Avian influenza outbreak
In wild birds 2022

Final report: April 1 to October 31

Alberta

Classification: Public

Avian Influenza Outbreak in wild birds, 2022

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Published by Alberta Environment and Parks

November 2022

ISBN 978-1-4601-5569-1

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Avian Influenza

April to October 2022

Summary

In late winter and spring 2021-22, a continental outbreak of Highly Pathogenic Avian Influenza (HPAI) involving a new North American strain of H5N1 swept across Canada and the USA. For the first time in North America, HPAI was associated with widespread mortality in wild birds. The wave hit Alberta in early April 2022, washed over the province in April/May/June, and had a few lingering ripples through July. August went by with very few reports of unusual sick or dead wild birds and no detections of the virus. However, through September and October there was a slight increase in individual sick or dead bird reports. H5N1 was found in a number of these birds as well as the first dabbling ducks in Alberta since the outbreak began.

Overall, we confirmed North American HPAI H5N1 in multiple wild bird and mammal species. There appeared to be a primary outbreak associated with spring migrating waterfowl (April to May). The virus also spilled over into many sick and dead skunks. In June and July, patterns in wild birds and extent of the outbreak changed to limited reports of unexpected mortality in colonial nesting species, with detections of H5 AIV largely in grebes and cormorants. A smaller third wave occurred in September and October as fall migrating waterfowl again passed through the province. The fall wave involved individual neurologic Canada geese, a few owls, clusters of dead magpies, and the first documentation of H5N1 in ducks in Alberta. A few infected skunks also were reported in October. Through the summer and fall, additional outbreaks of HPAI were detected in poultry in Alberta, with a noticeable increase in September and October (56 domestic outbreaks, April 1 to October 31, 2022).

Avian Influenza in wild birds, 2022. April 1 to October 31

Based on passive surveillance reports of sick or dead birds, it seems early mortality was greatest in snow geese (*Anser caerulescens*) and to a lesser extent Canada geese (*Branta canadensis*). Subsequent mortality involved great horned owls (*Bubo virginianus*, adults and youngsters), red-tailed hawks (*Buteo jamaicensis*), American crows (*Corvus brachyrhynchos)*, and black-billed magpies (*Pica hudsonia*). The same H5N1 virus was confirmed in many striped skunks (*Mephitis mephitis)*: adults in April and May, and juveniles in June. As well as in a few juvenile red fox (*Vulpes vulpes*) in early May. Throughout the spring outbreak, HPAI H5N1 was detected in 31 commercial or backyard poultry flocks (April 1 to June 30) across Alberta involving up to a million domestic birds.

The 2022 form of North American HPAI H5N1 was a widespread and very hot avian influenza virus. It remains to be seen if the virus will return in the same form with northward migrating waterfowl next spring. Patterns of HPAI in wild birds in Europe, Asia, and Africa in recent years suggest it is very likely that some form of highly pathogenic avian influenza virus may be incorporated into the genetic pool of AIV in North America. Whether it remains pathogenic for wild species (birds or mammals), is less clear. Stay tuned and we will all see what Mother Nature has in store.

Background

Avian Influenza Virus (AIV) coevolved with birds over millennia. This ongoing relationship is a struggle that reflects the chaos in natural systems wherein change is the norm and stability is under constant challenge. Influenza viruses, like so many other viruses, are extremely malleable. Their genetic components, primarily eighteen different hemagglutinin (H1-18) and eleven neuraminidase (N 1-11) proteins, constantly re-assort within the melting pot of cumulative global genetic variations that drift in multiple directions.

Given their ancient existence, the global melting pot of AIV genetics in waterfowl is extensive, and displays many patterns in the predominant strains at continental, flyway, regional, and local levels. Occurrence and makeup of AIV has been monitored in Canada for over 50 yrs. Extensive data from live ducks collected by the Canadian Wildlife Service (CWS) across the prairies in previous decades revealed patterns in predominant AIV strains/subtypes that changed from year to year, month to month, species to species, week to week, and pond to pond. Avian influenza virus constantly changes.

AIV and Birds

The basic relationship between AIV and wild birds was established a long long time ago. The virus persists, the birds persist, and it all works well for both parties. Despite global occurrence of AIV, primarily in waterfowl and shorebirds, disease and mortality of wild birds as a result of AIV infection traditionally is limited to individual birds or small local events that generally involve co-morbidity factors and spurious viral infection.

The relationship in domestic poultry is very different. Some avian influenza viruses are deadly for domestic birds (primarily chickens, ducks, geese, turkeys) and sporadic outbreaks occur around the world. These birds do not have the benefits of taking part in the natural global circulation of the virus and they have little, if any, immune defense against AIV whenever they are exposed to it. A benign strain of AIV in wild birds can rapidly become a significant highly pathogenic strain of avian influenza (HPAI) in domestic birds. In particular, low pathogenic strains of H5 and H7 subtypes in wild waterfowl readily mutate to HPAI H5 or H7 subtypes in domestic poultry.

Historic Change: In 2002, the relationship of AIV with wild birds in Asia changed. A HPAI H5N1 strain in domestic chickens spilled back into a few wild birds. Subsequently, this pathogenic form spread among wild birds across Asia, and on to Europe and northern Africa. The change resulted in AIV mortality of wild waterfowl, something not seen before.

In 2015, a Eurasian form of HPAI H5N1 was detected in the Western Hemisphere. It affected domestic poultry across Canada and USA in one of the most devastating foreign animal disease occurrences in North America (Ramey et al. 2021). It also was detected in a limited number of wild birds in North America for the first time. However, there were no such outbreaks or occurrences in domestic or wild birds in 2016 (or 2017) and this high path form of AIV seemed to disappear (Krauss et al. 2016).

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However, the virus roared back in 2022….

2022 Outbreak

Continental forewarning came from eastern regions in December 2021.

A few dead wild birds in Newfoundland & Labrador harboured a highly pathogenic form of avian influenza virus – the first time a HPAI form was found in wild birds in N. America since 2015. Soon thereafter, mortality events were reported in wild and domestic birds in the maritime provinces and along the US Atlantic coast.

The ball was rolling. Within a few short weeks, truly amazing spatial and temporal patterns emerged. Mortality in wild and domestic birds was detected systematically from east to west on all four continental wild bird flyways (Atlantic, Mississippi, Central, and Pacific). Generally, it started in southern regions and progressively advanced as migrating waterfowl left their wintering areas and headed north into mid-continental and then northern regions. Rapid genetic assessment of the 2022 strain revealed this was a new North American HPAI H5N1, closely related to, but different than, the previous Eurasian HPAI H5N1 detected in 2015.

Alberta gets ready

Alberta contributes to the ongoing national surveillance of avian influenza in wild birds since the program was formally initiated in 2006 www.cwhc-rcsf.ca/avian_influenza_testing_results.php. Thus, the province has a process and procedures in place for sampling, testing, and reporting AIV in wild birds. The AB program focuses on species most likely to be infected, primarily waterfowl and shorebirds. In addition, we collect samples from all suitable birds that pass through our wildlife disease lab. Viral swabs are screened for Matrix H5 or H7 positive samples in the Alberta Agriculture, Food and Rural Development (now Alberta Agriculture and Irrigation AGI) molecular lab in Edmonton. Any Matrix positive samples are forwarded to the national virus lab in Winnipeg (NCFAD) for confirmation and genetic characterization. In early 2022, we reestablished connections with AGI to support initial screening of anticipated wild bird samples. Similarly AGI geared up all aspects of their provincial AI programs aimed at poultry producers and owners.

In 2006 Alberta established a provincial avian influenza working group with representatives from provincial agriculture, wildlife and health agencies. A provincial AIV plan was developed in 2006 and updated in 2011 to reflect current information and risks at the time. That plan outlines roles and responsibilities across the three primary government agencies. A provincial AI working group convened in February 2022 to review the provincial plan and prepare for anticipated outbreaks within the province. The group reaffirmed that the 2011 provincial plan remains in effect as guidance for 2022.

There was little doubt that a wave of HPAI H5N1 was heading towards the province.

Materials and Methods

Staff information and heads-up

In late March, AEP wildlife biologists and Fish and Wildlife officers in Alberta Justice & Solicitor General (SolGen) were given updates as the AIV outbreak spread north through western states. The information provided background to the situation likely to unfold in Alberta when migrating waterfowl arrived. We also circulated Key Messages that could be used to answer staff and public enquiries. The provincial wild bird AI factsheet was updated to reflect current information https://www.alberta.ca/avian-influenza-in-wild-birds.aspx .

Communications staff in AEP were alerted to the expected outbreak. Regional communications involving the western provinces were coordinated through the Prairie region of Canadian Wildlife Service in Winnipeg. National connections were established with Environment Canada and the Canadian Food Inspection Agency. International connections and updates were provided through the Wildlife Health Committee of the Western Association of Fish and Wildlife Agencies as well as the national AI Coordinator for US Geological Service.

Public reports

Classification: Public

Passive surveillance using public reports of sick or dead birds often is the bedrock of documenting the occurrence and effects on wildlife during disease outbreaks. AIV is no different. The public are keen observers of wildlife, birds in particular, and readily report anything unusual. Two primary portals for public reports were established. Alberta maintains a toll-free provincial phone network (310-0000) that takes in various public reports and specific to the impending AI outbreak, procedures were put in place to channel dead wild bird reports to AEP. In addition, the Canadian Wildlife Health Cooperative geared up to receive public dead bird reports through their Alberta node based at the University of Calgary veterinary school. Local offices of AEP and SolGen also were given heads up notice and information about an anticipated increase in dead bird reports likely to come to their staff. Messages and public reports also were coordinated with AGI: wild bird reports were forwarded to AEP, poultry reports were forwarded to AGI.

In conjunction with CWHC, the impending workload of tracking and sampling the anticipated outbreak coming our way was partitioned. In general, AEP tracked and responded to reports of sick or dead birds from Red Deer and north, CWHC Calgary dealt with anything south of Red Deer.

Wild bird testing & reporting

Since avian influenza viruses are largely present in specific groups of birds, AI surveillance was focused on reports of unusual mortality in any waterfowl species as well as predators or scavengers that may consume live or dead waterfowl. Small songbirds were not included as there is no evidence that AIV is significantly present or active in passerines.

Lab AIV sampling procedures were reviewed in light of 2022 guidelines and verified as in line with national standards. Viral swabs of oral/nasopharyngeal and cloacal tissues of wild bird carcasses remained the primary sample (Appendix 1). Swabs taken by the Wildlife Disease Unit of AEP were submitted to the AGI molecular lab in Edmonton (Appendix 2). Swabs collected by CWHC in Calgary were shipped on ice to the Wildlife Disease Unit for submission to AGI. Given the scale of the provincial outbreak that resulted in huge numbers of poultry samples submitted to AGI molecular lab, wild bird samples were first screened as suspect or non-suspect based on species (waterfowl, raptor, corvid) or clinical signs (impaired neurologic conditions). Non-suspect samples were held back and stored at -80C until the lab workload declined to 'normal' levels [late July/early August]. Initially, testing of suspect samples was somewhat delayed but occurred whenever there was a 'lull' in poultry samples at the lab. After May, wild bird suspect samples were tested as received. During July, wild bird non-suspect samples were submitted for testing. Ongoing wild bird test results were reported on the AEP AI web site https://www.alberta.ca/avian-influenza-in-wild-birds.aspx . In addition, ongoing test results were provided to CWHC regarding samples they collected. Ongoing provincial testing data were provided to the national AI surveillance program, as per normal procedures.

Given the wide assemblage of avian influenza viruses present in wild birds, initial screening is a sequential assessment of AIV strains, with a focus on potential highly pathogenic forms of H5 or H7. Thus testing involves a matrix of decisions: is the sample broadly positive or negative for AIV, and if positive, is it H5 or H7? All samples positive for AIV are forwarded to the national virology lab in Winnipeg for genetic characterization and confirmation of H and N components. Given the workload at the national lab, wild bird results were significantly delayed beyond the time period of the actual outbreak.

As part of the ongoing AIV surveillance across Canada, staff with CWS actively sampled ducks handled in the federal migratory waterfowl banding activities in August as well as a sample of ducks harvested by hunters in late August and September 2022 in central Alberta. Results were provided to the provincial AIV surveillance program and included herein.

Wild mammal testing & reporting

As the outbreak developed, reports of sick or dead mammals came in through established channels. The intra-provincial network that supports ongoing passive surveillance of disease in wildlife is actively engaged in reporting anything unusual. For example, the ongoing provincial rabies hotline takes in reports of sick or dead striped skunks (*Mephitis mephitis*). In addition, permitted wildlife rehabilitation centres hear about or receive reports of unusual situations of sick or dead mammals and often report these to AEP. Field staff of AEP and SolGen report unusual situations involving sick or dead mammals to the Wildlife Disease Unit. Similarly the Alberta node of CWHC based in Calgary receives reports of sick or dead mammals from various public and government sources. In early April, an increased number of sick or dead skunk reports came in from all of these sources. The geographic area encompassing the reports fully overlapped the area with the large numbers of sick and dead snow geese (*Anser caerulescens*).

Lab guidelines and procedures were reviewed to incorporate possible testing of mammal samples for AIV, in concert with the testing of wild and domestic birds. Additional samples were collected to support diagnostic testing for rabies and

canine distemper as well as allow further investigation of any AIV positive mammals. Standard oropharyngeal or nasal viral swabs and supplementary fresh and fixed tissues were collected from mammals that were found dead within the area where AIV was detected in wild birds, as well as any mammal that displayed clinical neurologic dysfunction within the time period when AIV was detected in wild birds.

Results

Birds

Overall

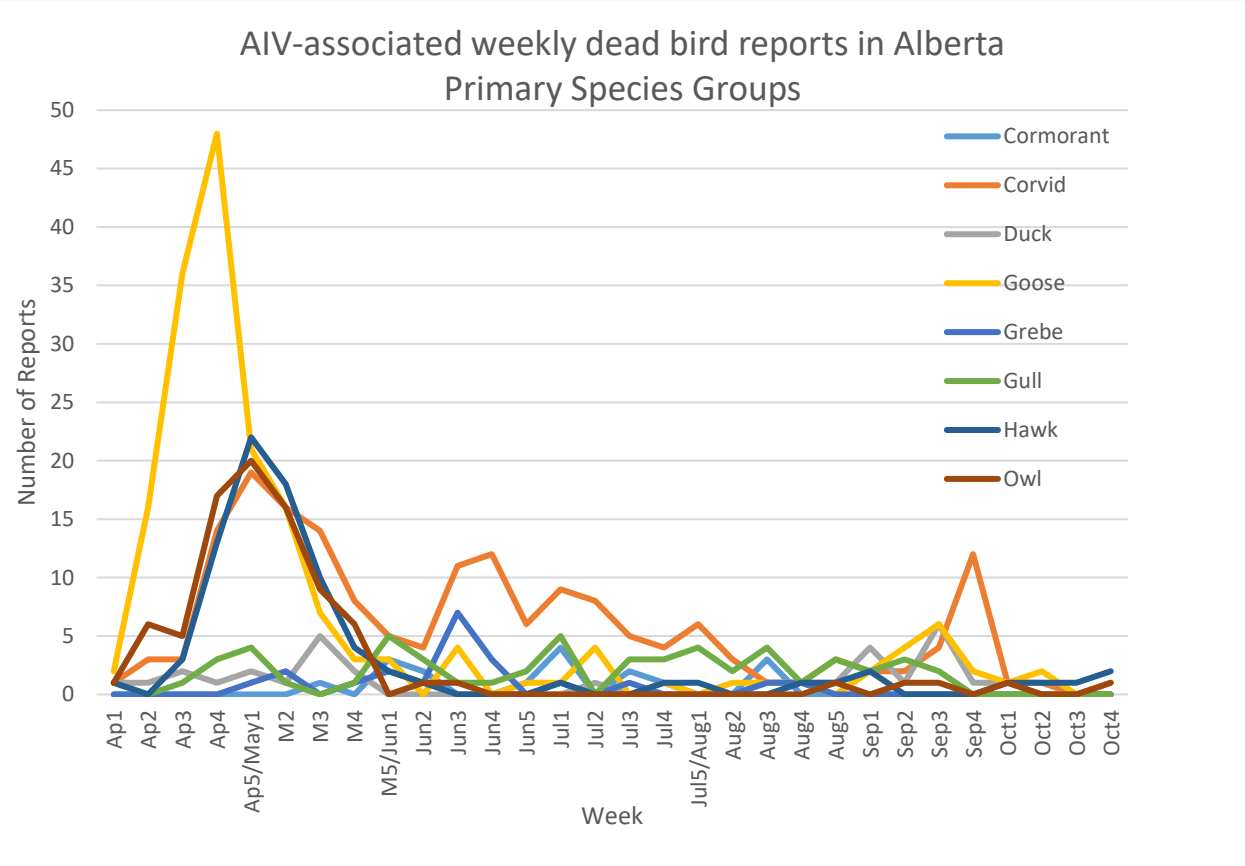

Figure 1. Primary species groups of sick or dead wild birds reported from early April to late October 2022

Cumulatively, reports of sick or dead birds began in early April, peaked in late April, declined significantly through May and remained relatively low through the rest of the summer and fall (Figure 1). However, patterns differed among species and species groups.

Timing & general location

Public reports of dead geese in early April indicated the start of the avian influenza outbreak in wild birds in Alberta (Figure 2). Each report often involved 1-10 birds, although clusters of 20-200 birds in a single field also were reported. Through the following weeks, sick and dead geese were the primary species group reported to AEP and CWHC. Most mortality reports involved snow geese, and to a lesser extent Canada geese (*Branta canadensis*) (Figure 3). Reports of large numbers of fresh dead snow geese came from throughout central and east central Alberta, particularly the areas around Camrose and Andrew.

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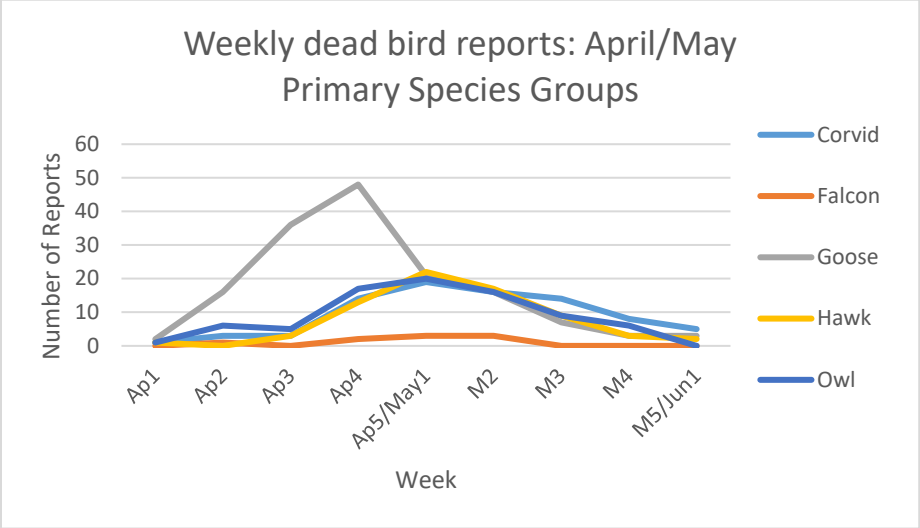

Figure 2. Primary species group of sick or dead wild birds reported from early April to early June 2022

By the 2nd week of April public reports included sick or dead raptors, particularly great horned owls (*Bubo virginianus*) and red-tailed hawks (*Buteo jamaicensis*). From late April and through May, these two species made up the largest portion of the sick or dead bird reports. Additional raptors included a few peregrine falcons (*Falco peregrinus*), merlin falcons (*Falco columbarius*), Cooper's hawks (*Accipiter cooperii*), rough-legged hawks (*Buteo lagopus*), sharp-shinned hawks (*Accipiter striatus*), snowy owls (*Bubo scandiacus*), Swainson's hawks (*Buteo swainsoni*), and individual northern goshawk (*Accipiter gentilis*), northern hawk-owl (*Surnia ulula*), and a broad-winged hawk (*Buteo platypterus*). Reported species identity could be verified only for birds submitted for testing.

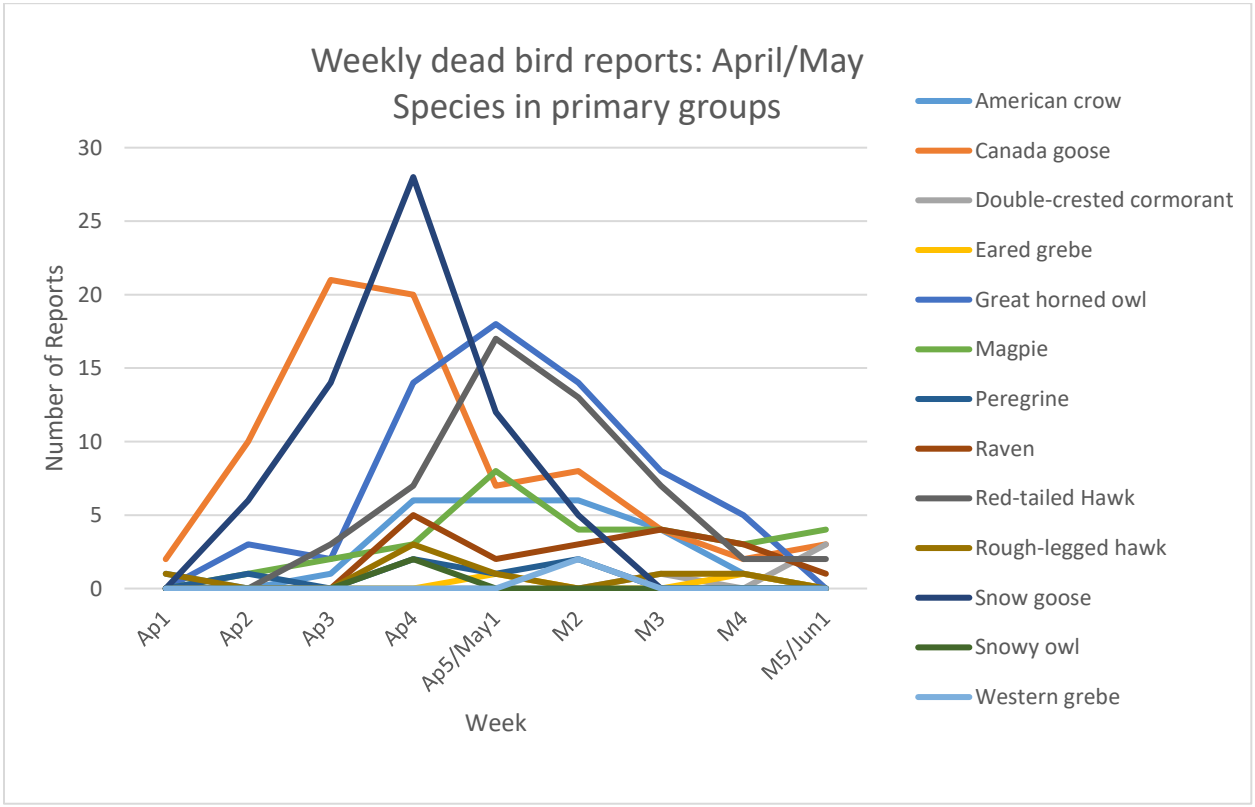

Figure 3. Species in major species groups of sick or dead wild birds reported in Alberta, early April to early June 2022.

At the same time, there was a similar increase in the number of sick or dead corvids reported in late April and through May. This group includes American crow (*Corvus brachyrhynchos*), black-billed magpie (*Pica hudsonia*), common raven (*Corvus corax*), and a few blue jays (*Cyanocitta cristata*).

Public reports associated with the primary outbreak began to wind down in late May and early June. However, at this time an influx of calls about sick and dead birds associated with nesting colonies of grebes and cormorants on various lakes signaled the beginning of a secondary outbreak (Figure 4). These reports largely involved sick or dead eared grebes (*Podiceps nigricollis*), western grebes (*Aechmophorus occidentalis*), or double-crested cormorants (*Phalacrocorax auritus*) (Figure 5). However, all sick or dead bird reports consistent with possible AIV infection declined through July.

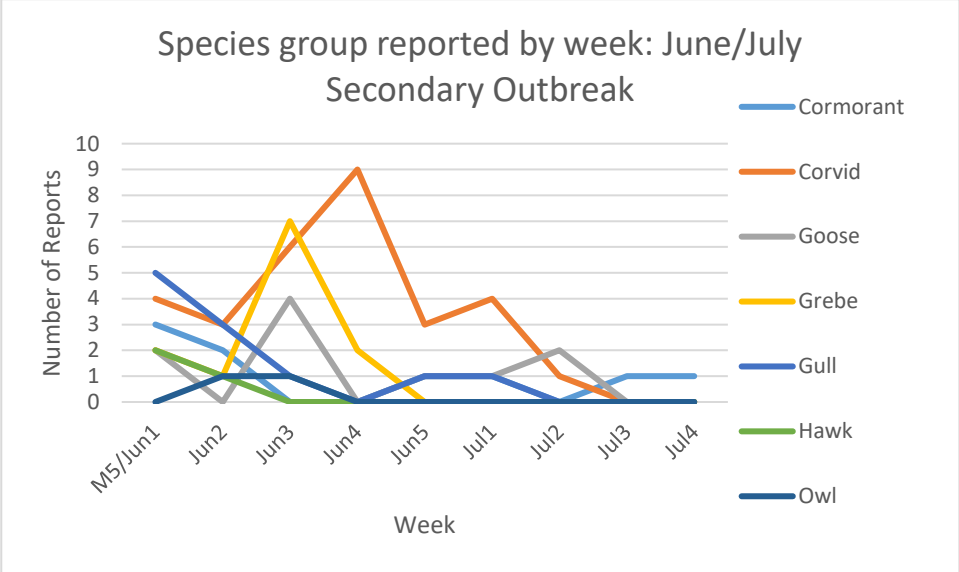

Figure 4. Major species groups of sick or dead wild birds reported in Alberta, June and July 2022.

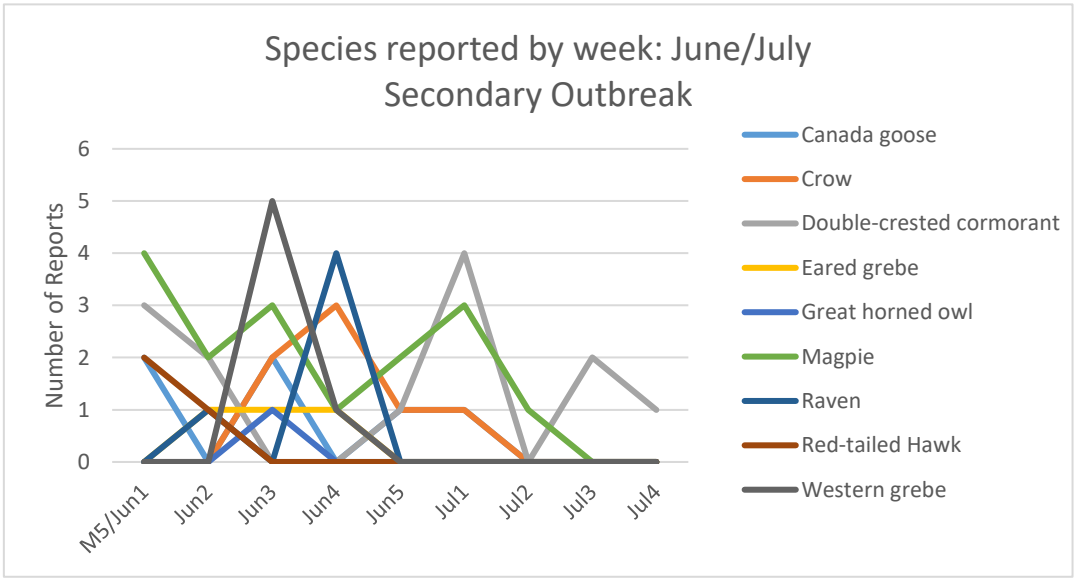

Figure 5. Species in major species groups of sick or dead wild birds reported in Alberta, June and July 2022.

Number and species of dead birds

Geese: The most common reports involved dead snow geese (Appendix 3), involving at least 785 dead birds. The number of carcasses per report ranged from 1 to 200 ($\bar{x}$ = 15) but involved many field situations of rough estimates of carcasses at the site. In contrast, reports of 166 sick or dead Canada geese ranged from 1 to 8 ($\bar{x}$ =2) birds per report. Of note with this species, in a group of Canada geese nesting at the ponds at Enchant, Alberta, a total of 11 adult geese died by mid-April. In mid-June, ~10 adults remained, with ~10 goslings. This implies approximately 50% mortality in adult geese at this site in April 2022. Extensive mortality was not seen at the site in previous years. Other goose reports included one mention of Ross' geese (*Chen rossi*) in a mixed flock of sick and dead snow geese, Canada geese, and Ross' geese. There were no reports of dead white-fronted geese (*Anser albifrons*).

Corvids: A total of 530 dead corvids was reported. A number of reports mentioned large numbers of dead crows in small local areas – presumably migrating flocks. One group of dead crows in Lloydminster was estimated to involve ~150 individuals. Other corvid species were reported as one or two dead birds at any one time and place.

Owls: A staggering number of 127 sick or dead great horned owls were collected or reported in April and May. Mortality included adult birds, often at or near a tree with an active owl nest. In quite a few situations, young owlets also were found dead below the nest. In addition, three snowy owls, four great grey owls (*Strix nebulosa*), three barred owls (*Strix varia*), two short-eared owls (*Asio flammeus*), and a northern saw-whet (*Aegolius acadicus*) were reported sick or dead.

Hawks: A total 112 sick or dead hawks were reported, most of which were red-tailed hawks (n=78). The redtails included three adult research birds tagged with radio trackers in eastern Kansas early in 2022. They arrived in Alberta in mid to late April and died soon thereafter. One additional red-tailed hawk banded locally as an adult in 2018 died near Grande Prairie in early May 2022. Similarly, two tagged and one banded rough-legged hawk were found dead in late April. Nine rough-legs were collected or reported dead this spring.

Falcons: A total of seven sick or dead peregrine and 12 merlin falcons were reported. Of the peregrines, three displayed severe neurologic clinical signs and were euthanized, the others were found dead. One bird had been banded as a juvenile in May 2017 in Alberta (5 yr old in 2022). Seven of the merlins died in care at rehabilitation facilities in August.

Eagles: Ten bald eagles were reported sick or found dead largely through AEP channels, nine of which occurred in April and May. One golden eagle (*Aquila chrysaetos*) was found in late October.

Cormorants: In late May and early June, AEP staff conducting scheduled surveys at cormorant colonies in the northeast region found mortality beyond what is normally seen early in the nesting season. By mid-June surveys at 6 lakes visited by staff indicated up to 200 dead cormorants beyond anticipated background mortality, an estimated 3-5% of the local populations. Ongoing surveys through June and July continued to report mortality associated with unusual clinical signs in sick birds. Perhaps incidental, the lake that had the most serious mortality in adult cormorants in the June surveys seemed largely unaffected during the July surveys. In contrast, those with less adult mortality in June had significant numbers of dead and sick juveniles in July. Young birds displayed lethargy, head tremors, and labored breathing. During June and July, a few sick or dead birds were collected at most sites for testing. During colony surveys in mid July, ~ 370 additional sick and dead juvenile cormorants were seen at two lakes (Frog, Muriel), tho there was little fresh mortality of adult birds. Overall, at least 657 sick or dead cormorants were recorded at four surveyed lakes, of which 566 (86%) were juveniles.

Grebes: Overall, 370 grebes were reported as AIV-related mortality. In late May and early June, public reports of sick and dead grebes started coming in from a few lakes with active nesting colonies. Colonies of western and/or eared grebes near Bonnyville (Jesse Lake), Stettler (Buffalo Lake), and Lac la Biche (Lac la Biche Lake, Missawaii Lake) all had increased mortality. A minimum of 200 eared grebes died at Jesse lake in mid June. An estimated 85 western grebes died at Buffalo Lake and Lac la Biche. A few sick or dead birds were collected at each site for testing. There were no further public reports of sick or dead grebes at these lakes, and a survey of the largest provincial western grebe colony (Lac la Biche) in late July indicated an abundance of healthy young and adult birds at a very active and noisy colony with no sign of sick birds nor any undue mortality.

Clinical signs

Neurologic dysfunction was a primary aspect of most birds reported as sick, regardless of species. Head tremors, swaying head and neck, disorientation, inability to fly or walk, lethargy, and depression were key features described verbally or present in videos provided by the public or AEP staff. Cloudy eyes, nasal discharge, and swollen tissues of the head and around the eyes were additional features often reported. Quite a few of the perching corvids (magpies, blue jay) were reported to have neurologic signs (head tremors, incoordination) prior to falling dead out of a tree.

Gross and microscopic lesions

Gross post mortem and histologic investigations were conducted at the veterinary school in Calgary. Overarching gross lesions included marked multifocal necrotic sites throughout the pancreas and generalized congestion and oedema in most internal tissues and surfaces, including the eyes and brain. At a cellular level, the primary feature was a necrotizing encephalitis and associated damage within the brain, and similar inflammatory reaction in many tissues, including the heart, pancreas, kidney, and eyes.

Classification: Public

Test results BIRDS

Data Limitations: Data presented herein reflect selective testing of novel species, species of interest, species of concern, and individuals with neurologic clinical signs. They also reflect the interest and engagement of public and staff to submit birds for testing. As such, the patterns displayed do not represent the occurrence of the virus nor the extent of mortality within species or species groups. For example, there was extensive early mortality in snow geese and so testing of snows was limited to a few birds to confirm presence of the virus or explain neurologic clinical signs. Overall, more Canada geese were tested than snow geese, yet the mortality associated with AIV was far more widespread and significant in snow geese. Similarly all the snow geese tested (n=15) were HPAI or H5 positive but that does not infer that all snow geese were infected with the virus but rather that testing selected for highly suspect AIV individual geese, and was discontinued with this species soon after the outbreak began. In contrast, 33 of 52 (64%) of the Canada geese tested in April and May were H5 positive. Initially all positive geese were adults. Juvenile Canadas tested in May were negative for AIV; however, in mid July we received cumulative reports from two lakes of approx. 20 young geese that ran or swam in tight circles. We tested 3 such youngsters and all were positive for H5 AIV. One of the lakes was the site of H5 detected in cormorants. The other had cormorant colonies nearby. In September/October, we tested 27 Canada geese, of which 16 (60%) were H5 positive. Within this same period, no sick or dead snow geese were reported. The data herein thus reflect the patterns of AIV as found in the birds tested.

Also, the test result is limited by the cascade of lab methods. Results presented as HPAI have full confirmation by the federal virology lab as highly pathogenic H5N1. Results presented as H5 are PCR confirmed by the provincial molecular biology lab (and sent for further testing by the federal lab). Inconclusive H5, Positive matrix, and Inconclusive matrix indicate detection of an avian influenza virus of undetermined subtype (subject to further testing). Any of these categories indicate AIV occurred in the bird, that is, it was positive for AIV.

And finally, results from live banded birds and hunter-killed ducks sampled by CWS are not comparable to those from birds originally reported as sick or found dead.

Although AIV was detected in individuals of various species groups (Figure 6), the groups with the most positive results were cormorant, corvid, duck, falcon, goose, grebe, gull, hawk, and owl (Figure 7, Table 1).

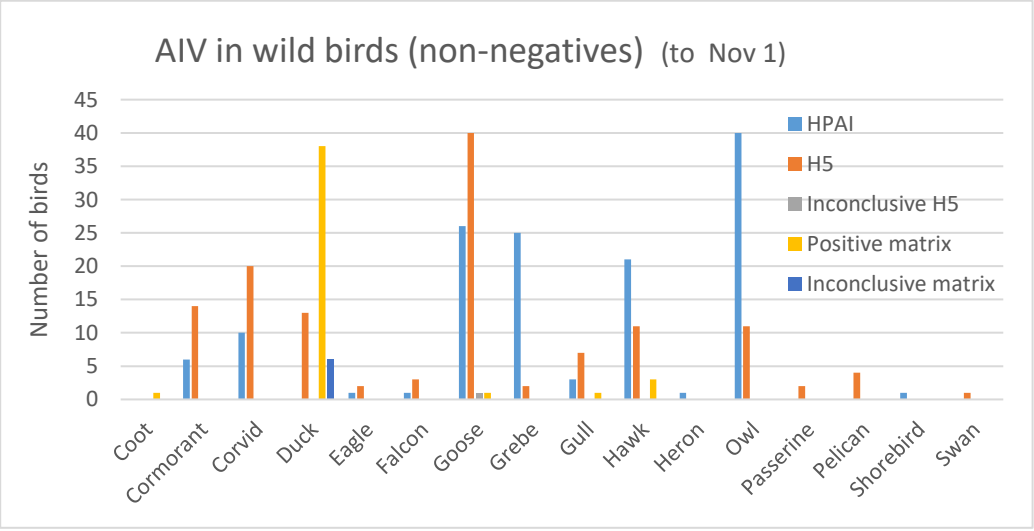

Figure 6: Avian influenza virus in 2022, all species groups.

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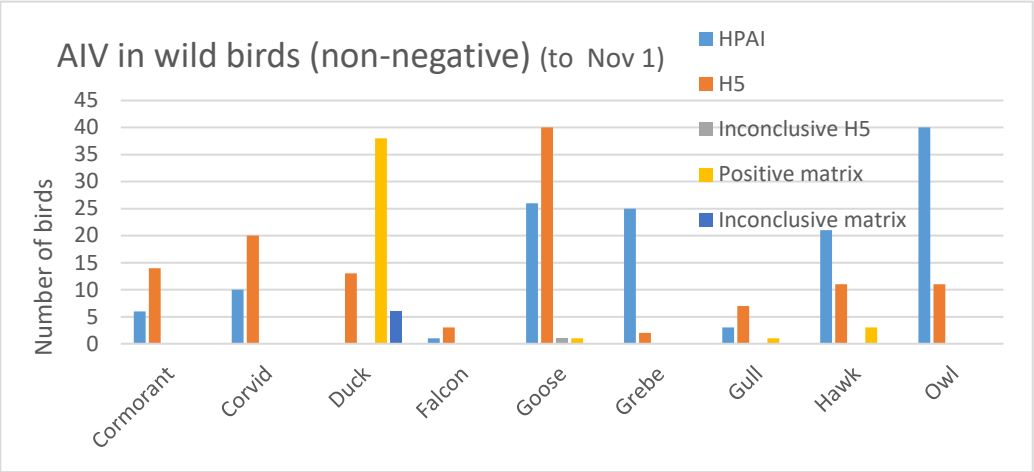

Figure 7. Avian influenza virus in major species groups in 2022.

Within the major groups (Figure 8), most of the corvids tested were magpies (71 of 138) and many were HPAI or H5 positive (18 of 71). Five of 30 crows, six of 28 ravens, and one of 9 blue jays were HPAI or H5 positive.

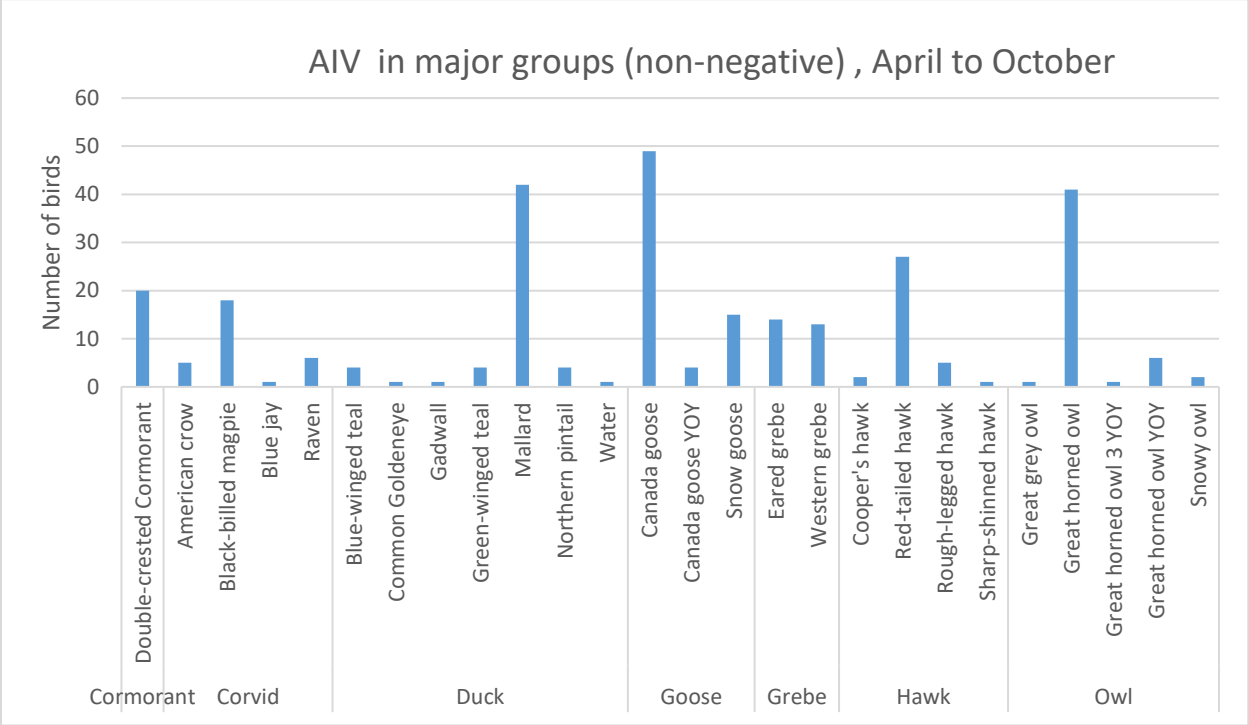

Figure 8: AIV in species within the major species groups tested in Alberta 2022.

Most of the geese tested were Canada geese (96 of 119), and of the 53 positive for AIV all but two were confirmed HPAI or H5. All 15 snow geese were confirmed HPAI or H5.

The great majority of hawks tested were red-tails (37 of 62) and also were H5 positive (25 of 37). Five of eight rough-legged hawks tested were H5 positive, one of which was found dead on Oct. 24. Two of four Cooper's hawks were positive. AIV was not detected in 5 of 6 sharp-shinned hawks (remaining bird was matrix positive and is subject to further testing), any of the four Swainsons' hawks, nor the single hawk-owl, broad-wing, or goshawk.

Most owls tested for AIV were great-horns (63 of 73, including 51 adults and 11 owlets). H5 AIV was detected in 41 adults, and all 11 young of year (YOY, included one pooled sample of 3 siblings). The two snowy owls tested were H5 positive, as was 1 of 7 great grey owls. AIV was not detected in two short-ears, two barred, or one saw-whet owl.

Classification: Public

All tested cormorants, western grebes, or eared grebes found dead or euthanized due to neurologic dysfunction at or near their nesting colonies tested positive for H5 avian influenza.

AIV was not detected in ducks until late August. During August and September 56 of 274 ducks were AIV positive, of which 42 were mallards. Remaining AIV positive ducks were H5 (4 blue-wings, 2 green-wings, 1 gadwall, 1 pintail), matrix positive (2 green-wings, 2 pintails, 1 goldeneye), or inconclusive matrix (1 pintail). However, 45 of 56 positives were live banded birds (n=24) or those shot by hunters (n=31) and only two of the 45 were H5 (a pintail and a mallard). A single water sample from the lake where positive ducks were harvested also was matrix positive for AIV. In addition, all four ducks submitted as sick (neurologic, head tremors) or found dead in September were confirmed with H5.

Table 1. AIV results, by species and species group, tested in 2022.

Species	H5	HPAI	Inconclusive H5	Positive matrix	Inconclusive matrix	Negative matrix	Grand Total
Cormorant							
Double-crested cormorant	14	6				2	22
Corvid							
American crow	3	2				25	30
Black-billed magpie	12	6				51	69
Blue jay	1					8	9
Raven	2	2				19	23
Duck							
Blue-winged teal	4						4
Canvasback						1	1
Common goldeneye				1			1
Gadwall	1					2	3
Green-winged teal	2			2			4
Lesser scaup						1	1
Mallard	3			29	5	149	186
Northern pintail	1			2	1	2	6
Redhead						1	1
Ruddy duck						3	3
Water				1			1
Goose							
Canada goose	24	19	1	1		34	79
Canada goose YOY	1	3				6	10
goose						1	1
Greater white-front goose						6	6
Snow goose	11	4					15
Grebe							
Eared grebe	1	13				3	17
Grebe						1	1
Pied-billed grebe						1	1
Red-necked grebe						2	2
Western grebe	1	12				1	14
Hawk							
Broad-winged hawk						1	1
Cooper's hawk	1	1				2	4

Classification: Public

Northern goshawk						1	1
Northern hawk owl						1	1
Red-tailed hawk	8	16		2		7	33
Rough-legged hawk		4				3	7
Sharp-shinned hawk				1		4	5
Swainson's hawk						3	3
Owl							
Barred owl						1	1
Great grey owl		1				6	7
Great horned owl	7	32				9	48
Great horned owl 3 YOY		1					1
Great horned owl YOY		6				1	7
Northern saw-whet						1	1
Short-eared owl						1	1
Snowy owl	2						2
Grand Total	**99**	**128**	**1**	**39**	**6**	**360**	**633**

Temporal distribution of AIV test results (April - August)

The majority of birds were collected late April to early May and most of them were AIV positive geese, hawks, owls, or corvids (Figure 9, 10). The lack of AIV negative birds at this time largely reflects the selection criteria for accepting birds with clinical visible or behavioural signs consistent with possible AIV infection. In the summer months, birds in these groups generally were AIV negative (Figure 10). There was a noticeable upturn in corvids tested through the summer but none was positive for AIV. In late summer, AIV was detected again in geese, corvids, and live and dead ducks.

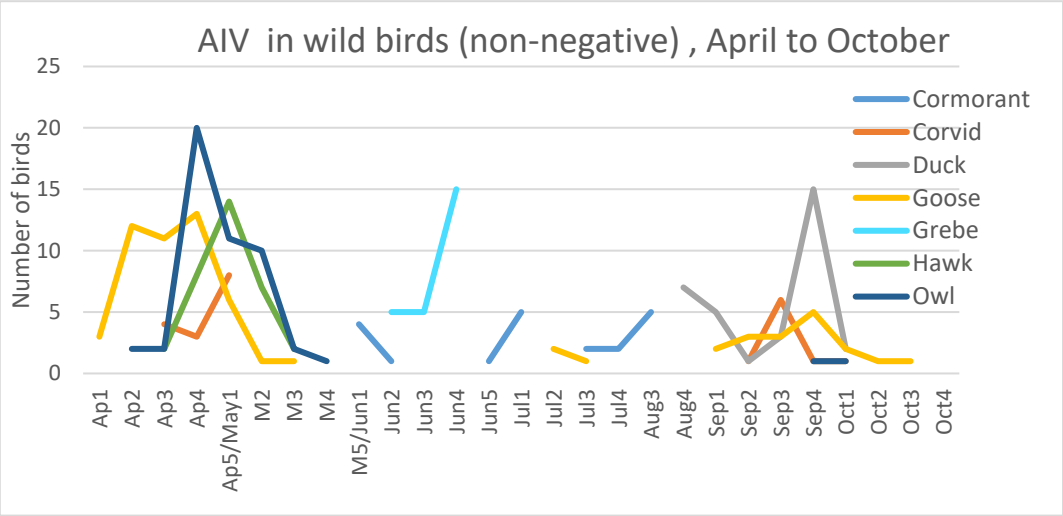

Figure 9. AIV p*ositive wild birds, by major species group in Alberta, April to August, 2022*

Classification: Public

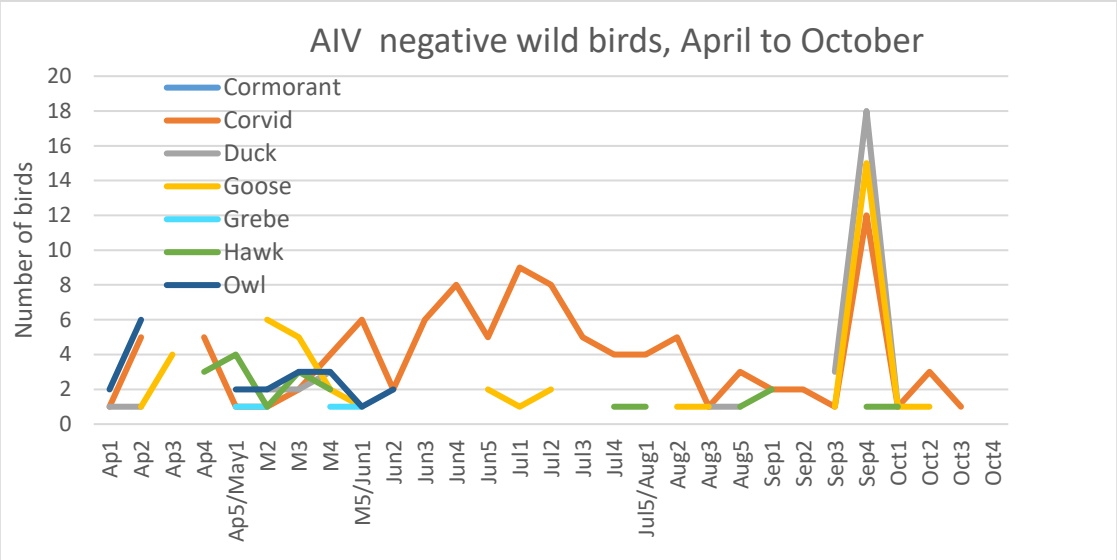

Figure 10. AIV negative wild birds, by major species group in Alberta, April to August, 2022

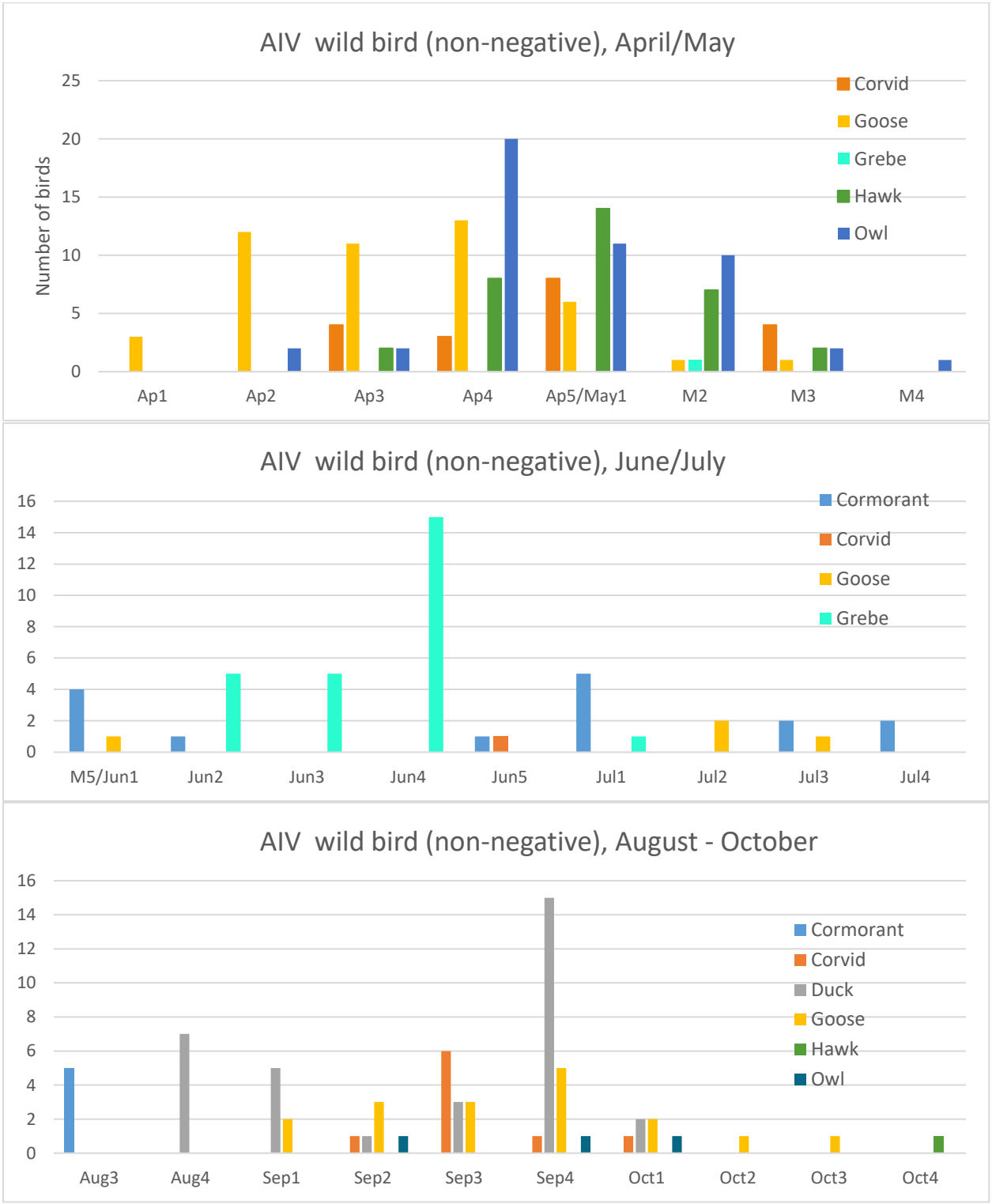

Figure 11. Detailed temporal shift in AIV detections in major species groups: April/May, June/July, August to October 2022.

Classification: Public

Mammals

The number of sick or dead skunk reports increased sharply in late April and tapered off through May (Figure 12). At least 80 sick or dead skunks were reported (75 of which were in April & May). Early reports all involved adult skunks found in fields, ditches, farmyards or at ponds or sloughs. Most of the locations were within the immediate vicinity of dead snow geese. In a few cases, skunks were seen alive prior to death and invariably were reported as having major seizures, head tremors, convulsions, lethargy and disorientation. A few reports of individual sick or dead skunk kits came in during June and July. However, after early June there were no dead adult reports until late August and then October.

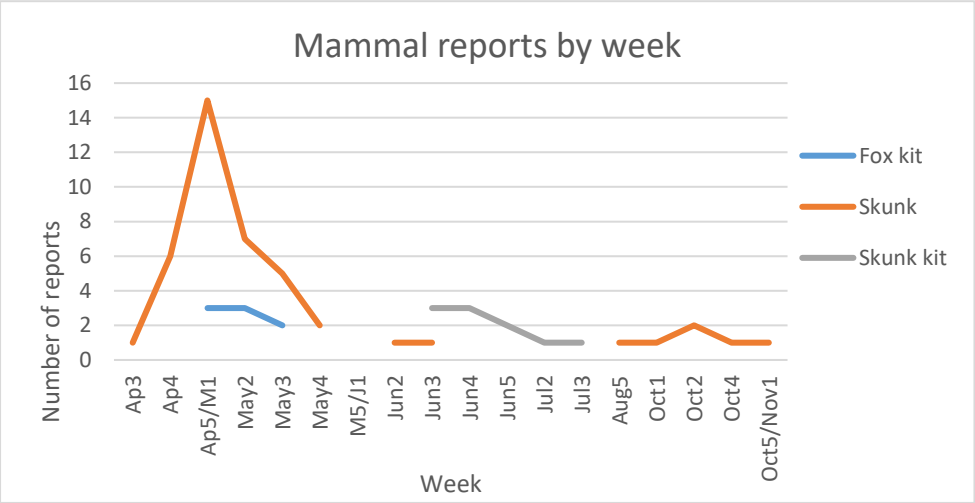

Figure 12. Sick or dead skunk and fox reports during the AIV outbreak.

In early May two permitted wildlife rehabilitators received more young of year red foxes (*Vulpes vulpes*) than usual. These fox kits arrived with variable clinical signs that ranged from mild transient neurologic dysfunction and blindness to severe seizures, persistent bilateral blindness, head tremors, and marked lethargy. In the latter case, kits were euthanized when received. A total of 14 fox kits were reported, 12 of which died or were euthanized. No such adult foxes were reported or received.

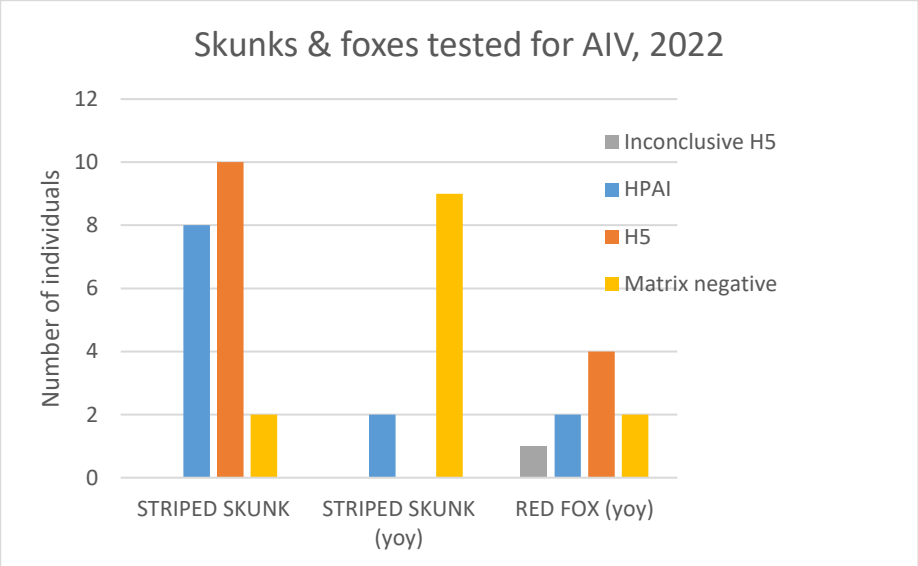

Figure 13. AIV in skunks and red fox tested in Alberta 2022.

AIV (HPAI, H5, or inconclusive H5) was detected in most of the adult skunks tested (Figure 13). To date, all samples sent for genetic analyses at the national virology lab were confirmed as HPAI H5N1 (10 skunks, 2 red fox). The eighteen HPAI or H5 positive adult skunks were found dead (n=4) or displayed severe neurologic signs (n=14) and died or were euthanized. The two adults that tested negative had evidence of trauma. Very few sick or dead young skunks were reported. Two kits that displayed neurologic signs and were euthanized in late June were H5 positive. All remaining skunk kits sampled in June and July were negative for AIV.

Classification: Public

In contrast, all reports of sick or dead red foxes involved young of year (yoy) kits in late April and early May. Of the nine kits tested, two were HPAI confirmed, four were H5 positive, one was H5 inconclusive, and two were negative for AIV. Five of the six AIV positive kits displayed mild to severe neurologic signs, the remaining kit was found dead. Both of the negative kits displayed mild neurologic signs and poor vision.

We also tested an emaciated badger (*Taxidea taxus*) found dead on May 30 near Delburne, Alberta. There was external blood on the carcass but it seemed unusual for a badger to be thin when abundant prey was readily available. The badger was negative for avian influenza and on post mortem there was evidence of recent trauma and previous pleuritis of unknown cause.

In mid June we received a report and video of a young adult female black bear (*Ursus americana*) that was lethargic, anterior ataxic, and displayed disoriented circling behavior. The bear was in the general vicinity of a previous snow goose staging area near Athabasca. Testing of the adult bear was inconclusive: It was Matrix positive but did not register as an H5 (or H7) virus. Further investigation will follow. The cub was negative for influenza virus.

Geographic occurrence of H5

The great majority of reports of dead birds and mammals came from central and eastcentral Alberta generally from the US border north to Lac la Biche (Figure 9: A). Additional reports came from Peace country and a few from the boreal forest region. The distribution of reports of sick or dead skunks and foxes completely overlapped the central core area where sick and dead birds were reported. Many of these animals were not available for testing.

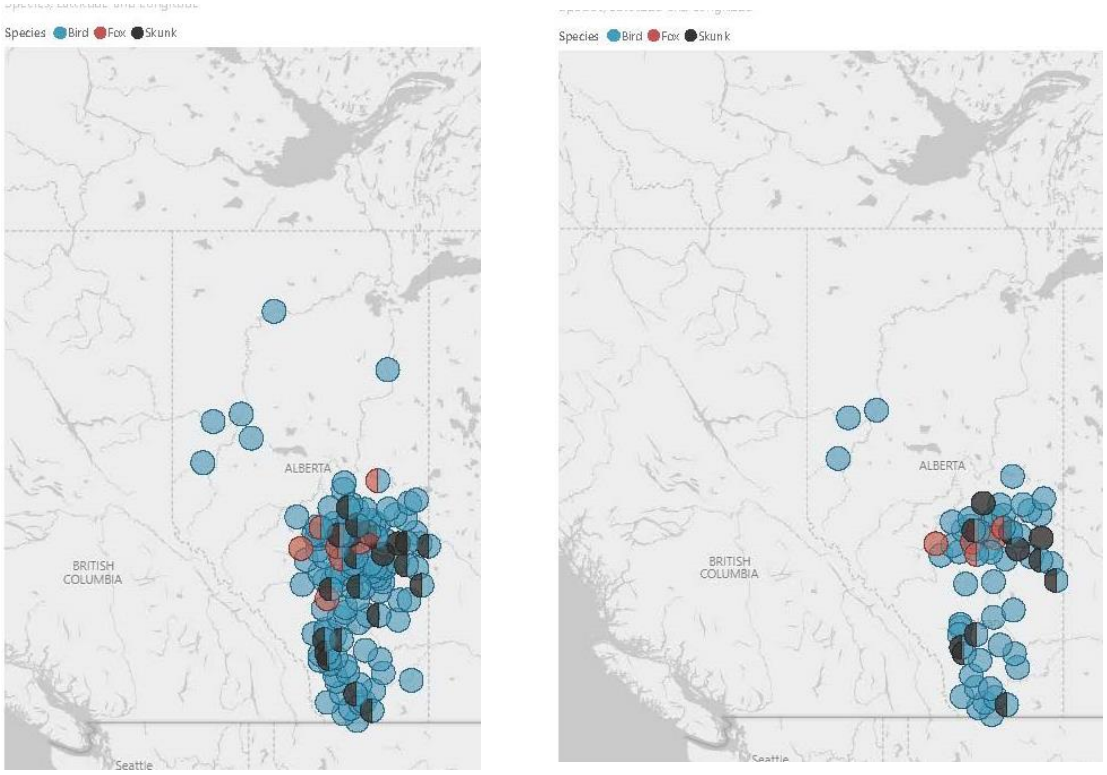

Figure 14. Distribution of sick or dead wild birds, skunks, and foxes from early April to early June 2022. A. All reports. B. All individuals positive for avian influenza.

Avian influenza virus was detected in birds and skunks throughout the central core where sick or dead birds were reported (Figure 14: B). The AIV positive foxes were focused in central Alberta generally around Edmonton.

Classification: Public

DISCUSSION

The avian influenza wave arrived in Alberta in early April. Within a few days, phone lines lit up with sick and dead bird reports – largely snow geese in southern AB. But very quickly reports indicated the whole of central and east central Alberta was awash with sick and dead snow geese and a few Canada geese. Large white bodies on bare agricultural fields and sloughs were particularly visible in early spring due to lack of new or emergent vegetation. Carcasses also were highly visible when field agricultural operations began and farmers were tilling or seeding large tracts of central and eastern Alberta croplands.

In a normal year, large flocks of geese move through the province in March, April, and May before moving on to their traditional arctic breeding grounds. During migration, flocks tend to stay together and concentrate at specific staging sites. The fields in east and central Alberta provide local staging/resting areas for millions of geese of various species each spring. Something in the order of 1.5-2 million snow geese alone pass through Alberta each spring (AEP unpub). Spilled grain on harvested fields, accumulations of spring meltwater, and scattered permanent sloughs provide food, water, and night roosts for staging geese. Panoramic visibility on flat bare fields also offers maximum opportunity to see potential predators at a distance. Specific to 2022, a storm event in mid May resulted in unusually cold temperatures and a thick blanket of heavy wet snow over much of Alberta for about a week. Staging snow geese remained on the ground in large concentrated flocks until the weather warmed and the snow melted. Influenza virus generally transmits by direct contact among individual birds or with infected faeces. The latter perhaps while preening soiled feathers or feeding off vegetation and soil contaminated with goose droppings. The extended stay of many 1000s of birds concentrated in small local areas may have added to the transmission of AIV in 2022 throughout east and central Alberta.

The mortality in 2022 was quite dramatic but unlikely to seriously affect the overall population of snow geese on the Central Flyway. However, this was a virulent virus in snow geese and noticeable mortality occurred across North America in all jurisdictions where migrating snow geese staged or passed through in the spring. We do not yet know whether the cumulative effects may be significant for the flyway or continental snow goose populations.

In contrast, approximately 800,000 Canada geese arrive in Alberta each spring. Of these, ~500,000 nest in the province and ~300,000 move north into arctic nesting areas (AEP unpub.). Canada geese generally arrive in Alberta in March, prior to the mass of snow geese that arrive in April and May. Once here, the large flocks of early Canadas spread widely and nest in pairs or small groups across the province. Large numbers of non-breeding birds may stay in relatively small flocks or groups. The earlier arrival and social spacing inherent in Canada geese may have limited the opportunity for transmission of the HPAI H5 in 2022 in this species.

Within a few days of the initial mortality in snow geese, secondary AIV infection and mortality was reported in raptors and corvids. Dead snow geese in particular were a bonanza for avian scavengers but the free food came with a high price.

Through April and May we received many many reports of sick or dead hawks, owls, and a few falcons. Some of the birds identified by the public as red-tailed hawks may have included Swainson's hawks – the two are very difficult to differentiate. Regardless, the relatively large number of dead hawks reported to this program are likely a small portion of the actual mortality across the province. A few research birds equipped with radio trackers and mortality sensors provided insight into the scale of the mortality, at least in red-tailed hawks (data & information courtesy of Bryce Robinson, Cornell University). Eighteen redtails carrying trackers arrived in Alberta this spring. Of these, three (17%) died soon after arrival and were positive for HPAI H5N1. Two others had lost signals and were presumed dead. In addition to these five birds in Alberta, two tagged redtails died in North Dakota and three died in South Dakota this spring (2 of the 5 were collected and both tested positive for H5 AIV). This is the 4th year of the redtail research study and each year approximately the same number of migrating individual hawks were monitored. The mortality in 2022 is the first time any hawks with trackers died during spring migration.

Similarly, the number of dead owls reported to the program no doubt under-represents the scale of the mortality. Great horned owls in Alberta start nesting in late winter. The synchrony in annual natural events leads to young owls hatching just as the spring migrating birds arrive – a bounty of food for growing owlets. But in 2022 this apparently resulted in many young owls being fed portions of birds infected with H5 AIV, likely dead geese scavenged by adult owls among the carcasses that lay available across much of the province. Entire adult pairs and broods of young owls died as a result. Many reports in May 2022 involved dead owls associated with nest sites, as well as empty or abandoned nests.

The large number of sick or dead adult skunks reported in spring 2022 also is very unusual. These were conspicuous in fields, ditches, and farmyards and would not have gone unnoticed or unreported if similar mortality occurred in previous

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years. Rural residents tend to have high awareness of the potential for rabies in wild species, and the Alberta rabies program has a high profile in many areas. This is evidenced by the number of sick or dead skunks reported to the provincial rabies hotline in mid April 2022. Yet skunks tested during the AIV outbreak were negative for rabies. Similarly, we were able to rule out canine distemper virus in these skunks. Our data, and the geographic overlap with the virus in dead snow geese, support AIV as the cause of the increased skunk mortality across central Alberta.

It bears noting that small songbirds were NOT involved in the avian influenza outbreak. This group of birds, particularly neotropical migrants face significant challenges and risk factors in recent decades (Hames et al. 2006), but avian influenza virus is not one of them. Ongoing surveillance over many years also reinforces that AI viruses and associated disease rarely occur in passerine species (Alexander 2000).

In general, the extent of clinical manifestation of avian influenza differs considerably depending on a wide range of factors (Cardona et al. 2009). In the 2022 spring outbreak, striking numbers of sick or dead geese were reported. However, the great majority of snow geese continued north with their migration and apparently either avoided infection with AIV or were able to suppress its lethal effects. Birds and mammals that developed apparent secondary infection from scavenged geese seemed highly susceptible to AIV infection.

Regardless of species, sick birds and mammals that tested positive for HPAI exhibited consistent neurologic signs that included head tremors, weak neck, ataxia (incoordination), lethargy, and disorientation. Often these signs progressed to significant seizures and convulsions. Affected individuals invariable died or were euthanized due to moderate to severe neurologic clinical signs. AIV invades and replicates in neurons in the brain, leading to acute to severe neurologic dysfunction (Cardona et al. 2009).

The temporal and spatial overlap of infected geese and subsequent AIV in predatory or scavenging species supports an assumption that infected geese were a primary source of the virus detected in hawks, owls, falcons, crows, magpies, skunks, and foxes. And similar overlapping field situations were detected in other provinces and in states across N. America. Yet, this remains largely a working hypothesis. Some of the species affected are not known to be prolific scavengers or to include geese in the normal diet. There is a nagging concern that perhaps live ducks, dabbling ducks in particular, are a silent source of the N. American H5N1 that spread so quickly across the continent this spring. Passive surveillance programs tend to focus on morbidity and mortality (sick or dead individuals) to track disease events. Very few live birds are tested during a disease outbreak. Yet many years of previous AIV surveillance indicate that dabbling ducks on the prairies, are a constant and abundant source of influenza virus. Perhaps the North American HPAI H5N1 in the 2022 spring outbreak also contained a component of being pathogenic to wild birds and mammals that consumed live ducks but not the ducks themselves …. ? Detection of HPAI and H5 virus in live ducks in August and September in Alberta appear to reinforce this hypothesis. It may be that these late summer findings were incidental and reflect the broad role that ducks across North America play as the primary source of ongoing continental populations of avian influenza virus.

It seems worth reiterating that the data contained herein do not reflect the actual occurrence or impact of the virus in wild birds. The data are limited by the lack of standardized or consistent criteria governing public reports (including human density and activities), key species or groups of interest for testing, field investigations, diagnostic screening procedures, recognition or report of suspect clinical signs, and implications of geographic location, in addition to lab testing capacity and priority, all of which perhaps changed over the course of the outbreak. Thus the patterns described in this report are grounded in the specific birds reported, collected, or tested. We believe the patterns clearly indicate which species and in some overall measure, the numerical and geographical extent of the outbreak.

It would be remiss not to put the Alberta situation in perspective. The patterns of mortality in wild birds and mammals in spring and into summer 2022 are consistent across many provinces and states. It is only the scale that differs at increasing regional, national, and international scope. Waterfowl that migrate through Alberta have connections to all four continental flyways and the mortality associated with this particular HPAI H5N1 was a visible reiteration of interconnected nature of the continental waterfowl populations.

The unique North American HPAI H5N1, initially present in migrating waterfowl and later spilled over into scavengers, predators, and colonial nesting species, left indelible effects whenever and wherever the virus arrived. And not just in wild birds and mammals. The associated effects in domestic birds continue to ripple across poultry industries. By November 2022, over 4 million domestic birds died of AIV or were killed during AIV control programs in Canada, ~1.5 million of which were in Alberta. This is indeed a record year for AIV outbreaks across Canada and the US.

Classification: Public

Good disease surveillance programs open the door to many unanswered questions. When it involves a unique disease event, such as the 2022 continental AIV outbreak, often questions arise that were not even considered based on previous knowledge, experience, and data. The 2022 outbreak of HPAI H5N1 in North America will support innumerable research, management, and policy discussions, programs, and careers for decades to come.

Lessons learned

Planning

- Alberta started planning early and was well prepared when the virus finally arrived
    - Wildlife, agriculture, and human health reps monitored the AIV situation in other jurisdictions, alerted appropriate audiences, and planned accordingly
    - Renewed discussions among agriculture, wildlife, and health representatives ensured that each discipline was ready and had similar messages ready to roll out as needed
    - Lines of communication were confirmed so that ongoing information could be shared internally and with external audiences

Delivery

- Defined roles for the Wildlife Disease Unit of AEP and the Wildlife Health Cooperative at UCVM also facilitated transfer of information, aligning of procedures & testing protocols, partitioning of workloads, and sharing of data & experiences
- Two consolidated lines of reporting to a provincial (AEP) and national (CWHC) dead bird hotline offered broad yet focused coverage of incoming calls and concerns
- Regular updates of information to biological, enforcement and admin staff, as well as contributing rehabilitation facilities, supported incoming information of dead bird events and collection of carcasses, as appropriate
- Ongoing public updates through an open provincial avian influenza web page kept a wide range of interested parties informed as the outbreak proceeded.
- Shared information between wildlife and agriculture staff helped inform program decisions and kept messages aligned and consistent

Challenges

Providing current ongoing information about such a complicated and widespread disease outbreak as AIV is a challenge. Intraprovincial policies, programs, and communication worked well, as did regional sharing of information among the western provinces. Seeing the picture at a national or international scope is much more difficult. Alberta offered direct data and observations to informal wildlife disease networks, colleagues, and wildlife agency representatives. We also provided provincial wild bird and mammal data directly to the public on a web page dedicated to avian influenza in Alberta wildlife. https://www.alberta.ca/avian-influenza-in-wild-birds.aspx

The effects of avian influenza on domestic poultry operations, markets, and international trade are the first priority in tracking and responding to AIV outbreaks. Rightly so. The challenge is to also document, in a timely manner, an AIV outbreak in wild bird and mammal species, and provide current data that may directly support risk evaluations associated with domestic birds.

Ongoing efforts

This report is a summation of the efforts and results to date. We have more to do, including .

- Continue to monitor sick and dead bird or mammal reports in light of potential involvement of AIV. Tests samples as appropriate.

Classification: Public

- In conjunction with AB agriculture, follow up on banked tissues from H5 positive mammals. Brain and lung tissues are particularly interesting based on the neurologic and respiratory clinical signs in many of these individuals.
- Maintain ongoing connections and activities among provincial agencies that conduct surveillance, management, and policies associated with wild and domestic animal health and disease.
- In conjunction with federal, provincial, and territorial partners, contribute the abundant Alberta AIV surveillance data to the cumulative national datasets, and directly contribute to subsequent summary analyses and reports.
- Share Alberta data and experiences with all interested audiences. In particular, post a full report to the provincial public AIV webpage.

Acknowledgements

Alberta's avian influenza wild bird surveillance program could not be completed without the ongoing support from the public to see, report, and in some cases collect sick or dead wild birds. Secondarily this includes permitted wildlife rehabilitation facilities. These combined sources are the mainstay of many wildlife disease surveillance programs and such efforts directed towards the recent AIV outbreak are fully acknowledged and appreciated. Similarly, significant efforts of staff of Fish and Wildlife Stewardship Branch of Alberta Environment and Protected Areas, Fish and Wildlife Enforcement Branch of Alberta Justice, and the College of Veterinary Medicine of the University of Calgary is gratefully acknowledged. This was a fast-moving outbreak with a flood of information coming from many sources. Samantha Stamler, AEP Wildlife Disease Tech did a masterful job of coordinating, receiving, recording, and testing incoming samples. Special thanks to Dayna Goldsmith with CWHC in Calgary for sharing data, experiences, and work load – we would have bogged down completely in the primary outbreak without the Calgary efforts. The long-standing working relationship between AEP and AGI in regards to a wide range of disease testing and investigation also is key to the success of the 2022 AIV wild bird surveillance program, and a list of other wildlife diseases and situations of concern.

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Classification: Public

Appendix 1: Modified AIV wild animal Sampling Protocol for 2022

Sampling Procedure:

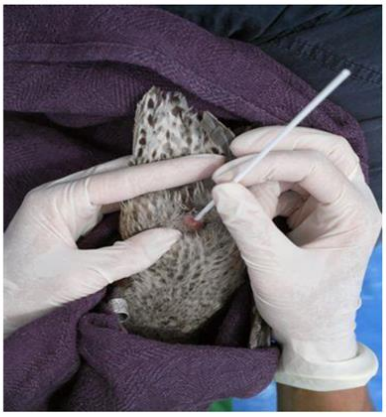
- From **each** bird one cloacal (fecal) swab and one oral swab should be collected. Both swabs are **placed into a single vial** (one bird, one vial, two swabs in the single vial).

For Cloacal swabs:

1. Insert swab into the cloaca about 1 cm, rotate it to collect a sample of excreta, and remove it.
    a. **Keep swab as sterile as possible, avoid contact with anything other than what is being sampled**. If the applicator end of the swab touches anything other than the intended sample, discard and use a new swab.
    b. **Gently** insert swab into cloaca and run along mucosa. Getting fecal matter onto swab is good.
2. Insert the swab about 3/5ths of the length of the tube with virus transport medium. Break the swab tip off in the tube by prying against the lip of the tube. Do not use scissors to cut the swabs off, to avoid spillage and contaminating vials with the content of other vials or swabs (cross-contamination).
    a. It is important to try to avoid cross contamination recognizing that even a small amount of contamination between samples could generate false results.
3. Close the tube tightly immediately after putting the swab in, and keep chilled.

For Oral samples:

1. Open the applicator swab envelope from the ‘stick’ end being careful to keep the swab sterile. Insert swab into the oral cavity, swab the back of the mouth, near the larynx and back of the tongue.
    a. **Gently** insert swab and run across the tongue, under the tongue, back and roof of the mouth, and over the choanal slit.
2. Insert the swab well into the tube containing the virus transport medium, and break the swab tip off by prying it against the lip of the tube. Take care to avoid cross-contamination between samples.
3. Close the tube tightly immediately after putting the swab in it, and keep chilled according to storage instructions above.

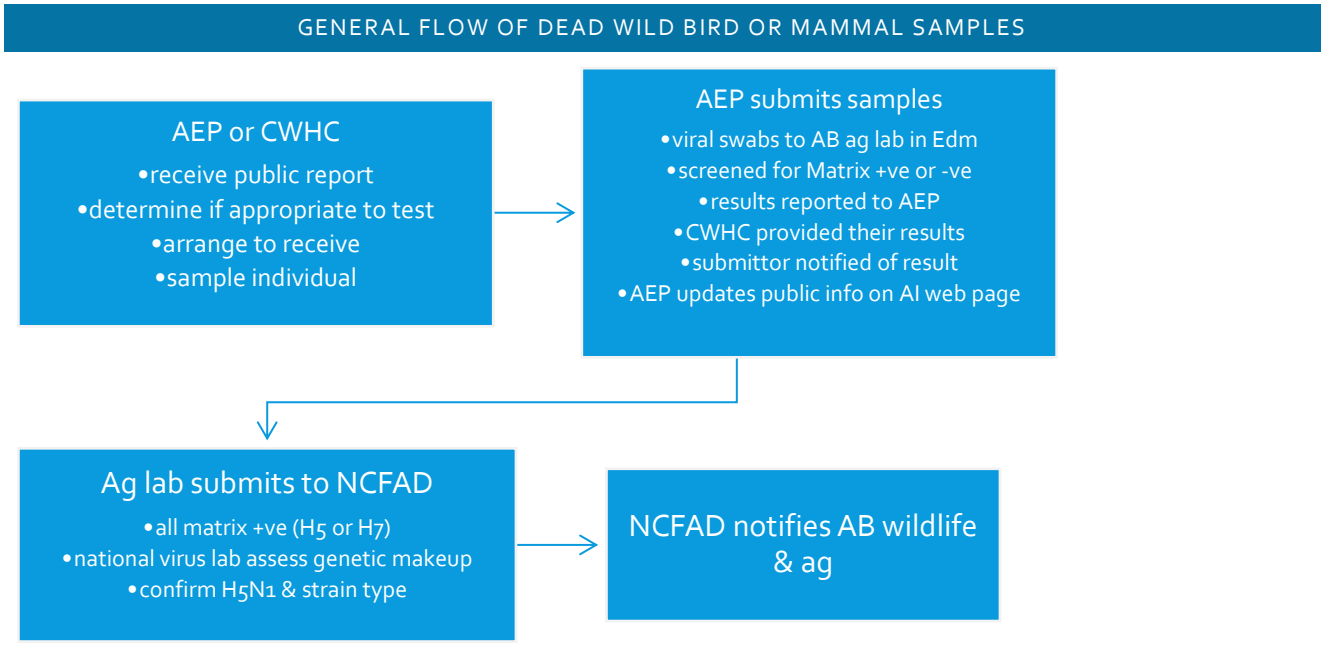


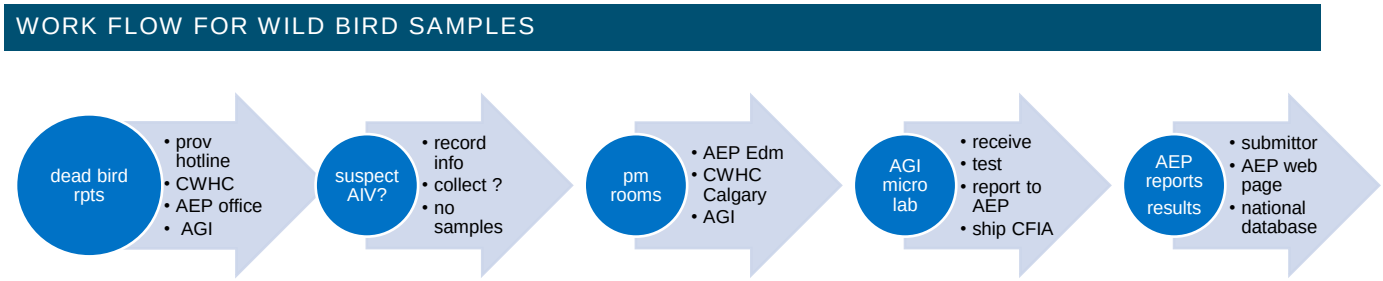
Classification: Public

Appendix 2: avian influenza testing overview

Background

Testing for avian influenza is complicated. Carcasses are sampled in Calgary (CWHC) and Edmonton (AEP). Viral swabs are collected and submitted to the Alberta agriculture molecular biology lab where they are screened for highly pathogenic forms of H5 or H7 avian influenzas using national standardized tests and procedures (these are called Matrix results). All matrix positive samples are submitted to the national virus lab of the Canadian Food Inspection Agency in Winnipeg (NCFAD). Here the detailed genetic makeup of the isolated viruses is determined and definitive confirmation as a specific strain of H5N1 is completed.





Classification: Public

Appendix 3. Gallery of AIV in Alberta, spring 2022