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**REVIEW OF THE NECROPSY STUDIES
BY THE U.S. FISH AND WILDLIFE SERVICE
ON ANIMALS FROM THE ROCKY MOUNTAIN ARSENAL**

Over the past five years, the U.S. Fish and Wildlife Service (USFWS) has recorded 244 instances of wildlife mortality at the Rocky Mountain Arsenal (RMA). Since 1990, records of these animal mortalities have been kept in the form of a document entitled the Special Purpose Salvage Log (SPSL). This log is intended not only to describe animal mortalities, but is also used to record incidents related to morbidity and trauma. The dead or moribund animals acquired by the USFWS are referred to as, "Fortuitous Samples".

Recently, USFWS personnel have summarized the fortuitous samples collected on the RMA site between 1989 and 1993. This summary indicates that a total of 192 bird samples were collected during this period, of which 66 were birds of prey, and 126 were birds of other species. Nine of the 192 birds were reported as alive, and referred for rehabilitation, 7 specimens were reported as mounted, 35 birds were indicated as being archived, 126 birds were reported to have been discarded for various reasons, and 24 birds were allegedly submitted for necropsy. If the 9 referred for rehabilitation are excluded, the sum of these categories equals the reported total of birds collected on the RMA during this period. Remarkably, of the total of 192 fortuitous specimens collected between 1989 and 1993, only one bird was reported to have been submitted for organochlorine chemical residue analysis.

A second category of fortuitous samples are mammals collected at the RMA. A total of 52 mammals were reported as having been collected between 1989 and 1993. Of this total, 32 specimens were reported as having been discarded for various reasons, 9 indicated as having been archived, and 10 mammals were reported to have been submitted for necropsy. As in the case of the birds, it is remarkable that only one mammal was reported to have been submitted for organochlorine chemical residue analysis. Thus, of the 244 fortuitous samples taken, only two, or 0.8 percent, have been studied for the presence of the chlorinated organic compounds of concern on the RMA.

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The data provided by the USFWS indicates the following distribution of known or suspected causes of death among the birds collected as fortuitous samples between 1989 and 1993:

Cause of Death	Number of Birds	Percent of Total
Poaching	1	0.5
Disease/Parasite	3	1.6
Roadkill	6	3.1
Predation	8	4.2
Trapped in buildings	12	6.3
Accidental death	13	6.8
Electrocution	19	9.8
Collision with structures	21	10.9
Unknown causes	109	56.8
	192	100.0

Similarly, the USFWS data provides the following distribution for the known or suspected causes of death among the mammals collected as fortuitous samples between 1989 and 1993:

Cause of Death	Number of Birds	Percent of Total of 47 Reports
Toxic chemicals	1	2.1
Poaching	3	6.4
Starvation	3	6.4
Disease	5	10.6
Predation	6	12.8
Roadkill	11	23.4
Unintentional (mammal traps)	18	38.3
	47	100.0

In this data set, the first of several inconsistencies can be seen. The narrative report and tabular summary indicated that a total of 52 mammals were reported as having been collected. However, in their summary of causes of death, only 47 mammals were summarized by the USFWS. The disposition of the remaining five specimens is not considered further. This situation is further confused by a separate table, Attachment 3, that lists 10 species of mammals fortuitously collected, the total of which is 52 individual specimens.

Physiologic Responses to Chlorinated Hydrocarbons

Before considering the individual findings of the necropsy reports of the USFWS, it may be useful to review the physiologic responses of animals to chlorinated hydrocarbon substances. Most of the compounds of concern at the RMA are organochlorine compounds. These compounds have in common the chemical composition implied by the group name, i.e., they are hydrocarbon-based substances, usually in the form of ring structures, upon which chlorine has been substituted for hydrogen. However, beyond this broad similarity, the compounds vary widely in specific structure and activity. Although much is known about the pharmacology of the individual substances, virtually nothing is known about the combined effects of groups of these substances. The U.S. Public Health Service has provided a listing of acute oral and dermal LD₅₀ values in rats of many of these compounds. This listing, shown in the following table, provides some indication of the variability of the effect of these compounds on mammals.

ACUTE ORAL AND DERMAL LD₅₀ VALUES OF CHLORINATED HYDROCARBON INSECTICIDES FOR MALE AND FEMALE WHITE RATS

Compound	Oral LD ₅₀ (mg./kg.)		Dermal LD ₅₀ (mg./kg.)	
	Males	Females	Males	Females
Aldrin	39	60	98	98
Chlordane	335	430	840	690
Chlorobenzilate	1040	1220	—	—
DDT	113	118	—	—
DDA+	740	600	—	—
DDE+	880	1240	—	2510
DDD (TDE)	(3400) ^m	—	—	—
Dieldrin	46	46	90	60
Dilan	—	—	6900	5900
Endrin	17.8	7.5	—	15
Heptachlor	100	162	195	250
Isodrin	15.5	7.0	35	23
Kelthane	1100	1000	1230	1000
Lindane	88	91	1000	900
Methoxychlor	(6000.0) ^m	—	—	> 6000
Perthane	> 4000	> 4000	—	—
Thiodan	43	18	130	74
Toxaphene	90	80	1075	780

^m Sex not specified

In general, chlorinated hydrocarbons insecticide toxicity in mammals is expressed by action on the central nervous system. Findings have typically included disorientation, malaise, prostration, collapse, convulsion, tetany, dilation of blood vessels, hemorrhages, both dermally and in internal organs. Frequently, changes are observed in the liver of mammals repeatedly exposed to these compounds. Such changes include liver hypertrophy, cytoplasmic granulation, fatty infiltration, discoloration and the like. At high dosages, liver cell necrosis is a usual finding.

Dieldrin, as a specific substance, has been demonstrated to effect the central nervous system. In both man and animals, a single acute dose produces increasing stimulation of the nervous system accompanied by headache, nausea, vomiting, general malaise, disorientation, dizziness, and ultimately collapse. In more severe cases, or in those cases involving long-term poisoning, convulsions ensue, or they may simply appear without the precursor symptoms noted above. It is particularly noteworthy that these convulsions are both clonic, i.e., marked by alternating contraction and relaxation of muscles, and ultimately tonic, i.e., a state of continuous and unremitting muscular contraction.

Classical symptoms of dieldrin poisoning in animals would be expected to include regurgitation (in these species where such action is possible), diarrhea, complete loss of appetite, weight loss — often to the extreme of emaciation — disorientation, strange behaviors, rapid breathing, rapid heart rate, convulsions, loss of consciousness, muscle rigidity, and death.

The classic antidote for dieldrin poisoning in warm blooded animals has been the administration of phenobarbital, a barbiturate known to control convulsions of central nervous system origin. The object is not to induce sedation, but rather to restore a relative calm and interrupt the convulsive cycle. Typically the dosage required to prevent central nervous system effects in experimental animals is often at a level which would induce sleep or even anaesthesia in an unexposed animal of the same species. Historically, calcium gluconate has also been used in experimental animals. Because its method of action is apparently different from phenobarbital, it has also been suggested as a supplement to the administration of sedatives.

Review of Mammal Necropsy Reports

The table provided as Attachment #1 of the USFWS documents indicates a total of 10 mammals were necropsied. However, in the necropsy reports provided, a total of 11 mammals were examined. These reports include data from the examinations of three coyotes, two badgers, two rabbits and four deer. It is likely that the discrepancy in reporting is a function of a field post-mortem examination of a mule deer fawn performed by John Wegrzyn et al. on 19 July 1990. This euthanized fawn (and its subsequent post-mortem) is not included in the USFWS Special Purpose Salvage Log (SPSL), and thus may not have been counted in the summary of fortuitous specimens.

Coyotes

1. CVDL Record Number 901-13120, date 2-12-91.

The SPSL lists this animal as being found at Lake Mary (following word illegible) as a, "sick coyote, found dead later". The CVDL report indicates this animal as being, "observed extremely sick near the Visitor's Center. The animal died several hours later."

This animal was extremely thin and in poor body condition. The abdominal organs close to the stomach were adhered to each other. The mesentery was hemorrhagic with large quantities of fibrin and inflammatory cells. Kidney tissue was also found to contain extensive hemorrhage of an acute nature. The skin was ulcerated and inflammation of the dermis was observed. The proximal cause of death was a penetrating duodenal ulcer leading to diffuse peritonitis. The cause of the ulcer was unknown, but the attending veterinarian noted that it, "may have been associated with severe chronic stress in this young male coyote".

The findings suggest that this animal was a good candidate for chlorinated hydrocarbon residue testing.

2. CVDL Record Number 912-21430, Date 5-6-92.

The SPSL lists this animal as a collared coyote found north of 7th Avenue and east of E Street, with a possible cause of death/injury as distemper, followed by the word, "no". The CVDL report lists this animal as having, "discharge from the eyes, limited muscle contractions." Upon approach the coyote began circling. This animal is indicated as, "a second coyote recently found ill on arsenal [sic]".

This animal was emaciated with no body fat. This condition was determined to be chronic as there was no evidence of atrophy. The kidney was observed to have white streaks due to fatty change in cells and associated cloudy swelling. The liver demonstrated small foci of necrosis and the heart was found to have nonsuppurative myocarditis and chronic myocardial necrosis. The animal was found to be debilitated as a result of chronic heart pathology and interstitial pneumonia. Tests for distemper were negative.

Based upon the findings (and the lack of definitive causation) this animal was an excellent candidate for chlorinated hydrocarbon residue testing.

3. CVDL Record Number 923-856, Date 7-92.

The SPSL lists this animal (out of sequence) as being found alive at the West Gate Guard House by a security guard. The animal was euthanized at CVDL. The CVDL report lists this animal as a coyote pup with no history provided.

This animal was thinner than normal with a poor hair coat. Very little body fat was present, although the stomach was full of recently digested meat and a few small rodents. The heart had a small focus of necrosis and the thymus was small, depleted of mature lymphocytes, and had a thin cortex. Rabies examination was negative.

Based upon the findings, particularly related to the thymus, this animal was an excellent candidate for chlorinated hydrocarbon residue testing.

Badgers

1. CVDL Record Number 912-4555. Date 9-3-91.

The SPSL, in contrast to the CVDL record, lists this badger as having been taken on 9-5-91 from the Basin F waste pile.

This animal was found alive and was displaying central nervous system signs of an unspecified nature. The animal was reported to be in poor body condition. Lungs, brain, and intestines were found to be generally normal, although parasites were observed in both the lungs and the intestines. The animal was negative for rabies, but positive for canine distemper.

Because of the confirmation of canine distemper, this animal cannot be considered as a good candidate for chlorinated hydrocarbon testing based upon its behavior or the general findings at necropsy.

2. CVDL Report No. 923-5002. Date 9-4-92.

The SPSL lists this animal as a "badger juvenile" taken on 7th Avenue east of Fire Station. It was noted as, "alive, sitting in middle of road not moving."

This animal was reported as a young adult female badger in fair to poor body condition. There was no evidence of trauma. The spleen was observed to be enlarged with acute hemorrhage. Several small hemorrhages were found in the lungs. Lymph nodes were enlarged with individual cell necrosis. The axon sheath of the spinal cord was swollen with degeneration reported. The brain stem had numerous small hemorrhages. Lesions found in the spleen and lymph nodes were consistent with chronic antigenic stimulation. The cause of the caudal paresis (partial or incomplete paralysis of the rear legs) was not determined. Acetylcholinesterase was found to be normal and rabies was ruled out.

This animal was an excellent candidate for chlorinated hydrocarbon residue testing. Such testing revealed an exposure to dieldrin resulting in the identification of 13 ppm dieldrin in the liver and 75 ppm in body fat. This animal was the single mammal tested for chlorinated hydrocarbon residues.

Rabbits

1. CVDL Report Number 901-14668. Date listed as 11/06/91.

The SPSL lists this animal out of sequence as being captured on 3-6-91 on the Basin F Sludge Pile.

This adult female cottontail rabbit was extremely thin, weight 0.91 kg. The wall of the intestines were moderately to severely hemorrhaging.

The primary cause of death was indicated as severe acute necrotizing enteritis compatible with clostridium perfringens type C. The origin of the infection was not considered.

Based upon the association of organochlorine compounds with immune system disruption, this animal may have been a reasonable candidate for chlorinated hydrocarbon testing.

2. CVDL Report Number 912-19496. Date 4-10-92.

The SPSL lists this animal as one of two cottontail rabbits taken on 3-10-92. The other animal was listed as roadkill, "S36 N of South Plants underpass."

This cottontail rabbit was found on the South Tank Farm. It was observed running in circles and ran into a wall. The animal then fell down and could not right itself. It subsequently experienced heavy breathing and spasms. The animal died en route to the CVDL. The animal was observed to have meningeal hemorrhage and two areas of liver necrosis associated with dead parasites. The cause of death was not determined.

Based upon the history of the animal and the lack of causation associated with its death, this animal was an excellent candidate for chlorinated hydrocarbon residue testing.

Deer

1. No CVDL report. No SPSL listing. Field post-mortem examination report dated 7-19-90 by John Wegrzyn.

This report presents a male mule deer fawn found near Building 111. The animal was weak and alone with no mother nearby. It was found with a pendulous mass of bowel loops hanging from the abdomen. The animal was killed.

The cause of injury was determined as an attack by canine predators, probably a coyote.

This animal is not deemed to have been appropriate for chlorinated hydrocarbon residue testing, based on the history and the post-mortem results.

2. CVDL Report Number 901-12482. Date 2-1-91.

SPSL indicates capture in a clover trap on 1-31-91. The discrepancy in the date of the CVDL report is likely a typographical error and should read 2-1-92, as it also indicates the animal was found in a clover trap on 1-31-91.

The table provided as Attachment #1 of the USFWS documents indicates a total of 24 birds were submitted for necropsy. However, in the necropsy reports provided, only 12 birds were examined. The reports include data from one bald eagle, one great horned owl, two barn owls, one kestrel, three red tailed hawks, one Swainson's hawk, one great blue heron, one robin, and one starling. No explanation was provided for the discrepancy, or for the apparently missing necropsy reports.

Bald Eagle

CVDL Record Number 901-17203. Date 4/11/91.

The SPSL reports this bald eagle was found on 4-10-91 under the roost at First Creek.

The eagle was decomposing when submitted for examination. X-ray indicated no broken bones and no evidence of gun shot. The eagle was banded with band number 629-33205. The cause of death was undetermined.

Depending upon the degree of decomposition, this animal may have been a good candidate for chlorinated hydrocarbon residue testing.

Great Horned Owl

NWHRC Record Number 10943-001. Date collected 8-05-92; Date examined 8-6-92.

The SPSL contains no listing for this collection date for this bird. The bird was probably the owl reported as being found at South Plants "alive then dead" on 7-30-92.

This bird was seen in the morning behaving in an unusual manner on the top of an unspecified building. No further comments about behavior were available. It was subsequently found dead later that day with an apparent mucopurulent discharge from the mouth.

The bird had no evidence of trauma or broken bones. Excessive quantities of mucus were coming from the opening of the nasal cavity into the nasopharynx. The talons of both feet were tightly clenched and could not be opened. There was no subcutaneous, pericardial or peritoneal fat to be seen. Brain cholinesterase testing indicated no inhibition, and lead

in the liver was 0.05 ppm wet weight. The final diagnosis was death by emaciation, complicated by a mild myocarditis.

Based on the history and the findings, this bird was an excellent candidate for chlorinated hydrocarbon residue testing.

Barn Owls

1. NWHRC Number 11088-001. Date collected 10-13-92; Date examined 10/15/92.

The SPSL indicates two emaciated barn owls were taken in the North Plants, one dead, the other alive but later died, on 10/14/92. There is no explanation provided for the disparity between the entries.

This bird was severely emaciated, weighing 330 grams. The ribs, spine and keel were easily felt through the skin. Brain cholinesterase levels were within normal limits, and no significant bacteriological findings were reported. The principle diagnosis was emaciation, but the cause of death was not determined.

Based upon the history of this bird and the findings reported, this animal was a good candidate for chlorinated hydrocarbon residue testing.

2. NWHRC Number 11088-002. Date collected 10/13/92; Date examined 10/15/92.

This bird was apparently the second barn owl from the SPSL listing of 10/14/92. No explanation was provided for the apparent disparity between entries.

This bird was severely emaciated, weighing 300 grams. The ribs, spine and keel could be easily felt through the skin. There was no subcutaneous, pericardial or peritoneal fat. Bacteriological testing of this animal was negative, and brain cholinesterase levels were normal. The principle diagnosis was emaciation, but the cause of death could not be determined.

Based upon the history and the findings in this report, this bird was a good candidate for chlorinated hydrocarbon residue testing.

Kestrel

CVDL Record Number 912-22822. Date 5-26-92.

The SPSL lists two kestrels that died in May of 1992. One, indicated as a male is reported to have died on 5/28, but the 28 is scratched out and a 14 is substituted. This male, occupying nesting box 118, died of unknown causes and was disposed of "on-post". The second kestrel, a female, was also found in box 118 alive, but in convulsions. This bird was listed as having been found on 5/28/92. However, the CVDL report specifically states that this bird died at "approximately 2:55 p.m. on 5/26/92." No mention was made of the apparent "coincidence" of the nest-mate's death either within a few days, or possibly the same day. From the confusion of the records, exact dates of death are not possible to determine.

The female kestrel was found in convulsions in nest box 118. According to the CVDL report its talons were clenched, but it was still alive. It had lost muscular control and all sense of balance. The bird was in poor condition, but had no evidence of muscle atrophy or wasting. Axonal swelling was found in the brain with hemorrhage in both the brain and the spinal cord. Severe focal necrosis of the cerebrum was noted with hemorrhage in the cerebellum. Tests for organophosphorus compounds were negative, and lead, arsenic and mercury were within normal limits.

The history and findings related to this bird indicate that it is an exceptional candidate for chlorinated hydrocarbon residue testing. In fact, the attending veterinarian states, "Tests [sic] analysis of tissues for organochlorines is highly suggested." The dead nest-mate, disposed of "on-post" was an equally exceptional candidate.

Red Tailed Hawks

1. CVDL Record Number 901-01535. Date 7-27-90.

The SPSL listing indicates this bird was, "picked up at Lower Derby Lake alive." The Possible Cause of Death/Injury category carries the notation, "died at Bldg. 1710 polson?".

The bird was a red tailed hawk in good body condition. The animal was in a general state of tetany unable to move its wings or its legs and talons. The talons were clenched in a

closed position. CVDL examination indicated a moderate degree of edema of the axons of the brain stem, spinal cord and brachial plexus. The lesions observed were associated with acute neurotoxins or "some type of metabolic disturbance." No report of acetylcholinesterase testing is available. The specific cause of death was not determined.

A file memorandum prepared by a senior toxicologist states, "This is the second case of acute-morbidity/mortality [sic] in a sub-adult [sic] red tailed hawk since early May." According to the SPSL listings, this loss was, in fact, the third death of a red tailed hawk between May of 1990 and July, 1990. A previous death was listed for 6/27/90 with no further data provided, and a death of a red tailed hawk was listed for 5/11/90. This bird was a male found in the Rod and Gun Club area, and was reportedly attacked by a cat.

Based upon the history and the findings, this bird is an excellent candidate for chlorinated hydrocarbon residue testing.

2. CVDL Record Number 901-8085. Date 11-15-90.

The SPSL lists this bird as having been found on 11-14-90 at 6th Avenue and F Street. No further information is provided.

The CVDL report indicates that this bird was in excellent body condition. An abundance of fat was present in the body cavity. The stomach contained a partially digested rodent meal, likely a ground squirrel or young prairie dog. The liver and kidneys had a few small areas with inflammatory cells. Cause of death was not determined. Bacterial infection and organophosphate poisoning were ruled out.

Based upon the history and the findings, this bird was good candidate for chlorinated hydrocarbon residue testing. In fact, the attending veterinarian suggested, "Another consideration would be organochlorines or possibly some other type of toxic material".

3. CVDL Record Number 901-16992. Date 4-8-91.

The SPSL lists this bird as being taken on 4-8-91 between Building 333 and 334, and lists "electrocution" as the possible cause of death.

This immature red tailed hawk was found in the South Plants area beneath and electric line. The hawk was extremely emaciated. According to the attending veterinarian there was no evidence of electrocution. Radiographs showed no evidence of gunshot or broken bones. The cause of death was not determined.

The history and findings related to this bird suggest that it is a good candidate for chlorinated hydrocarbon residue testing. The findings also throw serious doubt on the general category of "electrocution" used as a presumptive cause of death by the USFWS. This aspect will be discussed later in this summary.

Swainson's Hawk

NWHRC Number 10802-001. Date collected 5-28-92; Date examined 6-3-92.

The SPSL indicates a male Swainson's hawk was taken on Montbello at Crown and 56th Streets in a backyard. The bird was reported to be dying.

Contrary to the SPSL listing, the NWHRC report lists a female Swainson's hawk with ovaries characteristic of an adult female. This bird is reported to weight 800 grams and was emaciated with no subcutaneous fat. Only mild changes were noted in body organs. The brain and spinal cord were apparently not considered. No evidence of cholinesterase inhibition was found, and lead in the liver was normal. No cause of death could be determined, and the final diagnosis was listed as "undetermined".

The history and the findings associated with this bird suggest that it was a reasonable candidate for chlorinated hydrocarbon residue testing.

Great Blue Heron

CVDL Record Number 901-21736. Date 6-14-91.

SPSL lists this bird as having been taken at Basin F waste pile after it "nosedived out of the sky" with "no visible signs." The bird was alive when it hit and was gasping for breath prior to expiring.

The necropsy findings suggest a, "structure within the sulci of the cerebellum that is suggestive of a larval state of a tapeworm. There is a possibility that this migration of this particular parasite caused this bird to abruptly lose its ability to fly and, therefore, resulted in the chemical signs manifested by this bird."

Given the history, and despite the clinical findings, this bird was a reasonable candidate for chlorinated hydrocarbon residue analysis.

Robin

CVDL Record Number 912-4879. Date 9-9-91.

The SPSL lists this bird as a robin juvenile taken on 9-6-91 at "Bldg.". It is further listed as being "sick". No other comments are provided.

This bird was an immature female robin with both eyes protruding from the sockets. Red-black material, suggestive of blood clots, was located behind both eyes. The bird apparently died, since the primary cause of death is indicated as a severe infection of the vessels of the brain with a protozoan parasite, highly compatible with a leukocytozoan organisms.

The findings suggest that this bird was not an appropriate candidate for chlorinated hydrocarbon residue testing.

Starling

CVDL Record Number (Diagnostic Lab) 2336. Date 8-3-92.

The SPSL listing for this bird indicates a starling fledgling taken on 7-31-92 at Building 111 which was alive with its talons clenched. It is further reported as, "unbalanced". The summary note indicates the bird was sent to the "CSU Vet Diag Lab - ACHE only".

The CVDL report indicates that acetylcholinesterase activity was assayed in the brain of this bird. No indication of inhibition was found.

The history and the findings associated with this bird indicates that it was an excellent candidate for chlorinated hydrocarbon residue testing.

Categorization of Cause of Death

Mammals

Attachment 5 of the USFWS documents indicates seven possible causes of death in the records of RMA mammal populations. These include roadkill, unintentional, predation, poaching, disease, starvation, and toxic chemicals. As previously noted, the table associated with Attachment 5 enumerates 47 animal deaths and assigns them to the above seven categories. The table in Attachment 1, however, indicates a total of 52 mammals collected as fortuitous specimens. To further complicate the difficulties, the SPSL lists 59 mammals taken between 1989 and 1993, not considering aquatic species, animal parts, and those deer shot as a part of the Deer Herd Health Study. The categories selected do not appear to be mutually exclusive, nor all inclusive. For example, considerable crossover would be expected between the categories "disease" and "starvation". For example, the coyote pup found emaciated with little or no body fat, but whose stomach was full of meat, and which behaved strangely might logically be put in either category. Further, there is no category for unknown causes of death or illness. Two or three of the mammals examined fall into this category, and a number of those listed in the SPSL appear to as well. Finally, neither the "unintentional" category sub-headed "(caught in small mammal trap)" nor the "roadkill" category appear to cover those animals dying of trauma resulting from lawn mowing accidents and the like.

Birds

For at least two categories of known or suspected cause of death (Attachment 4), the criteria for inclusion may be considered suspect. These categories are "electrocution" and "collision with buildings, powerlines, etc.". The SPSL presents no criteria for inclusion of birds into these categories. Further, on at least one occasion, 4-8-91, a red tailed hawk was indicated as having died by electrocution, but the necropsy report indicates that no evidence of electrocution was found.

From the SPSL record, it appears that if the body of a deceased bird is found in an area which contains a powerline, a transformer, or a power pole, the bird is a candidate for the category "electrocution". This supposition is supported by notations in the record, e.g., the 2-28-92 listing of a great horned owl, which states, "no obvious signs of death; not under a power pole." It would also appear that few of the alleged "collisions" with power lines or buildings have been witnessed by observers. Thus, it appears possible that the observation of a dead bird in the vicinity of a man-made structure is sufficient for inclusion in one of these categories.

In addition to the obvious potential difficulties, it must also be recalled that the majority of the RMA site is open, arid ground with a limited number of resting or perching sites that are not man-made. Thus, an exhausted, moribund bird, ill for any number of other reasons, including toxic substances, which lands on a powerline or the cross arm of a power pole containing a transformer and ultimately dies could inadvertently be categorized as either "electrocution" or "collision".

Given the number of birds in these categories (approximately 10 percent of total in each), and the difficulty involved in electrocuting a bird, i.e., one part of the bird's body must be in contact with an electrical line or transformer, and another portion in contact with a grounded structure or a line bearing electricity of the opposite charge, it is difficult to believe that either of these categories represent the actual causes of death at the RMA. Thus, it is entirely possible that up to 78 percent of the deaths in bird population at the RMA are of unknown causes.

A consideration of the distribution of deaths among species (Attachment 2) is also instructive. This distribution is presented in the table below.

**DISTRIBUTION OF DEATHS BY SPECIES OF BIRDS
COLLECTED FORTUITOUSLY - 1989-1993**

Rank Order	Species	Number Dead	Percent of Total
1	European Starling	31	16.1
2	Great Horned Owl	21	11.0
3	Red-tailed Hawk	16	8.3
4	American Robin	14	7.3
5	House Finch	12	6.3
6	Magpie	11	5.7
7	American Kestrel	10	5.2
8	Ring-necked Pheasant	9	4.7
9	Morning Dove	9	4.7
10	Barn Owl	8	4.2

From these data, it appears that despite their larger size (and, hence, fewer numbers) a disproportionate number of raptors are dying from all causes at the RMA. Of the top ten deaths of bird species, four are raptors. The deaths within the raptor group represent 28.7 percent of the total of 192 birds that died. For all bird deaths, raptors represented more than 34 percent. While the listings of probable cause of death leave much to be desired in terms of completeness of entry and precision in determination of cause, at least two and possibly three of the raptors are known to have died with

symptoms of clenched talon syndrome. Another three are known to have been severely emaciated.

Of particular concern are the pair of kestrel which had occupied nesting box 118, both of which died within a maximum of two weeks of each other, the female being known to have died in convulsions with clenched talon syndrome. In addition to the raptors, three starlings and one robin were reported to have died from "toxins from lawn?". An additional starling died with symptoms of clenched talon syndrome. A grackle was also noted as having a nervous system disorder, and a mourning dove and a magpie were listed as having convulsions prior to death. A black crowned night heron was also found to be emaciated. A complete analysis is hampered by the number of birds dying of unknown causes, and the assumptions made with respect to the cause of death as discussed above.

Summary

From the data available, it appears that there has been a group of deaths in the animal populations of the RMA for which no cause is known, and which frequently appeared to follow a similar course and pattern. Many of the signs and symptoms displayed by these animals prior to their deaths are similar to those observed in experimental animals exposed to organochlorine compounds. Between 1989 and 1993, the USFWS tested two animals for chlorinated hydrocarbon residues; one badger found to have 75 ppm dieldrin in its body fat, and one bird, for which data are unavailable. Without exception, testing for acetylcholinesterase inhibition has proved negative in all species examined. Given the lack of evidence for effects from organophosphorus compounds, it would seem logical to abandon this approach in favor of testing for organochlorine residues, at least among those individuals displaying similar symptoms. Supporting this conclusion are the repeated recommendations of the attending veterinarians conducting the necropsies.

If, in fact, organochlorine compounds are found to be associated with any or all of the deaths involving the related effects, further efforts would then be in order. If mortalities are being produced in the resident populations as a result of exposure to organochlorine compounds, a wide variety of sub-lethal effects can also be expected. In the event of a positive initial association with mortality, additional studies specific for RMA populations would have to be undertaken to understand the potential for sub-lethal effects.