Pesticide Exposures & Mortalities in Non-target Wildlife

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

2024 Annual Report
Wildlife Health Laboratory

2024 Summary of Pesticide Exposures & Mortalities in Non-target Wildlife

By Ryan Bourbour, Krysta Rogers, Nicholas Shirkey, Brandon Munk, Deana Clifford

With contributions from Wildlife Health Lab staff

PREPARED BY THE WILDLIFE HEALTH LABORAOTRY OF THE CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

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INTRODUCTION

The mission of the California Department of Fish and Wildlife (CDFW) is to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public. As such, a memorandum of understanding (MOU) was developed between the California Department of Pesticide Regulation (CDPR), the County Agriculture Commissioners (CAC), and the CDFW. The purpose of the memorandum is to ensure that pesticides registered in the state of California are used in a manner that protects non-target fish and wildlife resources, while recognizing the need for responsible pest management.

In partial fulfillment of the MOU, this 2024 annual report summarizes documented pesticide exposure and toxicosis in California's fish and wildlife for the respective authorities of CDPR, CAC, and CDFW. These data represent a minimum number of reports for tested animals that died within the reported calendar year and are subject to change as new information becomes available.

DATA COLLECTION & ANALYSIS

The Wildlife Health Laboratory (WHL, formerly the Wildlife Investigations Laboratory) was established in 1941 and is mandated by Fish and Game Code Section 1008 to investigate diseases and problems relating to wildlife. The WHL has accomplished this goal through collaboration with the public and various organizations to record, collect, and submit wildlife mortalities of interest to the WHL for examination and further diagnostics as needed. The WHL continues communication with interested parties as new information is discovered to aid further cooperation in the goal of maintaining healthy wildlife populations throughout California.

Programmatically the WHL is divided into three units which address health issues: 1) avian, 2) big game, 3) small game and non-game species. The avian unit oversees nearly 600 avian species including non-game (e.g., songbirds, raptors, shorebirds, waders, and seabirds) and game species (e.g., doves, pigeons, quail, turkey, and waterfowl). The big game unit primarily oversees black bear, bighorn sheep, deer, elk, pronghorn, and wild pig with shared responsibility of small game, such as tree squirrels, rabbits, and hares. In addition to sharing health surveillance responsibilities with the big game unit, the non-game unit also oversees native non-game mammals, fur bearers, reptiles, and amphibians. This includes a consortium of species such as California tiger salamander, western pond turtles, pika, riparian brush rabbits, skunks, raccoons, foxes, bobcats, mountain lions, and gray wolves.

Wildlife Submissions

Wildlife remains are submitted to the WHL in various ways, primarily by the public – either direct submissions of deceased wildlife to the WHL, submission of living or deceased wildlife to wildlife rehabilitation centers ("rehab"), notification of mortalities to CDFW staff and law enforcement, or other government agency reports (e.g., animal control, sheriff, state and federal Department of Agriculture, U.S. Fish and Wildlife Service, National Park Service, etc.). The WHL also collaborates with academic universities, non-governmental organizations (NGO), and other agencies on statewide population monitoring projects and provides diagnostic support by conducting postmortem examinations. The WHL contracts with the California Animal Health and Food Safety (CAHFS) Laboratory system of the University of California, Davis for further disease and toxicology testing.

Postmortem Examination

Postmortem examinations (necropsies) are performed on wildlife remains at the WHL or the CAHFS Laboratory. If remains cannot be examined within 48 hours of collection, they are stored in a -20°C freezer until an examination can be performed. Prior to necropsy, frozen carcasses are thawed at 4°C or room temperature until they are ready for necropsy. Sex, age class, body condition and, when possible, the cause of death is determined. In addition to necropsy, mortality investigations often include microscopic evaluation of tissues (histology) and ancillary disease and toxicology testing. Tissue samples are collected and placed in 10% formalin for histological evaluation, and a complimentary set of tissues are archived in -20C° freezers until submitted to the CAHFS Laboratory for analysis.

Carcasses in advanced stages of decomposition and autolysis are necropsied but formalin tissues may not be collected or submitted since autolysis can obscure or destroy microscopic lesions. In these cases, necropsies are performed, and tissue samples are collected for toxicology testing to assess pesticide exposure but not necessarily toxicosis.

Anticoagulant Rodenticides: Anticoagulant rodenticides (ARs) are grouped into two categories: 1) first-generation anticoagulant rodenticides (FGARs), which include warfarin (war), coumachlor (cou), diphacinone (diph), and chlorophacinone (chl) and 2) the more toxic second-generation anticoagulant rodenticides (SGARs), which include brodifacoum (brd), bromadiolone (brm), difethialone (dif), and difenacoum (dfn). AR screenings for this report were exclusively conducted on liver tissue samples submitted to CAHFS.

***Non-Anticoagulant Rodenticides & Other Pesticides*:** There are several acutely toxic compounds also used to manage rodent and insect pests, such as bromethalin, strychnine, zinc phosphide, cholecalciferol, organophosphates, and carbamates. Like anticoagulant rodenticides, these compounds, or their metabolites, have been documented in non-target wildlife as a form of mortality or exposure.

Exposure & Toxicosis

Pesticides, including ARs, are not always acutely fatal and there is a high degree of variability among species and individuals in their vulnerability. In the absence of a universal threshold residue concentration value that could indicate AR “toxicosis,” we must also rely on antemortem and/or postmortem evidence of coagulopathy unrelated to another identifiable cause of hemorrhage (e.g., trauma, disease, infection).

Individuals are considered to have AR “exposure” if their livers had detectable levels of one or more AR residues (regardless of concentration, reported in parts per billion or ppb) and lack antemortem and/or postmortem evidence of coagulopathy.

For non-ARs, diagnosing toxicosis requires the detection of the compound in the appropriate tissue sample or gastrointestinal contents, and antemortem and/or postmortem evidence in the absence of another identifiable cause (e.g., disease, infection, trauma).

In some cases, rodenticide residues are detected in the tissue sample, but postmortem evidence could not confirm or exclude toxicosis due to advanced decomposition which precludes a

definitive diagnosis. Therefore, these diagnoses are reported as “suspected” or “undetermined” toxicosis.

It is important to note that exposure in the absence of toxicosis should not be ignored[1]. The uncertainties about the magnitude and drivers of chronic exposure and/or sub-lethal levels of rodenticide exposure demonstrate the need for continued monitoring in wildlife populations. Exposure to ARs may predispose wildlife to excessive hemorrhage (bleeding) following an otherwise non-lethal traumatic injury or increase sensitivity to additional exposure(s)[1].

Additionally, it is important to note that the concentration of ARs quantified in tissue samples does not necessarily equate to risk of toxicosis, as even trace levels (quantities detected below the reporting limit) can be associated with signs of coagulopathy and a toxicosis diagnosis.

Golden Eagle (Aquila chrysaetos) hunting between an orchard and vineyard. Photo: Ryan Bourbour, CDFW

AVIAN SUMMARY

According to CDFW records at the time of this report, 842 birds were submitted to the WHL for necropsy, and/or disease or toxicology testing in calendar year 2024. Avian influenza H5N1 (Eurasian lineage goose/Guangdong H5 clade 2.3.4.4b) continued to impact a diversity of wild birds in California, elsewhere in the United States, and globally. Notably, avian influenza H5N1 was detected for the first time in dairy cattle in California in late August 2024. This, along with the Governor's State of Emergency Proclamation for avian influenza response, increased the demand for avian influenza surveillance testing of wild birds, resulting in an increased number of avian submissions to WHL in the later part of 2024.

Birds were submitted for various reasons by wildlife rehabilitators, members of the public, non-profit organizations, universities, CDFW staff and law enforcement, and other agencies (Table 1). Wildlife rehabilitators made up most submissions, followed by agencies and specifically, CDFW. However, it should be noted that the majority of these reports originated with a member of the public.

It is important to note that raptors (birds of prey) are preferentially selected for AR surveillance. Additionally, birds with signs suspicious for AR exposure or toxicosis are more likely to be included in AR surveillance testing. Individual birds may be suspicious for AR exposure based on clinical signs and/or evidence of unexplained coagulopathy on necropsy. Young birds in good nutritional condition also may be preferentially selected for surveillance testing to help evaluate recent exposure.

Table 1. The total number of wild bird remains submitted to the Wildlife Health Laboratory for necropsy in 2024 based on the primary submitter's affiliation. Many non-public submissions originated as a public report.

Submitter Affiliation	No. Birds Submitted
CDFW	155
NGO/Non-Profit	10
Other Government / Military	32
Private Consultant / Energy	37
Public	21
Rehab / Zoo / Sanctuary	581
University	6
Total	**842**

Anticoagulant Rodenticide Exposure & Toxicosis

Waterfowl and waterbirds (n = 388) accounted for the largest percentage of birds submitted to WHL followed by raptors (n = 292), songbirds (n = 111), and upland game birds (n = 51). Of necropsied birds, 54 were tested for AR exposure. Tested birds represent 39.7% (23/58) of California counties (Figure 1; Table 2). All age classes and sexes were represented in submitted carcasses.

Only raptor species were included in AR surveillance testing in 2024. Twenty-nine of the 54 (53.7%) raptors tested for ARs were exposed to one or more analytes (Figure 1; Table 3). Of the 54 raptors tested for AR exposure, 10 (20.8%) were cases of AR toxicosis (Table 3).

Nineteen of the 54 raptors tested for AR exposure had two or more ARs detected in the liver (Figure 2). Prevalence of exposure to SGARs was 44.4% (24/54) while exposure to FGARs was 29.6% (16/54). Brodifacoum, bromadiolone, and difethialone were the most common SGARs detected in liver samples (Figure 3). Diphacinone and chlorophacinone were the most common FGARs detected in liver samples (Figure 3). Diagnoses of AR toxicosis were associated with varying liver concentration levels including trace detections (Figure 4; Table 4). Detectable FGAR concentration levels ranged from 98 to 230 ppb with 17 detections of trace levels (Table 5). Detectable SGAR concentration levels ranged from 55 to 510 ppb with 38 detections of trace levels (Table 5). None of the birds sampled had detectable levels of exposure to warfarin, difenacoum, or coumachlor in tested liver tissues. Out of the 29 birds exposed to ARs, 69.0% (20/29) were juveniles (<1 year old) or immatures (≤ 4 years old; Table 6). Out of the young birds with AR exposure, 15.0% (3/20) died from suspected or confirmed AR toxicosis (Table 6).

Other Pesticides

Other pesticide-related investigations included one incident involving strychnine bait. Strychnine was detected in Canada geese collected from Contra Costa County in October 2024 where at least two adult geese were found dead in a park pond by a local resident. Milo-seed strychnine bait was present in the gizzards of both geese. The incident was reported to the office of the Contra Costa County Department of Agriculture Weights and Measure, but the location of the application was unable to be determined.

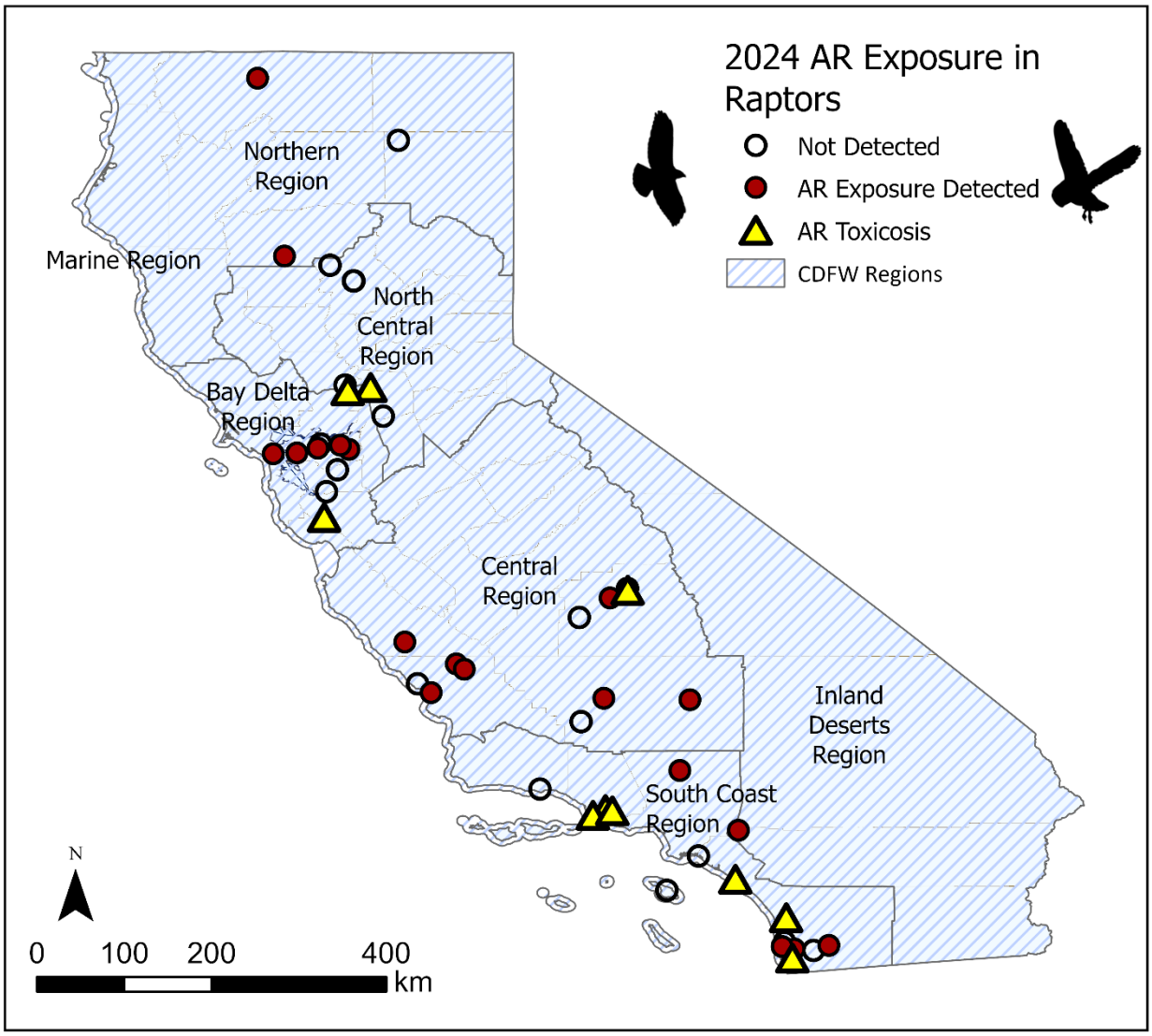

Figure 1. Map of anticoagulant rodenticide (AR) exposures and suspected/confirmed toxicoses in raptors tested in 2024 in California.

Turkey Vulture *(Cathartes aura).* Photo: Ryan Bourbour, CDFW

Red-tailed Hawk *(Buteo jamaicensis).* Photo: Ryan Bourbour, CDFW

Table 2. Anticoagulant rodenticide exposure prevalence and number of suspected/confirmed toxicoses in 54 tested raptors submitted to the Wildlife Health Laboratory in 2024 by county. After postmortem examination, livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

County	No. Birds Tested	No. Birds Exposed	Exposure Prevalence (%)	No. Confirmed or Suspected Toxicosis
Alameda	2	0	0	0
Butte	4	0	0	0
Contra Costa	5	4	80.0	0
Kern	3	2	66.7	0
Lassen	1	0	0	0
Los Angeles	3	1	33.3	0
Marin	1	1	100	0
Monterey	1	1	100	0
Orange	2	1	50.0	1
Riverside	1	0	0	0
Sacramento	1	0	0	0
San Bernardino	1	1	100	0
San Diego	7	5	71.4	2
San Luis Obispo	4	3	75.0	0
Santa Barbara	2	0	0	0
Santa Clara	1	1	100	1
Santa Cruz	1	0	0	0
Siskiyou	1	1	100	0
Solano	1	0	0	0
Tehama	1	1	100	0
Tulare	4	2	50.0	1
Ventura	5	4	80.0	4
Yolo	2	1	50.0	1
Total	**54**	**29**	**53.7**	**10**

Red-shouldered Hawk *(Buteo lineatus).* Photo: Ryan Bourbour, CDFW

Table 3. Anticoagulant rodenticide exposure prevalence and number of suspected/confirmed toxicoses in 54 raptors submitted to the Wildlife Health Laboratory in 2024 by species (common name).

Species	No. Birds Tested	No. Birds Exposed	Exposure Prevalence (%)	No. Confirmed or Suspected Toxicosis
American Goshawk	1	0	0	0
American Kestrel	1	0	0	0
Bald Eagle	2	1	50.0	0
American Barn Owl	7	1	14.3	1
Burrowing Owl	1	0	0	0
Cooper's Hawk	5	3	60.0	0
Great Horned Owl	11	8	72.7	5
Golden Eagle	7	7	100	0
Red-shouldered Hawk	6	5	83.3	3
Red-tailed Hawk	5	2	40.0	0
Swainson's Hawk	2	0	0	0
Turkey Vulture	2	2	100	1
White-tailed Kite	4	0	0	0
Total	**54**	**29**	**53.7**	**10**

Turkey Vultures *(Cathartes aura).* Photo: Ryan Bourbour, CDFW

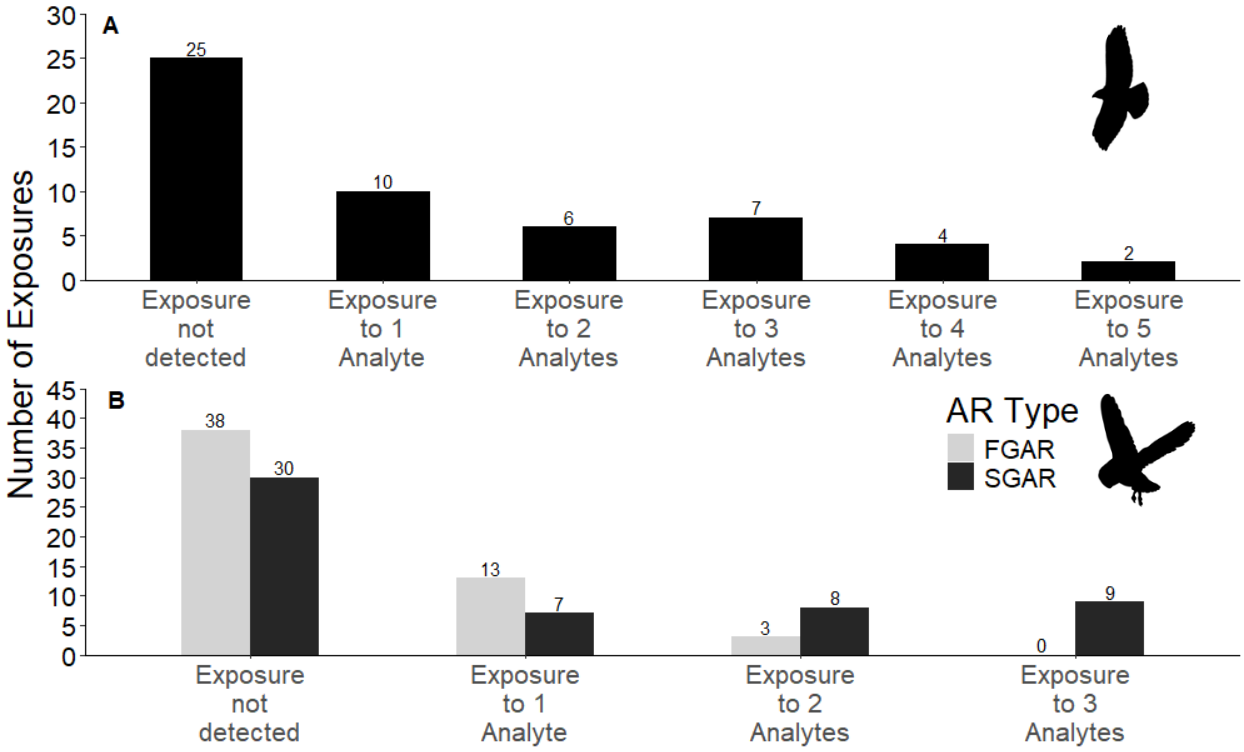

Figure 2. (A) Number of anticoagulant rodenticide (AR) analytes detected in the livers of 54 raptors in 2024. **(B)** Number of AR analytes detected in the livers of 54 raptors separated by first (FGAR) and second (SGAR) generation ARs.

Cooper's Hawk *(Astur cooperii) with tree squirrel prey*. Photo: Ryan Bourbour, CDFW

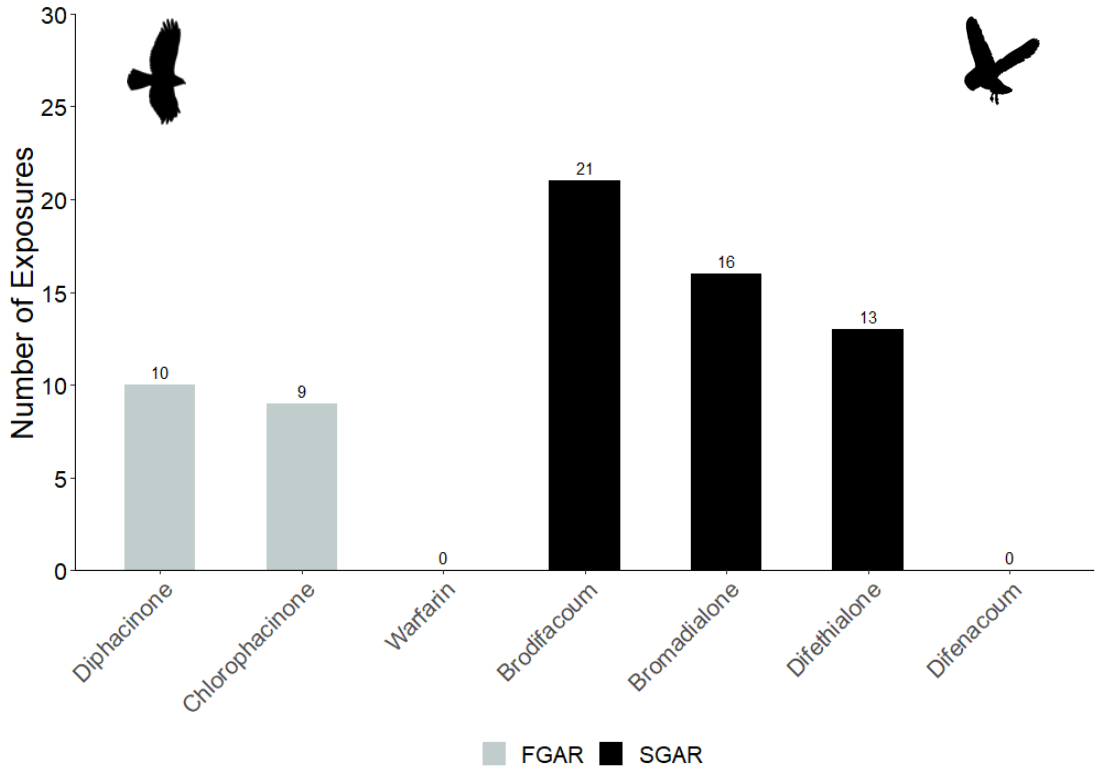

Figure 3. Anticoagulant rodenticide (AR) analytes detected in the livers of 29 of the 54 tested raptors submitted to the Wildlife Health Laboratory in 2024. Analytes are grouped by first (FGAR) and second (SGAR) generation ARs.

Table 4. Ten out of 54 raptors had evidence supporting a diagnosis for anticoagulant rodenticide (AR) toxicosis in 2024. Note that toxicosis can occur at varying levels of AR concentrations for all analytes detected, including trace levels.

Species	Brd (ppb)	Brm (ppb)	Dif (ppb)	Diph (ppb)	Chl (ppb)	Final Diagnosis
American Barn Owl	130	Trace	—	—	—	AR toxicosis
Great Horned Owl	Trace	Trace	Trace	—	—	AR toxicosis suspect
Great Horned Owl	Trace	—	55	Trace	—	AR toxicosis suspect
Great Horned Owl	380	—	Trace	—	—	AR toxicosis
Great Horned Owl	—	71	—	—	Trace	AR toxicosis suspect
Great Horned Owl	170	150	Trace	Trace	230	AR toxicosis
Red-shouldered Hawk	510	Trace	—	—	—	AR toxicosis
Red-shouldered Hawk	—	130	—	Trace	Trace	AR toxicosis
Red-shouldered Hawk	200	Trace	Trace	—	Trace	AR toxicosis
Turkey Vulture	66	Trace	Trace	—	Trace	AR toxicosis suspect

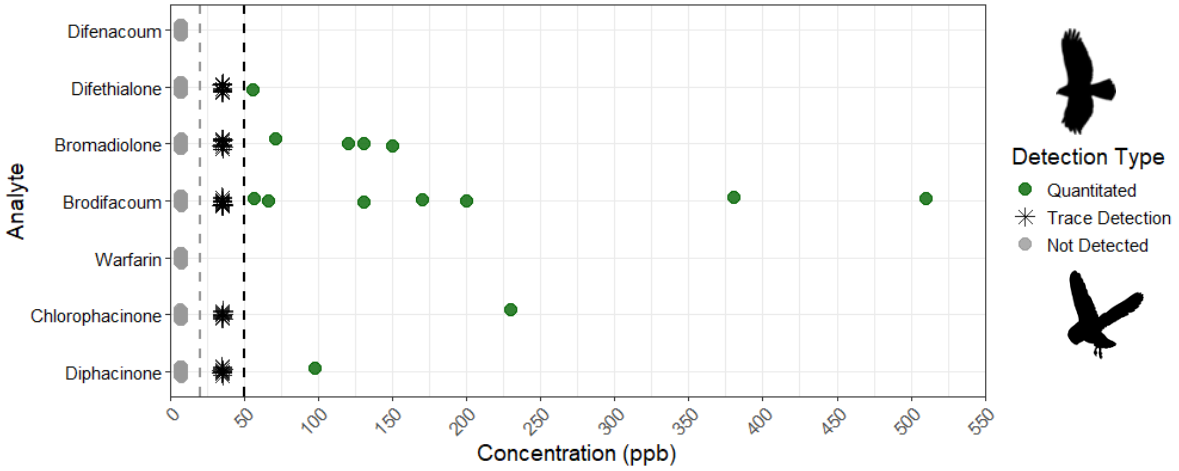

Figure 4. Raw AR concentration (ppb) in the livers of 54 raptors screened for ARs in 2024. Quantitated AR concentrations are represented by green circles. Trace detections (black asterisks) are AR concentrations above the limit of detection (20 ppb) and below the limit of quantitation (50 ppb). Non-detections (gray circles) indicate that AR analytes were not detected in the tested liver sample. The number of trace detections per analyte can be found in Table 5. Note that toxicosis can occur at varying levels of AR concentrations for all analytes detected, including trace levels (Table 5).

Table 5. Summary of anticoagulant rodenticide (AR) liver concentrations (ppb) detected in the 29 raptors that tested positive for AR exposure in 2024. Trace represents detections of concentrations above the limit of detection (20 ppb) and below the limit of quantitation (50 ppb).

AR Type	Analyte	Range (ppb)	No. of Trace Detections
FGAR	Diphacinone (n=10)	Trace – 98	9
	Chlorophacinone (n=9)	Trace – 230	8
SGAR	Brodifacoum (n=21)	Trace – 510	14
	Bromadiolone (n=16)	Trace – 150	12
	Difethialone (n=13)	Trace – 55	12

Great Horned Owl *(Bubo virginianus).* Photo: Ryan Bourbour, CDFW

Table 6. Number of FGAR and SGAR analytes found in the livers of the 29 raptors with AR exposure submitted in 2024 by species, county, sex, age class, and cause of death. All SGAR detections are probable exposures after implementation of AB1788's restrictions on SGAR-use in California. Note: hatch-year (HY) and nestling birds are <1 year old, second-year (SY) birds are 1-2 years old, third-year (TY) birds are 2-3 years old, and immature birds are 2-4 years old. Sex includes female (F), male (M), and undetermined (U).

Species	County	Sex	Age Class	No. FGARs	No. SGARs	Cause of Death
American Barn Owl	Ventura	F	Adult	0	2	**AR toxicosis**
Bald Eagle	Monterey	M	Immature	1	0	Trauma
Cooper's Hawk	Contra Costa	F	TY	0	1	Trauma
Cooper's Hawk	Los Angeles	F	TY	0	1	Trauma
Cooper's Hawk	San Bernardino	U	Nestling	1	0	Nutritional
Golden Eagle	Kern	M	SY	0	1	Trauma
Golden Eagle	San Luis Obispo	F	SY	1	0	Trauma
Golden Eagle	San Luis Obispo	M	Nestling	1	0	Trauma
Golden Eagle	San Luis Obispo	M	Immature	0	1	Trauma
Golden Eagle	Siskiyou	M	Immature	0	2	Trauma
Golden Eagle	Tehama	M	Immature	1	2	Trauma
Golden Eagle	Tulare	F	Immature	0	2	Trauma
Great Horned Owl	Contra Costa	M	Adult	0	3	Trauma
Great Horned Owl	Contra Costa	M	HY	1	3	Trauma
Great Horned Owl	Marin	F	HY	1	2	Trauma
Great Horned Owl	Orange	F	Adult	0	3	**AR toxicosis suspect**
Great Horned Owl	Tulare	F	Adult	1	2	**AR toxicosis suspect**
Great Horned Owl	Ventura	M	Adult	0	2	**AR toxicosis**
Great Horned Owl	Ventura	M	Nestling	1	1	**AR toxicosis suspect**
Great Horned Owl	Ventura	M	Adult	2	3	**AR toxicosis**
Red-shouldered Hawk	Kern	F	Adult	0	3	Trauma
Red-shouldered Hawk	San Diego	M	Nestling	2	1	**AR toxicosis**
Red-shouldered Hawk	San Diego	M	HY	2	3	Undetermined
Red-shouldered Hawk	San Diego	M	HY	1	3	**AR toxicosis**
Red-shouldered Hawk	Yolo	F	Adult	0	2	**AR toxicosis**
Red-tailed Hawk	San Diego	F	Nestling	0	1	Orphan
Red-tailed Hawk	San Diego	F	HY	1	0	Orphan
Turkey Vulture	Contra Costa	F	HY	1	3	Trauma
Turkey Vulture	Santa Clara	F	Adult	1	3	**AR toxicosis suspect**

Red-shouldered Hawk (*Buteo lineatus*). Photo: Ryan Bourbour, CDFW

American Black Bear *(Ursus americanus)* sow and cub. Photo: CDFW Sentinel Sites for Nature

BIG GAME SUMMARY

The remains and/or tissues of 21 American black bears were submitted to the WHL for necropsy or testing in 2024.

Approximately 95.2% (20/21) of the black bear carcasses were submitted by the CDFW; one submission came from another government agency (Table 7). However, it should be noted that public reports represent the original source for most CDFW submissions.

Table 7. Total number of black bear tissues or remains submitted to the Wildlife Health Laboratory in 2024 based on the primary submitter's affiliation. Many submissions that are non-public originated as a public report.

Submitter Affiliation	No. Big Game Mammals (Black Bears) Tested
CDFW	20
Other Government Agency	1
Total	**21**

Anticoagulant Rodenticide Exposure

Of necropsied black bears, 15 were tested for AR exposure. Tested black bears were submitted from 10 of the 58 counties in California (Figure 5; Table 8).

Ten of the 15 black bears (66.7%) tested positive for AR exposure. Of the 15 black bears tested, two (13.3%) were exposed to one AR, one (6.7%) was exposed to two ARs, three (20%) were exposed to

three ARs, three (20%) were exposed to four ARs, and one (6.7%) black bear was exposed to five ARs (Figure 6).

Bromadiolone was the most common analyte detected in tested liver samples (Figure 7). Coumachlor and difenacoum were not detected in any of the tested liver samples in 2024.

Of the 10 black bears that tested positive for ARs, 8 were exposed to one or more SGARs: brodifacoum (n=5 bears); bromadiolone (n=7 bears), and difethialone (n=6 bears). Eight black bears tested positive for one or more FGARs: diphacinone (n=6 bears), chlorophacinone (n=4 bears), and warfarin (n=2 bears). SGAR concentrations in liver tissue ranged from trace to 670 ppb and FGAR concentrations in liver tissue ranged from trace to 1,500 ppb (Figure 8; Table 10).

None of the 10 exposures were diagnosed as suspected or confirmed cases of anticoagulant rodenticide toxicosis.

Bromethalin Exposure & Other Pesticides

Adipose, brain, or liver tissue from 16 black bears from 10 California counties were tested for exposure to the neurotoxic rodenticide, bromethalin (Table 10). Of the one case where bromethalin was detected, concurrent exposure to ARs was also detected (Figure 5; Table 12). To investigate possible exposure to cholinesterase-inhibiting pesticides (i.e., organophosphates, carbamates), acetylcholinesterase activity was measured for one bear from Tuolumne County; the levels were within normal limits. One bear from Inyo County was screened for organophosphate and carbamate compounds; the test was negative.

Table 8. Anticoagulant rodenticide exposure prevalence and number of suspected/confirmed toxicoses in 15 tested wild black bears submitted to the Wildlife Health Laboratory in 2024 by county.

County	No. Big Game Tested	No. Big Game Exposed	Exposure Prevalence (%)	No. Confirmed or Suspected Toxicosis
Calaveras	1	0	0	0
El Dorado	2	2	100	0
Inyo	1	0	0	0
Los Angeles	4	4	100	0
Mono	1	0	0	0
Napa	1	0	0	0
Nevada	1	1	100	0
Placer	2	2	100	0
Plumas	1	1	100	0
Tuolumne	1	0	0	0
Total	**15**	**10**	**66.7**	**0**

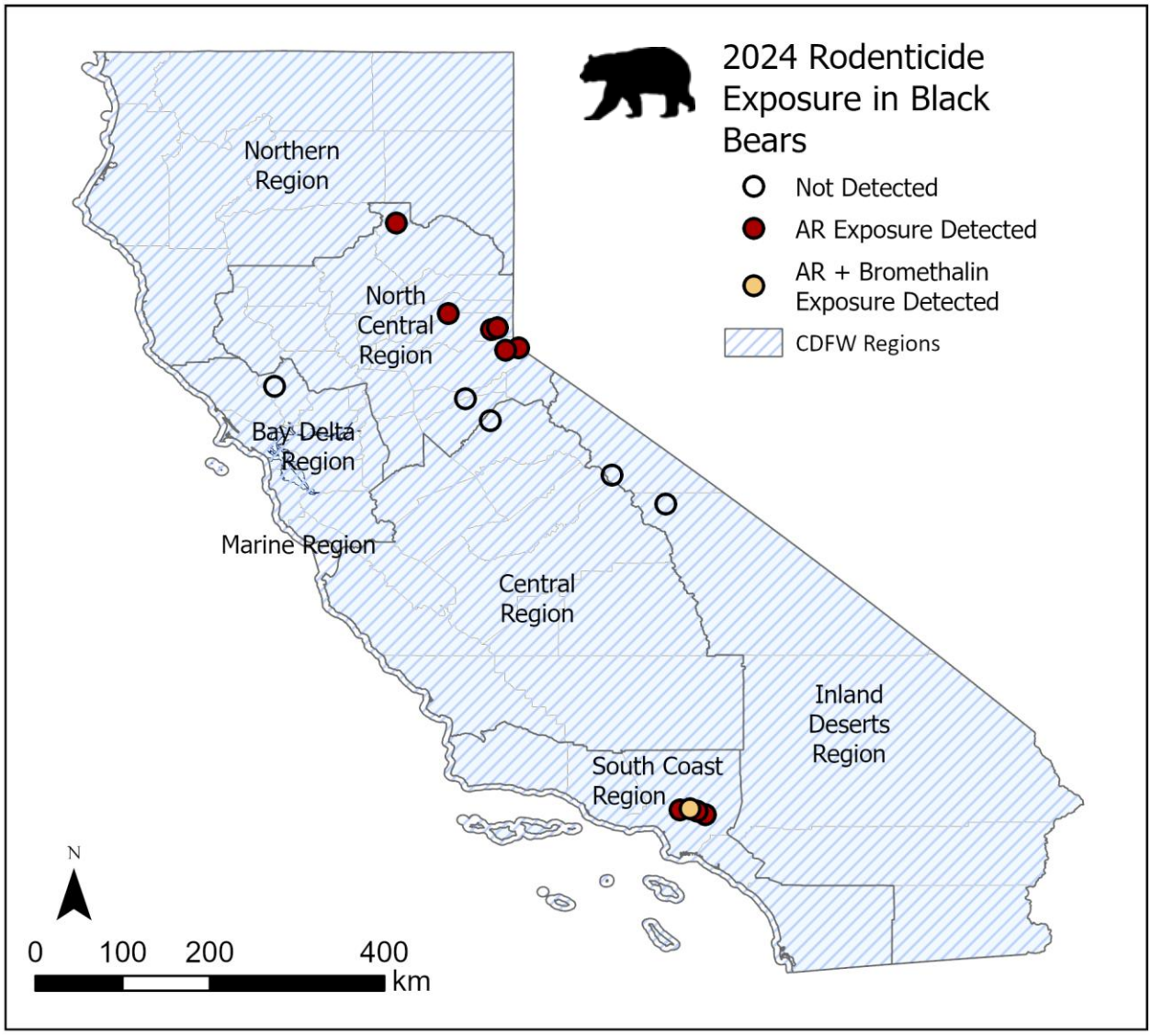

Figure 5. Map of anticoagulant rodenticide (AR) and bromethalin exposures in American black bears tested in 2024.

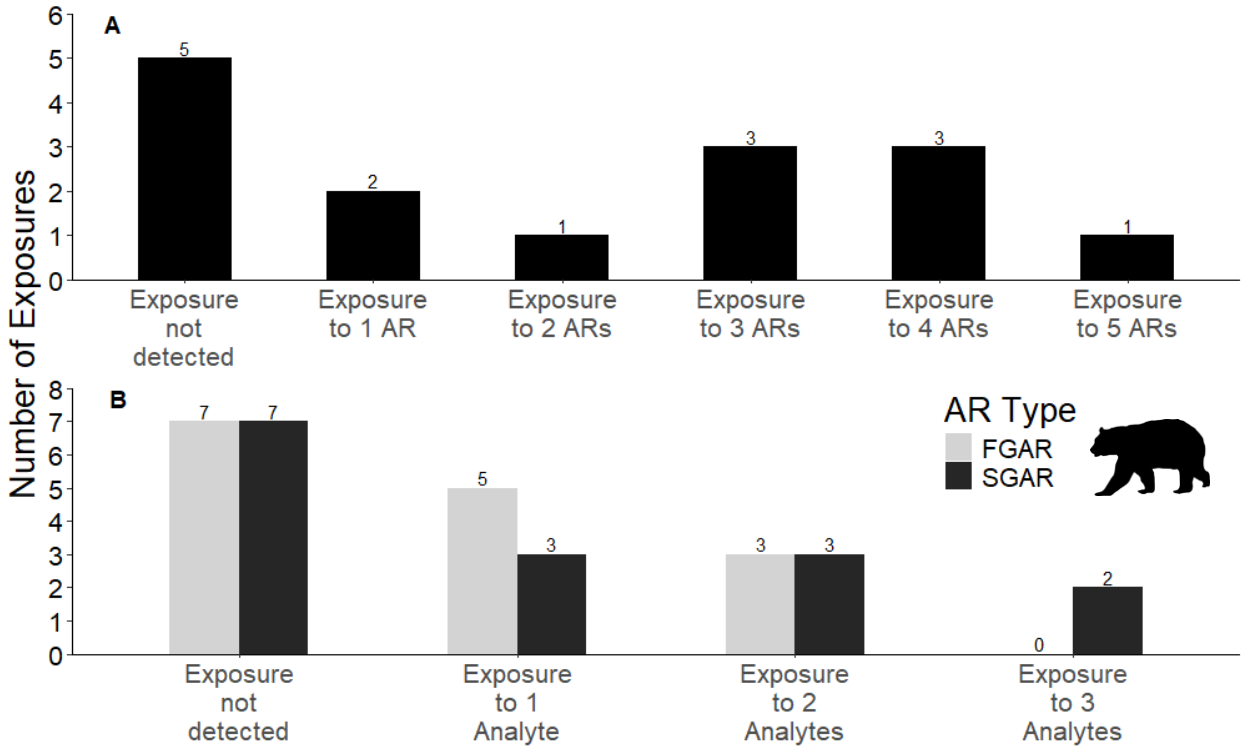

Figure 6. **(A)** Number of anticoagulant rodenticide (AR) analytes detected in the livers of 15 black bears in 2024. **(B)** Number of AR analytes detected in the livers of 15 black bears separated by first (FGAR) and second (SGAR) generation ARs.

American Black Bear *(Ursus americanus).* Photo: CDFW Sentinel Sites for Nature

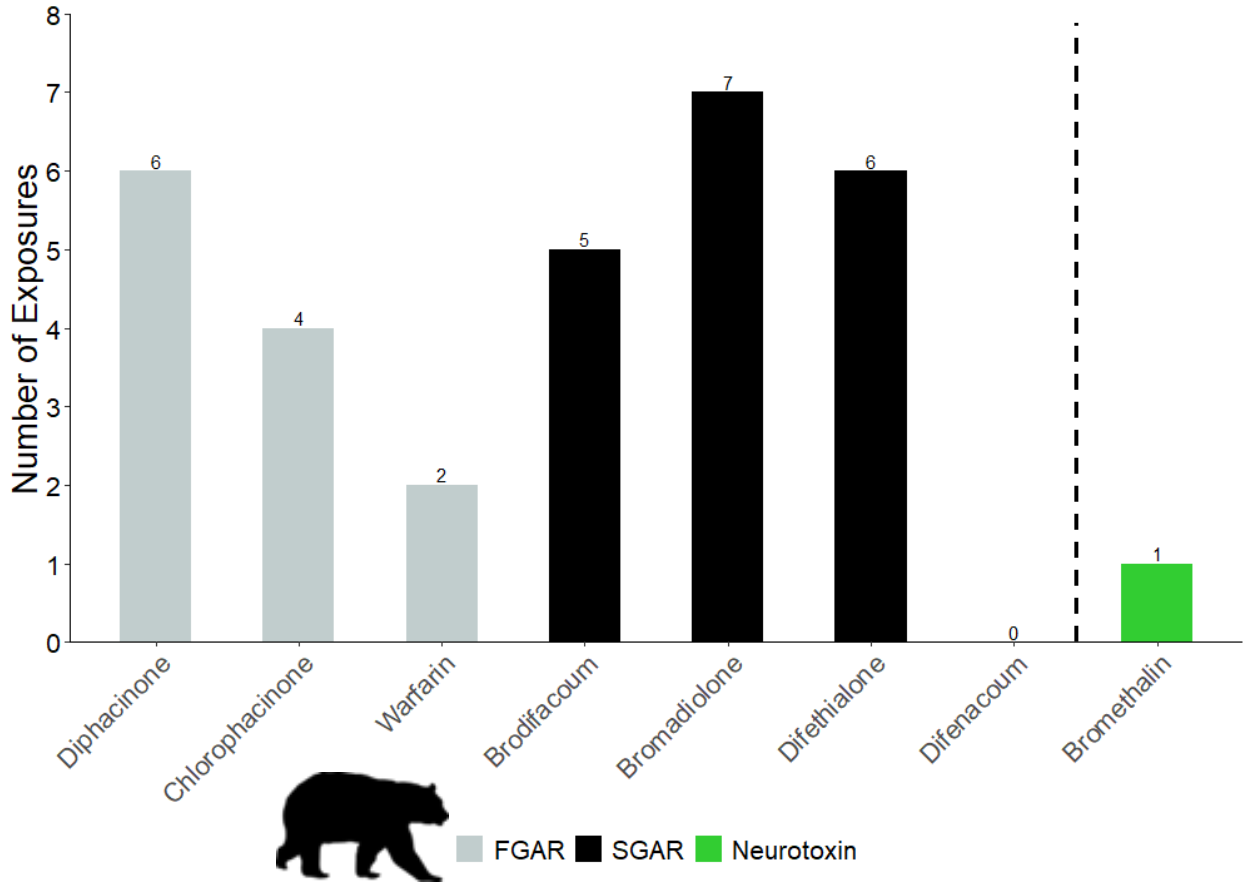

Figure 7. Anticoagulant rodenticide (AR) analytes detected in the livers of 10 of the 15 tested black bears submitted to the Wildlife Health Laboratory in 2024. Right of the vertical dashed line are the number of bromethalin detections in the 16 wild black bears tested for exposure. Analytes are grouped by first (FGAR) and second (SGAR) generation ARs and neurotoxin (bromethalin).

Table 10. Summary of anticoagulant rodenticide (AR) liver concentrations (ppb) detected in the 10 black bears that tested positive for AR exposure in 2024. Trace represents detections of concentrations above the limit of detection (20 ppb) and below the limit of quantitation (50 ppb).

AR Type	Analyte	Range (ppb)	No. of Trace Detections
FGAR	Diphacinone (n=6)	Trace – 890	1
	Chlorophacinone (n=4)	Trace – 1,500	2
	Warfarin (n=2)	Trace – 69	1
SGAR	Brodifacoum (n=5)	Trace – 670	4
	Bromadiolone (n=7)	Trace – 560	4
	Difethialone (n=6)	Trace – 180	3

American Black Bear (Ursus americanus). Photo: CDFW Sentinel Sites for Nature

Table 11. Bromethalin exposure in 16 wild black bears submitted to the Wildlife Health Laboratory in 2024 by county. Adipose, brain, or liver were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

County	No. Big Game Tested	No. Big Game Exposed	Exposure Prevalence (%)	No. Confirmed or Suspected Toxicosis
Calaveras	1	0	0	0
El Dorado	2	0	0	0
Inyo	1	0	0	0
Los Angeles	4	1	25.0	0
Mono	2	0	0	0
Napa	1	0	0	0
Nevada	1	0	0	0
Placer	2	0	0	0
Plumas	1	0	0	0
Tuolumne	1	0	0	0
Total	**16**	**1**	**6.25**	**0**

Table 12. Number of FGAR and SGAR analytes and bromethalin exposure detected in 10 wild black bears submitted to the Wildlife Health Laboratory in 2024. Note: 2nd Year bears are aged between 1-2 years old; Sub-adult bears are aged between 2-3 years old; Adult bears are aged >4 years old.

			AR Exposure		
County	**Sex**	**Age Class**	**No. FGARs**	**No. SGARS**	**Bromethalin Exposure**
El Dorado	Male	2nd Year	1	1	–
El Dorado	Unknown	Adult	2	3	–
Los Angeles	Female	Adult	0	3	–
Los Angeles	Female	Adult	1	2	Yes
Los Angeles	Female	Adult	2	2	–
Los Angeles	Male	Sub-adult	1	0	–
Mono	Male	Adult	Not Tested	Not Tested	–
Nevada	Female	Sub-adult	0	1	–
Placer	Female	2nd Year	1	1	–
Placer	Unknown	2nd Year	2	2	–
Plumas	Male	Sub-adult	1	0	–

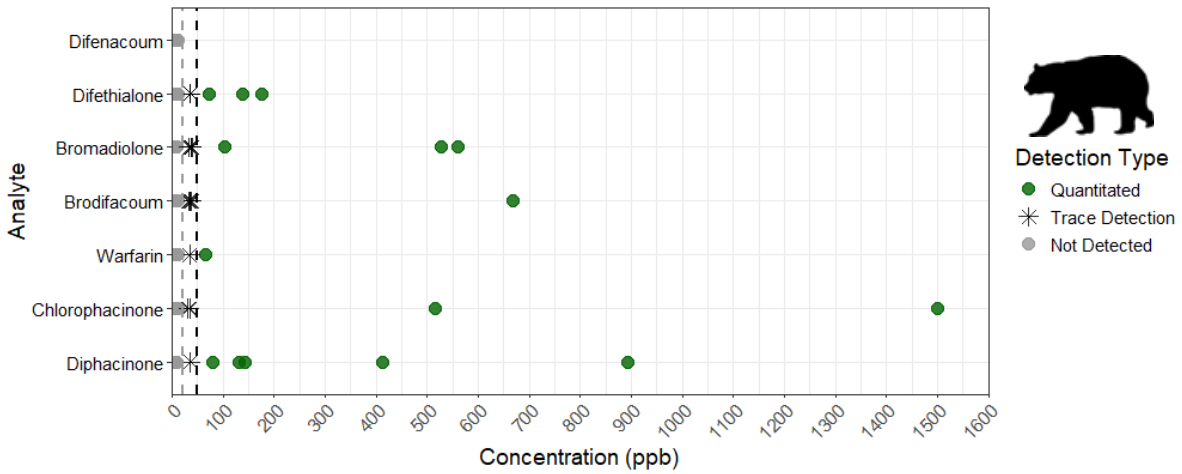

Figure 8. Raw anticoagulant rodenticide (AR) concentrations (ppb) in the livers of 15 black bears tested for ARs in 2024. Quantitated AR concentrations are represented by green circles. Trace detections (black asterisks) are AR concentrations above the limit of detection (20 ppb) and below the limit of quantitation (50 ppb). Non-detections (gray circles) indicate that AR analytes were not detected in the tested liver sample. The number of trace detections per analyte can be found in Table 10.

Mountain Lion *(Puma concolor)* family. *Photo: CDFW Sentinel Sites for Nature*

SMALL GAME & NON-GAME SUMMARY

In 2024, 186 small- and non-game wildlife were submitted to the WHL for necropsy, disease testing, and/or toxicological screening. Small game and non-game animals were submitted for various reasons by wildlife rehabilitators, members of the public, non-profit organizations, universities, CDFW staff and law enforcement, and other agencies. Submissions from CDFW made up 43.5% (81/186) of total records, followed by 28.5% (53/186) submitted from wildlife rehabilitators (Table 13). Similar to other species, most reports originated from members of the public. Pesticide screening was not performed on any amphibians or reptiles in 2024.

Table 13. Total number of small- and non-game animal tissues or remains submitted to the Wildlife Health Laboratory in 2024 based on the primary submitter's affiliation. Many submissions that are non-public originated as a public report.

Submitter Affiliation	No. of Small and Non-game Animals Submitted
CDFW	81
Wildlife Rehabilitation Center	53
Public	19
Other Government Agency	13
NGO/Non-Profit	10
Private Biological Consultant	5
University Affiliate	4
Other	1
Total	**186**

Anticoagulant Rodenticide Exposure

Of necropsied small- and non-game wildlife, 97 were tested for anticoagulant rodenticide (AR) exposure. Sampled remains with final reports represent 58.6% (34/58) of California counties in 2024 (Table 14). All age classes and sexes were represented.

Mountain lions accounted for the largest percentage (42.3%; 41/97) of non-game mammal samples submitted to the WHL for necropsy and toxicology (Table 15). In total, 77.3% (75/97) of non-game mammals tested had exposure to one or more AR (Figure 9) and 54.6% (53/97) had exposure to two or more ARs regardless of first- or second generation (Figure 10). Two mountain lions from Ventura and San Diego counties tested positive for six different ARs. Twelve animals had exposure to five AR compounds (Figure 10), including mountain lions (n=6), bobcats (n=2), coyotes (n=2), raccoon (n=1), and gray fox (n=1). In 2024, there were four confirmed or suspected AR toxicosis cases involving two raccoons from Orange and Contra Costa Counties, a coyote from Riverside County, and a San Joaquin kit fox from Kern County (a state and federally endangered species).

Brodifacoum, bromadiolone, and diphacinone were the most common analytes detected in liver samples (Figure 11). Analytes detected in liver tissues were quantitated at a wide range of concentrations, including trace levels (Figure 12; Table 16). None of the tested non-game samples in 2024 had detectable levels of exposure to coumachlor or difenacoum.

Coyote *(Canis latrans).* Photo: CDFW Sentinel Sites for Nature

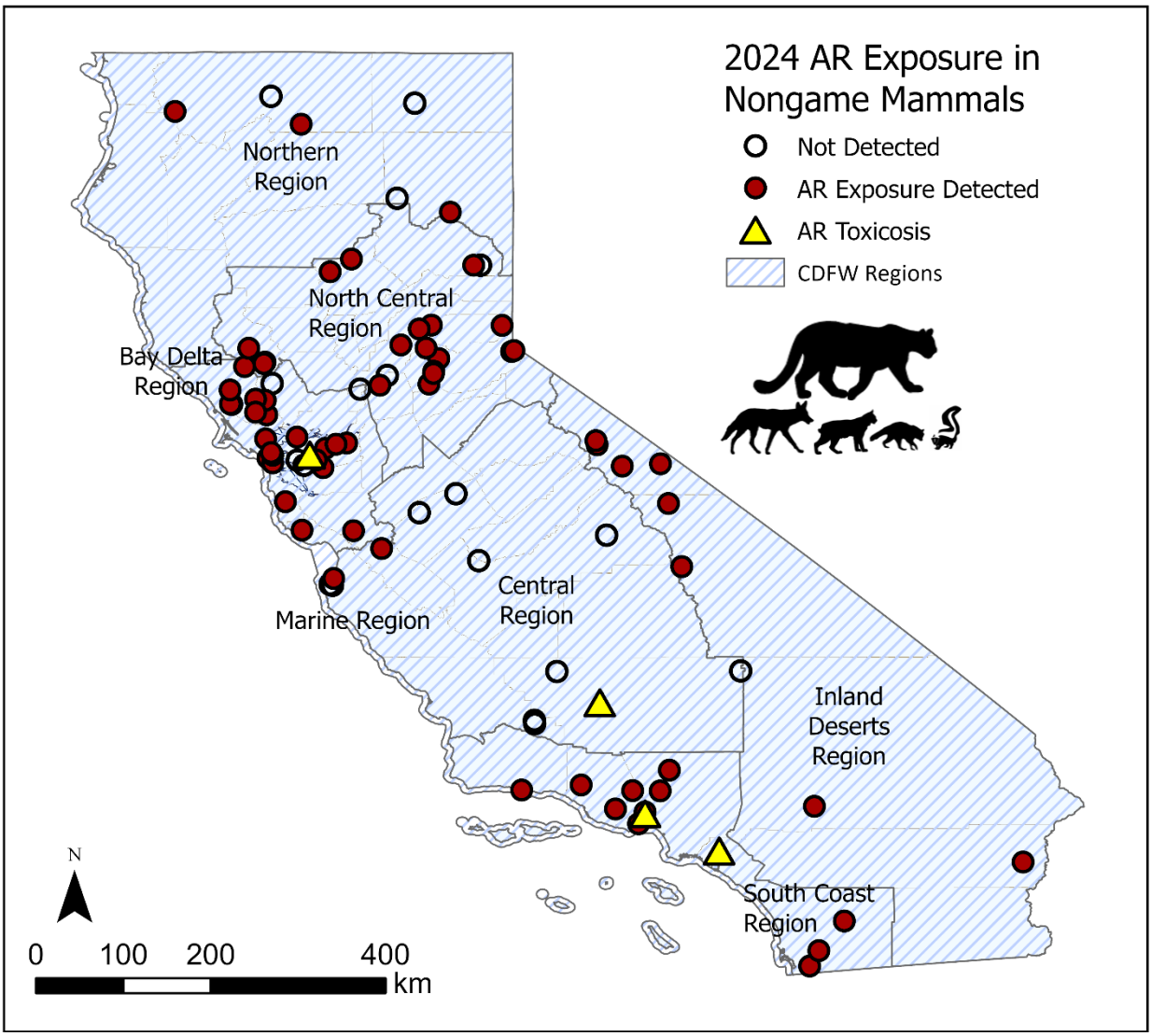

Figure 9. Map of anticoagulant rodenticide (AR) exposures and suspected/confirmed toxicoses in non-game mammals tested in 2024 in California.

Bobcat (Lynx rufus). Photo: CDFW Sentinel Sites for Nature

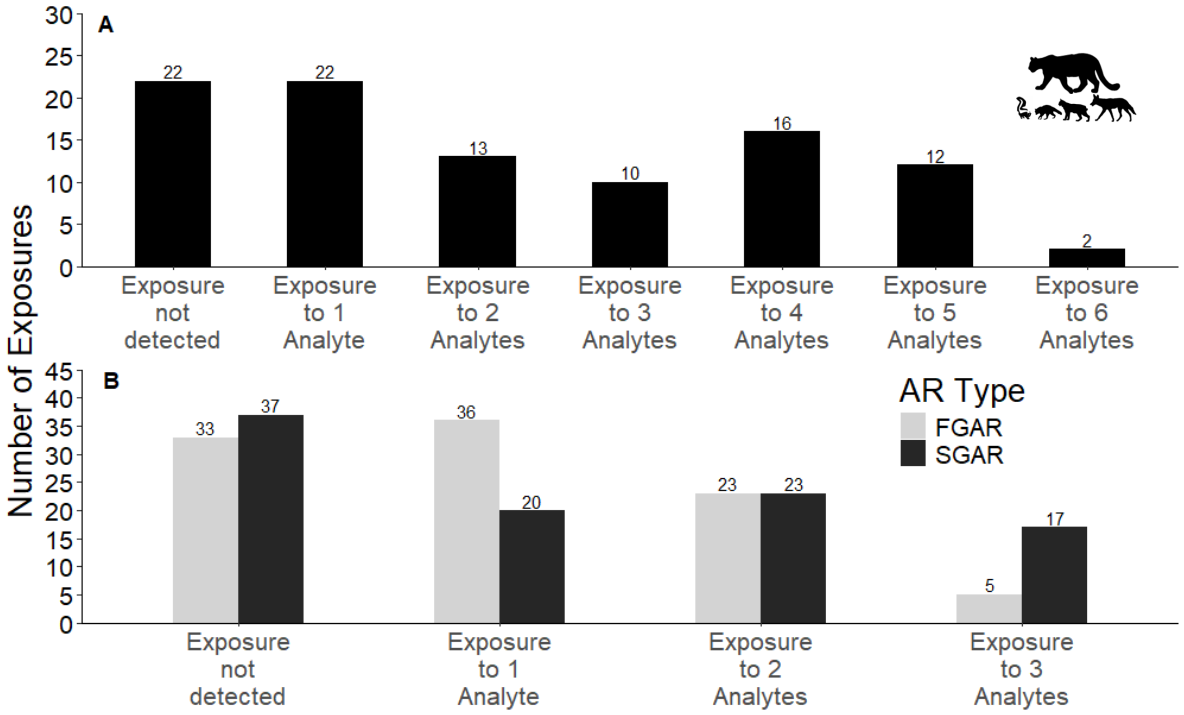

Figure 10. **(A)** Number of anticoagulant rodenticide (AR) analytes detected in the livers of 97 non-game mammals in 2024. **(B)** Number of AR analytes detected in the livers of 97 non-game mammals separated by first (FGAR) and second (SGAR) generation ARs in 2024.

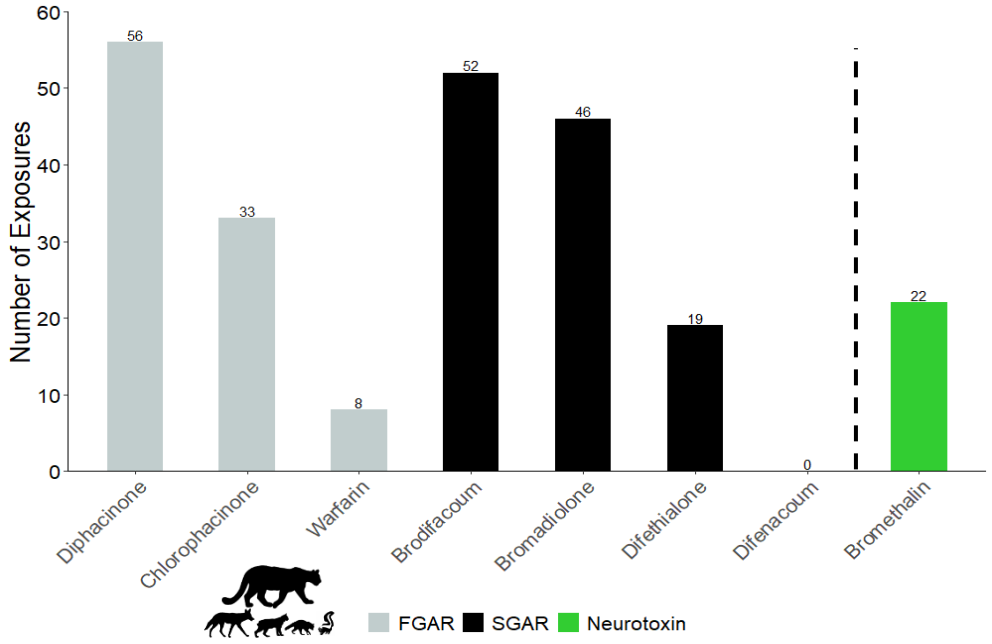

Figure 11. *Left of dashed line*: AR analytes detected in the livers of 75 of the 97 tested non-game mammals submitted to the Wildlife Health Laboratory in 2024. *Right of dashed line*: Bromethalin exposure detected in 22 of 84 wild non-game mammals tested in 2024. Each bar displays number of exposures at the top. Analytes are grouped by first (FGAR) and second (SGAR) generation ARs and neurotoxin (bromethalin).

Table 14. Exposure prevalence and number of suspected/confirmed toxicosis cases of anticoagulant rodenticides in 97 tested wild non-game animals submitted to the Wildlife Health Laboratory in 2024 by California county.

County	No. Non-game Tested	No. Non-game Exposed	Exposure Prevalence (%)	No. Toxicosis
Alameda	3	0	0	0
Butte	2	2	100	0
Contra Costa	7	7	100	1
El Dorado	6	6	100	0
Fresno	3	1	33.3	0
Inyo	2	2	100	0
Kern	3	1	33.3	1
Lake	3	3	100	0
Lassen	2	1	50.0	0
Los Angeles	4	4	100	0
Marin	4	4	100	0
Merced	2	0	0	0
Modoc	3	2	66.7	0
Mono	4	4	100	0
Monterey	4	2	50.0	0
Napa	1	0	0	0
Nevada	1	1	100	0
Orange	1	1	100	1
Placer	4	4	100	0
Plumas	2	1	50.0	0
Riverside	3	3	100	1
Sacramento	3	1	33.3	0
San Benito	1	1	100	0
San Bernardino	2	2	100	0
San Diego	3	3	100	0
San Francisco	1	1	100	0
San Luis Obispo	2	0	0	0
San Mateo	1	1	100	0
Santa Barbara	1	1	100	0
Santa Clara	1	1	100	0
Santa Cruz	1	1	100	0
Siskiyou	3	2	66.7	0
Sonoma	9	7	77.8	0
Ventura	5	5	100	0
Total	**97**	**75**	**77.3**	**4**

Table 15. Exposure prevalence and number of suspected/confirmed toxicosis cases of anticoagulant rodenticides in 97 wild non-game mammals submitted to the Wildlife Health Laboratory in 2024 by species (common name).

Species	No. Tested	No. Exposed	Exposure Prevalence (%)	No. FGARs Detected	No. SGARs Detected	No. Toxicosis
Mountain Lion	41	39	95.1	56	57	0
Raccoon	12	10	83.3	12	14	2
Coyote	6	6	100	10	15	1
Gray Fox	6	5	83.3	8	8	0
American River Otter	4	2	50.0	0	4	0
Bobcat	4	3	75.0	7	7	0
Pacific Fisher	2	2	100	1	3	0
Nutria	3	0	0	0	0	0
Long-tailed Weasel	2	1	50.0	1	2	0
Red Fox	2	2	100	0	3	0
Virginia Opossum	2	1	50.0	0	1	0
Giant Kangaroo Rat	2	0	0	0	0	0
Eastern Fox Squirrel	2	0	0	0	0	0
Desert Kit Fox	1	1	100	0	1	0
Striped Skunk	1	1	100	0	1	0
Sierra Nevada Red Fox	1	0	0	0	0	0
Gray Wolf	1	0	0	0	0	0
Tipton's Kangaroo Rat	1	0	0	0	0	0
Pacific Marten	1	0	0	0	0	0
North American Porcupine	1	0	0	0	0	0
San Joaquin Kit Fox	1	1	100	1	0	1
California Ringtail	1	1	100	1	1	0
Total	**97**	**75**	**77.3**	**97**	**117**	**4**

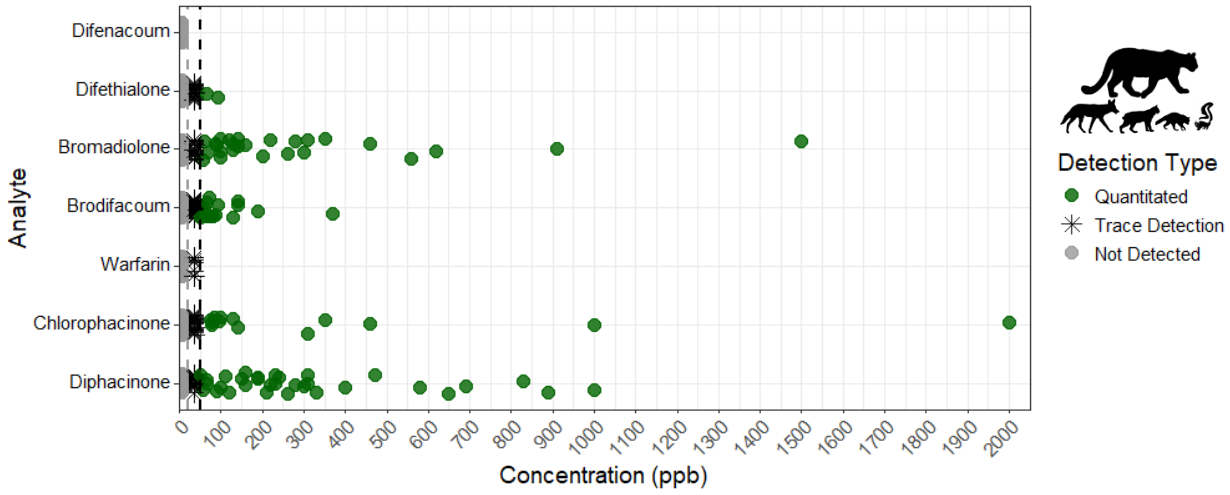

Figure 12. Raw anticoagulant rodenticide (AR) concentrations (ppb) in the livers of 97 non-game mammals tested for ARs in 2024. Quantitated AR concentrations are represented by green circles. Trace detections (black asterisks) are AR concentrations above the limit of detection (20 ppb) and below the limit of quantitation (50 ppb). Non-detections (gray circles) indicate that AR analytes were not detected in the tested liver sample. The number of trace detections per analyte can be found in Table 16.

Table 16. Anticoagulant rodenticide (AR) concentrations (ppb) and number of trace detections in the livers of non-game mammals submitted to the Wildlife Health Laboratory in 2024. Trace represents detections of concentrations above the limit of detection (20 ppb) and below the limit of quantitation (50 ppb).

AR Type	Analyte	Range (ppb)	No. of Trace Detections
FGAR	Diphacinone (n=56)	Trace – 1,000	24
	Chlorophacinone (n=33)	Trace – 2,000	20
	Warfarin (n=8)	Trace	8
SGAR	Brodifacoum (n=52)	Trace – 370	37
	Bromadiolone (n=46)	Trace – 1,500	20
	Difethialone (n=19)	Trace – 94	17

Coyote *(Canis latrans)*. Photo: Ryan Bourbour, CDFW

Bromethalin Exposure

Adipose, brain, or liver tissue from 84 animals across 31 counties were tested for exposure to the neurotoxic rodenticide, bromethalin (Figure 13; Table 17). Twenty-two out of 84 (26.1%) non-game wildlife tested positive for exposure to bromethalin (Table 18). These exposures resulted in four cases of suspected or confirmed toxicosis (Table 17; Table 18).

All 22 non-game wildlife that tested positive for bromethalin exposure were also screened for anticoagulant rodenticide (AR) exposure. Twenty-one out of 22 (95.5%) non-target wildlife were concurrently exposed to both bromethalin and to one or more ARs. Concurrent exposures for all ages are summarized in Tables 19 and 20.

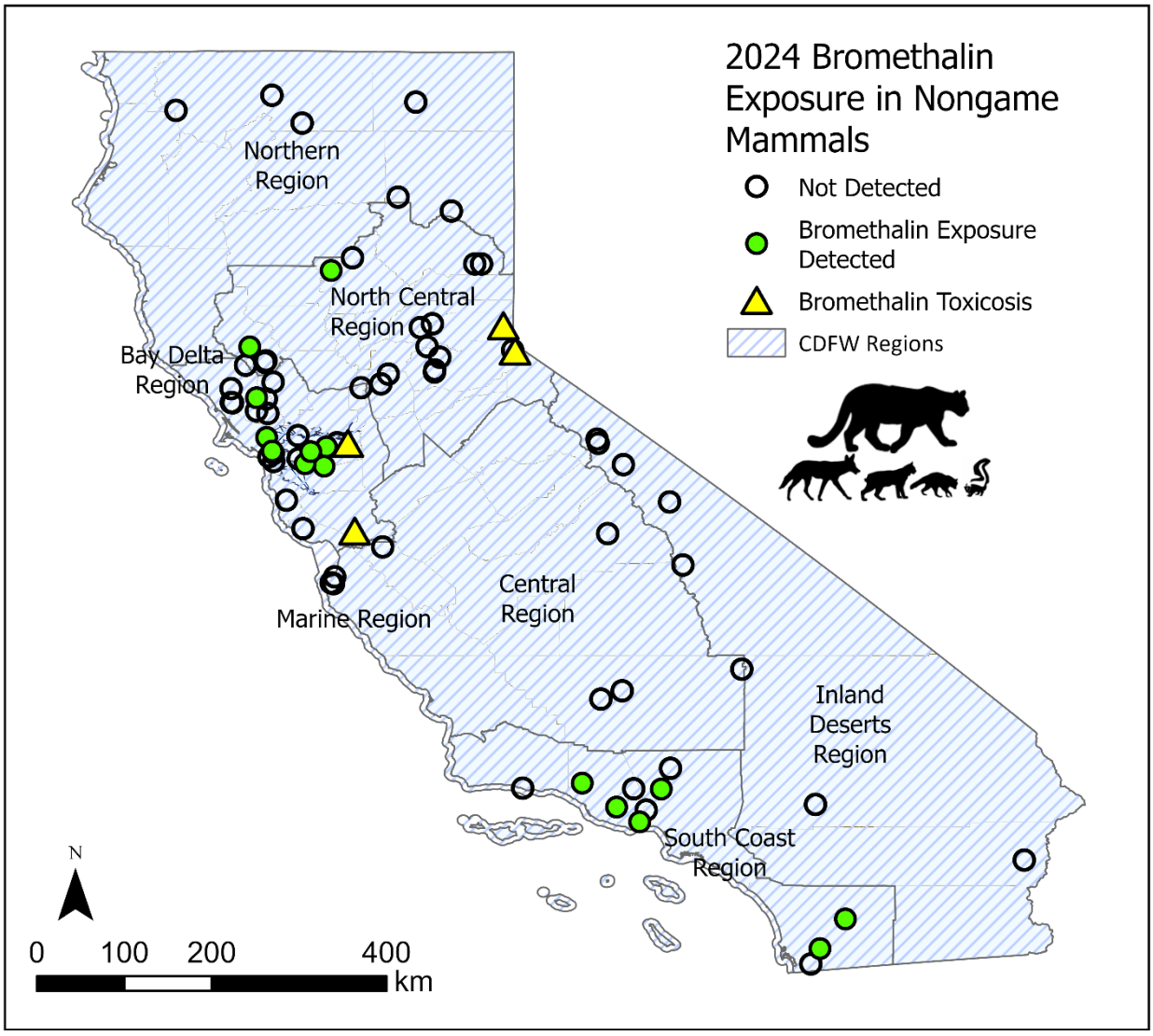

Figure 13. Map of bromethalin exposures and suspected/confirmed toxicoses in non-game mammals tested in 2024. Twenty-one of the 22 animals (95.5%) with bromethalin exposure also had confirmed exposure to one or more anticoagulant rodenticides in 2024.

Table 17. Bromethalin exposures by county. Bromethalin was detected in 22 of the 84 non-game mammals investigated by the Wildlife Health Laboratory in 2024. Twenty-one of the 22 individuals that were exposed to bromethalin were also exposed to one or more anticoagulant rodenticides.

County	No. Tested	No. Exposed	Exposure Prevalence (%)	Confirmed/Suspected Toxicosis
Alameda	2	1	50.0	0
Butte	2	1	50	0
Contra Costa	7	4	57.1	1
El Dorado	5	1	20.0	1
Fresno	2	0	0	0
Inyo	2	0	0	0
Kern	3	0	0	0
Lake	3	1	33.3	0
Lassen	2	0	0	0
Los Angeles	4	2	50.0	0
Marin	4	3	75.0	0
Modoc	3	0	0	0
Mono	3	0	0	0
Monterey	4	0	0	0
Napa	1	0	0	0
Nevada	1	0	0	0
Placer	3	1	33.3	1
Plumas	2	0	0	0
Riverside	1	0	0	0
Sacramento	3	0	0	0
San Benito	1	0	0	0
San Bernardino	2	0	0	0
San Diego	3	2	66.7	0
San Francisco	1	0	0	0
San Mateo	1	0	0.0	0
Santa Barbara	1	0	0	0
Santa Clara	1	1	100	1
Santa Cruz	1	0	0	0
Siskiyou	3	0	0	0
Sonoma	9	2	22.2	0
Ventura	4	3	75.0	0
Total	**84**	**22**	**26.1**	**4**

Table 18. Bromethalin exposures by non-game species (common names). Bromethalin was detected in 22 of the 84 wild non-game mammals investigated by the Wildlife Health Laboratory in 2024 by species. Of the 85 non-game mammals tested for bromethalin, 83 were also screened for anticoagulant rodenticides (ARs). Twenty-one of the 22 individuals that were exposed to bromethalin were also exposed to ARs (concurrent exposure). Adipose, brain, or liver were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

Species	No. Tested	No. Bromethalin Exposures	Exposure Prevalence (%)	Confirmed/Suspect Toxicosis	Concurrent Exposure to Bromethalin & ARs
Mountain Lion	38	6	15.8	0	6
Raccoon	11	10	90.9	4	9
Gray Fox	6	2	33.3	0	2
American River Otter	5	0	0	0	0
Coyote	5	2	40.0	0	2
Pacific Fisher	4	0	0	0	0
Red Fox	2	1	50.0	0	1
Virginia Opossum	2	0	0	0	0
Long-tailed Weasel	2	0	0	0	0
Bobcat	2	1	50.0	0	1
Striped Skunk	1	0	0	0	0
San Joaquin Kit Fox	1	0	0	0	0
Pacific Marten	1	0	0	0	0
Desert Kit Fox	1	0	0	0	0
Sierra Nevada Red Fox	1	0	0	0	0
Desert Cottontail	1	0	0	0	0
Gray Wolf	1	0	0	0	0
California Ringtail	1	0	0	0	0
Eastern Fox Squirrel	1	0	0	0	0
North American Porcupine	1	0	0	0	0
Total	**84**	**22**	**26.2**	**4**	**21**

Table 19. Number of FGAR and SGAR analytes and bromethalin exposure detected in 26 young non-game mammals submitted to the Wildlife Health Laboratory in 2024. SGAR exposures occurred after the implementation of AB1788. *****Represents suspected/confirmed bromethalin toxicosis case. Sex: female (F) and male (M).

Species	County	Sex	Age Class	No. FGAR Detected	No. SGAR Detected	Bromethalin Detected
Coyote	Riverside	M	Juvenile (<1 year)	1	3	not tested
Gray Fox	Marin	F	Yearling (1 year)	2	3	Yes
Gray Fox	Nevada	F	Juvenile (<1 year)	1	0	–
Gray Fox	Ventura	M	Juvenile (<1 year)	1	1	Yes
Mountain Lion	El Dorado	F	Pup/Cub (<1 year)	1	0	–
Mountain Lion	El Dorado	M	Sub-adult (<2 years)	1	0	–
Mountain Lion	Fresno	M	Pup/Cub (<1 year)	2	0	–
Mountain Lion	Inyo	F	Sub-adult (<2 years)	1	1	–
Mountain Lion	Lake	F	Juvenile (<1 year)	1	0	–
Mountain Lion	Lake	F	Pup/Cub (<1 year)	2	1	–
Mountain Lion	Los Angeles	M	Juvenile (<1 year)	2	2	Yes
Mountain Lion	Los Angeles	M	Pup/Cub (<1 year)	1	0	–
Mountain Lion	Placer	M	Sub-adult (<2 years)	1	2	–
Mountain Lion	Placer	M	Sub-adult (<2 years)	1	1	–
Mountain Lion	San Diego	M	Juvenile (<1 year)	3	3	Yes
Mountain Lion	Siskiyou	F	Sub-adult (<2 years)	1	0	–
Mountain Lion	Sonoma	M	Pup/Cub (<1 year)	1	0	–
Mountain Lion	Sonoma	F	Pup/Cub (<1 year)	1	0	–
Mountain Lion	Ventura	M	Sub-adult (<2 years)	3	3	–
Raccoon	Contra Costa	F	Juvenile (<1 year)	2	2	Yes*
Raccoon	Contra Costa	F	Pup/Cub (<1 year)	1	1	Yes
Raccoon	El Dorado	M	Juvenile (<1 year)	2	3	Yes*
Raccoon	Orange	M	Juvenile (<1 year)	1	0	not tested
Raccoon	Placer	F	Juvenile (<1 year)	2	2	Yes*
Red Fox	Mono	M	Yearling (1 year)	0	2	–
San Joaquin Kit Fox	Kern	M	Yearling (1 year)	1	0	–

Table 20. Number of FGAR and SGAR analytes and bromethalin exposure detected in 49 adult non-game mammals submitted in 2024. SGAR exposures likely occurred after the implementation of AB1788. *****Represents suspected/confirmed bromethalin toxicosis. Sex: female (F) and male (M).

Species	County	Sex	Age Class	No. FGAR Detected	No. SGAR Detected	Bromethalin Detected
Bobcat	Lake	F	Adult	3	2	Yes
Bobcat	Riverside	M	Adult	2	2	not tested
Bobcat	Ventura	M	Adult	2	3	not tested
Coyote	Butte	M	Adult	1	2	Yes
Coyote	Los Angeles	M	Adult	2	2	–
Coyote	Marin	F	Adult	2	3	–
Coyote	Marin	M	Adult	2	3	Yes
Coyote	Santa Barbara	F	Adult	2	2	–
Desert Kit Fox	Riverside	F	Adult	0	1	–
Fisher	Siskiyou	M	Adult	0	1	–
Fisher	Butte	F	Adult	1	2	–
Gray Fox	Contra Costa	M	Adult	2	2	–
Gray Fox	Sacramento	M	Adult	2	2	–
Long-tailed weasel	San Diego	M	Adult	1	2	–
Mountain Lion	El Dorado	M	Adult	1	2	not tested
Mountain Lion	El Dorado	M	Adult	1	1	–
Mountain Lion	Inyo	M	Adult	1	2	–
Mountain Lion	Lassen	F	Adult	3	1	–
Mountain Lion	Los Angeles	F	Adult	2	3	Yes
Mountain Lion	Modoc	F	Adult	1	0	–
Mountain Lion	Modoc	F	Adult	1	0	–
Mountain Lion	Mono	F	Adult	1	1	not tested
Mountain Lion	Mono	M	Adult	1	1	–
Mountain Lion	Mono	F	Adult	0	2	–
Mountain Lion	Monterey	M	Adult	0	1	–
Mountain Lion	Placer	M	Adult	2	2	not tested
Mountain Lion	Plumas	M	Adult	1	3	–
Mountain Lion	San Benito	M	Adult	1	0	–
Mountain Lion	San Bernardino	F	Adult	2	2	–
Mountain Lion	San Bernardino	F	Adult	2	3	–
Mountain Lion	San Diego	F	Adult	1	3	Yes
Mountain Lion	San Mateo	M	Adult	2	3	–
Mountain Lion	Santa Cruz	F	Adult	1	2	–
Mountain Lion	Sonoma	F	Adult	3	2	–
Mountain Lion	Sonoma	F	Adult	1	2	–
Mountain Lion	Sonoma	F	Adult	2	3	Yes
Mountain Lion	Sonoma	M	Adult	2	2	–
Mountain Lion	Ventura	F	Adult	2	3	Yes

Table 20 Continued:

Species	County	Sex	Age Class	No. FGAR Detected	No. SGAR Detected	Bromethalin Detected
Raccoon	Contra Costa	F	Adult	1	1	Yes
Raccoon	Contra Costa	U	Adult	1	1	Yes
Raccoon	Marin	M	Adult	1	3	Yes
Raccoon	San Francisco	U	Adult	1	0	–
Raccoon	Santa Clara	F	Adult	0	1	Yes*
Red Fox	Ventura	M	Adult	0	1	Yes
Ringtail	Sonoma	M	Adult	1	1	–
River Otter	Contra Costa	F	Adult	0	1	–
River Otter	El Dorado	F	Adult	0	3	–
Striped Skunk	Contra Costa	F	Adult	0	1	–
Virginia Opossum	Monterey	F	Adult	0	1	–

Other Pesticide Surveillance

When warranted, small- and non-game wildlife were tested for additional pesticides, including organophosphates and carbamates, neonicotinoids, pyrethroids, and other compounds.

In January 2024, CDFW was notified about a mass mortality event of monarch butterflies (*Danaus plexippus plexippus*) occurring on a property neighboring the Pacific Grove Monarch Sanctuary in Monterey County. Community science volunteers collected and submitted ten butterflies for pesticide residue analysis at the U.S. Geological Survey's Organic Chemistry Research Laboratory in Sacramento, California. The results revealed the butterflies were exposed to an average of seven pesticides. The pyrethroid bifenthrin and cypermethrin were detected in each tested butterfly, and permethrin was detected in 8 of 10 tested butterflies. All three pyrethroids were detected at concentrations at or near levels of clinical significance (i.e., LD_{50} levels). Details and results from the incident are published and accessible in the journal of Environmental Toxicology and Chemistry[2].

In February 2024, volunteers with the California Bumble Bee Atlas, a community science project administered by the Xerces Society for Invertebrate Conservation, reported a bee mortality event to CDFW occurring in Ventura County. The affected bees were exhibiting clinical signs suspected to be from pesticide poisoning, including twitching and repeatedly everting of the tongue before death. CDFW coordinated sample collection and toxicology screenings of six bumblebees (all *Bombus* species) with the U.S. Geological Survey's Organic Chemistry Research Laboratory in Sacramento, California. Pesticide residues were detected in two of the six bumble bees tested. Bifenthrin (3.8 ng/g) and tetramethrin (23.0 ng/g) were detected in one individual, and bifenthrin (5.7 ng/g) and propiconazole (78.9 ng/g) were detected in another individual. While exposure to pesticide residues was confirmed in two individual bumble bees, the cause of the observed mass mortality event remained inconclusive.

In December 2024, CDFW was notified about a mass mortality event of bumble bees (*Bombus spp.*) observed at the University of California San Diego campus. The WHL received specimens collected at the scene and submitted samples to CAHFS for non-targeted mass spectrometry tests (GC/MS & LC/MS) and a neonicotinoid screening on a pooled sample of bumble bees. The neonicotinoid screening yielded a positive detection for dinotefuran exposure, which is known to be toxic to bees. The LC/MS test yielded a positive result for the ionophore lasalocid, a compound commonly used as anticoccidials in livestock; however, this compound is thought to be an incidental finding for this case. CDFW reported these results to the San Diego County Agricultural Commissioner's Office for further investigation.

In August of 2024, the WHL was notified about a fish mortality event at Lake Gregory in San Bernardino County. Dissolved oxygen at the site was measured at 2.73-3.67 mg/L and fish tested for cyanobacteria yielded a negative result. Four tule perch (*Hysterocarpus traski*) were submitted to the WHL. Pooled viscera, gills, and brain tissue were tested using GC/MS and LC/MS mass spectrometry. The GC/MS screen detected the compounds homosalate and oxybenzene, common UV filter ingredients in sunscreen products. The LC/MS screen detected nicotine. All compounds detected in the tested sample are suspected to be incidental to the cause of death for the fish.

In October of 2024, the WHL investigated a report of a coyote that was observed staggering then deceased in Marin County. The postmortem findings revealed that the coyote had signs of ethylene glycol intoxication (i.e., antifreeze poisoning). In the kidneys, there was evidence of acute tubular degeneration and necrosis in association with oxalate crystals and elevated kidney calcium levels. Oxalate crystals were also observed in the brain tissue. Additionally, the coyote tested positive for exposure to five anticoagulant rodenticides (brodifacoum, bromadiolone, difethialone, diphacinone, and chlorophacinone) and the neurotoxic rodenticide bromethalin.

Mountain Lion *(Puma concolor).* Photo: CDFW Sentinel Sites for Nature

RECENT WILDLIFE-RODENTICIDE LEGISLATION AND NON-TARGET WILDLIFE EXPOSURES

Since 2020, the state of California has passed a series of laws that place statewide moratoriums on AR-use with exemptions for public health, agriculture, and conservation efforts to protect threatened or endangered species: The Ecosystem Protection Act of 2020 (AB1788) placed a moratorium on all SGARs, The California Ecosystem Protection Act of 2023 expanded the moratorium by adding the FGAR diphacinone[3], and The Poison-Free Wildlife Act of 2024 further expanded the moratorium to include the remaining FGARs (chlorophacinone and warfarin). These laws were enacted with intentions to limit AR exposures and impacts to non-target wildlife species and remain in effect until the CDPR completes the reevaluation process and adopts mitigation strategies that can reduce ecological risks. Although current AR surveillance efforts have species, spatial, and diagnostic biases (e.g., AR screenings typically done on suspected AR exposure cases), recent CDFW surveillance data indicate AR exposures and toxicoses continue to be documented in wildlife mortality investigations across California (Table 21).[4,5,6,7]

In 2024, AR exposure was detected at various concentrations in 68.7% (114/166) of non-target wildlife tested (Figure 14; Table 21). Despite the long-half lives of SGARs, which may persist in liver tissues for upwards of 6–12 months and potentially longer (i.e., brodifacoum can have a half-life of approximately 350 days in liver tissues[8]), exposures detected in 2024 were most likely related to use after AB1788 was implemented (January 1, 2021). Furthermore, diphacinone detections in wildlife born in 2024 were most likely related to use after AB1322 was implemented (January 1, 2024); although, maternal transfer of ARs to young has been documented in mammals.[9]

Table 21. Summary of anticoagulant rodenticide (AR) exposure and toxicosis rates in non-target wildlife from CDFW WHL Annual Reports 2020–2024[4,5,6,7]. The % Toxicosis represents the percentage of cases diagnoses as a confirmed or suspected AR toxicoses out of the total number of confirmed AR exposures for the corresponding year.

Year	Total Submitted to WHL	Total Tested for ARs	Total Exposed to ARs	% Exposed to ARs	Total Toxicosis	% Toxicosis
2020	1,040	159	108	67.9	24	22.2
2021	1,020	250	175	70.0	19	10.9
2022	1,543	158	128	81.0	18	14.1
2023	1,250	128	92	71.9	11	12.0
2024	1,044	166	114	68.7	14	12.3

Burrowing Owls *(Athene cunicularia)* in Imperial County. Photo: Ryan Bourbour, CDFW

Table 22. Anticoagulant rodenticide (AR) concentrations (ppb) and number of trace detections in the livers of all non-target wildlife species across programs submitted to the Wildlife Health Laboratory in 2024. Trace represents detections of concentrations above the limit of detection (20 ppb) and below the limit of quantitation (50 ppb).

AR Type	Analyte	Range (ppb)	No. of Trace Detections
FGAR	Diphacinone (n=72)	Trace – 1,000	34
	Chlorophacinone (n=46)	Trace – 2,000	30
	Warfarin (n=10)	Trace – 69	9
SGAR	Brodifacoum (n=78)	Trace – 670	55
	Bromadiolone (n=69)	Trace – 1,500	36
	Difethialone (n=38)	Trace – 180	32

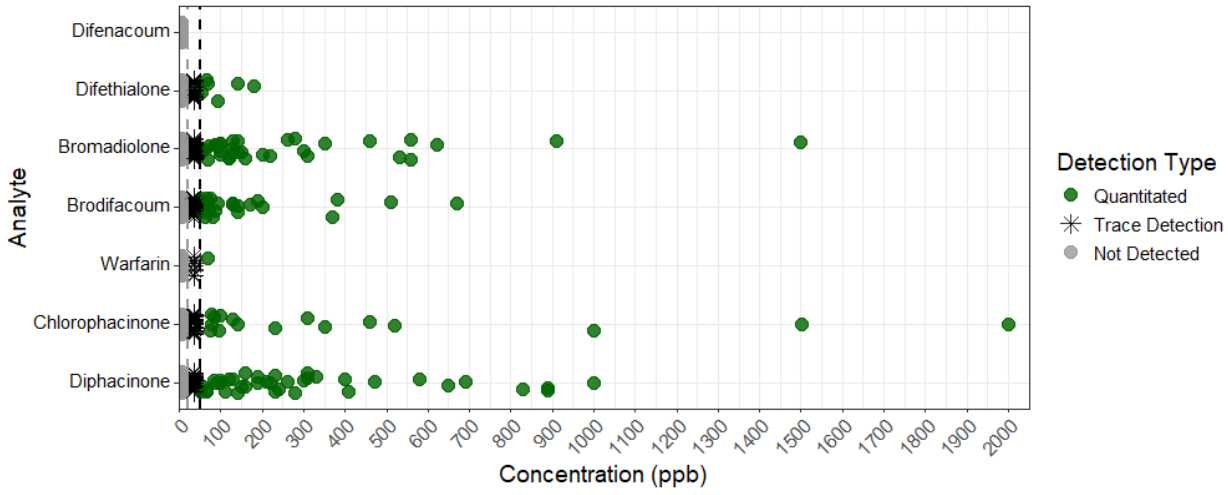

Figure 14. Raw anticoagulant rodenticide (AR) concentrations (ppb) in the livers of 166 non-target wildlife species tested for ARs in 2024. Quantitated (green circles) are AR concentrations above the reporting limit of 50 ppb. Trace detections (black asterisks) are AR concentrations above the limit of detection (20 ppb) and below the limit of quantitation (50 ppb). Non-detections (gray circles) indicate that AR analytes were not detected in the tested liver sample. The number of trace detections per analyte can be found in Table 22.

Surveillance of bromethalin following anticoagulant rodenticide legislation

Bromethalin exposure is an emerging wildlife health concern that has followed the increased restrictions on ARs in the United States beginning in 2008 and recent restrictions in California beginning in 2020.[2,10,11] Legislation enacted to mitigate negative adverse impacts of ARs in non-target wildlife populations may unintentionally result in widespread use of AR alternatives, such as bromethalin.[11,12] Currently, ecological risk assessments on non-target bromethalin exposure and toxicity remain data deficient for wildlife species outside of controlled studies or feeding trials.[13,14] In the scientific literature, bromethalin exposures and toxicoses have increasingly been documented for non-target species, such as companion animals and wildlife throughout the food web in North America, including apex predators.[9 - 11,15 – 17] Lastly, CDFW surveillance data has also indicated potential risks of bromethalin exposure and toxicosis across multiple species [4-7] (Tables 11,12, 18–20).

Cooper's Hawk *(Astur cooperii)* with rat prey in city canopy. Photo: Ryan Bourbour, CDFW

REFERENCES

1. van den Brink, N.W., Elliott, J.E., Shore, R.F., & Rattner, B.A. (2018). Anticoagulant rodenticides and wildlife. Springer, Cham.

2. Cibotti, S., Hladik, M. L., May, E., Pelton, E., Bargar, T. A., Johnston, N., & Code, A. (2025). Pyrethroid insecticides implicated in mass mortality of monarch butterflies at an overwintering site in California. Environmental Toxicology and Chemistry, vgaf163. https://doi.org/10.1093/etojnl/vgaf163

3. Duarte, E. O. (2024). A Regulatory Update on Rodenticides for California Applicators. In Proceedings of the Vertebrate Pest Conference (Vol. 31, No. 31).

4. California Department of Fish and Wildlife. (2021). The 2020 Summary of Pesticide Exposures & Mortalities in Non-target Wildlife. California Department of Fish and Wildlife, Wildlife Health Laboratory Annual Report.

5. California Department of Fish and Wildlife. (2022). The 2021 Summary of Pesticide Exposures & Mortalities in Non-target Wildlife. California Department of Fish and Wildlife, Wildlife Health Laboratory Annual Report.

6. California Department of Fish and Wildlife. (2023). The 2022 Summary of Pesticide Exposures & Mortalities in Non-target Wildlife. California Department of Fish and Wildlife, Wildlife Health Laboratory Annual Report.

7. California Department of Fish and Wildlife. (2024). The 2023 Summary of Pesticide Exposures & Mortalities in Non-target Wildlife. California Department of Fish and Wildlife, Wildlife Health Laboratory Annual Report.

8. Horak, K. E., Fisher, P. M., & Hopkins, B. (2018). Pharmacokinetics of anticoagulant rodenticides in target and non-target organisms. Anticoagulant rodenticides and wildlife, 87-108.

9. Rudd, J. L., Poppenga, R. H., Woods, L. W., Riley, S. P., Sikich, J. A., Streitenberger, N., & Clifford, D. L. (2024). Detection of rodenticides in pregnant mountain lions (*Puma concolor*) and their fetuses in California. *Canadian Wildlife Biology & Management*, *13*(2).

10. McMillin, S., Piazza, M. S., Woods, L. W., & Poppenga, R. H. (2016). New rodenticide on the block: Diagnosing bromethalin intoxication in wildlife. In Proceedings of the Vertebrate Pest Conference (Vol. 27, No. 27).

11. Klainbart, S., Pérez-López, M., Filigenzi, M. S., Poppenga, R. H. (2025). Bromethalin Exposure in Dogs and Cats: A 14-Year Retrospective Study (2010–2023) From the California Animal Health and Food Safety Laboratory System. Journal of Veterinary Internal Medicine, 39: e70057.

12. Feldman, R., Stanton, M., Borys, D., Kostic, M., & Gummin, D. (2019). Medical outcomes of bromethalin rodenticide exposures reported to US poison centers after federal restriction of anticoagulants. Clinical Toxicology, 57: 1109-1114.

13. U.S. EPA. (2024) Rodenticides: Final Biological Evaluation and Effects Determinations for Federally Endangered and Threatened Species and Designated Critical Habitats. Environmental Protection Agency. Available at https://www.regulations.gov/document/EPA-HQ-OPP-2023-0567-0116.

14. USDA. (2025). Chapter XXXII: Use of Bromethalin in Wildlife Damage Management. Human Health and Ecological Risk Assessment for the Use of Wildlife Damage Management Methods by United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services. https://www.aphis.usda.gov/sites/default/files/32-bromethalin.pdf. Accessed (accessed 12 June 2025).

15. Cox, S. L., Stevens, B., & Reggeti, F. (2022). Bromethalin exposure in a free-ranging American black bear (*Ursus americanus*). The Journal of Wildlife Diseases, 58: 235-237.

16. Murray, M., & Cox, E. C. (2023a). Active metabolite of the neurotoxic rodenticide bromethalin along with anticoagulant rodenticides detected in birds of prey in the northeastern United States. Environmental Pollution, 333: 122076.

17. Murray, M., & Cox, E. C. (2023b). Bromethalin Exposure and Possible Toxicosis in a Bald Eagle (*Haliaeetus leucocephalus*). The Journal of Wildlife Diseases, 59: 815-817.

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