Lewis's Woodpecker breeding population size and trends in Grand Forks, British Columbia, after a severe flood event

Les W. Gyug[1], Jenny Coleshill[2], Megan Harrison[3], Jared Hobbs[4], and Tanya Luszcz[5]

[1]Okanagan Wildlife Consulting, 3130 Ensign Way, West Kelowna, B.C. V4T 1T9; email: les_gyug@shaw.ca
[2]Granby Ecological, Grand Forks, B.C.
[3]Environment and Climate Change Canada – Canadian Wildlife Service, 351 Boulevard St-Joseph, Gatineau, Q.C. J8Y 3Z5
[4]J Hobbs Ecological Consulting Ltd., 9809 Spalding Road, Pender Island, B.C. V0N 2M3
[5]Environment and Climate Change Canada, 1238 Discovery Avenue, Kelowna, B.C. V1V 1V9

Abstract: Lewis's Woodpecker (*Melanerpes lewis*) population size and trends were estimated for the City of Grand Forks and surroundings from 2011 to 2023. Lewis's Woodpecker in the 13.1 km^2 study area nested primarily in black cottonwoods on the banks and within the floodplains of the Kettle and Granby rivers. A catastrophic flood hit the study area in 2018, and prompted an examination of whether the flood affected Lewis's Woodpeckers in Grand Forks. In 2011, the Lewis's Woodpecker population of the study area was estimated as 48 confirmed and probable nests (95% CI 34–88) as part of a wider regional population size estimate using a dual-frame method consisting of re-visits to previously known nest trees and stratified random sampling of the remainder of the area. A 100% nest census in 2012 found 47 confirmed and probable nests in the study area, which confirmed the accuracy and reliability of the dual-frame method used in 2011. The central core of the study area (2.32 km^2) bordering the Kettle and Granby rivers within the city had the highest density (9.1 nests/km^2) of Lewis's Woodpecker found in Canada, and was on par with the highest densities reported anywhere. Annual roadside monitoring using a systematic sample of 13 points at 1–km intervals in the study area from 2014–2022 suggested a 22% decrease in Lewis's Woodpecker relative abundance after the 2018 flood. Including possible nest sites in addition to the confirmed and probable nest sites, the 2023 nest census found 36 nests, which was a 31% decrease from the 52 found in 2012. Re-survey in 2023 of 57 documented nest trees in the study area that were known to be standing in 2012 (of which only 47 were actually used in 2012) found 12% of those trees had been washed away in the 2018 flood. The unprecedented floods of 2018 appear to have been at least partly responsible for a decline in Lewis's Woodpecker abundance in the Grand Forks area from 2011 to 2023. Such events may become more frequent with climate change.

Key words: Lewis's Woodpecker, *Melanerpes lewis*, Grand Forks, British Columbia, population size, population estimate, population trends, climate change, flooding

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Introduction

Lewis's Woodpecker (*Melanerpes lewis*) is a migratory bird that has been assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Threatened (COSEWIC 2010). At the time of assessment, there were no statistically reliable population size or trend estimates available for Lewis's Woodpecker in British Columbia, the only Canadian province with a breeding population. Cooper *et al.* (1998) informally estimated the B.C. population at 350–600 pairs, which was updated to 630–920 mature individuals by COSEWIC (2010). North American Breeding Bird Survey relative densities converted to absolute densities estimated 5,909 mature individual Lewis's Woodpeckers in B.C. with very wide (but not expressly stated) confidence intervals (Blancher *et al.* 2007). Further development of the Breeding Bird Survey population estimation methods still yielded very wide confidence intervals, with 4,000 mature individuals estimated in B.C. and 95% confidence intervals of 770–9,900 (Partners in Flight 2020). The Breeding Bird Survey has not been effective for monitoring Lewis's Woodpeckers because the numbers detected are very small (Abele *et al.* 2004), and they are relatively inactive in early mornings and have only weak vocalizations so are infrequently detected by sound. Both the Management Plan for the Lewis's Woodpecker in Canada (Environment Canada 2014) and the subsequent Recovery Strategy (Environment and Climate Change Canada 2017) identified a long-term population monitoring strategy in B.C. as a high-priority action to de-

termine population trends, and to estimate magnitude and severity of impacts from threats to the species over time. A long-term monitoring strategy was initiated in 2010, and further developed and adapted as information was gathered (Environment and Climate Change Canada 2017).

The most commonly applied method to determine Lewis's Woodpecker densities has been nest searches on relatively small areas because active nests are relatively easy to find at the nestling stage. These have included complete nest censuses such as Cooper and Beauchesne (2000) in the Findlay Creek Burn (3 km^2) in the East Kootenay in B.C.; Saab and Vierling (2001) in a 25–km^2 area in plains/cottonwood habitat in the U.S.A.; nest searches along variable-width transects at 200–m spacing that completely covered each study site (average 5–km^2 area; Saab and Dudley 1998); complete searches of belt transects of 1–km length and 0.4–km width (Saab and Vierling 2001; Saab *et al.* 2007); and nest searches in areas ranging in size from 2.5 to 4 km^2 using straight-line transects at 200–m spacing (Vierling *et al.* 2008). None of those studies attempted to extrapolate densities to areas larger than their study sites to estimate population size.

Abele *et al.* (2004) could find only one estimate of Lewis's Woodpecker population size, which was the informal estimate of Cooper *et al.* (1998) for B.C. referred to above. Abele *et al.* (2004) thought that patchy distributions prevented meaningful estimates of density that could be widely applied. Still, if nest densities can be estimated within habitats (however those habitats may be defined) and if habitat modelling can be efficiently applied to large areas, then quantitative population estimates should be achievable using stratified random sampling. The long-term monitoring strategy in B.C. was based on the assumption that densities could be determined for habitat strata to estimate regional population sizes using habitat models (Gyug 2010, 2013).

Long-term Lewis's Woodpecker monitoring in B.C. began in 2011 with the first of a series of regional population estimates. The first year of sampling in the Boundary region indicated that the Grand Forks area alone supported a population of Lewis's Woodpeckers as large as previously estimated using informal methods for the entire region (COSEWIC 2010), which was 35 times larger than the Grand Forks area. The higher-than-expected nest abundance estimated for Grand Forks suggested that either the initial informal population estimates (COSEWIC 2010) were significant underestimates, or that the 2011 methods overestimated the local nest density in Grand Forks. As such, in 2012, a complete nest census was undertaken in the Grand Forks area to attempt to determine which of these was the case.

In addition to the regional nest population estimates, an annual roadside monitoring program for Lewis's Woodpecker relative abundance in B.C. was initiated in 2014 to estimate long-term population trends in four of the six regions across the province where Lewis's Woodpecker were abundant enough to monitor efficiently. In early 2023, preliminary examination of that data in the Grand Forks area showed a slight decline in relative abundance after the unprecedented and catastrophic floods of 2018 that exceeded 200–year flood levels (Columbia Basin Climate Source, undated), and that were thought to be largely due to climate change (Grand Forks Flood Mitigation Program 2021). In 2023, we sought additional data to test whether that decline could be corroborated by 1) repeating the Grand Forks nest census of 2012 and 2) assessing the current status of nest trees there that were known to be standing in 2012, most of which were on the riverbanks and likely vulnerable to flooding.

We report here on only the portion of Lewis's Woodpecker monitoring in B.C. from the Grand Forks area. The Grand Forks area was of particular interest because of 1) the mismatch between initial informal population estimates (COSEWIC 2010) and the 2011 population estimate, 2) the relatively high densities estimated in the area compared to other areas in B.C., and 3) the potential to evaluate impacts of catastrophic flooding associated with climate change on Lewis's Woodpecker.

Methods

Study area

For the 2011 breeding population estimate, the Grand Forks area was part of a larger project estimating the breeding population of the Boundary region, although here we limit reported results to the Grand Forks study area. The Grand Forks study area was selected in 2012 to encompass all known Lewis's Woodpecker nesting locations in or near the City of Grand Forks, and any adjacent possible foraging areas or other possible nest sites in the area. The study area included 13.12 km^2 near the confluence of the Kettle and Granby rivers, 39% of which was within the City of Grand Forks (estimated population 4,112 in 2021, Statistics Canada 2023), and 61% in the adjacent rural district (Electoral Area D) (Figure 1). In the city, the study area consisted of shopping areas, offices, industrial areas, residences and parks, and outside the city consisted mainly of agricultural holdings <10 ha in size and of other rural properties.

Total length of the Kettle and Granby rivers in the study area was 17.47 km. Most of the riverbanks have a narrow border of mixed black cottonwood (*Populus trichocarpa*) and ponderosa pine (*Pinus ponderosae*), including many mature stands, that also extend into other parts of the floodplain. Black cottonwood stands occupied only 1.20 km^2 or 9.1% of the study area.

Nest population estimate 2011

The long-term population monitoring strategy for Lewis's Woodpecker, first piloted in the Grand Forks and broader Boundary region in 2011, employed a dual-frame design (*e.g.,* Haines and Pollock 1998). The design consist-

ed of two components ('frames'): a list frame consisting of previously known nests, which were resampled for current occupancy, and an independent area frame, sampled by stratified random point counts followed by nest searches. Each active nest was considered to have two mature individuals such that the number of breeding individuals would be twice the nest population estimate. Throughout this report, when we refer to population estimate, we are referring to numbers of active nests.

The list frame was defined to include 100–m radius circles around all previously documented nests. A complete search of the 100–m radius around each previously documented nest was conducted in case a different nest tree was used, or in case the precise location of the previously documented nest was not known, *i.e.,* where it could have been in one of several closely spaced trees (Figure 2). The list frame was sampled on 21–22 June 2011 to determine if there were any active nests within 100 m of each of the 30 previously documented nests in the study area. Date, time, location, bird count and breeding activity of Lewis's Woodpecker were recorded to determine nest occupancy and to record any new nests within 100 m of previously documented nests. B.C. Breeding Bird Atlas (Davidson *et al.* 2015) codes were used to assign nesting status as follows: Possible breeding – including **H** (observed in breeding habitat) and **S** (giving territorial call); Probable breeding – including **P** (pair observed in suitable nesting habitat), **A** (agitated) and **V** (visiting probable nest site); and Confirmed breeding – including **AE** (adult entering and leaving nest cavity), **FS** (adult carrying fecal sac from nest), **CF** (adult carrying food for young) and **NY** (young seen or heard in nest).

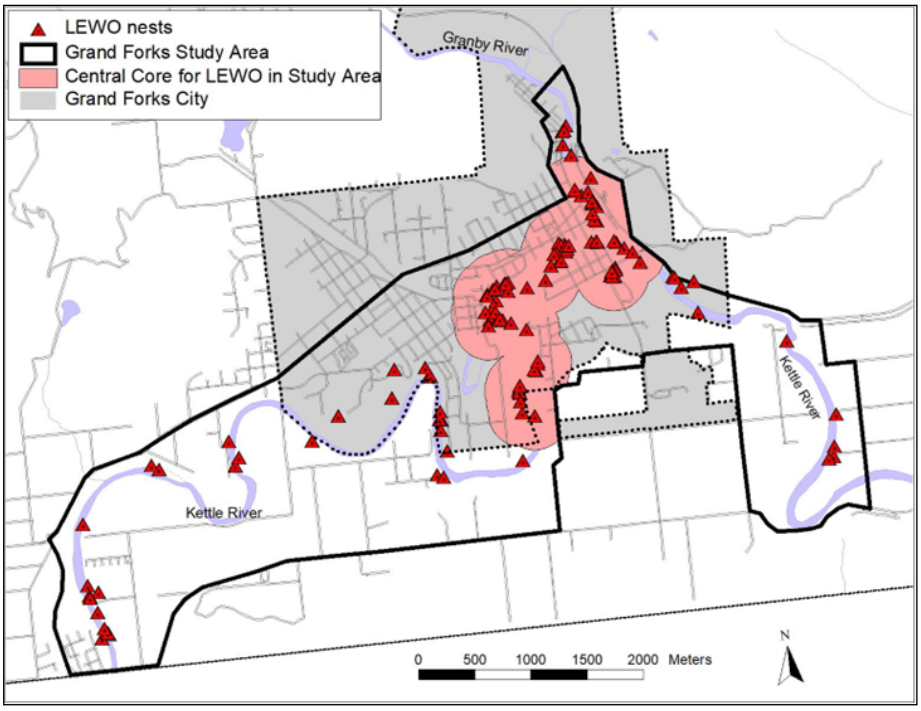

Figure 1. Grand Forks study area in B.C. showing all known Lewis's Woodpecker (LEWO) nests from all years including central core area.

The area frame in the Grand Forks study area consisted of potential breeding habitat stratified based on a preliminary model (Gyug 2010), excluding any overlap with the list frame to preserve independence of the two frames (Figure 2). The study area was almost entirely within the Moderate Habitat Suitability stratum. At the regional level, sample points were selected randomly within the Moderate Habitat stratum such that sample points were at least 150 m from the habitat stratum boundary and at least 800 m from any other randomly chosen point.

The area frame in the Grand Forks study area was sampled in 2011 by 17 variable radius point counts from 17–24 June. Point counts were only conducted when winds were less than Beaufort 4 (<20 km/h) and it was not raining. Point counts were 20 minutes in duration and, in the Grand Forks study area, were conducted between 07:44 and 17:20. Air temperatures ranged from 17°C to 27°C during surveys. All Lewis's Woodpecker detected were recorded, even if sight lines were long and it was felt that it might have been already recorded at another point because distance sampling does not assume independence of observations from separate sampling points (Buckland *et al.* 2001). For every Lewis's Woodpecker detected at a point count sample station, a nest search was undertaken. If a nest was detected, the location of each nest was recorded, or the location coordinates were estimated where the nest could not actually be approached. The number and activity type of Lewis's Woodpecker were recorded, as well as nest tree information including tree species, decay class, diameter at breast height and tree height where possible.

Sample points that were inaccessible, *i.e.,* on private land where the owners could not be found to ask permission to access the site, were repositioned to the nearest public road. Six of 17 points were relocated between 36 m and 167 m from the randomly selected points (mean 95 m, SD 50 m). The new locations were all within the Effective Detection Radius (264 m, see Results – Nest Population Estimate 2011) of the original points.

The nest population estimate consisted of the sum of the list and area frame estimates. The list frame estimate was a 100% census of the 100–m radius around previously documented nest trees. The area frame estimate was based on the

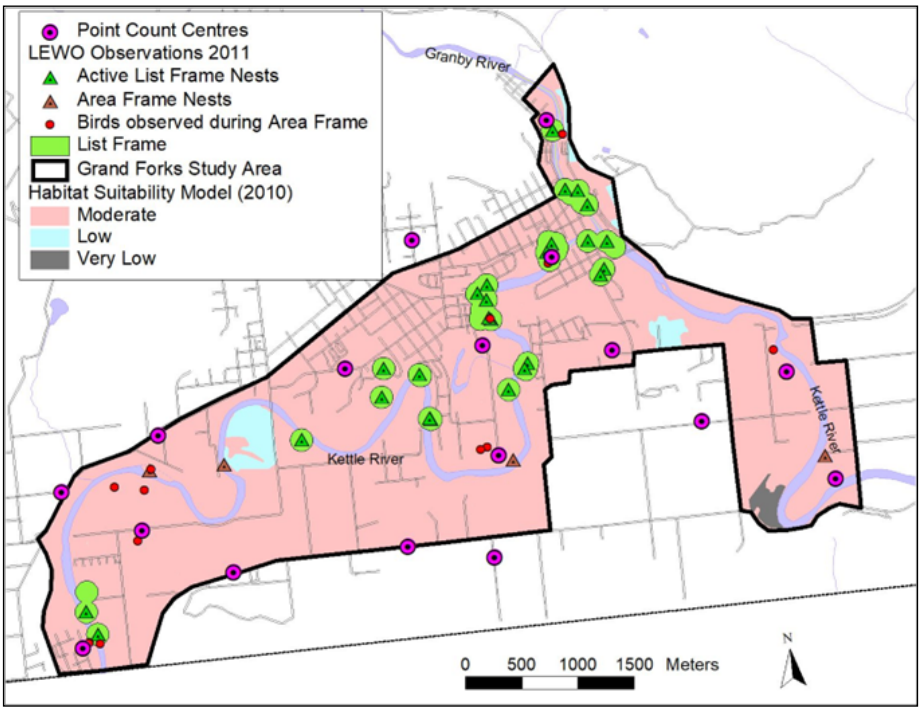

Figure 2. Lewis's Woodpecker (LEWO) point count locations, list frame location and observations in 2011 for dual-frame nest population estimate in the Grand Forks study area, B.C. The habitat suitability shown is from the preliminary model of Gyug (2010). Each of the Point Count centres shown had at least some portion of their 500–m radius overlapping the study area.

distance of the nest from the point analyzed using Distance sampling methods (Buckland *et al.* 2001), discounting any nests found during area frame sampling that were in the list frame areas.

Point-to-nest distance was used for the Distance analysis and density estimates. A 500–m cutoff radius of nest distance was used in the analysis based on the recommendation of Buckland *et al.* (2001) to discard the 10–15% of observations furthest from the point centre. To determine sampled area for each point, the 500–m radius was used, only included the habitat stratum within which the point was located, the portion of the radius within the study area, and discounted any areas within the list frame. For this re-analysis in 2023, the detection function used the pooled data of points-to-nests from all regional Lewis's Woodpecker population estimate point counts in B.C. from 2011 to 2018 (Gyug 2019).

Nest census – 2012 and 2023

Researchers attempted a complete count, *i.e.,* census, of all nests in the study area in 2012 to verify the population estimation methods used in 2011. In 2012, an attempt was made to count every active Lewis's Woodpecker nest in Grand Forks from 1–3 July. This was repeated again in 1–2 July 2023 to examine potential population changes.

Two teams of 1–3 people each covered separate portions of the study area in a manner deemed to be thorough enough to find every active nest. Every previously known nest was re-checked for occupancy, and every possible nesting stand or tree was viewed from as close as practicable without intruding on private land (except where permission had been granted). Stands or trees were viewed for at least 20 minutes, or longer when birds were seen and we sought to confirm nesting activity. In 2012, three follow-up visits on 5 July, 6 July, and 11 July were also made to confirm nesting activity in sites where only possible or probable breeding activity had been noted from 1–3 July. Breeding activity was recorded using the Breeding Bird Atlas codes previously described so that breeding activity could be assigned as Confirmed, Probable, or Possible. Locations of nests or birds were recorded using GPS units where the nest tree or site could be approached, or projected from the observer's GPS-measured location using compass bearing and distance measured with a laser range finder.

Annual relative abundance monitoring 2014–2022

In 2014, eight monitoring routes were established along roads in general areas where Lewis's Woodpecker were known to be present and there were significant amounts of moderate or better habitat suitability. In the Grand Forks area, where almost all nests were on the riverbank or in floodplain cottonwood stands, points were established systematically at 1–km intervals starting on the bank of the Kettle River at the U.S. border, and then at 1–km (straight-line) intervals moving downstream on any road that had a good view of riverbank or floodplain cottonwood stands. The intent was to emulate (using roads) what might be seen by doing a float down the Kettle River and stopping every km (Figure 3). The same 13 roadside points were monitored in the Grand Forks study area from 2014–2022 as part of a longer 20-point route in the region.

Routes were sampled twice annually in the first four years to separate within-year (sampling) variation from be-

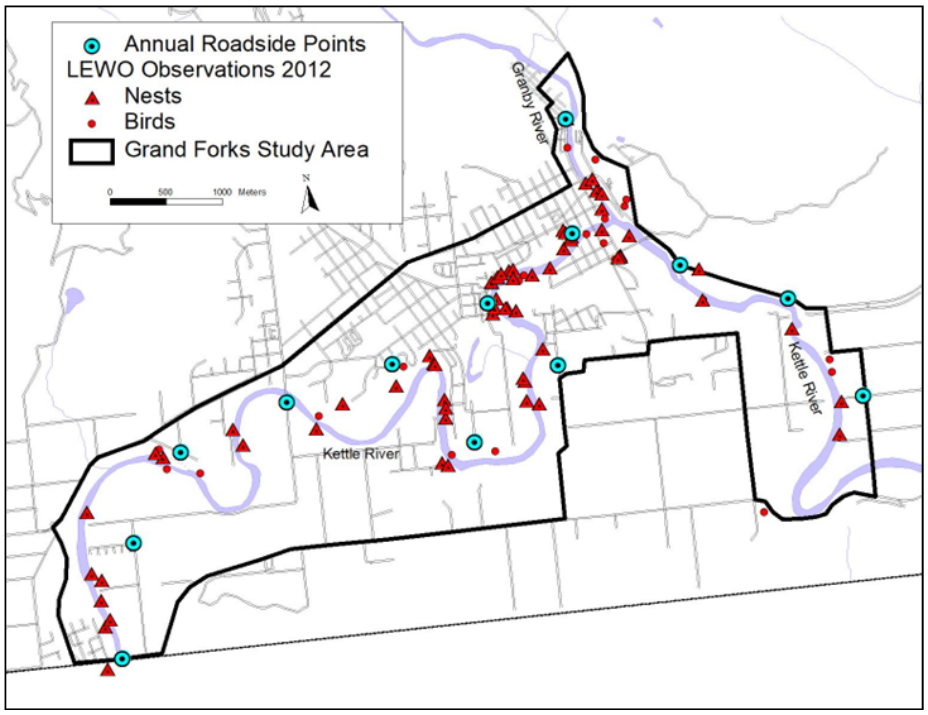

Figure 3. Lewis's Woodpecker (LEWO) nest and other observations in 2012 for the breeding population census in the Grand Forks study area, B.C., and the 13 annual roadside monitoring points used in the study area from 2014–2022.

tween-year (process) variation to model the power of the monitoring to detect trends (*e.g.,* Gibbs and Ene 2010). Routes were sampled between 20 June and 14 July each year. All Lewis's Woodpeckers detected within 15 minutes in an unlimited radius around each point were recorded, including time of first detection of each bird or group of birds, the distance and direction of the first detection, the number of birds in the group, and any breeding activity using the Breeding Bird Atlas codes previously described so that breeding activity could be assigned a status of Confirmed, Probable or Possible.

Examination of the annual relative abundance monitoring data for the Boundary region as a whole found three groups of observers that differed significantly in the distances at which they detected Lewis's Woodpeckers during these roadside surveys (ANOVA $F_{2, 592} = 79.5$, $p < 0.0001$). The 2014 surveyors (Observer Group 1 of Figure 4) detected birds at the longest average distance (221 m, SD 144 m, N = 144), other observers (Observer Group 2) detected birds at a shorter average distance (175 m, SD 133 m, N = 221) and a single observer (Observer 3) who ran one survey in each of 2016 and 2017, and then all the surveys after 2017 in the Grand Forks area, had a much shorter average distance of detection (79 m, SD 54 m, N = 230). To adjust for these inter-observer differences, the Grand Forks data were re-analyzed using the data from just Observer 3.

Nest tree survival 2012 to 2023

Almost 90% of the nest trees in the Grand Forks study area were either on or within 50 m of river banks that flooded in 2018. In 2012, there were 57 standing Lewis's Woodpecker nest trees used in or prior to 2012. Each of these was checked in the spring of 2023 to determine the current status. In 2023 it was not always possible to determine which was the prior nesting tree where mature cottonwoods occurred in clumps. Therefore, we assumed that if there were no suitable nest trees within a clump at an old nest site, or where the old nest tree was previously noted as "standing dead" and there were no standing dead trees in the clump, the nest tree was presumed to be down. Where there were suitable nest trees within the clump, the nest tree was presumed to be still present, and available for nesting.

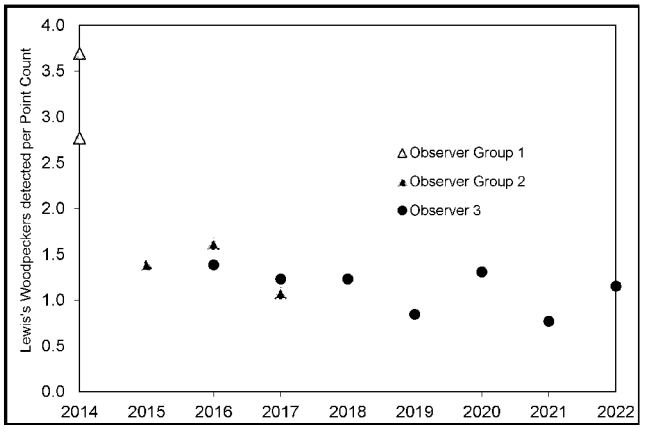

Figure 4. Lewis's Woodpecker detected on 13 annual roadside monitoring point counts in the Grand Forks study area. Counts were done twice annually from 2014 to 2017. To account for inter-observer differences, the analysis was based on the data of Observer 3, *i.e.,* one of the two counts in each of 2016 and 2017, and the single count/year from 2018 to 2022.

Table 1. Estimate of confirmed and probable Lewis's Woodpecker nests in the Grand Forks, B.C., study area in 2011 using the dual-frame study design with 100% sample of the List Frame around previously documented nest trees, and random sampling of the Area Frame.

		List Frame		Area Frame					Total Estimate		
Habitat stratum	Total area	Area	Nest count	Area	Point count numbers and areas sampled		Nest est.	95% C.I.	Nest est.	95% C.I.	Nest density
	km²	km²	N_1	km²	n	km²	N_2		N_1+N_2	/km²	/km²
Moderate	12.72	0.77	27	11.95	17	7.83	21	7–61	48	34–88	3.77
Low	0.32	0.00	0	0.32	2	0.07	0	–	0		0.00
Very Low	0.08	0.00	0	0.08	2	0.001	0	–	0		0.00
Total	**13.12**	**0.77**	**27**	**12.35**	**21**	**7.90**	**21**	**7–61**	**48**	**34–88**	**3.66**

Results

Nest population estimate 2011

The dual-frame population estimate of the Grand Forks study area was 48 Lewis's Woodpecker confirmed and probable nests (95% CI 34–88) based on 27 confirmed and probable nests counted on the list frame, and 21 estimated on the area frame from three nests found within 500–m of the points (Table 1, Figure 2). The Effective Detection Radius (EDR) of sample points to active nests was 264 m (SE 35 m, 95% CI 203–343 m) using the pooled Lewis's Woodpecker regional point count data in B.C. from 2011–2018 based on 76 nests found within 500 m of point count sample stations. This yielded a combined estimated density of 3.7 nests/km² in the entire Grand Forks study area.

Grand Forks nest censuses

In 2012, we found 44 confirmed active nests, three probable nests and five possible breeding sites for a total of 52 nesting sites including all three levels of breeding status (Table 2, Figure 3). This was a minimum estimate since some nests may have failed prior to the survey period. Forty-six of the 52 confirmed, probable or possible nest sites were within 50 m of the Kettle or Granby riverbanks or adjacent oxbow channels, with the remainder within 300 m. All trees with confirmed active nests in the Grand Forks study area in 2012 were black cottonwoods.

In 2023, we found 22 confirmed active nests, eight probable and six possible breeding sites for a total of 36 (Table 2, Figure 5). The 2013 final revised habitat model for the Grand Forks study area is shown in Figure 5, although the 2023 nest census was an attempted complete count and did not require habitat stratification. There was a 31% decrease in the number of Lewis's Woodpecker breeding sites in the Grand Forks study area between 2012 (N = 52) and 2023 (N = 36).

Overall nest density in the 13.1 km² study area was 4.0 nests/km² in 2012 and 2.7 nests/km² in 2023. However, not all of the study area was actually used by Lewis's Woodpeckers, with the highest proportion found along the riverbanks, and the highest densities in an area 2.5 km upstream and 400 m downstream on the Kettle River from the Kettle–Granby confluence, and 500 m upstream on the Granby River (Figure 1, hereafter termed the central core). A foraging distance of 300 m from a nest would normally contain approximately 99% of foraging activity (Zhu 2006). Using a foraging distance of 300 m from all confirmed, probable and

Table 2. Numbers of Lewis's Woodpecker nests found in Grand Forks city and surrounding rural areas within the Grand Forks study area during nest censuses in 2012 and in 2023.

Year	Locality	Number of nests by status			
		Confirmed	Probable	Possible	Total
2012	City of Grand Forks	33	0	2	35
	Rural area	11	3	3	17
	Total	**44**	**3**	**5**	**52**
2023	City of Grand Forks	20	6	4	30
	Rural area	2	2	2	6
	Total	**22**	**8**	**6**	**36**

possible breeding sites from all years in the central core, the actual area used by foraging Lewis's Woodpecker was 2.32 km^2. In 2012, there were 19 nests there for a density of 8.2 nests/km^2. In 2023, there were 21 nests in the central core for a density of 9.1 nests/km^2. While the nest density in the central core of Grand Forks slightly increased from 2012 to 2023, the number of nests outside the central core decreased by 55% from 33 nests in 2012 to 15 nests in 2023.

Annual relative abundance monitoring

Using the annual roadside point count data from just the single observer who had completed a single survey round each year in 2016 and 2017, and then did all the surveys after 2017 (Figure 4), a 22% decrease in Lewis's Woodpecker relative abundance was found after the 2018 flood. An average of 1.31 (SD = 0.11, N = 2 years) Lewis's Woodpeckers were counted per survey point prior to 2018 compared to 1.06 per point after (SD = 0.23, N = 5 years). The probability of a difference between these two periods was only 76% using ANOVA; however, the statistical power to detect any change between the two periods was low because of small sample sizes. Using Cohen's *d*, which compares differences in means relative to the size of the pooled standard deviation and is independent of sample size (Cohen 1988), the effect size (d = 1.12) was considered to be large.

Nest tree survival

Of the 57 nest trees that were known to be standing in 2012, 44% were not standing in 2023 (Table 3). The sites upon which 12% had stood had been washed away by the 2018 flood (Figure 5). Of the 12% fallen or down for other reasons, 5% of those had been cut down—presumably for safety reasons as they were beside roads or trails—and the stump was still visible, and 7% were down but no cut stump was seen. A further 19% were down for reasons other than the 2018 flood, *i.e.,* they had either fallen over or been cut down, but the exact tree or stump could not be identified. Of the 56% still considered suitable for nesting, only 19% could be definitely identified, and the other 37% assumed to be the same tree, or in the same clump of trees. Two of the trees that were considered still suitable for nesting had been topped—again presumably for safety reasons because they were beside trails or roads—but the trees had been topped above a nest cavity. Although neither of those two particular trees were used for nesting in 2023, two active Lewis's Woodpecker nests were found in 2023 in other trees that had been topped above a nest cavity.

All except one of these 57 trees were black cottonwoods; the other tree was a non-native willow (*Salix* sp.) located in City Park. Seventy percent of the nest trees in the study area occurred within the City of Grand Forks and the remainder in the surrounding rural areas of the regional district.

Discussion

The 2012 nest census of 47 confirmed and probable nests in the Grand Forks study area was within 2% of the 2011 estimate of 48 confirmed and probable nests, and well within the 95% confidence interval (34–88) of the 2011 estimate. Applying two independent methods to estimate the nest population of the area, and achieving final estimates that were almost identical provides confidence in the population estimates generated from the dual-frame and distance sampling methods. The concurrence of the two population estimates also indicated that an accurate population estimate of Lewis's Woodpecker can be achieved using a dual-frame

Table 3. Status of Lewis's Woodpecker nest trees in 2023 that were known to be standing in 2012 in the Grand Forks study area.

	Numbers of nest trees			
Tree status	**City of Grand Forks**	**Rural area**	**Total**	**% of nest trees**
Site washed away in 2018 flood	2	5	7	12.3
Tree cut down (cut stump seen)	3	0	3	5.3
Tree fallen down (no cut stump)	4	0	4	7.0
Tree probably fallen	11	0	11	19.3
Tree still suitable for nesting	8	3	11	19.3
Tree probably still suitable for nesting	12	9	21	36.8
Total	**40**	**17**	**57**	**100.0**

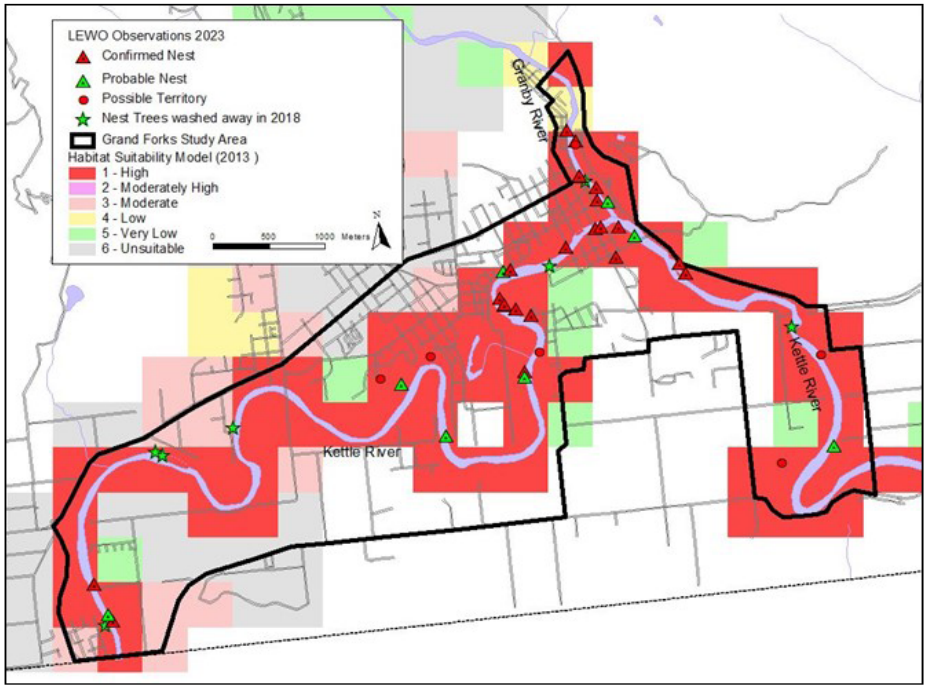

Figure 5. Lewis's Woodpecker (LEWO) confirmed and probable nest locations, and possible breeding territory centres in 2023 for the breeding population census in the Grand Forks study area, B.C. The habitat model shown is the 2013 revised model (Gyug 2013). White areas on the map were outside the modelled areas.

approach of independent frames consisting of 1) previously documented nests and 2) the remainder of the area stratified using a habitat model.

The local Lewis's Woodpecker nest density of 9.1 nests/km^2 in the central core of Grand Forks was higher than any other observed nest densities reported or known elsewhere in B.C. (Gyug 2013). This density was similar to maximum nest densities in the range of 9–11 nests/km^2 reported for two burn areas surveyed in Idaho 9–12 years post fire (Saab *et al.* 2007). The Grand Forks study area density has now become the benchmark Lewis's Woodpecker nesting density in B.C., against which other areas and habitats can be rated. This density was higher than the previous highest known density from the Columbia Lake burn in the East Kootenays that was estimated at approximately six nests/km^2 (Gyug 2010 using data from Cooper and Beauchesne 2010).

While the power to detect a change using the annual roadside monitoring was not very high, the effect size was considered to be large, and when coupled with the observed decline in the nest abundance from 2012 to 2023, and the loss of nest trees on the riverbank, we conclude the estimated decline is real, and not just the result of annual fluctuations. There were very small changes in nest estimates between 2011 and 2012, and there is relatively low annual variability in relative abundance monitoring, not including the anomaly of 2014 that was believed due to observer differences. Based on both the breeding population estimates in the two widely spaced years and the annual monitoring, there appears to have been a long-term downward population decline in the range of 22–31% in the Grand Forks area. Given the documented losses of 12% of previously known nesting trees during the catastrophic flooding in 2018, it is plausible that similar extreme floods, which may be expected more often with climate change, could further reduce the availability of suitable nesting trees in the future.

Other nest tree losses came from dead trees that simply fell over, or from trees that were cut down. At least some potential nest tree losses for public safety reasons appeared to have been mitigated where trees had been topped above nest cavities, and the trees continued to be used. However, we could not precisely identify all previous nest trees and their exact status, and the monitoring is not going on every year or in enough detail to accurately quantify re-use of trees that have been modified for public safety. We can however say that topping trees above nest cavities can be successfully used in at least some cases to accommodate both Lewis's Woodpecker nests and safe public use of an area.

Further, new dikes and cofferdams have been built in the study area, and perhaps more will be built, to mitigate future flood impacts from climate change (Grand Forks Flood Mitigation Program 2021). Given that almost all of the Lewis's Woodpecker nest trees in Grand Forks have been in black cottonwood trees on or within 50 m of the riverbanks, these mitigation measures may have additional deleterious impacts on Lewis's Woodpecker nest trees. Dikes are often built on the same riverbanks where the nest trees occur, and nesting trees may be removed to make way for these dikes. Although a management plan for Lewis's Woodpecker was prepared for the City of Grand Forks prior to the flood (Coleshill 2018), it has not been formally adopted as policy, nor updated to take into account current conditions after the flood.

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