

2018 Eastern Loggerhead Shrike Recovery Program - Summary Report

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Table of Contents

1.0 Highlights from the 2018 field season	1
2.0 Wild population	2
2.1 Monitoring	2
2.1.1 Summary.....	2
2.1.2 Returning captive-bred birds.....	3
2.1.3 Nest checks.....	3
2.1.4 Nest failures.....	4
2.2 Volunteer Adopt-A-Site surveys	4
2.3 Banding	4
2.4 Development and critical habitat	5
2.5 Staffing	6
3.0 Captive population	6
3.1 Status of the captive population	6
3.2 Activities at partner facilities	6
3.2.1 Captive breeding summary.....	6
3.2.2 Breeding facility results and wintering status.....	7
3.2.3 Non-breeding facility status.....	7
3.3 Mortality	8
3.3.1 Adults.....	8
3.3.2 Fledglings.....	8
3.4 Captive-bred releases	9
3.4.1 Banding.....	9
3.4.2 Radio tags.....	9
3.4.3 Post-release movements.....	10
3.5 Population management	10
3.5.1 Program capacity.....	10
3.5.2 New partner facilities and changes at existing facilities.....	10
3.5.3 Studbook management tools.....	10
3.5.4 Husbandry manual updates.....	11
3.6 Carden cage decommissioning	11
4.0 Public education and outreach	12
4.1 Public presentations	12
4.2 Events	12
4.3 Media	12
5.0 Habitat stewardship	13
6.0 Ongoing research	13
6.1 Identification of wintering grounds and migratory routes	13
6.2 Migratory urge study	14
6.3 Genomic tools for species conservation and management	14
6.4 Genetic suitability of mates chosen by captive birds	15
6.5 Stress hormone research	15
6.6 West Nile virus seroconversion in Loggerhead Shrike after vaccination with a killed virus vaccine	15
7.0 Partnerships and collaboration	16
7.1 Loggerhead Shrike Working Group	16
7.2 Building Regional Capacity	16
8.0 WPC fundraising	17
Appendix 1. Non-LOSH birds detected on WPC-operated Motus towers	18

1.0 Highlights from the 2018 field season

Wild population

- 19 wild pairs (8 in Carden, 11 in Napanee)
- 53 wild young fledged (25 in Carden, 28 in Napanee)
- 0 wild young recruited for captive population
- 4 unmated single birds (2 in Carden and 2 in Napanee)
- At least 21% of all birds detected in the wild this year were captive-bred

Captive population

- 31 initial pairs, and 3 repairing attempts
- 24 pairs fledged young
- 132 fledglings survived to release or retention
- 16 fledglings died while in captivity
- 1 fledgling retained
- 130 fledglings released (+1 escape from a breeding facility); 14 with radio tags

Status of the captive population (as of Nov 9)

- 74 birds in captivity
- 67 breeding adults
- 2 unreleasable non-breeders
- 3 retired birds, all at U.S. facilities
- 2 hand-reared education birds (2013HY bird at Mountsberg, 2014HY bird at Toronto Zoo)

2.0 Wild population

2.1 Monitoring

2.1.1 Summary

Nineteen pairs of Loggerhead Shrike were confirmed in Ontario this season: 11 in Napanee, and 8 in Carden (Fig. 1). This is a marked drop from the 26 pairs found in Ontario last year, and a strong reminder of the precarious nature of the Ontario population. Pair counts in both cores decreased compared to last year, with a 15% decrease in Napanee, and a 33% decrease in Carden.

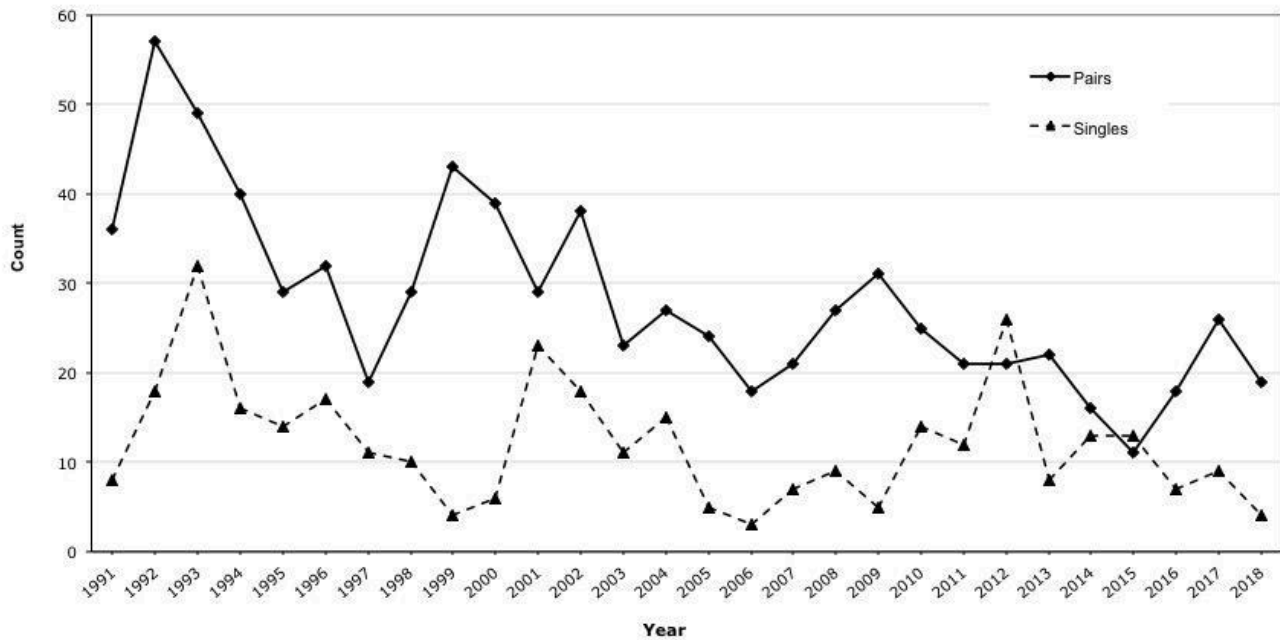


Figure 1. Number of LOSH pairs and single birds in Ontario and Quebec, 1991-2018

Breeding success was variable between the two cores, with all pairs successfully fledging young in Carden, but only 64% of pairs successful in Napanee. Though nearly two-thirds of pairs in Napanee successfully bred, the success by nesting attempt in that core was much lower (54%), with six nest failures observed (see Section 2.1.4). Despite the high number of nest failures in Napanee, 53 fledglings were confirmed across Ontario (28 in Napanee, 25 in Carden), which is just five fewer fledglings than were observed in 2017 when there were 26 nesting pairs in the province. On average, this amounts to 3.5 young per successful nest this past season. Though three pairs did make multiple nesting attempts, none successfully double-brooded this year.

In addition to breeding pairs, four single birds were confirmed this year: two each in Carden and Napanee. Only one of these birds was banded so allowed a definite ID, but the remaining three were determined to be separate individuals based on location and timing of sightings.

Sightings outside of the Carden and Napanee cores were sparse this year. One transient bird was seen near the end of April near Woodstock, and another was seen for a period of almost two weeks from April-May on St. Joseph's Island, near Sault Ste. Marie. Both of these sightings came from eBird.

Using conservative counts of confirmed pairs and single birds, the LOSH population in Ontario was 42 adults this year.

2.1.2 Returning captive-bred birds

Nine captive-released birds were confirmed returning to Ontario breeding grounds this year (Table 1). Ultimately, captive-origin birds made up 21% of the population of adult shrike seen in Ontario this year.

Eight of these birds were observed as part of breeding pairs, and the other was a single bird that was often seen mingling with this year's releases at the Napanee field site. Six of the breeding birds had confirmed pairings with wild birds; the mates for the remaining two breeding birds were never seen, so their origin (wild or captive) is unknown. Seven of the eight pairs bred successfully, with at least 21 fledglings confirmed (40% of all wild juveniles seen in Ontario); however, this fledgling count may be an underestimate, as two successful nests were confirmed after young had already fledged, and both adults were never seen. Breeding birds will typically split fledgling groups between them once the young become more mobile, so the unobserved adults from those two pairings may have been tending to other fledglings.

Five of these birds were confirmed as 2017-releases (3.9% return rate). The remaining four captive-origin birds were released in 2016, three of which were not observed in 2017. The fourth 2016-release bird (SI/[YE]:OR/GY) may have been seen last year as well, as there was a bird for which only a partial band combination was seen in 2017 (YE:OR). Though the bird seen this year had lost the colour band on its left leg, review of banding records showed yellow to be the only option for that lost band. Had the bird observed this year retained its yellow band through the 2017 season, it is conceivable that the grey band on the right leg could have been missed by field staff that year, as grey is a notoriously difficult band colour to see. Taking the conservative approach and assuming this bird was the same seen last year, this would mean that 7.6% of birds released in 2016 returned to breeding in Ontario in subsequent years, which is an increase from the 4% seen in 2017.

Table 1. Captive-bred birds observed in 2018

Core	Band combination	Hatch year	Hatch site	Release site	Sex	Paired?	Breeding outcome
Carden	SI/RD:DB/OR	2017	MRC	Carden	M	Y	3 fledglings
	SI/RD:WH/RD	2017	MRC	Carden	M	Y ^a	3 fledglings
	SI/RD:DB/WH	2017	ALS	Carden	F	Y ^a	2 fledglings
	SI/YE:DG/RD	2016	TZ	Carden	F	Y	3 fledglings
	SI/YE:DG/LB	2016	TZ	Carden	F	Y	2 fledglings
Napanee	RD/SI:RD/OR	2017	TZ	Carden	U	N	--
	RD/SI:YE/DG	2017	ALS	Napanee	M	Y	Unknown ^b
	SI/(YE):OR/GY ^c	2016	MRC	Napanee	F	Y	4 fledglings
	SI/YE:YE/LB	2016	MRC	Napanee	F	Y	4 fledglings

^a Mates never seen, so unknown if pairing is with wild or captive-origin bird

^b Secretive pair, nest site not found; breeding outcome unknown

^c Colour band lost on left leg, but determined to be YE based on review of banding records. Two birds were released in 2016 with OR/GY on right leg: SI/YE in Napanee, and YE/SI in Carden. Bird is more likely to be the Napanee release, so those details included above, but with some uncertainty. YE/SI:OR/GY was hatched at SCBI, and sex was unknown at release.

One other captive-bred bird was seen in mid-April in Dunkirk, IN, during spring migration. This bird was hatched in 2015 in Mountsberg, and released in Carden. Interestingly, this bird was never reported in Ontario.

2.1.3 Nest checks

Five nest checks were conducted this year, all in Napanee, and all done when nest status was uncertain. Checks at three nests, completed by the Lead Biologist or by field staff in consultation with the Lead Biologist, revealed failed nests (see Section 2.1.4). The other two nest checks both occurred at the same nest site: the first, on May 28, was completed by the Napanee Biologist when to check on a suspected failure at a site where the adults did not visit the nest over the span of a two-hour observation. The check revealed five nestlings, and though the adults were observed provisioning the nest the following day, the frequency was very low, with only one visit

over 90 minutes. The second check at this nest occurred on June 15 as no fledglings had been seen on site so the nest was again suspected to have failed. The nest was intact and contained a single egg, which the Lead Biologist advised field staff to leave for a day in case the female was laying a new clutch in the same nest. A subsequent check of the nest the next day found no new eggs and no LOSH behaviour in the area, so the nest was considered a failure and the egg collected.

2.1.4 Nest failures

Six nest failures were observed this season, all in Napanee. Unfortunately, logistical difficulties precluded cameras from being deployed at any of the failed nests, so cause of failure could only be deduced from examination of the nesting sites after failure. Nest checks following two of these failures revealed mammalian predation as the likely cause (determined by heavily damaged nests). Two other failed nests had no signs of damage, so may have been avian predators, though one of the pairs was notoriously inattentive to their young so a lack of nestling provisioning may have been a factor. One nest failure was on a site to which staff did not have access, so no cause could be determined, and the final failure occurred before the nest location had been confirmed by staff, so could not be further investigated.

One additional pair was seen together on multiple days, but no further signs of nesting were observed before the pair disappeared.

2.2 Volunteer Adopt-A-Site surveys

WPC staff survey efforts continue to be augmented through the Adopt-A-Site (AAS) survey, which uses citizen scientists to survey for LOSH, and a suite of other birds found in similar habitats. Thirty volunteers conducted roadside AAS surveys of 114 priority patches across Ontario. Carden and Grey-Bruce had the best coverage, with 34 and 33 sites surveyed in each respective core. Conversely, Pembroke-Renfrew was a low-engagement area, with only one active volunteer, and Manitoulin Island had no surveyors for the second year in a row. Volunteer recruitment continues to be a challenge in areas where LOSH have not been recently observed.

Volunteers reported LOSH on eight sites: seven in Carden and one in Napanee. The Napanee report and one of the Carden reports were sites that were already known to field staff, but the remainder were either the first observation on a site, thus augmenting early-spring occupancy data, or were mid-season reports that helped to locate elusive birds that were not reliably seen by field staff. Thirteen volunteers used call-playback (CPB) during their surveys this year, with one positive result.

No on-site surveys were conducted this year because of time constraints on the Lead Biologist at the start of the season. Efforts will be made over the winter to find landowners who are willing to allow volunteers to conduct on-site surveys, so there will be established in-roads by the time surveys need to be organized. Some progress was made this year towards getting volunteers on a large site in the Napanee core owned by the Mohawks of the Bay of Quinte, so those discussions will be reopened with the goal of connecting them with some volunteers in 2019.

2.3 Banding

Five wild LOSH were trapped and banded this year, two in Napanee and three in Carden. All trapping was led by Hazel Wheeler, with assistance from area field staff. Both birds trapped in Napanee were from the same breeding pair, and trapping in Carden included birds from two separate territories. Birds were banded with either SI/DB or DB/SI on right, to indicate wild adults caught in 2018. Regular behaviour was observed at all territories the day after trapping activities.

Josh Robertson, PhD student studying stress in LOSH, accompanied Wheeler on trapping in both cores to assess whether acute stress could be gauged in LOSH through the use of thermal imaging cameras. A GoPro and a thermal camera were trained on one of two traps during each session; by chance, four of the birds were caught in

the trap that was not within frame of the cameras, but data was collected for the one bird that was caught in the camera trap. Preliminary interpretation of the data from this one bird is pending.

After trapping activities, at least 52% of the wild LOSH population remained unbanded in Ontario; band combinations were only confirmed for 44% of birds in Carden, and 29% in Napanee. This rising percentage of unbanded birds in Ontario is making decreasing the quality of demographic and territory use data that we are able to gather each year, so an increase in trapping effort is strongly recommended in 2019.

2.4 Development and critical habitat

Habitat protection continues to be a high-priority activity for the LOSH Recovery Program. WPC continues to submit all LOSH nest locations to the Ministry of Natural Resources and Forestry (MNRF) on an annual basis, and these locations are used to direct habitat protection through the MNRF's General Habitat Description (GHD) for Loggerhead Shrike. The locations of single birds on territory are also being submitted to the MNRF, though it is not yet clear what protection these territories may be afforded.

The LOSH Recovery Team agrees that the current GHD, which leads to the protection of only the habitat within 400m of nest trees, does not offer sufficient habitat protection to support the recovery of the species, so WPC staff and Amy Chabot met with the MNRF staff in the Policy Division in February 2017 to propose that the province adopt the federal definition of critical habitat for the species (as described in last year's report). Though the meeting felt positive, it is as yet unknown if the MNRF have started the process to enact changes to their GHD for LOSH. Hazel Wheeler followed up with Amy Mougénel at the MNRF earlier this month to ask if any progress has been made, but no response has yet been received.

This follow-up with the Mougénel was spurred by discussions with MNRF staff in another division about another solar development (Solar Flow Through) that is planned for the property immediately adjacent to the Napanee Shrike Release site. This development involves the installation of a one hectare array at the front of the neighbouring property to the east, within 300m of nest sites active this year and last. MNRF staff agreed that this array is poorly placed and will negatively affect LOSH habitat, but because of the current GHD they are unable to intervene. WPC continues to be in discussion with the solar developer to try to minimize the impacts of this development, and advocate for effective habitat management. WPC has also reached out to the Nature Conservancy of Canada (NCC), who has had separate discussions with the solar developer about the project, and has a vested interest as they own the land on which the release site operates. A recent conversation between WPC and NCC has shown that neither organization is getting full information from the developer, so going forward there will be a push for both organizations to be included in all discussions.

WPC continues to work with BluEarth Renewables on the Loyalist Solar Project in the Napanee core, for which construction should be complete by end of year. BluEarth has approached WPC to submit a proposal for post-construction monitoring of LOSH on both their habitat enhancement sites (which include high priority LOSH patches), and the "generation sites", where solar arrays have been installed; BluEarth's permits require annual monitoring of these sites for the first five years after construction. Rather than proposing simple monitoring which would only supply anecdotal evidence of habitat use (or avoidance) by LOSH, the submitted proposal includes a three year study to examine the use of generation sites by wild LOSH compared to typical habitat, and whether there is any difference in foraging success or diet composition. If BluEarth deem the study to be unnecessary for their needs, a simplified monitoring plan will be proposed as an alternative. Discussions with BluEarth will continue over the winter.

Beyond the post-construction monitoring project, Amy Chabot has also been working with BluEarth development a LOSH landscape analysis research project that would help the company meet their Overall Benefit permit obligations. The MNRF has been consulted throughout the process, and are generally in support; project development is ongoing.

2.5 Staffing

Field activities were carried out this year by teams of two contract staff in each core. This is still the preferred staffing level, to ensure adequate monitoring of wild birds throughout the season, proper care and observation of captive birds at the release sites, and for the safety and well being of field staff.

Field activities were disrupted somewhat this year because of a complete turnover of the Carden field team by mid-season. The field assistant, hired for May 1, left the position within the first two weeks so was replaced by the end of that month, and the field biologist had to be replaced by the end of June as she had found a longer-term opportunity elsewhere. Though this turnover certainly affected wild population surveys, and fewer sites were surveyed than anticipated this year, higher priority sites still had adequate survey coverage, so we can have confidence in the results from that core.

3.0 Captive population

3.1 Status of the captive population

As of November 9, there were 74 birds in the captive population (including partner facilities in both Canada and the US). Sixty-six of these birds are considered breeding stock, three are retired birds that have aged out of the breeding population, three are education/exhibit birds, and two are unreleasable non-breeders. The current breeding stock includes: 44 birds that are 5 years or younger (HY 2013-2017), 21 birds that are 6-10 year olds (HY 2008-2012), and two over 10 years old. No juveniles were retained this year to add to the breeding population because of uncertainty surrounding overwinter holding space, as detailed in Section 3.5.1.

3.2 Activities at partner facilities

3.2.1 Captive breeding summary

There were 31 initial pairs this season, and an additional 3 re-pairing attempts, for a total of 34 pairings. Twenty-four of these pairs produced 132 young that survived to release or retention (as of Nov 8; Fig. 2). One hundred and thirty young were released to the wild at our field release sites (73 in Carden, 57 in Napanee), which is a new record for the program (highest previous release count was 128 in 2017). One additional independent fledgling escaped at the breeding facility just prior to transfer to the release site, which would bring our release count to 131 individuals for the year. No retentions were planned for juveniles this year due to a shortage in overwinter holdings, but one fledgling was retained at the Toronto Zoo as it was too large to be banded, thus the program coordinator deemed it unreleasable. This bird will not be used for breeding, so its fate is currently unknown. Sixteen young died before the end of the season, and for the second year West Nile Virus (WNV) featured heavily, with four individuals confirmed positive for WNV so far; final counts will be tallied once all necropsy reports have been received (details in Mortality section below).

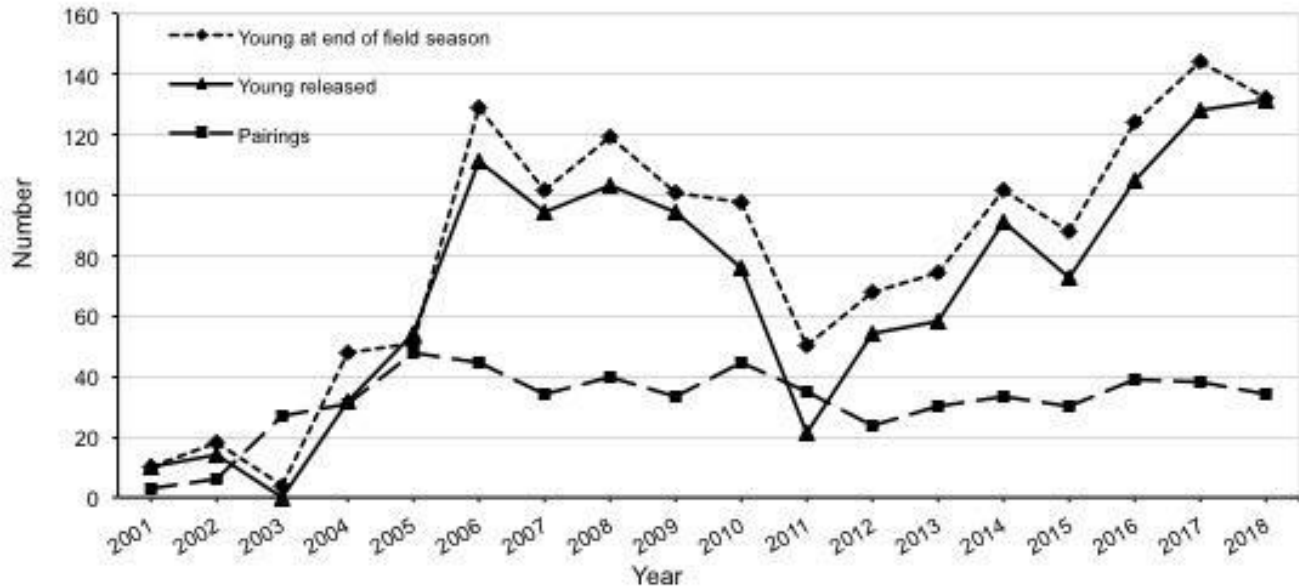


Figure 2. LOSH captive pairings, young surviving to end of season, and young released, 2001-2018

3.2.2 Breeding facility results and wintering status

African Lion Safari (ALS): 8 of 11 pairings fledged 46 surviving young (36 from 1st clutches, 10 from 2nd clutches). Forty-six birds were released (31 in Napanee, 15 in Carden), one with a radio tag. Eleven young died or were euthanized prior to release (five from 1st clutch, six from 2nd clutch; see Section 3.3.2 for details). This facility is currently holding 20 birds, and a second Shrike Pod will be built this winter, which will increase both breeding and overwintering capacity for 2019.

Mountsberg Raptor Centre (MRC): 5 of 5 pairings fledged 27 young (12 from 1st clutches, 15 from 2nd clutches). Twenty-six were released (22 in Carden, 4 in Napanee), one with a radio tags, and one additional fledgling escaped at the facility three days prior to the transfer of that clutch to the release site. The escaped bird was seen occasionally over the next week, but attempts to retrap were unsuccessful, and sightings stopped shortly thereafter. This facility is currently holding 12 breed birds and one outreach bird.

Smithsonian Conservation Biology Institute (SCBI): 5 of 9 pairings fledged 26 surviving young (18 from 1st clutches, 8 from 2nd clutches). All surviving fledglings were transferred to Ontario in August and released at the Carden field site (five with radio tags). Two additional fledglings died prior to transfer. This facility is currently wintering 19 birds, including one retired bird, but two of those individuals will be transferred to Ontario this fall, in preparation for breeding next year. One additional bird with low genetic importance for the breeding population will be transferred to Carolina Raptor Center this winter, to be put on exhibit.

Toronto Zoo (TZ): 6 of 9 pairings fledged 33 surviving young (23 from 1st clutches, 10 from 2nd clutches). Thirty-two birds were released (22 in Napanee, 10 in Carden), seven with radio tags. One fledgling was deemed unreleasable as it was too large to be banded, so was retained. This bird will not be used for breeding, so the fate of this individual is uncertain. Five additional 1st clutch fledglings died prior to release, four of which were from the same clutch (see Section 3.3.2 for details). This facility is currently holding 19 birds, which is one more bird than can properly be housed for the winter, but five of those birds will be transferred to the Nashville Zoo at Grassmere as soon as permits allow. One additional education bird is on display at the Zoo.

3.2.3 Non-breeding facility status

Little Ray’s Reptile Zoo (LRR): Little Ray’s was not able to hold any birds this winter as their facility is moving; however, they do intend to be ready for overwinter holding for winter 2019/20, and have also expressed interest

in expanding their participation to include breeding. The possibility will be investigated next spring, following their move.

Nashville Zoo at Grassmere (NZG): The Nashville Zoo is holding two retired birds that have aged out of the captive breeding population, and has been working to develop methods to study the effect of captivity on migratory urge in LOSH (see Section 6.2). Nashville is expanding their involvement, however, and will start breeding birds for release in 2019. Four enclosures were built to house breeders, and two pairs will be transferred down from Ontario this fall for this purpose. An additional non-breeding bird (hatched in 2017 and deemed unreleasable) will be transferred with those pairs, to expand the migratory urge pilot to include a young bird, in addition to the retired birds that have been used thus far.

3.3 Mortality

3.3.1 Adults

We had 11 adult deaths in the captive population this year, as of November 9, plus one escaped bird.

Three birds were euthanized at SCBI: one 7-year-old bird that had suffered from chronic illness, including a persistent parasite load, and deteriorating condition; a 1-year-old bird that presented with acute and severe symptoms (inability to fly, prolapsed cloaca, blood on feathers) for which euthanasia was the humane option; and another 1-year-old bird that was unable to fly and did not respond to treatment. Both of the young birds were found to have heavy capillaria loads upon necropsy, and one had a bacterial infection that may have been due to a vitamin A deficiency.

One of the retired birds at NZG died, presumably from old age, as this bird was 16 years old. Another 13-year-old bird died at ALS, and though the necropsy gave no clear diagnosis, age was likely a factor. The remaining six deaths were all younger birds, hatched in 2013 or later. At ALS, a 3-year-old bird was found drowned in a food bin after a night of extremely heavy rain, and a 5-year-old bird at TZ was found in distress and died when brought to in for treatment. Cause of death could not be determined from necropsy for the latter, but it was found at around the same time that three juveniles were predated in an adjacent cage, so stress may have been a factor. One other 5-year-old bird died at ALS after the breeding season, and the preliminary necropsy reported the carcass positive for West Nile, despite this bird being vaccinated in the spring, which is cause for concern. Necropsy results for the remaining four birds pending.

In addition to the deaths, one adult bird escaped when it was being boxed for transport from LRR in April.

3.3.2 Fledglings

Eighteen fledglings (12% of all those produced) died during the breeding season this year, which is the same level of fledgling death that was seen in 2017 (Fig. 3). Eleven of these deaths were birds hatched at ALS, five were from TZ, and two were from SCBI.

Four juvenile deaths (all at ALS) were attributed to West Nile Virus (WNV), which is the second consecutive year that the virus has caused multiple deaths in captive-bred juveniles. Other deaths were attributed to predation (three fledglings from a single clutch at TZ), fungal infection (two birds), or pulmonary haemorrhage (one bird). One bird was euthanized because of a chronic foot infection, and the causes of death for the remaining seven young were undetermined.

In addition to deaths, one fledgling escaped at MRC just prior to its scheduled transfer to the release site. This bird was fully banded and at a releasable age, and was seen by facility staff over the following week before it disappeared. The ultimate status of this bird is unknown.

Though not included in the above tally, one additional fledgling was confirmed predated (assumedly by a raptor) after release in Napanee, when some remains (including the legs and colour bands) were found by a local resident on a property approximately 7 km away from the release site.

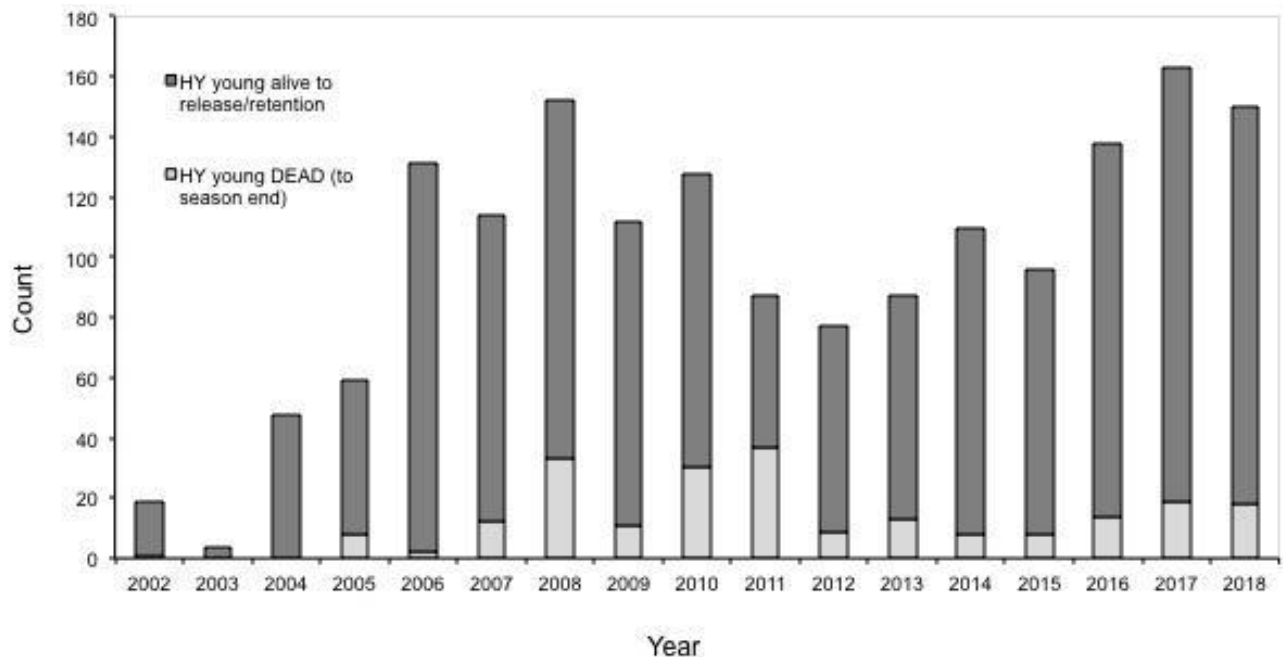


Figure 3. Number of fledglings produced each year that died or survived to release or retention

3.4 Captive-bred releases

3.4.1 Banding

One hundred and thirty-three captive juvenile shrikes received stainless steel bands this season. Released birds that received colour-bands were given a combination that included either DB/SI (69 birds) or SI/DB (57 birds) on the left leg to identify them as a 2018 release bird. One captive-bred bird was banded with DB/SI on the right leg prior to release because an injury on the left leg prevented use of the regular colour band scheme. Radio tags used in 2018 were a slightly different, and lighter, design than used in past years, so birds released with radio tags (14 individuals) were able to be banded with the full year combination (DB/SI) on their left leg, if they took a size 1D band; eight were released with SI/DB, and three with DB/SI. Radio-tagged birds that took a size 2 band received only SI on left, as the larger bands were too heavy to allow addition of the DB band as well. All birds received some sort of temporary colour-marking (Sharpie) to aid in individual identification while in the release enclosures and during post-release monitoring.

3.4.2 Radio tags

Fourteen birds were released with radio tags on the Motus network this season, using the same nylon-coated elastic cord harness attachment technique used since 2015. Five additional birds were fitted with radio tags, but two had fallen off because of poor fit, and three were removed at pre-release checks either because the harness was causing abrasions (two birds), or weight had dropped below the 50-gram cutoff (one bird).

Though WPC is permitted to deploy radio tags on up to 50% of the birds released, logistical challenges often prevent us from reaching that level of deployment. This year, uncertainty around the arrival of US juveniles prevented some possible deployments early in the season. Two release groups were moved through the Carden field site quickly (thus not tagged) to create space for the US juveniles; however, permitting issues delayed that transfer until much later in the season, so the rush on those first groups was ultimately unnecessary. Additionally, a cohort of 26 juveniles from African Lion Safari was also omitted from the potential tagging pool because of their inclusion in the West Nile virus study (see Section 6.6). These birds were subjected to more stress than is typical for juveniles in the captive-breeding program, so they were excluded from tagging to minimize their stress at the release sites.

Details on tracking results to-date can be found in Section 6.1.

3.4.3 Post-release movements

Field staff did not see any released juveniles outside of the field sites this year, though the remains of one juvenile, released in Napanee on Aug. 22, was found by a local resident approximately 7 km west of the release site on Aug. 28. The only other sighting to-date is a tagged bird that was spotted in Winchester, VA from Oct. 16 to Oct. 30. This was a radio-tagged bird that was banded DB/SI, and while those details alone cannot individually identify the bird, it is hoped that Motus detection data received over the winter will elucidate its origins.

3.5 Population management

Andrea Morgan (African Lion Safari) continued in her role of studbook keeper in 2018, with Colleen Lynch, Consulting Population Biologist with the Population Management Centre, contracted by WPC to produce a Breeding and Transfer Plan for the season, including release prioritization and repairing recommendations throughout the breeding season.

3.5.1 Program capacity

Excluding holdings for education/outreach birds, holding capacity across all project partners is currently 90 birds; however, 10 of those spaces (at Little Ray's Reptile Zoo) are out of commission for the winter of 2018/19 as their facility is moving, leaving us with only 80 useable spaces.

There were concerns this summer that Mountsberg was going to discontinue their participation in the LOSH Recovery Program at the end of 2018, so the season progressed under the assumption that that facility would have to be emptied by the end of the year; this would mean only 68 available holding spaces over the winter. To address this crunch, African Lion Safari stepped in and approved the addition of a new Shrike Pod, which is now under construction, and will add space for eight birds over the winter (and four breeding pairs during the breeding season), which would bring our holding capacity to 76 for the winter. Ultimately, the Board of Directors for the Conservation Halton Foundation, which funds operations at Mountsberg, committed to remaining a breeding facility for at least one more year. This has eased the pressure on holding space for this year, but the Foundation will reevaluate their involvement in fall 2019, so the possibility of that facility closing will be considered throughout planning in the 2019 season.

3.5.2 New partner facilities and changes at existing facilities

Little concrete progress has been made over the past year with regards to expanding our network of partner facilities, though there are a few facilities that are considering collaboration. In the U.S., the Columbus Zoo (Columbus, OH), and Reflection Riding Arboretum and Nature Centre (Chattanooga, TN), have both expressed interest in the breeding program, so those conversations will be furthered as possible. Additionally, the Carolina Raptor Center (Huntersville, NC) will be taking a non-breeding exhibit bird this winter, which will further reduce the pressure on holding space. In Ontario, there may be an opportunity to have breeding/wintering holdings at the Earth Rangers Centre (Woodbridge, ON) that would be managed by WPC staff, though these discussions are still quite preliminary.

There were a few notable changes to both staffing and the management of the LOSH program at the Toronto Zoo. Dr. Simon Hollamby, who has been the program veterinarian since 2010, resigned from the Toronto Zoo on July 2 to take a position at the Territory Wildlife Park in Darwin, Australia. Charles Guthrie also retired this year; Guthrie has been a long-time keeper at the Zoo, and has been involved with the LOSH program since the creation of the captive population in the 90s. Along with staffing changes, the LOSH population at the Toronto Zoo will no longer be managed by the Wildlife Health Centre, but instead will be under the care of the Outreach and Discovery staff, one of whom, Natalie Lazure, was a captive technician at the Carden field site in 2012.

3.5.3 Studbook management tools

The studbook continues to be managed in PopLink, which offers suitable capabilities for our needs, with the benefit of being a free program. Species360/ZIMS was explored this past year, as a population management tool

with greater integration capabilities as it creates an online database that could be accessed across all facilities that pay for Species360 membership, whereas PopLink only runs off native files on a computer. Species360 is certainly a more powerful program with more functions than PopLink, but would also require an initial setup fee from all new facilities (normally US\$2500, but a discounted setup fee of US\$299 was offered to LOSH partners) and an annual membership fee (US\$900). These fees would also apply to WPC, which, with an increase in annual membership fee (US\$200), could also take on data management for facilities that did not want/need their own access. At this point, the price may be prohibitive, but adoption of Species360 should be considered if at any point the funding landscape allows.

3.5.4 Husbandry manual updates

Acting at the request of the captive subcommittee of the LOSH Recovery Team, WPC updated the standard operating procedure document for the captive program, the “Husbandry manual for the care, breeding, and maintenance of captive Loggerhead Shrikes (*Lanius ludovicianus alvarensis*)”. The manual, developed in 2012 and updated in 2015, was originally meant to serve as a guiding document for housing and care of LOSH during the overwintering period, with WPC’s captive breeding protocols used as reference during the breeding season. However, the captive breeding protocols were developed when WPC was still conducting in-situ field-breeding, so were no longer entirely applicable to the ex-situ breeding model that has been adopted by the LOSH Recovery Team. The husbandry manual was thus updated to include all protocols pertinent to the captive population, including captive breeding, nestling recruitment, and hand-rearing, with all protocols revised to address ex-situ breeding. The document is currently in draft form, with plans to finalize before the 2019 breeding season.

3.6 Carden cage decommissioning

The Carden LOSH release site, hosted on the Turnbull Ranch, has 14 cages that have been used in field-breeding and/or release of young bred at partner facilities. Hazel Wheeler and Dave Hawke (Couchiching Conservancy) inspected all of these cages on October 26, and seven were found to be deteriorating to the point that they could become hazards to wildlife; specifically, holes had started to develop in the plywood walls and ceiling panels, which could allow wildlife to enter the cage but not easily exit. All of these cages were built at the Smiths Falls release site in 2001-2003, and were moved to Carden in fall 2004. They were built from the original cage design, which included 8’ walls and smaller (2’x2’) release doors, in contrast to the newer cages which were all built with 10’ walls and release doors measuring at least 2’x4’. All were eventually retrofitted to increase their height by 2’, but they still retained the smaller release doors and more solid walls than the new cages, which increased the ratio of mesh walls to plywood walls, to increase air circulation. None of the older cages have been used to hold LOSH since 2014, and since this site now functions only as a release site, thus there is reduced need for so many cages, it was decided that these cages should not be repaired.



Figure 4. Decommissioned cage at the Carden release site. Removed doors/panels are outlined in yellow.

All seven older-style cages were decommissioned on November 19 by Hazel Wheeler and Nicola Inglefield (independent contractor). Decommissioning involved removing the staff access door and a 2’x4’ plywood panel from the top of a wall panel on each cage unit (Fig. 4). All wood was left inside the cages; fastening hardware (bolts, nuts, nails, screws) was removed where possible, though hinges were left on the doors for removal at a later date. These modifications should allow easy transit of wildlife through the cages over the winter, and full removal of the cages will be discussed with Couchiching Conservancy in spring/summer 2019, when weather will be more agreeable.

4.0 Public education and outreach

4.1 Public presentations

Lead Biologist, Hazel Wheeler was a guest speaker at the a species at risk workshop organized by the Ontario Land Trust Alliance on Dec. 11/17 in London, ON (not reported last year), and at the Ontario Bird Banding Association (OBBA) AGM on Mar. 3 at the Bird Studies Canada headquarters in Port Rowan, ON. Both meetings had very engaged audiences of 40-50 people, and were received very positively. The OBBA meeting in particular reached a very valuable audience in soliciting shrike sightings from across Ontario.

4.2 Events

WPC participated in the Nature Conservancy of Canada's event to announce the acquisition of the Irene Ockenden Alvar Tract, which lies immediately west of the existing Napanee Plain Alvar Nature Reserve, which hosts the Napanee release site. In preparation for the event, NCC sent a photographer and videographer to the Napanee release site gather some media about the LOSH program. The resulting video was screened at the acquisition announcement on July 25 at the NCC's Napanee office. Hazel Wheeler also spoke at the event about the importance of the Napanee core to the shrike program. The announcement garnered a great deal of media attention as federal Minister of Environment and Climate Change, Catherine McKenna, was in attendance and spoke on the importance of habitat protection. Beyond local news media, the event was also covered in the *Globe and Mail*; though WPC was not mentioned by name, pictures of WPC staff holding captive-bred shrike were featured in the article.

WPC also led in the organization of an "Alvar and Grassland Stewardship Workshop" that was held at the Lion's Head Rotary Hall on November 3. This was the third in a series of workshops geared towards local landowners (the others held in Napanee and Carden in 2016 and 2017, respectively), and provided education on the unique alvar flora and fauna of the, and information on responsible stewardship (including LOSH habitat). Thirty people were in attendance, including local landowners, environmental organizations, and citizen scientists. Feedback received after the workshop was generally positive, with respondents giving high ratings to the content of the workshop, and the applicability of topics to their concerns. The biggest critique was the lateness of the workshop, which concluded at 8:30pm, for those who came from a distance. The workshops run in past were both full day events, but an afternoon-evening format was planned for this latest workshop as the full day prevented some landowners from attending, especially in 2017. Clearly there are benefits and drawbacks to each format, so any similar events in future will include a comprehensive consideration of the target audience. This workshop was presented in partnership with the Nature Conservancy of Canada, Ontario Nature, and the Ontario Land Trust Alliance.

LOSH outreach displays were staffed at two events this year:

- Partners in Protection, February 4, Royal Ontario Museum, Toronto (with other WPC staff)
- Spring Birding Festival, May 26, Colonel Sam Smith Park, Toronto

4.3 Media

The LOSH Recovery Program broke in to the world of podcasting this year, when NCC invited us to be featured on an episode of their "Nature Talks" podcast (episode 4: The Home of the Butcher Bird). NCC staff recorded audio from the Carden release site, including an interview with Hazel Wheeler. This episode was the third-most downloaded out of the seven-episode series, with 967 downloads. For the entire series, the bulk of listeners (80%) were within Canada, 14% were from the U.S., and the remaining 6% were from dozens of other countries.

The LOSH Recovery Program was also the subject of a project initiated by Leah Gerber, an editor at *Alternatives Journal*, who wanted to start working on her own media. Leah made two visits to the Carden release site to gather footage of juvenile banding and a subsequent release, and conducted an interview with

Hazel Wheeler about the program. The video is in the final stages of editing, and is anticipated for release before the end of the year.

We continue to wait for the release of the Our Incredible Work series, “Sharing our Habitats”, which includes a section on the LOSH Recovery Program (<https://incredibleworld.ca/2017/>). The producers are now anticipating the series to be released next year.

Beyond media concerning the NCC land acquisition, WPC and the LOSH Recovery Program were featured in an article released on the TVO website, “How captive breeding can help save endangered species”.

5.0 Habitat stewardship

Habitat stewardship project funding was secured this year through both provincial (Species at Risk Stewardship Fund) and federal (Habitat Stewardship Program) grants. One project was identified in Carden during the field season, which will involve the repair of a length of cattle fencing on a private property that has been important for LOSH in the area.

In Napanee, discussions are in progress with the Nature Conservancy of Canada, to see what management is necessary on their newly acquired Irene Ockenden Alvar Tract Reserve to maintain the habitat for LOSH. No other projects were identified by field staff over the summer, so landowners will be contacted over the winter to solicit proposals.

6.0 Ongoing research

6.1 Identification of wintering grounds and migratory routes

Tracking results received continue to highlight migratory routes through Ontario; results from birds released in 2017 can be seen in Figure 5. All birds detected on towers in 2017 appeared to go southwest to get around the Great Lakes, with no birds going east around Lake Ontario as was seen in both 2015 and 2016. Data from 2018 is very preliminary at this stage, but two birds released in Carden were picked up on the tower that the Toronto Zoo erected this year.

It was thought that one of our birds released in 2016 was detected on a tower on Martha’s Vineyard in October of that year (the data were not made available to WPC until this year), but further scrutiny of the data showed that it was likely a false positive.

All tags deployed on LOSH to-date have been battery-powered nanotags manufactured by Lotek Wireless, Inc., which have a lifespan of maximum five months. These will be sufficient to gather fall migration data and potentially wintering ground locations at which point

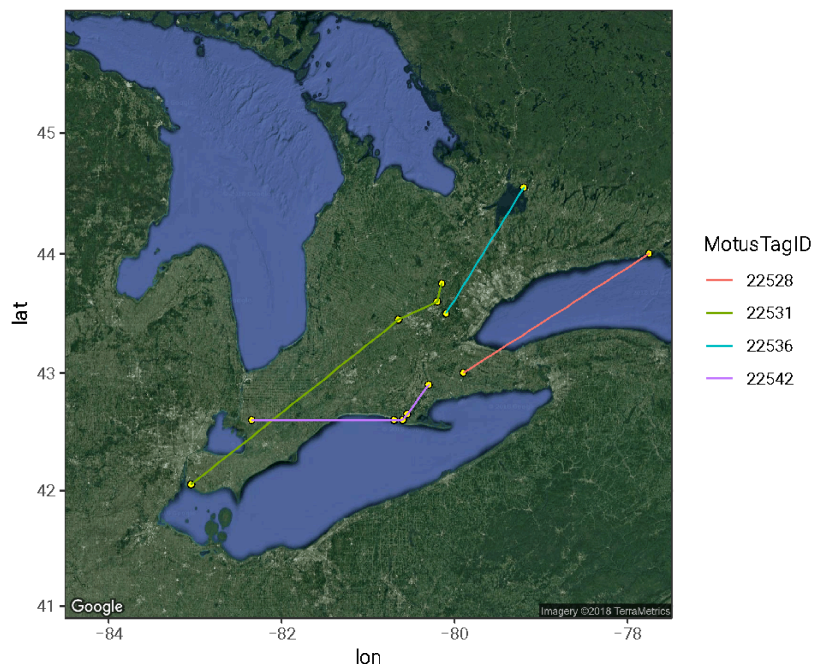


Figure 5. Fall 2017 detections for birds released that year. Tag 22528 was released in Napanee, and all other birds were released in Carden.

they are expected to stop functioning. However, WPC connected with a company in the U.S., Cellular Tracking Technologies (CTT), who make “Life Tags”, which are solar-powered radio tags small enough to be deployed on LOSH. Following an initial discussion between WPC and CTT about the challenges of tagging LOSH, which can readily damage unfortified devices, CTT sent three prototype “shrike-proof” tags to WPC to test on captive birds over the winter. The heavy weight of one tag precluded it from consideration, but the two lighter tags were attached to birds at African Lion Safari this fall. Trials will continue over the winter to gauge the tags’ durability.

The potential benefits of using a solar-powered radio tag on LOSH are great, as these tags could theoretically allow detections of birds over their entire lifespan. However, it is as yet unclear if and how the CTT tags will be detected by the existing Motus network, though the two groups have had discussions about the feasibility of a dual-tag network.

Beyond detecting shrike, the Motus stations operated by WPC have picked up several other birds during migration, and all detections to-date are listed in Appendix 1. Though it appears that the area around the Napanee tower is much more active, it should be noted that the Carden tower has been somewhat plagued by hardware issues, so has not been operational as much as its Napanee counterpart. The Carden receiver was damaged during servicing on Nov. 23/17, so was non-operational while it was being repaired over the winter. Unfortunately the replacement hardware did not function as expected – it would not reboot normally if it lost power, which is an expected occurrence since the Carden station is solar-powered, so was not a reliable unit. Regardless, this unit was deployed in September 2018 after a long period of trouble-shooting, to gather what data it could. When the station was serviced a month later, a deer mouse had made a home of the receiver, damaging the hardware in the process; the station had lost power after approximately three weeks, so had ceased operation. The receiver has again been removed for repair. Despite the problems with WPC’s Carden Motus station, the two towers owned by Couchiching Conservancy continue to operate, so the area still has good coverage.

6.2 Migratory urge study

Methods development for the migratory urge study, which will examine the effects of time in captivity of migratory restlessness in LOSH, has been ongoing at the Nashville Zoo this year, using the retired birds that were transferred to that facility in 2016. Test cages were constructed, and video imagery collected for the three birds. Unfortunately, the bulk of the video may have been destroyed by a disgruntled employee at the facility; however, the video that was recovered showed potential for use with analysis software (Noldus). Two of the original four birds that were transferred to Nashville have died (at 13 and 14 years old), so a young non-releasable non-breeding bird is going to be transferred to that facility this winter, to expand the methods pilot to a younger bird to test that the study cages will be safe for birds across age groups.

Progress on this study has been slow as there has not been a dedicated researcher, so work has occurred as it could around existing workloads. It is hoped that a graduate student can be found to take on this project, and Amy Chabot will be seeking a student to work with her at African Lion Safari to that end.

6.3 Genomic tools for species conservation and management

Dr. Amy Chabot, African Lion Safari, is developing genomic tools to assist in the management of the ex situ population of Loggerhead Shrike as follows: 1) developing markers for a suite of Single Nucleotide Polymorphism, markers to characterize both Class I and Class II genes in the Major Histocompatibility Complex and an annotated genome and to use the data to assess the effect of captivity and managed breeding on the genetic diversity of the ex situ population; 2) use previously developed nuclear genetic microsatellite markers (MSAT) to delineate the range limits of the subspecies of shrike found in Ontario; 3) determine the suitability of Ontario captive stock for captive breeding efforts in the northeastern United States; and 4) make recommendations to improve management of the shrike captive-breeding program in Ontario. SNP, MHC and MSAT analyses are in progress. Preliminary results will be presented at the November 2018 Recovery Team meeting. Final result will be prepared in manuscript form by spring 2019. The genome has been assembled and

data quality assessed. While quality is excellent, full coverage of the genome has not been achieved (~75% coverage of the genome has been assessed based on comparison with the genome of the Zebra Finch). Dovetail Genomics has awarded the project matching funding of work required to complete coverage and develop a chromosome level annotated genome. A quote for cost of this work is being developed and decision made as to how the project will proceed by end of 2018.

6.4 Genetic suitability of mates chosen by captive birds

African Lion Safari trialed a shrike “dating centre” in spring of 2017, where one female was given controlled access to several males at once (i.e. birds were in adjacent enclosures, with perching on shared mesh wall that allowed some interaction). The purpose of this experiment was to compare mate selection to breeding recommendations provided by the studbook keeper, and to see if the major histocompatibility complex (MHC) may influence mate selection in shrike. MHC, which plays a role in immune function, has been demonstrated to influence mate selection in some species, where mates are chosen based on dissimilar MHCs. In 2018, trials were limited to one male, which had never previously been successfully paired with a female. A pair was established based on the behaviour of the females trialed. Species-specific markers were developed for Class I and Class II genes in the MHC complex using the draft genome. The genetic diversity of these genes has been assayed for all founders, 2011 breeders and their progeny (both living and deceased) and 2016 breeders. Data analysis is underway. Preliminary results will be presented at the November 2018 Recovery Team meeting. Final result will be prepared in manuscript form by spring 2019. The “dating centre” protocol has been refined and plans are underway to repeat the experiment in spring of 2019.

6.5 Stress hormone research

Joshua Robertson, a PhD student at Trent University who is co-supervised by Gary Burness (Trent) and Gabriela Mastro Monaco (Toronto Zoo; through the ReNewZoo program), is finalizing validation of an infrared thermographic assay to measure acute, and chronic stress physiological profiles in wild birds. In collaboration with Oliver Wearing (PhD Candidate; McMaster University), Glenn Tattersall (PhD; Brock University), and Pauline Delnatte (DVM; Toronto Zoo), Joshua has identified rapid and robust decreases in bill temperature of domestic pigeons following exposure to acute behavioural stressors. Furthermore, he has shown cumulative decreases in eye temperature, following repeated and long-term exposure to randomized behavioural stressors, using Black-capped Chickadees as a model species. Currently, he is testing correlations between stress-responsive temperature profiles and hormonal markers of stress physiology; supported by the development of a novel, feather-based assays for time-averaged, autonomic stress (catecholamine metabolites). Following validation of infrared thermographic and feather-based assays, Robertson aims to leverage these tools to examine how chronic stress (quantified by both catecholaminergic and steroidal measures) relates to reproductive output in captive LOSH, and further, will examine if post-fledging survival is related to the stress levels of parents. In addition, Robertson proposes to use feather-derived DNA to test for selection on stress physiology axes in captivity (here, genes encoding enzymes involved in catecholamine and glucocorticoid production and metabolism).

6.6 West Nile virus seroconversion in Loggerhead Shrike after vaccination with a killed virus vaccine

Loggerhead Shrike have been shown to be exquisitely sensitive to West Nile virus (WNV) infection, with prior outbreaks at Ontario breeding facilities suggesting a 100% mortality rate, based on acute deaths in infected birds with no evidence of antibodies in surviving individuals. At least 9 naïve fledglings in the program died of confirmed WNV infection in the 2017 season. A vaccination program using a killed equine WNV vaccine is currently in place for retained fledglings and adult breeding birds, but a knowledge gap exists regarding the response of fledglings to single versus serial vaccinations, the long-term support provided by vaccination and the seroprevalence of WNV neutralizing antibodies in unvaccinated wild-caught adult shrike. This study was developed to investigate the humoral response to vaccination in hatch-year birds given single versus serial booster vaccinations, and to inform a vaccination strategy for fledglings being released into the wild and for wild shrike. Given the critical importance of each individual in this small population and the potentially devastating

impacts of WNV on the species, developing an effective vaccination strategy for captive-bred young is a very important tool in the recovery of this species. In addition, demonstration of a sustained virus neutralizing titre in fledglings given only a single vaccination will inform vaccination protocols for wild-caught individuals who cannot be reliably recaptured for a booster vaccination. To that end, twenty-six fledglings were sampled this year at African Lion Safari by Dr. Kerry Schutten, DVM. Half received a single vaccination, and half received a course of three (the current protocol for retained juveniles); blood samples were taken from all birds three times over the course of the sampling period, before vaccinations (if applicable). Analysis of blood samples is still pending; results will be circulated to the Recovery Team once they are available.

7.0 Partnerships and collaboration

7.1 Loggerhead Shrike Working Group

The 4th annual LOSH Working Group meeting was held on Mar. 19 and 20 at the Nashville Zoo at Grassmere, in Nashville, TN. The meeting was well attended, with 23 individuals present from 11 states plus Ontario, which is an expansion of last year's meeting (19 attendees from 9 states plus Ontario). Attendees included representation from academia, U.S. state government, Canadian federal government, consultants, non-profit organizations, and private facilities. Amy Chabot, Ken Tuininga, and Hazel Wheeler attended this meeting to represent Ontario interests.

This year's meeting was largely focused on research updates from working group members, a review of data priorities for the group, and development of the citizen science "Shrike Force" program. The following are highlights (full details available in the meeting minutes, available upon request):

- LOSH occupancy and detectability research continued in Arkansas (Than Boves, year 2 of 3), and Virginia and West Virginia, (Chris Lituma, final year of a two-year study); research in South Carolina (Amy Tegeler) was completed in 2017, and a manuscript was published in October (Froehly, J.L., Tegeler, A.K., Jachowski, C.M.B., and D.S. Jachowski. 2018. Effects of scale and land cover on loggerhead shrike occupancy. *The Journal of Wildlife Management*, 3:e3006)
- The wild shrike health assessment, developed by the Smithsonian Conservation Biology institute, has been ongoing in Kentucky, Virginia and West Virginia. Ontario remains interested, if funding and logistics can be sorted, though implementation was not feasible in 2018.
- A citizen science shrike monitoring program, the "Shrike Force", was created by the Rio Brazos chapter of the Texas Master Naturalists. The working group wants to expand the Shrike Force to increase volunteer participation in shrike monitoring across their range. A draft protocol was reviewed by the group to that end, and was nearing finalization.
- The public section of Loggerhead Shrike Working Group website is now up (www.loggerheadshrike.org), with hosting courtesy of C2S2. Design of a password-protected area where data can be submitted is pending.

The next Working Group meeting is anticipated in March 2019 in Birmingham, Alabama.

7.2 Building Regional Capacity

WPC staff continue to participate as a member of the steering committee for the Napanee Plain Joint Initiative (NPJI). The group met in April, at which point Hazel Wheeler was appointed co-chair, with Amanda Tracey from the Nature Conservancy of Canada (NCC). Public outreach continues to be the main focus for NPJI, and activities included producing a second run of our regional field guide, "A Guide to Alvar and Grassland Species on the Napanee Plain", and creation of an NPJI website (www.napaneeplain.org). Both of these products, as well as the natural wonder of the area, were promoted through an article submitted to a local newspaper, *The Scoop*, authored by Wheeler and other members of NPJI. The group was also activated for NCC's property acquisition announcement in July (see Section 4.2). Though the steering committee remains active, the broader

membership has not been engaged the past two years; the steering committee will be meeting at the end of November, and planning an event in the spring for the larger group will be the main focus of the agenda.

WPC remains engaged in the Carden community through the Carden Forum, organized by the Couchiching Conservancy. A proposal for a shooting range just north of Carden Alvar Provincial Park has been the main focus of the group this year, and WPC submitted a letter to local council in opposition to the proposal. The smaller Carden Working Group, which is more focused on environmental concerns than the larger Forum, did not have a formal meeting this year.

Relationships in the Grey-Bruce region were developed this year through the Alvar and Grassland Stewardship Workshop that was held in that region, in partnership with NCC, Ontario Land Trust Alliance, and Ontario Nature (see Section 4.2). Other organizations that attended the workshop included the Grey-Sauble Conservation Authority, Owen Sound Field Naturalists, and the Lake Huron Center for Coastal Conservation. A representative from the Chippewas of the Nawash was also in attendance, and co-led the outdoor portion of the event. Habitat stewardship for LOSH was one of the presentations given that evening, so the species and its needs were well promoted. This is an area that hasn't had breeding LOSH since 2012, but usually has a few sightings of transient birds every year. It is hoped that this workshop will elicit more sightings next year.

8.0 WPC fundraising

WPC implemented the recovery program this year with funding from the following sources:

- Species at Risk Stewardship Fund (SARSF; \$90K)
- Habitat Stewardship Program (HSP) for Species at Risk (\$35.5K, for activities after Sept. 13/18)
- Colleges and Institutes Canada – Clean Tech Internship (2 internships, \$13.5K each)
- Private foundations (\$22K)
- BluEarth Renewables (\$10K)
- Employment and Social Development Canada – Canada Summer Jobs (\$8K to subsidize two positions)

All grants received in 2018 were for a single year. HSP funding for 2018 was delayed until the end of the summer, so that grant will only cover activities undertaken between September 2018 and March 2019. Government funding streams are shrouded with uncertainty for 2019, and no calls for applications have yet been announcement for HSP or SARSF; applications will be submitted when possible. Private foundation grants will continue to be pursued as applicable.

Appendix 1. Non-LOSH birds detected on WPC-operated Motus towers

Tower	Detection date	Species	Tag deployment	
			Date	Origin
Napanee	22-Sep-16	Least Sandpiper	6-Sep-16	Ontario (James Bay)
	23-Sep-16	Least Sandpiper ^a	16-Aug-16	Ontario (James Bay)
	23-Sep-16	Gray-cheeked Thrush ^b	21-Apr-16	Magdalena, Colombia
	24-Sep-16	Swainson's Thrush	11-May-16	Pennsylvania
	24-Sep-16	Gray-cheeked Thrush ^b	21-Apr-16	Magdalena, Colombia
	25-Sep-16	Gray-cheeked Thrush	20-Apr-16	Magdalena, Colombia
	3-Oct-16	Semipalmated Plover	7-Sep-16	Ontario (James Bay)
	4-Oct-16	Swainson's Thrush	24-Sep-16	Quebec
	9-Oct-16	Least Sandpiper ^a	16-Aug-16	Ontario (James Bay)
	9-Oct-16	Swainson's Thrush	22-Sep-16	Quebec
	26-Feb-17	Snow Bunting	23-Dec-16	Ontario (Wellington Cty)
	17-May-17	Red Knot	29-Apr-17	South Carolina
	24-May-17	Red Knot	29-Apr-17	South Carolina
	28-May-17	Red Knot	28-Apr-17	South Carolina
	30-May-17	Silver-haired Bat	16-May-17	Pennsylvania
	5-Jun-17	Semipalmated Sandpiper	16-May-17	New Jersey
	24-Jun-17	Rock Pigeon (Feral Pigeon)	24-May-17	Ontario (Oxford Cty)
	24-Jun-17	Rock Pigeon (Feral Pigeon)	23-Jun-17	Ontario (Oxford Cty)
	19-Jul-17	Red Knot ^c	30-Apr-17	South Carolina
	20-Jul-17	Whimbrel	28-Jun-17	Ontario (Polar Bear PP)
	20-Jul-17	Gray-cheeked Thrush	20-Apr-16	Magdalena, Colombia
	25-Jul-17	Tree Swallow	20-Jun-17	Massachusetts
	25-Jul-17	Tree Swallow	23-Jun-17	Massachusetts
	25-Jul-17	Tree Swallow	26-Jun-17	Massachusetts
	25-Jul-17	Tree Swallow	26-Jun-17	Massachusetts
	25-Jul-17	Northern Saw-whet Owl	4-Oct-16	Nova Scotia
	25-Jul-17	Common Nighthawk	24-Jun-17	Ontario (Northumberland Cty)
	25-Jul-17	Northern Saw-whet Owl	3-Nov-15	Nova Scotia
	28-Jul-17	Whimbrel	26-Jul-17	Quebec
	2-Aug-17	Sanderling	30-May-17	Saskatchewan
	23-Aug-17	Semipalmated Plover	13-Aug-17	Ontario (James Bay)
	6-Sep-17	Canada Warbler	20-Jun-17	Quebec
	7-Sep-17	Semipalmated Sandpiper	14-Aug-17	Ontario (James Bay)
	8-Sep-17	White-rumped Sandpiper	20-Aug-17	Ontario (James Bay)
	8-Sep-17	White-rumped Sandpiper	13-Aug-17	Ontario (James Bay)
	10-Sep-17	Canada Warbler	15-Jun-17	Quebec
	21-Sep-17	Swainson's Thrush	30-Aug-17	Quebec
	22-Sep-17	Swainson's Thrush	14-Sep-17	Quebec
	1-Oct-17	Gray-cheeked Thrush	22-Sep-17	Quebec
	15-May-18	Swainson's Thrush	25-Apr-18	Florida
	22-May-18	Dunlin (hudsonia)	3-Apr-18	South Carolina
	22-May-18	Kirtland's Warbler	27-Mar-18	Bahamas
	26-May-18	Magnolia Warbler	20-May-18	Pennsylvania
	29-May-18	Red Knot	3-Oct-17	Unknown
	31-May-18	Red Knot	3-Oct-17	Unknown
	31-May-18	Red Knot	3-Oct-17	Unknown
	31-May-18	Red Knot	3-Oct-17	Unknown

Appendix 1. (cont.)

Tag deployment

Tower	Detection date	Species	Date	Origin
	1-Sep-16	Semipalmated Sandpiper	8-Aug-16	Ontario (James Bay)
	1-Sep-16	Semipalmated Sandpiper	11-Aug-16	Ontario (James Bay)
	1-Sep-16	White-rumped Sandpiper	6-Aug-16	Ontario (James Bay)
	23-Mar-17	Snow Bunting	23-Dec-16	Ontario (Wellington Cty)
	26-Apr-17	White-throated Sparrow	17-Apr-17	Ontario (Norfolk Cty)
	10-May-17	White-throated Sparrow	25-Apr-17	Ontario (Norfolk Cty)
	17-May-17	White-throated Sparrow	3-May-17	Ontario (Norfolk Cty)
	17-May-17	White-throated Sparrow	6-May-17	Ontario (Norfolk Cty)
	17-May-17	White-throated Sparrow	1-May-17	Ontario (Norfolk Cty)
	18-May-17	Red Knot	29-Apr-17	South Carolina
	18-May-17	Red Knot	30-Apr-17	South Carolina
Carden	20-May-17	Red Knot ^c	30-Apr-17	South Carolina
	21-May-17	Red Knot	29-Apr-17	South Carolina
	23-May-17	Yellow-rumped Warbler	3-May-17	Ontario (Norfolk Cty)
	24-May-17	Swainson's Thrush	7-May-17	Florida
	30-May-17	Kirtland's Warbler	11-Apr-17	Bahamas
	30-May-17	Blackpoll Warbler	13-May-17	Pennsylvania
	4-Jun-17	Blackpoll Warbler	20-May-17	Pennsylvania
	5-Jun-17	Semipalmated Sandpiper	16-May-17	New Jersey
	9-Jun-17	Kirtland's Warbler ^d	29-Mar-17	Bahamas
	10-Jun-17	Kirtland's Warbler ^d	29-Mar-17	Bahamas
	21-Jul-17	Semipalmated Sandpiper	16-May-17	New Jersey
	31-Aug-17	White-rumped Sandpiper	4-Aug-17	Ontario (James Bay)

^{a, b, c, d} Birds indicated by the same superscript are the same individual, detected on multiple occasions