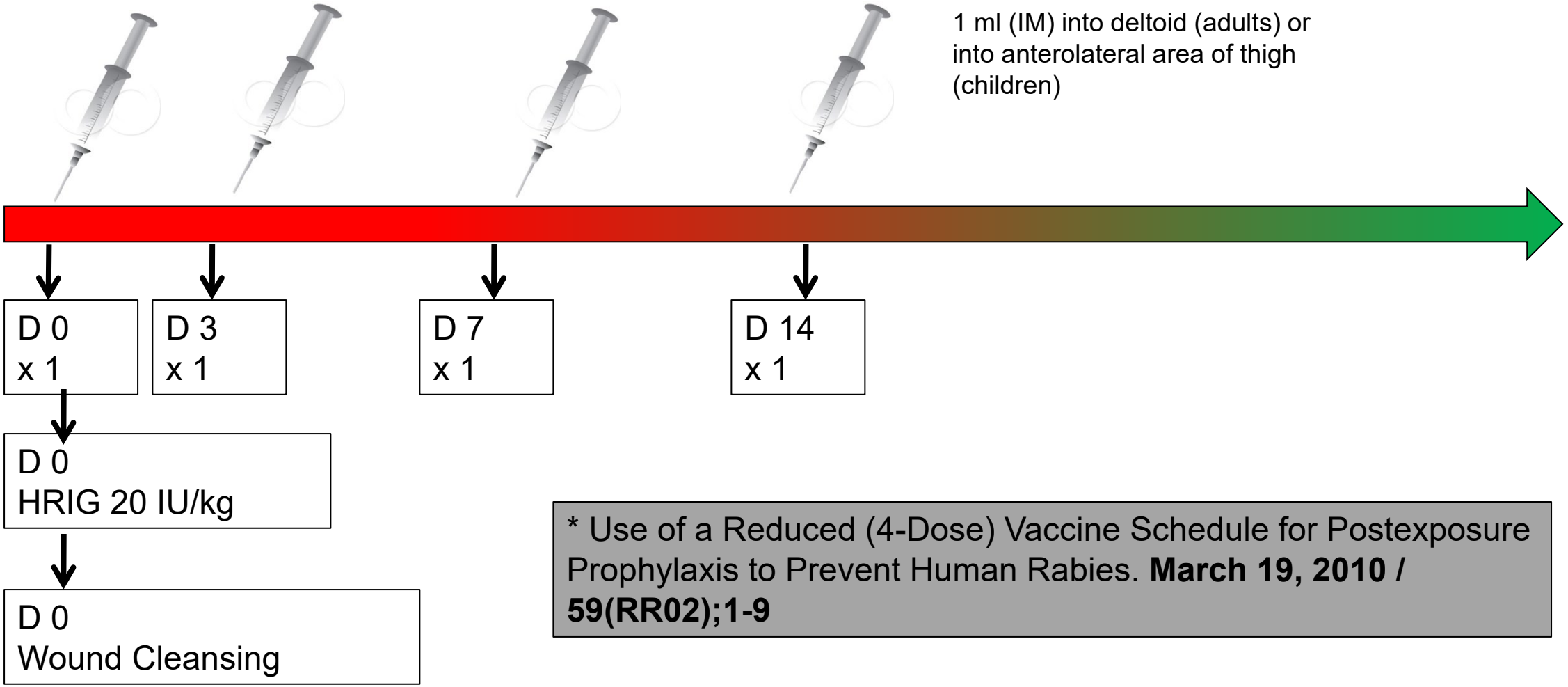
Risk category	Who this typically* affects	Recommendations
Risk category 1 *Highest risk*	People who work with live or concentrated rabies virus in laboratories	2 doses, days 0 and 7 Check titer every 6 months
Risk category 2	People who frequently do at least one of the following: handle bats, have contact with bats, enter high-density bat environments like caves, or perform animal necropsies	2 doses, days 0 and 7 Check titer every 2 years
Risk category 3	People who interact with, or are at higher risk to interact, with mammals other than bats that could be rabid, for a period longer than three years after they receive PrEP This group includes: • Most veterinarians, veterinary technicians, animal control officers, wildlife biologists, rehabilitators, trappers, and spelunkers (cave explorers) • Certain travelers to regions outside of the United States where rabies in dogs is commonly found	2 doses, days 0 and 7, plus: Either a one-time titer check after 1 year and up to 3 years following the first 2-dose vaccination **OR** 1-dose booster between 3 weeks and 3 years following the first vaccine in the 2-dose vaccination
Risk category 4	Same population as risk category 3, but at a higher risk for ≤ three years after they receive PrEP	2 doses, days 0 and 7
Risk category 5 *Lowest risk*	General U.S. population	None

Rationale for Rabies Pre-Exposure Immunization for People

- It may provide protection to persons with inapparent exposure to rabies
- It may protect persons whose post exposure therapy is expected to be delayed
- In the event of an exposure to rabies it simplifies therapy by
  - Eliminating need for HRIG
  - Decreasing number of vaccine doses required

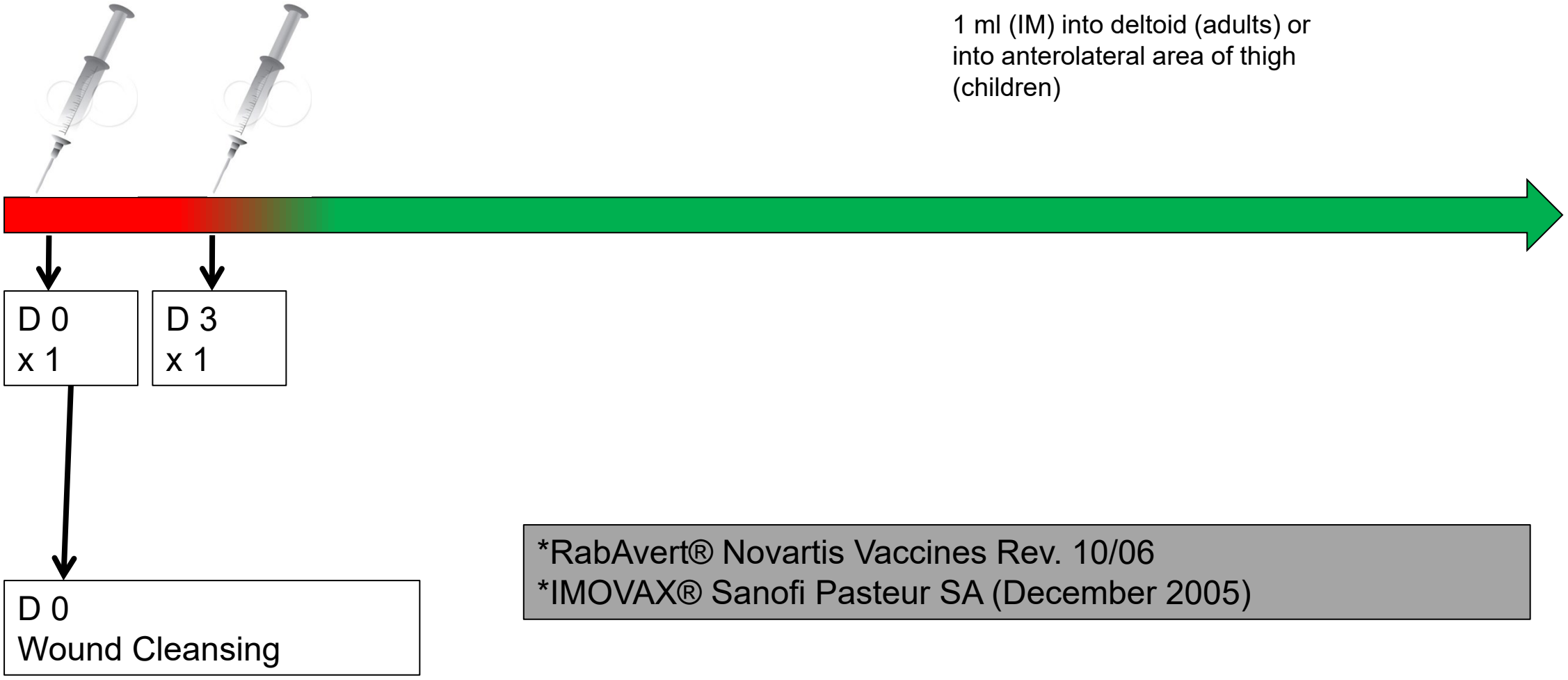
Human Rabies Prevention — United States, 2008, Recommendations of the Advisory Committee on Immunization Practices, MMWR May 23, 2008 / Vol. 57 / No. RR-3

Post-exposure Prophylaxis (not previously vaccinated) ACIP Modified Essen Schedule; 4 doses, 4 visits*



* Use of a Reduced (4-Dose) Vaccine Schedule for Postexposure Prophylaxis to Prevent Human Rabies. **March 19, 2010 / 59(RR02);1-9**

Human Rabies PEP IF previously vaccinated; 2 doses, 2 visits*



*RabAvert® Novartis Vaccines Rev. 10/06
*IMOVAX® Sanofi Pasteur SA (December 2005)

Why do Bats Pose Such a risk?

- **The virus from bats can replicate at a lower temperature, thus small superficial wounds from bat bites can lead to infection**
  - Characterization of a Unique Variant of Bat Rabies Virus Responsible for Newly Emerging Human Cases in North America. *Proc Natl Acad Sci USA* 1996;93:5653-5658
- **And / Or**
  - **Bat bites are not dramatic and may not be appreciated when they occur or when the patient is examined**
  - **Some may recognize the bite but not comprehend its implications**
  - **Others, such as young persons or those with disabilities may be unable to provide and accurate history of a bite**
    - Prophylaxis Against Rabies. *NEJM* 2004; 351:2626-2635

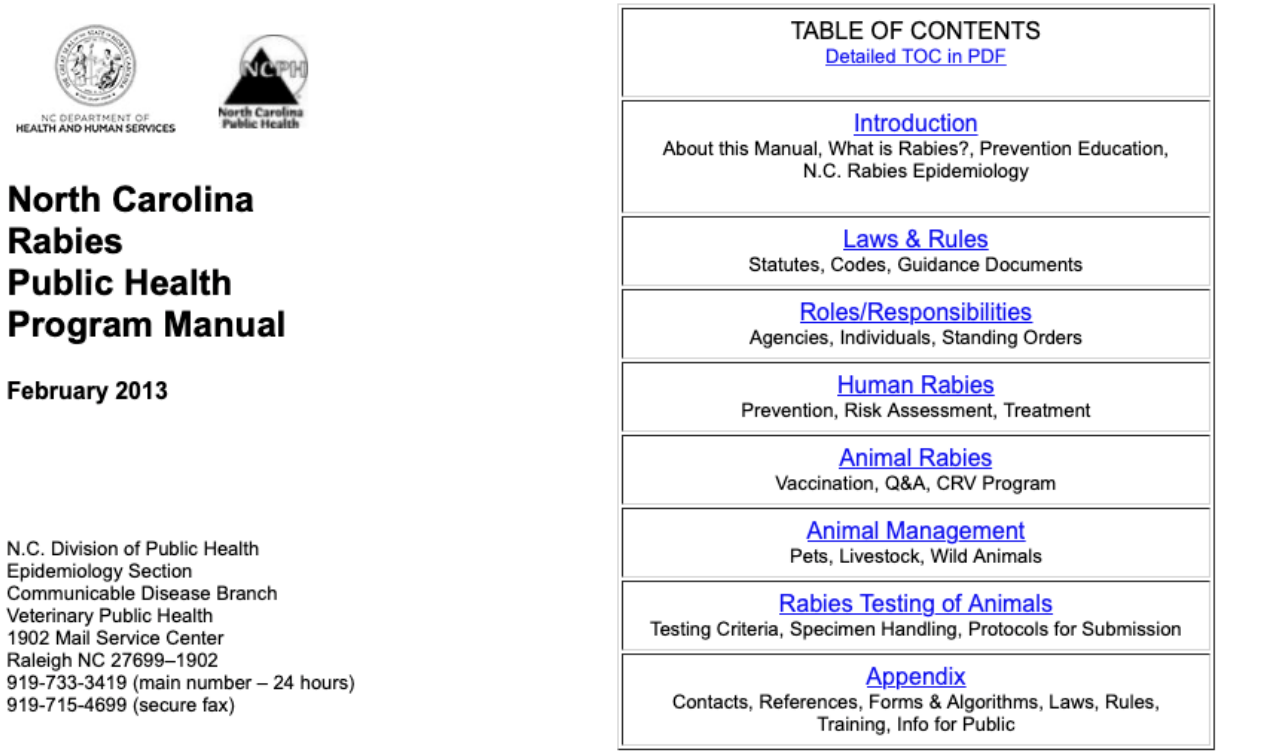
Small Rodents Present a Low Risk of Transmission

What About Opossums?

- Opossums are relatively resistant to infection with rabies and are considered a low risk for infection
- The viral dose required to infect opossums is 80,000 times that required to infect a fox
    - Beamer, et. al. Resistance of the Opossum to Rabies Virus. AJVR. 1960 May;21:507-10.
- Rabies virus binds to nAChR in skeletal muscle
- A high content of receptors in muscle of red fox makes them susceptible
- Low content of receptors in muscle of opossums makes them resistant
    - Rabies susceptibility and acetylcholine receptor [Letter]. Lancet 1990;335:664–5.

Rabies Resources Available to You

- NC Communicable Disease Manual
  - https://www.epi.state.nc.us/cd/lhds/manuals/rabies/toc.html



NC DEPARTMENT OF HEALTH AND HUMAN SERVICES

North Carolina Public Health

North Carolina Rabies Public Health Program Manual

February 2013

N.C. Division of Public Health
Epidemiology Section
Communicable Disease Branch
Veterinary Public Health
1902 Mail Service Center
Raleigh NC 27699–1902
919-733-3419 (main number – 24 hours)
919-715-4699 (secure fax)

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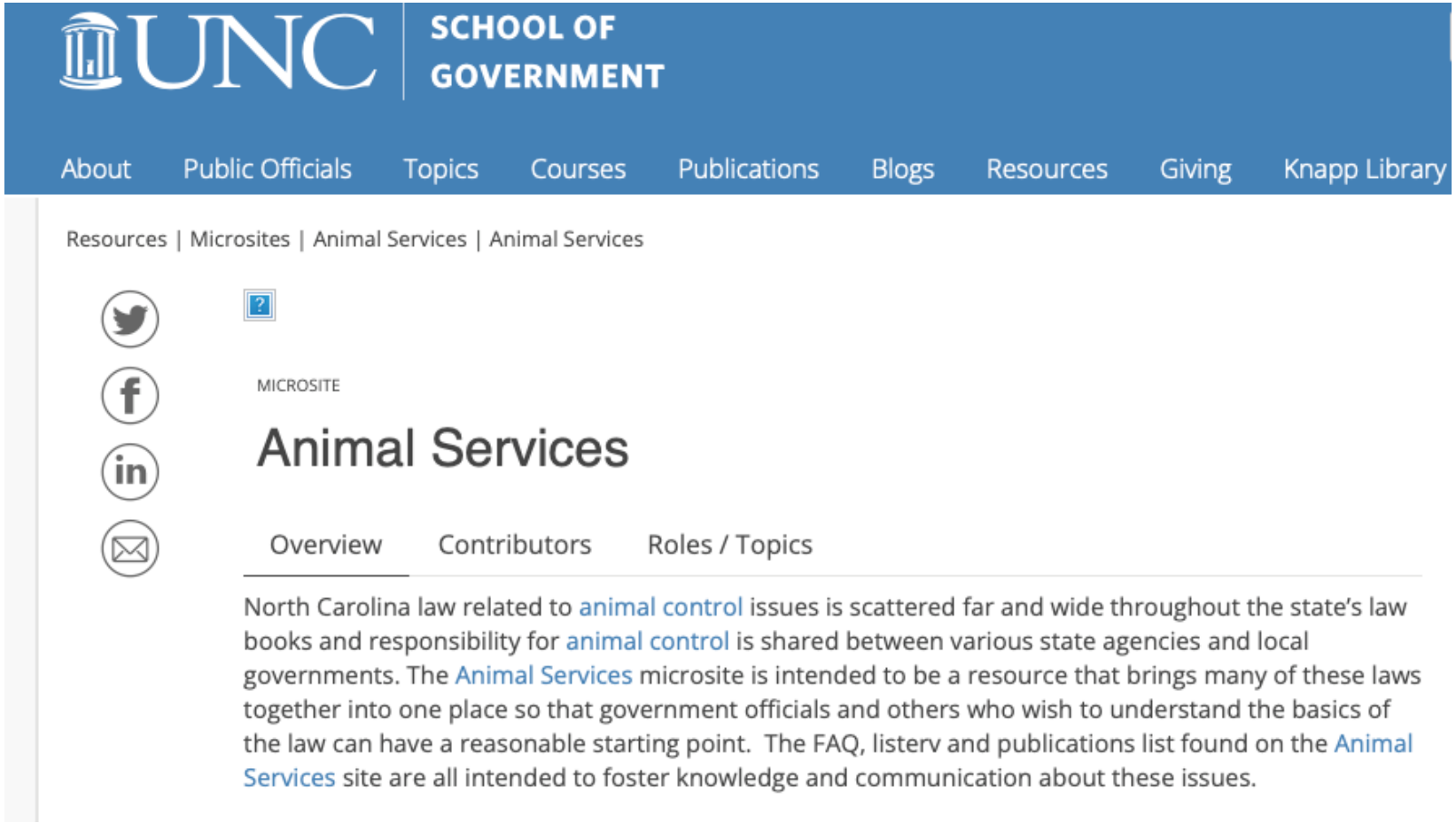
When to Call Public Health

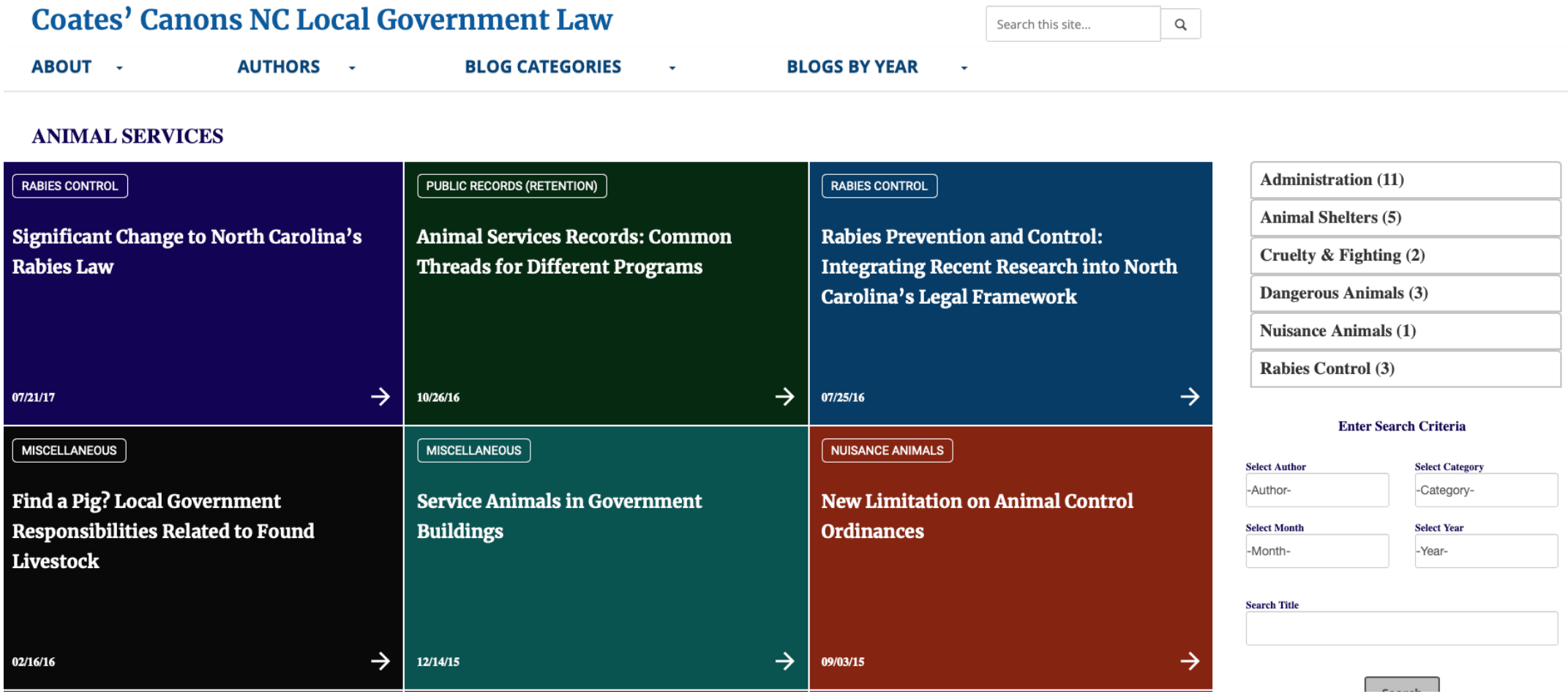
- A bite is reported
- An exposure is suspected
- You have any questions!

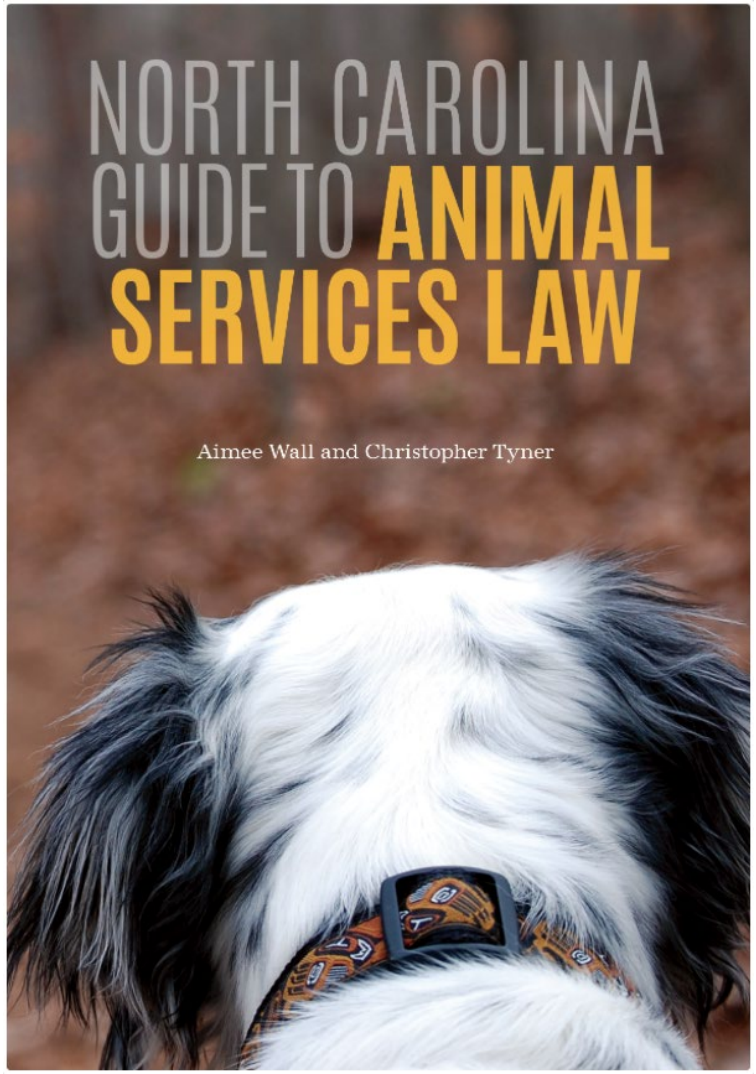
919-733-3419
24/7

- UNC Animal Services Site
  - https://www.sog.unc.edu/resources/microsites/animal-services/



- Coates’ canon
  - https://canons.sog.unc.edu/animal-services/





https://www.sog.unc.edu/publications/books/north-carolina-guide-animal-services-law

Questions?