



2023-2024

**GREATER VOYAGEURS ECOSYSTEM
WOLF POPULATION REPORT**

by Thomas Gable, Austin Homkes, and Joseph Bump



ACKNOWLEDGEMENTS

We first and foremost thank Sophie Heny and Otti Brueshaber who worked diligently through all sorts of strange winter conditions to ensure our trail cameras were working and capturing sufficient footage of all 24 wolf packs in the Greater Voyageurs Ecosystem. Their efforts were vital for making our 2023-2024 population survey our most comprehensive and successful effort to date!



Sophie Heny



Otti Brueshaber

We also thank our 2023 summer field crew—Andrea Hynes, Liv Coletta, Maeve Tuley, Jude Dickerson, Faith Jung, Lucas Paschal, Ian Smith, Maggie Baham, and Sophie Heny—whose hard work and effort in Summer 2023 also contributed to the findings detailed in this report.

We are very grateful to Anthony Souffle who has generously volunteered his time to join us in the field and photograph our work and the wolves we study. Many of the photographs in this report, in particular the ones with wolves and people in them, were taken by Anthony.

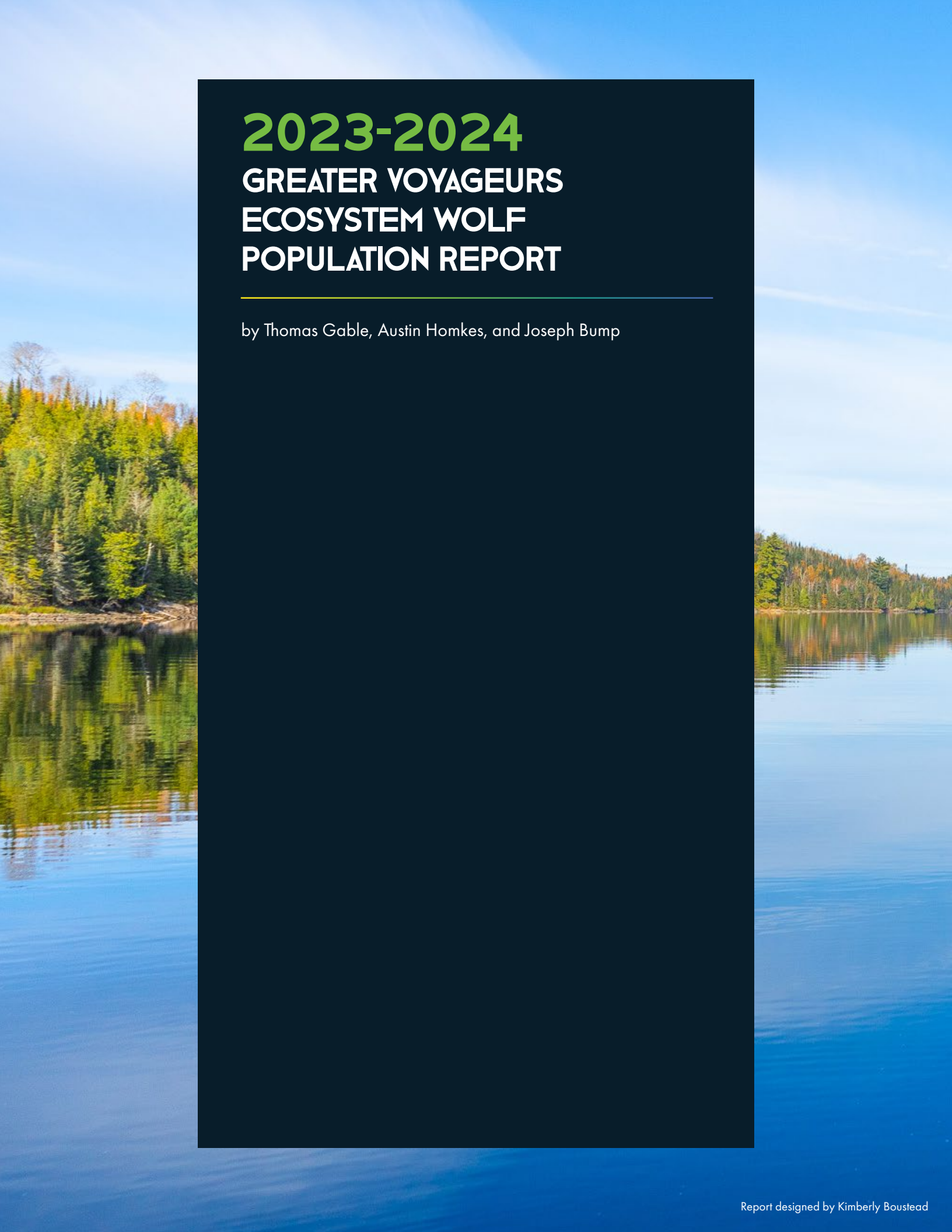
Lastly, we thank all Voyageurs National Park staff and collaborators who have dedicated their time, effort, and resources to studying the wolves of the Greater Voyageurs Ecosystem since 1975.

FUNDING AND SUPPORT

We are especially thankful for the substantial funding and support provided by the Minnesota Environment and Natural Resources Trust Fund as recommended by the Legislative-Citizen Commission on Minnesota Resources (LCCMR). We are also incredibly grateful for the 8,708 donors who have generously supported the project thus far.

We thank the many organizations and institutions that have supported our project over the past year including the University of Minnesota, International Wolf Center, Northern Michigan University, Van Sloun Foundation, Manitou Foundation, Voyageurs Conservancy, Voyageurs National Park, National Wolfwatcher Coalition, Rainy Lake Conservancy, Vectronic-Aerospace, NatureSpy, and Arc'teryx.





2023-2024 GREATER VOYAGEURS ECOSYSTEM WOLF POPULATION REPORT

by Thomas Gable, Austin Homkes, and Joseph Bump



WOLF POPULATION ESTIMATE: 2023-2024

OVERVIEW

During April 2023–April 2024, we studied the wolf population in the Greater Voyageurs Ecosystem (GVE), Minnesota to understand wolf population dynamics and how changes in population dynamics are connected to or influence predation behavior, wolf pup survival, and changes in prey density. Although our primary objective was to estimate wolf population density, we also wanted to estimate key population parameters including pack size, pack composition, recruitment of wolf pups, and territory size.

Our primary tools to study the wolf population were GPS-collars and remote trail cameras. We used data from GPS-collared wolves to collect data on the size and distribution of wolf territories in the GVE. After delineating the territories of almost half the packs in the GVE, we then calculated how much neighboring wolf pack territories overlap one another and, on average, how many neighboring packs surround a single pack’s territory. Calculating these metrics are important for accurately estimating wolf population density.

To estimate pack size, pack composition, and the number of surviving pups in each pack, we deployed >300 trail

cameras across the GVE from December 1, 2023 to April 10, 2024—we refer to this timeframe as our “winter survey period”—to capture repeated video observations of wolf packs during winter. In particular, we sought to capture repeated independent observations of packs at the same size during the monitoring period. We considered observations to be independent if they were on a different day than other observations of that pack. Multiple independent observations of a pack with the same number of members provides highly-reliable and accurate pack size estimates (Gable et al. 2022). Additionally, high-quality, repeated observations allow us to determine pack composition (number of breeding individuals, subordinate adults, and pups in a pack) and to identify most—and often all—the individual wolves in a pack based on physical characteristics.

Our objective during Winter 2023-2024 was to deploy cameras in every wolf pack territory (24 packs) in or overlapping the GVE to get detailed data on each pack that occupies the GVE (Fig. 1). We successfully did this during the Winter 2022-2023 survey—the first year we attempted

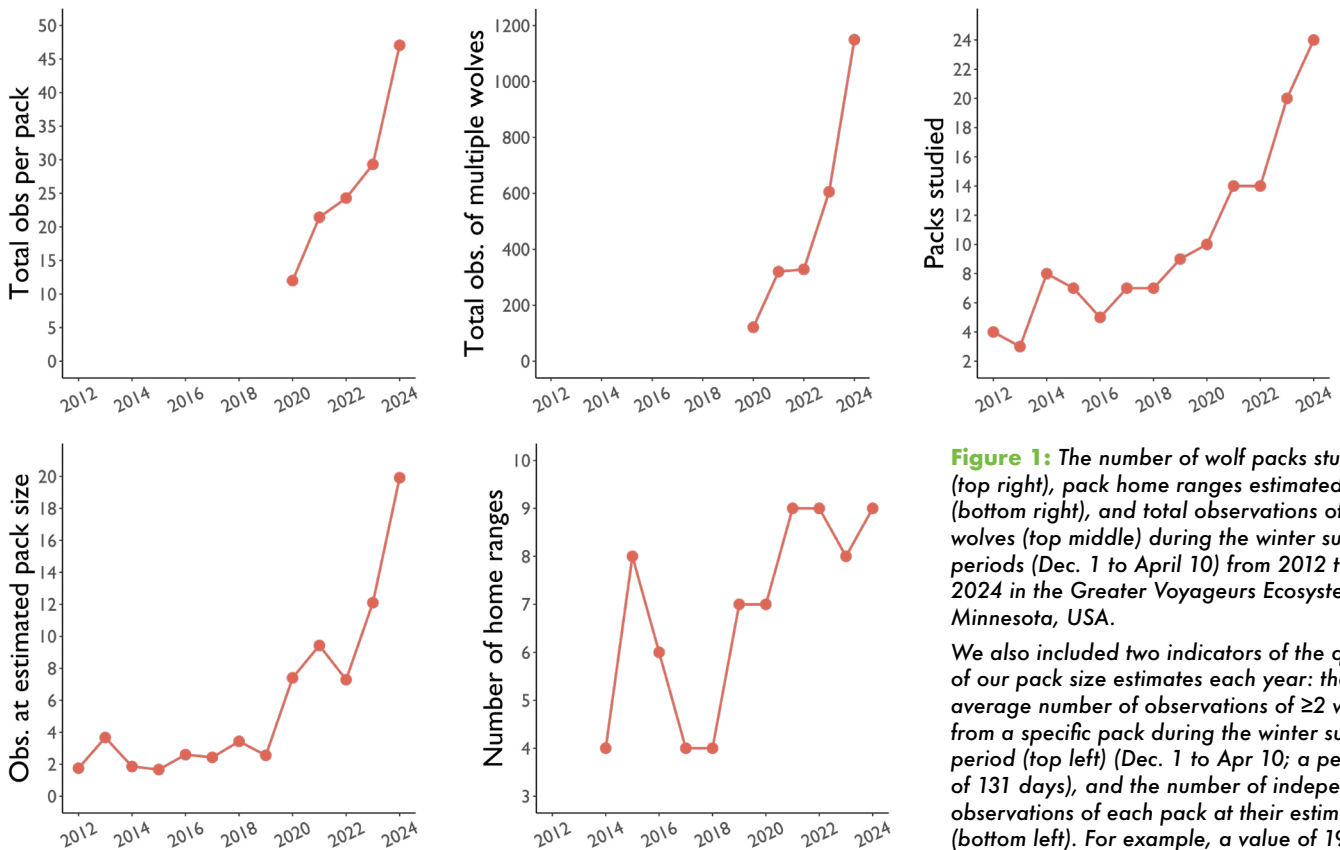


Figure 1: The number of wolf packs studied (top right), pack home ranges estimated (bottom right), and total observations of ≥ 2 wolves (top middle) during the winter survey periods (Dec. 1 to April 10) from 2012 to 2024 in the Greater Voyageurs Ecosystem, Minnesota, USA.

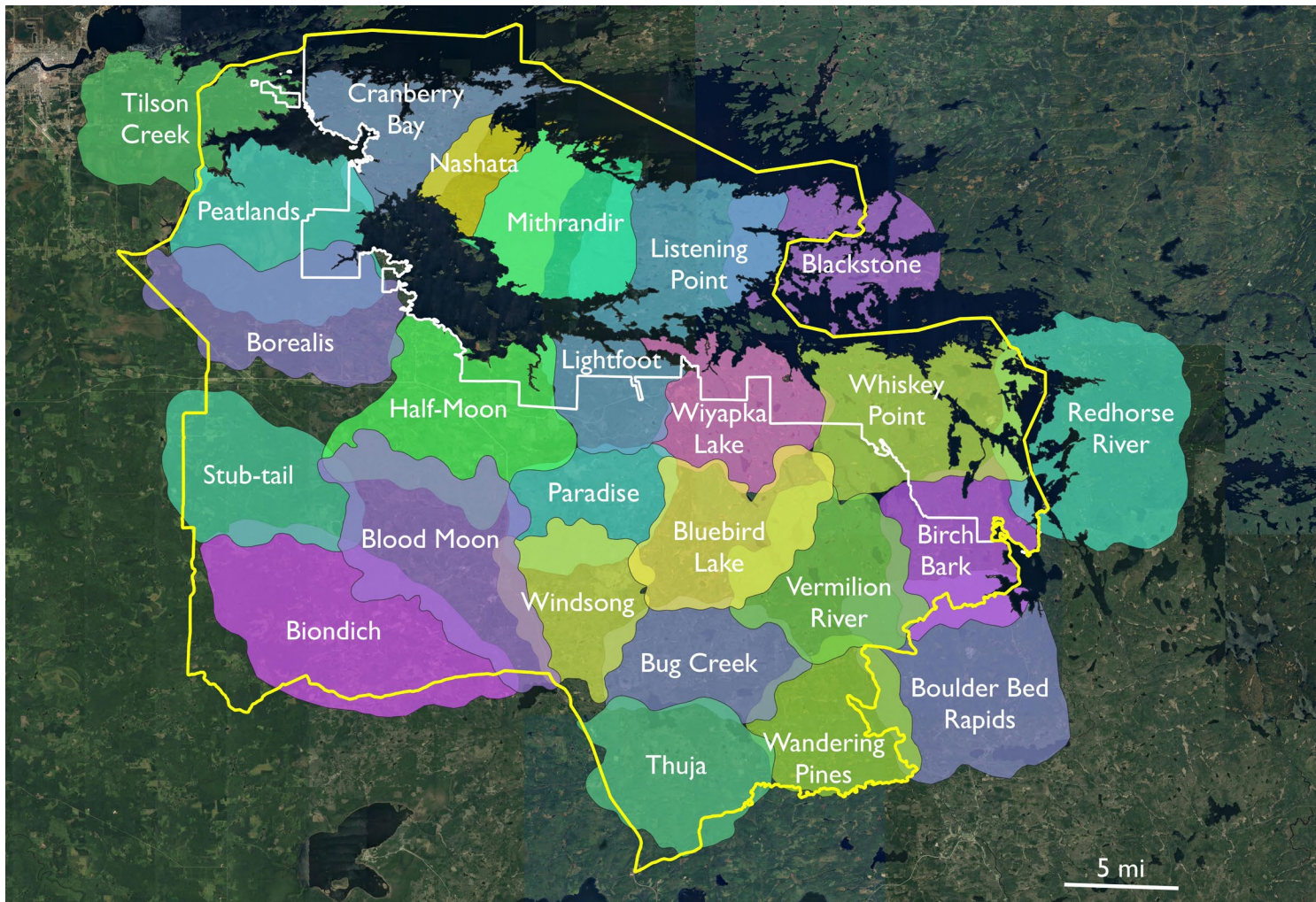
We also included two indicators of the quality of our pack size estimates each year: the average number of observations of ≥ 2 wolves from a specific pack during the winter survey period (top left) (Dec. 1 to Apr 10; a period of 131 days), and the number of independent observations of each pack at their estimate size (bottom left). For example, a value of 19.9 in 2024 indicates that, on average, we observed each pack at their estimated size on 19.9 different days during the winter survey period, or once every 6.6 days during the survey period.

this —when we estimated the size of 20 wolf packs. However, in 2024 we revised the boundaries of the GVE in an attempt to formalize the boundaries of the GVE using geographical landmarks such as prominent roads, rivers, and lakes, and to include two large winter deer yarding complexes—the Elephant Lake Deer Yard and a large deer yarding complex ~15 km south of Ray, Minnesota off the Haney Road— that previously were on the edge of the GVE boundary (Fig. 2). In doing so, we increased the size of the GVE by 372 km² (144 mi²), resulting in a total area of 2,338 km² (902 mi²). As such, the number of packs we surveyed in 2023-2024 increased from 20 in 2022-2023 to 24 in 2023-2024. Importantly, this increase in the number of packs studied was not due to an

actual increase in the number of packs in the study area but rather because of an increase in the area of the GVE (Fig. 1 & 2).

We used detailed data on wolf pack territories and wolf pack size to then estimate the size of the wolf population in the GVE and how population size changed relative to 2022-2023. We measure population size as the density of wolves per 1000 km², a standard metric used by most wolf biologists to measure the size of wolf populations. For a detailed description of how we calculated density and the other methods we briefly described above, please see the methods section at the end of this report, which provides a more technical description of our approach.

Figure 2: The known and estimated home ranges of 24 wolf packs in the Greater Voyageurs Ecosystem, Minnesota, USA from April 2023 to April 2024. The white outline represents the border of Voyageurs National Park, and the yellow outline is the border of the Greater Voyageurs Ecosystem. The territories of Blood Moon, Lightfoot, Half-Moon, Borealis, Wiyapka Lake, Bluebird Lake, Windsong, Vermilion River, and Thuja were estimated from GPS-collar data. We approximated all other territories using historical territory size and configurations in combination with remote camera data.





2023-2024 WOLF POPULATION SUMMARY

The 2023-2024 survey effort was the most intensive survey effort to date in the Greater Voyageurs Ecosystem, Minnesota (Fig. 1). From December 1, 2023 to April 10, 2024, we deployed >300 remote cameras across 24 wolf pack territories and in doing so captured 1,149 observations of ≥ 2 wolves (i.e., social groups or packs) traveling together (Table 1). We averaged 47 observations of ≥ 2 wolves from each pack during our winter survey period, which means we observed members of each pack once every 2.9 days on average (winter survey period=131 days). However, in many instances we did not observe all pack members traveling together but rather a subset of pack members. Nonetheless, we captured an average of 20 independent observations of each pack at its estimated size during our winter study period (detailed descriptions of each pack below). We used GPS-collar data from wolves in 9 of the 24 (38%) wolf packs that use the GVE to estimate territory size and to estimate average territory overlap between neighboring packs. Notably, of the 24 packs that use the GVE, only 20 have territories that are entirely or largely

Table 1. The key metrics of the wolf population in the Greater Voyageurs Ecosystem during 2023-2024

THE NUMBERS

Packs studied	24 packs
Territories delineated	9 territories
Total observations of ≥ 2 wolves	1,149 observations
Average number of observations per pack	47 observations
Average number of independent observations of packs at their estimated size	20 observations
Total pack wolves observed	104 wolves
Unique lone wolves observed	17 wolves
Percent of population that were estimated to be lone wolves	20.7%
Packs that produced pups	84% of packs
Average territory size	115 km ²
Average pack size	4.3 wolves
Average recruitment	1.7 pups
Average pack-on-pack overlap	11.9 km ²
Average number of neighboring packs	4.2 packs
Population density	55.4 wolves/1000 km ²
Percent change in population from previous year	-15%

within the GVE (Fig 2). Thus, we had territory size estimates for 45% (9/20 packs) of the packs residing entirely or largely within the boundaries of the GVE.

We estimate wolf population density in the Greater Voyageurs Ecosystem in 2023–2024 was 55.4 wolves/1000 km², a 15% decrease in wolf population density from 2022–2023 (65.1 wolves/1000 km²; Fig. 3). Because average pack size remained virtually the same between 2022–2023 and 2023–2024 (4.2 wolves vs 4.3 wolves; Fig. 4), the decrease in population density can be attributed entirely to a substantial increase in territory size. Indeed, average territory size increased by 21% from 95.5 km² in 2022–2023 to 115.6 km²

in 2023–2024 (Fig. 5). With the increase in territory size came a marginal increase (3.6 km²; Fig. 6) in territory overlap between neighboring packs that reduced, to a small degree, the effects of increased territory size on overall population density; i.e., territory size increased by 21% but population density only decreased by 15%.

Although wolf pack territory size changed substantially, pack size, structure, and reproduction remained nearly identical between this year (2023–2024) and last (2022–2023). Of the 19 packs for which we could determine whether reproduction occurred in Spring 2023, 84% (16) produced pups whereas 16% (3) did not—similar to the previous year when 82% of



Figure 3. Wolf density estimates (blue points) for the Greater Voyageurs Ecosystem, Minnesota, USA from 2015 to 2024. The red points and dashed red line represent wolf pack density if density was calculated solely by dividing mean wolf pack size by mean home range size (i.e., if density estimates did not account for pack home range overlap or lone wolves).

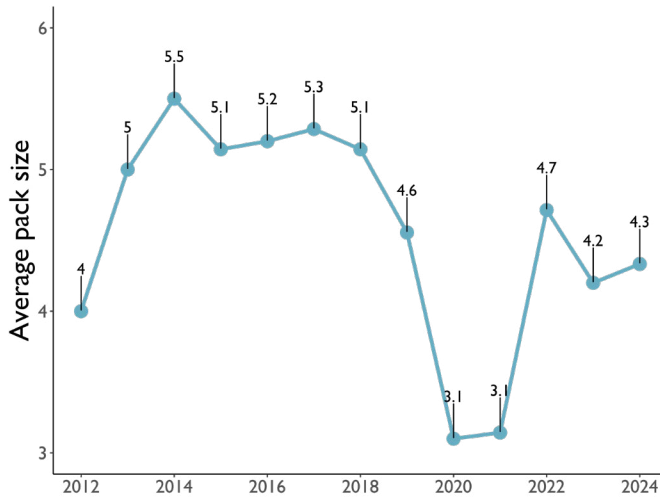


Figure 4. Wolf pack size estimates for the Greater Voyageurs Ecosystem, Minnesota, USA from 2012 to 2024.

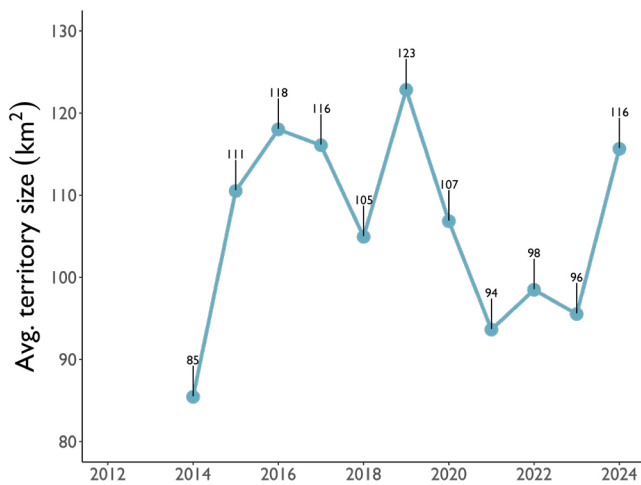


Figure 5. Wolf home range size estimates for the Greater Voyageurs Ecosystem, Minnesota, USA from 2012 to 2024.

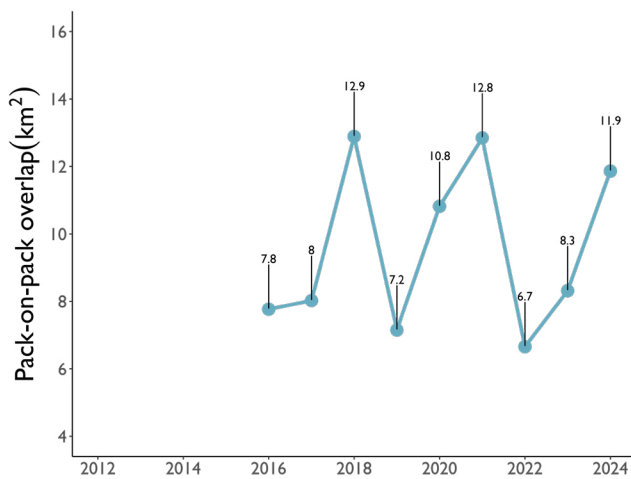


Figure 6. Wolf pack overlap estimates for the Greater Voyageurs Ecosystem, Minnesota, USA from 2012 to 2024. We considered pack-on-pack overlap to be the average territory overlap of each wolf pack territory with each neighboring pack. For instance, in 2023-2024, each wolf pack territory overlapped each neighboring pack territory by 11.9 km². Quantifying the overlap of wolf pack territories is crucial for deriving accurate wolf population density estimates.

packs produced pups (Gable et al. 2023). Similarly, wolf pup recruitment in 2023-2024 was 1.71 pups per pack which was the same as 2022-2023 when recruitment was 1.72 pups per pack (Table 2). The similarity in recruitment between years is likely why pack size remained the same between 2022-2023 and 2023-2024. Pack structure and composition remained similar as well. In 2022-2023, pack composition was 49% breeding wolves, 14% subordinate wolves (non-breeding wolves >1 yr old), and 37% pups, and in 2023-2024 pack composition was 47% breeding wolves, 12% subordinate wolves, and 41% pups.

Lone wolves constitute a meaningful proportion of any wolf population but estimating the percent of the population that

are lone wolves is difficult for myriad reasons. To account for the abundance of lone wolves in our population estimates, we calculated the percent of GPS-collared wolves that were lone wolves during Winters 2014-2024, and assumed that this number was representative of the annual abundance of lone wolves in the GVE during this period. Thus, we assumed that lone wolves constituted 20.7% of the wolf population in the GVE in Winter 2023-2024 as well in all previous years because 19 of 92 collared wolves during Winters 2014-2024 were lone wolves (Table 3). Notably, we update our ‘lone wolf estimate’ each year by adding data from the most recent year into our estimate (i.e., increasing our sample size), and then use the updated estimate to calculate population density for the current year and all subsequent years. As such, previous

Table 2. Pack size and pup recruitment estimates for all wolf packs in the Greater Voyageurs Ecosystem, Minnesota, USA during our 2023-2024 winter survey period. Total observations refer to the number of times we observed 2 or more members of a given pack together during the winter survey period (Dec.1 to Apr. 10). By contrast, the number of independent observations indicates the number of different days we observed a given pack at their estimated size during our winter survey period. For example, we observed 3 wolves together in the Birch Bark Pack on 20 different days during our winter survey period.

Pack	Pack Size	Recruitment	Total Observations	Number of Independent Observations
Biondich	7	5	19	5
Birch Bark	3	0	22	20
Blackstone	6	4	14	4
Blood Moon	2	0	33	22
Bluebird Lake	2	0	78	50
Boulder Bed Rapids	3	0	6	5
Bug Creek	6	3	104	20
Cranberry Bay	7	5	33	5
Half-Moon	7	3	83	20
Lightfoot	3	0	38	23
Listening Point	5	2	86	27
Mithrandir	2	0	125	75
Nashata	3	1	37	27
Paradise	2	0	125	75
Peatlands	10	5	31	3
Redhorse River	4	2	6	2
Stub-tail	7	4	53	7
Thuja	5	3	34	6
Tilson Creek	2	0	20	10
Vermilion River	6	3	65	14
Wandering Pines	3	0	18	9
Whiskey Point	5	3	39	6
Windsong	2	0	42	33
Wiyapka Lake	2	0	63	36
TOTAL	104	43	1129	478



population density estimates, as reported in our previous reports, often change from year to year as we collect more data. For example, we estimated the wolf population density in 2022-2023 to be 65.2 wolves/1000 km² when all data from 2014-2023 indicated lone wolves constituted 19.5% of the population during the 2014-2023 period (Gable et al. 2023). However, because all data from 2014-2024 indicates lone wolves actually constitute 20.7% of the population during this time period, we now estimate that wolf density during

2022-2023 was 65.8 wolves/1000 km² (a 0.9% change in our 2022-2023 estimate).

We also used remote camera data to provide a minimum estimate of the number of lone wolves in the GVE during Winter 2023-2024 as a means to validate the approach described above (Table 3). More specifically, we identified and counted lone wolves we observed on camera during the winter survey period. To be counted as a lone wolf, we had to observe the wolf multiple times over the survey period, be able to readily identify the wolf based on physical characteristics, and be confident the wolf was not part of any pack in the GVE based on regular observations of each pack during the same period. Because of these criteria, there were likely several lone wolves that we did not “count” via this approach (i.e., this approach is conservative and yields a minimum estimate). During the 2023-2024 winter survey period, we could confidently identify 17 lone wolves in the GVE (Table 2). Because we counted the number of wolves in all 24 packs in the GVE (104 wolves), we were able to determine that lone wolves constituted at least 14% of the wolf population in the GVE (17 lone wolves/[17 lone wolves + 104 pack wolves]*100). Although this approach underestimates the number of lone wolves in an area, the results from this year indicate the percent of lone wolves in the GVE in 2023-2024 was almost certainly >15%—the estimate many biologists use when estimating wolf density—and that our estimate, derived from GPS collared wolves, of 20.7% seems reasonable.

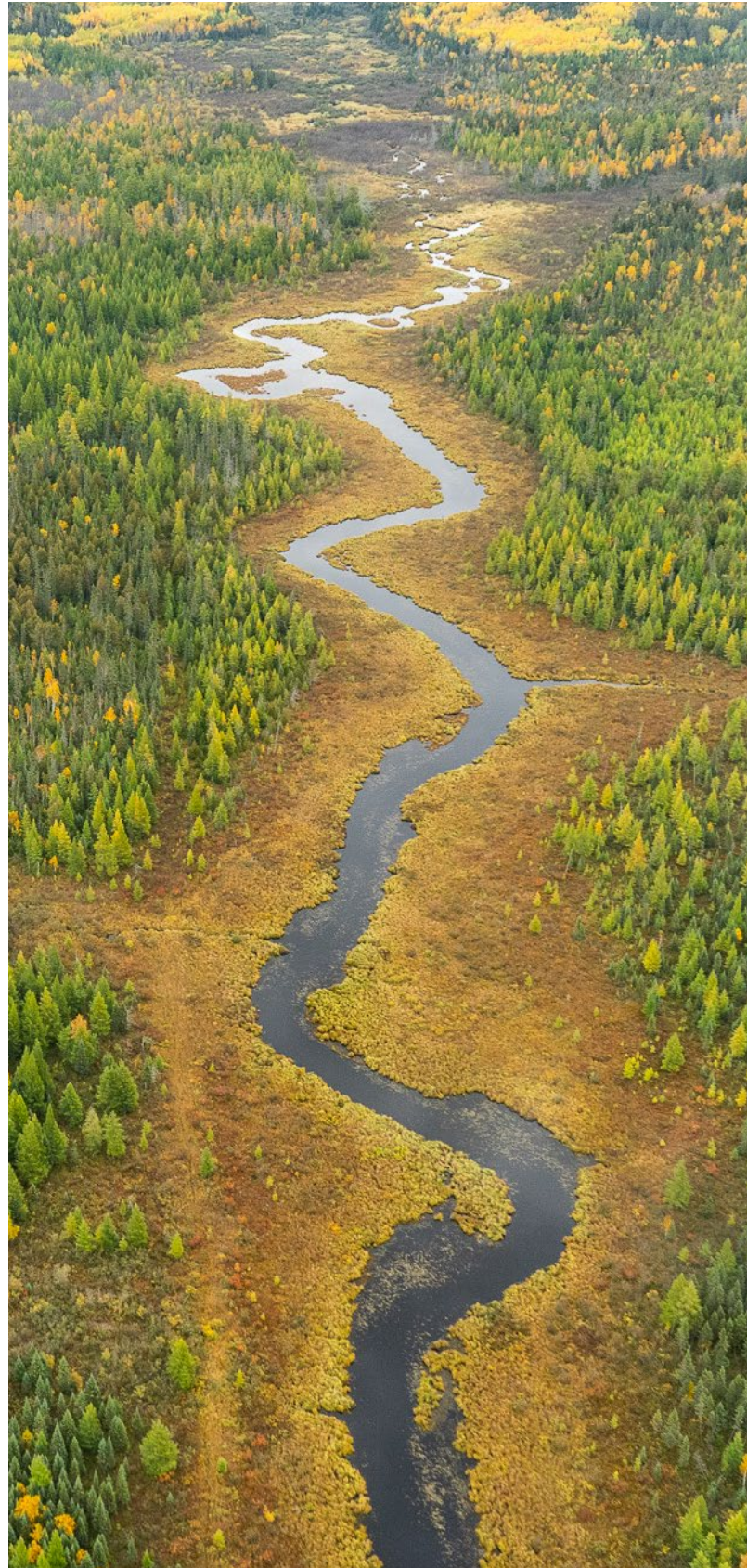
Table 3. Prevalence of lone wolves in the Greater Voyageurs Ecosystem, Minnesota, USA during the winter survey period (Dec. 1 to Apr. 10) based on collared wolves and remote cameras. We did not have a sufficient number of remote cameras deployed during 2014-2022 to estimate number of lone wolves using this approach.

Year	Lone wolves with functional collars during winter period	All wolves with functional collars during winter period	Percent of collared wolves that were lone wolves	Unique lone wolves observed on camera during winter period	Number of pack wolves observed on camera during winter period	Minimum percent of population that are lone wolves based on cameras
2014-2015	4	14	28.6			
2015-2016	1	9	11.1			
2016-2017	0	2	0.0			
2017-2018	0	3	0.0			
2018-2019	1	8	12.5			
2019-2020	3	12	25.0			
2020-2021	1	10	10.0			
2021-2022	3	12	25.0			
2022-2023	3	12	25.0	9	85	9.6
2023-2024	3	10	30.0	17	104	14.0
OVERALL	19	92	20.7			

POPULATION TREND

Wolf density during 2023-2024 (55.4 wolves/1000 km²) was the 3rd lowest wolf population estimate in the GVE in the last decade (Fig. 3); the only years with lower population estimates were 2019-2020 (51.3 wolves/1000 km²) and 2020-2021 (44.8 wolves/1000 km²). Because wolf density is largely driven by prey density (McRoberts and Mech 2014, Mech and Barber-Meyer 2015), the recent decrease in the wolf population is not surprising given the recent decline in deer populations in the GVE and northern Minnesota over the past few years. One of the mechanisms by which wolf populations adjust to decreases in prey density is by increasing territory size, which provides access to an increased number of prey (Sells et al. 2021, 2022)—a pattern documented in several ecosystems including Montana (Sells et al. 2021), Ontario (Kittle et al. 2015), and Northwestern Canada (Dickie et al. 2022). However, increases in territory are generally associated with decreases in wolf density because fewer packs can fit in a specified area. The 21% increase in territory size during a period when deer density decreased is generally consistent with previous research, though we are wary of making any definitive conclusions based on the change that occurred during a single year.

Despite the recent decrease in the wolf population, all evidence indicates that the wolf population in the Greater Voyageurs Ecosystem is a stable, high-density wolf population (Fig. 7–9). Certainly, wolf density has varied annually over the past decade, however, there is no indication of an increasing or decreasing trend in wolf density over time in the GVE. Instead, the wolf population has fluctuated around a density of 60 wolves/1000 km²—the average population density during 2015-2024—for the past decade and likely much longer (see Gable et al. 2022 for more details regarding historical patterns). Notably, the average density of wolves in the GVE during this 10-year period represents some of the highest sustained densities of gray wolves reported (Mech and Barber-Meyer 2015, Gable et al. 2022).



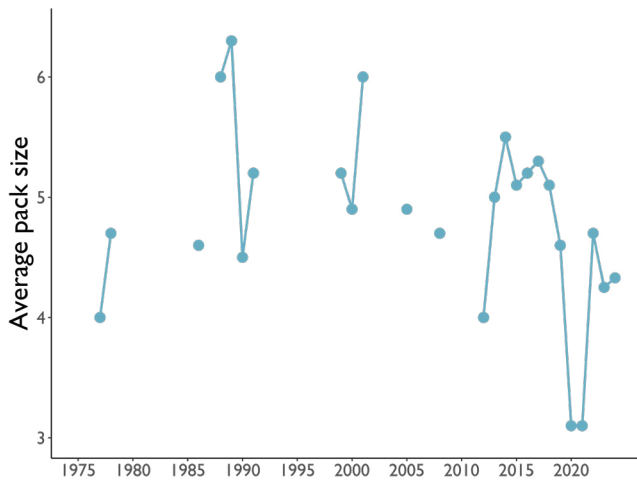


Figure 7. Mean wolf pack size in the Greater Voyageurs Ecosystem (GVE), Minnesota, USA from 1976 to 2024. Historical data on wolf pack sizes in the GVE were from 1976-1978 (Hardwig 1978), 1985-1986 (archived map by Voyageurs National Park biologist Glen Cole), 1987-1991 (Gogan et al. 2004), 1998-2001 (Fox et al. 2001), 2005 (Fox 2006), and 2008 (Ethier and Sayers 2008).

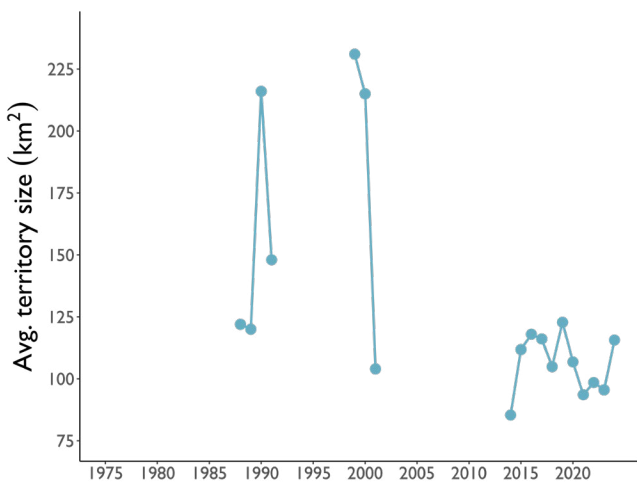


Figure 8. Mean home range size in the Greater Voyageurs Ecosystem, Minnesota, USA from 1975 to 2024. Data from 1987-1991 and 1998-2001 are from Gogan et al. (2004) and Fox et al. (2001), respectively. Home ranges from 1987 to 2001 were estimated using telemetry data and minimum convex polygons whereas home ranges from 2014-2024 were estimated using GPS-location data and kernel density estimators. Estimates from 1987 to 2001 almost certainly overestimated territory size substantially (see Gable et al. 2022 for detailed discussion) but we have included them here for posterity.

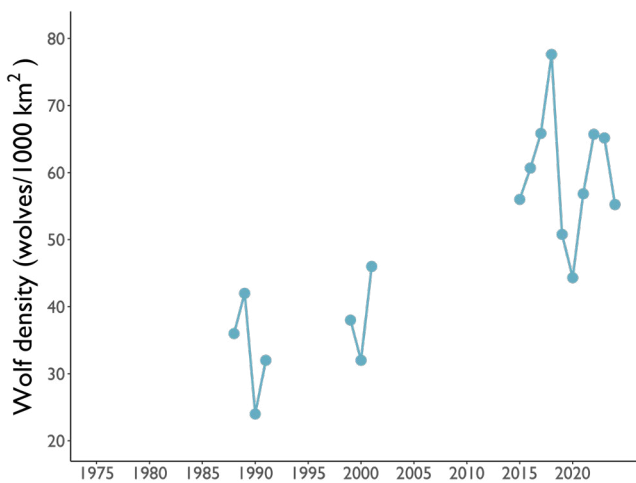


Figure 9. Wolf density in the Greater Voyageurs Ecosystem, Minnesota, USA from 1975 to 2024. Data from 1987-1991 and 1998-2001 are from Gogan et al. (2004) and Fox et al. (2001), respectively. Although wolf density during 2015-2024 was substantially higher than that reported in previous studies, we do not think wolf population density has increased—or at least increased substantially—over the past 35 years. Instead, the disparity in density from previous studies and ours likely stems from the coarser survey methods used in previous studies. For detailed discussion on this point, see Gable et al. (2022).



INDIVIDUAL WOLF PACK SUMMARIES

The following pages are summaries of the data collected on each wolf pack during the 2023-2024 winter survey period. The summaries provide an explanation of the size of each pack, pack composition, and any other pertinent details on that pack during 2023-2024. When possible, we refer to known wolves by their ID. Known wolves are either those we have tagged and collared or those that have distinctive physical appearances that allow us to identify them when they are recorded on our remote cameras. Collared and ear-tagged wolves have IDs that either begin with a “V” (e.g., V085) or are a three or four digit code (e.g., “Y1T” or “B11D”). Wolves that we have identified solely based on physical appearance have IDs based on their pack affiliation when first identified on camera (e.g., CB = Cranberry Bay, LP = Listening Point) and social status (e.g., BM = breeding male, BF = breeding female, SUB = subordinate). For instance, the breeding female of the Stub-tail Pack, who has never been collared but has a distinctive short tail from which we can easily identify her on camera, was assigned the ID: ST_BF. When we could readily identify multiple subordinate wolves in a pack, we included a number at the end of the ID so that each ID was unique (e.g., LP_SUB1, LP_SUB2).

BIONDICH

This past year was our second year studying the Biondich Pack. The Biondich Pack consisted of 7 wolves during Winter 2023-2024, a substantial increase from 2022-2023 when the pack was just a breeding pair (Wolves BI_BM and BI_BF). The increase in pack size was a result of the breeding pair successfully rearing 5 pups to adulthood. Throughout late summer and fall, we had several observations of 6 pups in the pack (for a total pack size of 8 wolves). However, our last observation of 8 wolves was on December 24, 2023 and all subsequent observations were of 7 wolves (the breeding pair and 2 pups). Based on this pattern, we suspect 1 of the 6 pups died in late December as we had observations of 7 starting in early January. We collared 2 of these 5 pups—Wolves R5E and R6D—in May 2024.

1 The breeding male of the Biondich Pack (Wolf BI_BM). **2** Several members of the Biondich Pack in December 2023.



1



2

BIRCH BARK

The Birch Bark Pack was three wolves again this past winter, and appeared to be the same 3 individuals that were in the pack in Winter 2022-2023: the older, grayish-white breeding female (Wolf BB_BF), the larger, grizzled old breeding male (Wolf BB_BM), and a subordinate male with a distinctive appearance, who we collared in July 2024 (Wolf W4D). We had 22 observations of the Birch Bark Pack in Winter 2023-2024, and 20 of those observations were of all 3 pack members together. The other 2 observations were just 2 of the pack members together.

The Birch Bark Pack did produce pups, or at least a pup, in Spring 2023. However, we do not know how many pups they had. The only observation we got of a pup in Summer 2023 was on August 12 when a pup was following what appeared to be the breeding female. We never observed a pup again in that pack territory despite observing adult wolves from the pack on remote cameras

regularly throughout late summer and fall. Therefore, it seems likely that the pup observed on camera, and any other pups the pack had in Spring 2023, died by late summer.

Because we did not have a GPS-collared wolf in the Birch Bark Pack in 2023, we estimated the pack's territory based on the territories of neighboring pack's that had a GPS-collared wolf (Vermilion River), and via remote cameras where we captured footage of the Birch Bark Pack. Based on these data, the northern extent of the Birch Bark territory appears to be just north of Mukooda Lake, and likely includes much of Staeger Bay. We suspect the eastern shoreline of Johnson Lake forms the western boundary of the territory and the western shoreline of Crane Lake the eastern boundary. The southern edge of the territory appears to be in the vicinity of Vermilion River Falls.

The breeding female (Wolf BB_BF) of the Birch Bark Pack in February 2024.





1 Wolf W4D of the Birch Bark Pack in Winter 2023-2024.



2 The breeding male of the Birch Bark Pack in January 2024 (Wolf BB_BM).



3 The breeding female of the Birch Bark Pack in early 2024 (Wolf BB_BF).

BLACKSTONE

We documented 5 packs with territories on or overlapping the Kabetogama Peninsula in Voyageurs National Park in Winter 2023-2024, the first time this has been documented since wolf research began in the park in the late 1970s. The Blackstone Pack appears to occupy the easternmost portion of the Kabetogama Peninsula based on remote camera footage and a substantial proportion of the pack's territory is likely in Ontario (i.e., the pack territory straddles the international border between the United States and Canada). We are basing this on the fact that most of the observations of this pack were on remote cameras near Kettle Falls, Mica Bay, and Weir Lake. Although we had a few observations of the Blackstone Pack as far west as Lost Bay and Shoepack Lake, those areas are clearly occupied by the Listening Point Pack who were regularly on our remote cameras in that area during fall and winter. In many regards, we suspect the Blackstone Pack territory is similar to that of the Mica Bay Pack territory in 2014-2015 which included the far eastern portion of the Kabetogama Peninsula as well as a large area in Ontario that included Blackstone Island, Oakpoint Island, and Knox Bay.

The Blackstone Pack was 6 wolves—a breeding pair and four pups—in Winter 2023-2024. The breeding male of the pack (Wolf BS_BM) is fortunately a distinctive looking wolf with a large scar under his left eye and relatively short fur across much of his body. This made it fairly easy to identify the pack in remote camera footage on the Kabetogama Peninsula, even on cameras where we observed both the Blackstone Pack and the Listening Point Pack (these packs have some territorial overlap on the eastern side of the Kabetogama Peninsula). Further, the breeding male's appearance allowed us to identify the pack when they made some large forays outside of their territory. For example, on January 14, 2024, we observed the Blackstone Pack traveling down a logging road about a mile south of Camp 90



Three pups from the Blackstone Pack in Winter 2023-2024

Road in the Paradise Pack territory, likely ~13-15 km from their territory. Similarly, on December 7-8, 2023, the Blackstone Pack traveled ~9-10 km into the Listening Point territory and were captured on two of our remote cameras south of Shoepack Lake during that foray. The pack again trespassed into the Listening Point territory on January 14, 2024 when we observed the pack just south of Shoepack Lake.

Because the Blackstone Pack only occupies a small portion of the GVE, we did not have nearly as many observations of the pack as we do of most packs that reside largely within the boundaries of the GVE. Nonetheless, we had 17 observations of the Blackstone Pack during the winter survey period and 4 of these observations were independent observations of all 6 wolves. Notably, we had observations of all 6 wolves in December, January, and March, indicating the pack was 6 wolves for most, if not all of the winter survey period.



1 The breeding female of the Blackstone Pack (Wolf BS_BF). **2** The breeding male of the Blackstone Pack (Wolf BS_BM) near Kettle Falls in Fall 2023. **3** Three of the four Blackstone pups on the portage between Little Shoepack and Shoepack Lake in early 2024.

BLOOD MOON

The Blood Moon Pack was a breeding pair in Winter 2023-2024. The pair included Wolf Y1T, the breeding male, and his mate, Wolf Y5E, who we collared in Spring 2024. The Blood Moon Pack had a litter of 4 pups in Spring 2023 and 3 of these pups survived until late summer. However, one of the three pups looked quite emaciated in August per remote camera footage, and by October there were only two pups alive (we suspect that emaciated pup likely starved to death). The two surviving pups looked quite small and underdeveloped in remote camera footage in October and November 2023. Yet, we had several observations of these pups traveling with one or both of their parents in late November. However,

neither pup survived past December. The last observation we had of a pup traveling with the Blood Moon breeding pair was December 9 when a single pup was traveling with Y1T and Y5E.

All other observations of the Blood Moon Pack during the winter survey period were just the breeding pair. We had robust data for this pack as we observed the pack 33 times during the winter survey period, which equates to an observation every 4 days for the duration of the winter. Given this, we are confident the pack did not recruit any pups to adulthood. Thus, the Blood Moon Pack was just 2 wolves for a second consecutive winter.

Wolf Y5E, the breeding female of the Blood Moon Pack, on a frozen beaver pond in March 2024.





1 Wolf Y1T, the breeding male of Blood Moon, carrying a beaver head in his mouth **2** Wolf Y1T, the breeding male of Blood Moon, with a pup in early December 2023. **3** The Blood Moon Pack in March 2024. The pack consisted of two wolves, Wolves Y1T and Y5E.



BLUEBIRD LAKE/CLEARCUT

In January 2023, the breeding male and female of the Bluebird Lake Pack were killed by other wolves one week apart, leaving only a 1.5 year old female in the pack (the pack was 3 wolves at the time). At that same time, we observed 3 wolves—a breeding pair and an older male wolf—we did not recognize traveling in the Bluebird Lake territory quite extensively. We concluded a new pack, which we referred to as the Clearcut Pack, had taken over the Bluebird Lake territory. Further, we noted the old male in this pack was frequently observed traveling with the 1.5 year old female from the Bluebird Lake Pack in the Bluebird Lake territory.

However, we recently realized we were incorrect in our assessment thanks to several pieces of new information. The newly-formed “Clearcut Pack” was not a new pack at all but rather the Whiskey Point Pack that had ventured several miles out of

their territory for a few weeklong periods in winter. Clear daytime video footage of the Whiskey Point Pack in their territory during Spring 2023 to Winter 2024 allowed us to note several unique physical identifiers on the breeding female (e.g., missing the upper portion of her right ear and has a distinctive, ~1-inch-long scar in the corner of her right eye) and male (e.g., missing a small portion of his right ear, orangish-red fur with dark fur on his back, and a distinctive muzzle).

After reviewing the footage of the purported “Clearcut Pack” in Winter 2022-2023 closely, it was clear we were simply observing the Whiskey Point breeding pair and an older male who was traveling with them. The Whiskey Point Pack largely trespassed into the Bluebird Lake territory in late January 2023 and early February 2023. Although we observed the Whiskey Point Pack in the Bluebird Lake area a few more times after

1 The Bluebird Lake Pack in Winter 2023-2024. Wolf B6T, the dominant female, is on the right and the dominant male, Wolf BL_BM, is on the left.

2 The dominant male of the Bluebird Lake Pack (Wolf BL_BM). **3** Wolf B6T, the dominant female of the Bluebird Lake Pack.



The Bluebird Lake Pack. Wolf B6T is in the front and following behind her is the dominant male, Wolf BL_BM.

early February 2023, it is clear that Whiskey Point did not take over any portion of the Bluebird Lake territory and instead returned to their territory by mid-to-late winter (e.g., the Whiskey Point Pack had a litter of pups in Spring 2023 and we observed the breeding pair in the Whiskey Point territory frequently in Summer 2023). We suspect wolves from Whiskey Point likely killed Wolf PoC, the breeding male of the Bluebird Lake Pack in January 2023, but cannot say for certain.

Intriguingly, we only observed the Whiskey Point breeding pair traveling with this older male for a ~2.5 week period from January 23, 2023 to February 9, 2023. All observations of the Whiskey Point Pack prior to and after this period were just 2 wolves. The reason is that by February 18, that older male was traveling extensively with the 1.5 year old Bluebird Lake female. Indeed, we observed this pair together on 15 different days from February 18 to April 10, 2023. Based on these patterns, we have updated our 2022-2023 pack count data to reflect the fact that Whiskey Point was 2 wolves in Winter 2022-2023, Bluebird Lake was 2 wolves as well, and the Clearcut Pack never existed.

In Spring 2023, we collared the surviving female of the Bluebird Lake Pack, who is now dubbed Wolf B6T. Her movements, as recorded via GPS-collar data in Summer 2023, demonstrated she was still occupying the original Bluebird Lake territory. Further,

genetic analysis confirmed she was the daughter of Wolves PoC and P3S, the original breeding pair of Bluebird Lake. Because B6T is a direct descendant of the Bluebird Lake pair, we consider her and any males she mates with to be part of the Bluebird Lake Pack (i.e., part of the same familial unit). B6T did not produce any pups in Spring 2023 and we are uncertain what occurred with her and the older male she had been traveling with. We did not observe this older male on camera after early April 2023, despite observing B6T several times.

In Summer 2023, Wolf B6T started traveling extensively with a different adult male, now dubbed Wolf BL_BM. The pair spent most of the summer and early fall in the original Bluebird Lake Pack territory. However, for a 2-3 month period in fall and early winter, the Bluebird Lake Pack appeared poised to take over the Wiyapka Lake territory. Starting in late September 2023, Wolves B6T and BL_BM left their territory, which was southerly adjacent to the Wiyapka Lake Pack territory, and began traveling extensively throughout the Wiyapka Lake territory. They would return periodically to the Bluebird Lake territory but most of their time in October and November was in the Wiyapka Lake territory, and it seemed a takeover was imminent.

Yet, somehow, the Wiyapka Lake Pack was able to defend their territory and stave off the Bluebird Lake Pack. By early 2024, the Bluebird Lake Pack was largely residing in their original territory, even though they still made occasional forays northward into the Wiyapka Lake territory. Nonetheless, Wiyapka Lake and Bluebird Lake did seem to have sizable overlap in their territories around Amundsen Lake and Gannon Creek area.

Wolf B6T and this new male remained together from Summer 2023 through the entirety of the 2023-2024 winter survey period. In total, we had 50 independent observations of this pair together—one observation of the pair every 2.6 days—during the winter survey period.

BOREALIS/LEATHERLEAF

In July 2023, we collared Wolf R4D, the breeding male of the Borealis Pack. However, in late October 2023, R4D was hit and killed by a vehicle on Highway 53 about 1 kilometer from where the breeding female of the Leatherleaf Pack (Wolf LL_BF)—the pack northerly adjacent to Borealis—was hit and killed by a car 3 months earlier. The death of these breeding animals seemed to have a large impact on both of these packs.

For the Borealis Pack, the death of the breeding male appeared to cause the dissolution of the pack by late fall. Despite having numerous remote cameras in the Borealis Pack territory, we never observed any groups of wolves traveling on most of those cameras during the winter survey period. The only pack captured on cameras in the Borealis territory was the Peatlands Pack (see individual description of the pack below), who we only observed in the northern portion of the Borealis territory. Given this, we conclude that the Borealis territory remained vacant for Winter 2023-2024, the first time we have documented a vacant, unoccupied territory during our winter survey.

What we do not fully understand is what wolves formed the Peatlands Pack, and whether any of those wolves are former Borealis Pack members. The Peatlands Pack took over the Leatherleaf Pack territory in late 2023, and we could clearly see on remote camera footage that the breeding male of the Peatlands Pack was not the breeding male of the Leatherleaf Pack from last year (the Leatherleaf female died in July 2023, so the new dominant female is a different wolf as well). In other words, there was a complete turnover in the breeding pair. However, the Peatlands Pack was the largest pack we observed in Winter 2023-2024 at 10 wolves strong: 2 breeding wolves, 3 subordinate adults, and 5 pups.

We strongly suspect that many of these pups and subordinate adults are either from the Leatherleaf or Borealis Pack as we think it highly unlikely that a nomadic pack of 10 wolves moved in and quickly took over the Leatherleaf territory. We do know that both the Leatherleaf and Borealis Packs had pups in Spring 2023, and several pups were alive in the Borealis Pack as of late summer. We do not have any information on pups in Leatherleaf during summer. All this to say that we think it is possible that the Peatlands Pack could be comprised, in part, of Borealis Pack members.

How we found the breeding female of the Leatherleaf Pack (Wolf LL_BF) in July 2023 after she had been hit by a vehicle.



BOULDER BED RAPIDS

We observed the Boulder Bed Rapids Pack on 5 occasions in Winter 2023-2024 and in all 5 instances the pack was the same 3 wolves: a breeding pair and a large subordinate male wolf with a substantial limp. All observations of this pack occurred between Vermilion River Falls and Johnson Lake (i.e., in the southern portion of the Birch Bark Pack territory). Thus, we think the Boulder Bed Rapids Pack is the pack southerly adjacent to the Birch Bark and Vermilion River Packs, and easterly adjacent to the Wandering Pines Pack. Based on typical territory size, we suspect the Boulder Bed Rapids territory includes

the southern shore of Crane Lake and likely extends southward to Echo Lake. Because the Boulder Bed Rapids Pack territory only overlaps the Greater Voyageurs Ecosystem by a small margin, we do not anticipate spending any additional effort to study the pack, and the only data we will likely have on this pack moving forward is when they periodically venture into the GVE and are captured on remote cameras.

The subordinate male with a significant limp in the Boulder Bed Rapids Pack.



BUG CREEK

The Bug Creek Pack was 6 wolves in Winter 2023-2024. We had a substantial number (104) of observations of the pack during the winter survey period, though the majority of the observations were of 2-5 pack members traveling together. Nonetheless, we still had 20 independent observations of 6 wolves in the pack throughout the survey period—5 observations in December, 5 in January, 6 in February, and 4 in March—so we are confident the pack was 6 wolves. The pack consisted of the breeding pair (Wolves BC_BF and BC_BM), a subordinate female (Wolf BC_SUB1), and 3 pups. We generally do not assign pups an ID during the winter because they are often very difficult to tell apart from other pups. However, one of the Bug Creek pups did not have a tail so we assigned it an ID (Wolf BC_SUB3) because it could be readily identified. Additionally, we collared one of the other pups, who is now dubbed Wolf P6T, in May 2024.

From at least early 2021 to Fall 2023, Wolf B5E was the breeding male of the Bug Creek Pack. His mate during this period was a female with a unique, white-tipped tail, who is still the breeding female (Wolf BC_BF) of the pack. However, Wolf B5E disappeared in Fall 2023 and a new dominant male (Wolf BC_BM) joined the pack during that same period. We do not know if B5E died and another male took his place, or if he was usurped by the current breeding male. All we can confidently say is that we have not observed B5E on camera since early Fall 2023.

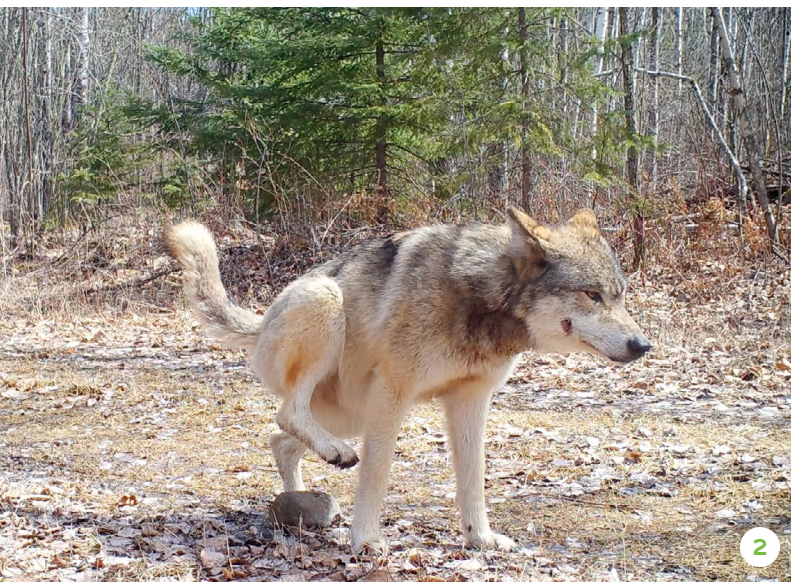
During Summer 2023, we collared a yearling Bug Creek male, Wolf P5E, and ear-tagged another yearling female, Wolf P4D. Wolf P5E wandered the territory for a brief period after we collared him before he dispersed and traveled around the larger area extensively (genetic analysis confirmed he was indeed a Bug Creek pack member). Because of his wandering, we were not able to calculate a territory for Bug Creek during 2023-2024. P5E continued to



The breeding female of the Bug Creek Pack (Wolf BC_BF).

wander in and out of the Greater Voyageurs Ecosystem during the winter survey period but was alone in every observation. Wolf P4D remained with the pack throughout the summer and early fall as we had several observations of her with other pack members and/or pups during that time. However, by late fall or early winter, she dispersed from the pack and became a lone wolf. We observed her traveling by herself on 5 occasions during mid-winter but did not have a single observation of her traveling with Bug Creek Pack members.

The other interesting observation from the winter is that BC_SUB1, a subordinate adult female, is still in the pack. This female has very distinctive coloration and therefore is easily identified. We first observed her in the pack in Winter 2021-2022 when we estimated she was a yearling wolf. She has remained in the pack since then, indicating she was 3.5-4 years old during Winter 2023-2024. It is fairly uncommon for subordinate wolves in our area to remain in a pack for such an extended period in the GVE.



1 All 6 members of the Bug Creek Pack in December 2023. **2** The subordinate adult female, Wolf BC_SUB1, that has remained in the Bug Creek Pack since at least 2021. **3** The breeding male, Wolf BC_BM, of the Bug Creek Pack.

CRANBERRY BAY

The Cranberry Bay Pack experienced another year of dramatic change, and some mysteries persist. In December 2022, Wolf VO84, the breeding female of the pack since 2019, split with her long-time mate Wolf VO83, the breeding male of Cranberry Bay since at least 2019. The split caused the pack of 8 wolves to fracture into 3 different social groups (see Gable et al. 2023 for more details). After the pair split, Wolf VO84 continued to occupy the Cranberry Bay territory with her new mate (CB_BM), a large adult male, and one of her pups for the remainder of Winter 2022-2023. Wolf VO84 and her new mate produced a litter of pups in Spring 2023.

Interestingly, sometime between April 2023 and October 2023, the new breeding male of the pack (Wolf CB_BM) disappeared and another male assumed that position (Wolf CB_BM2). This new dominant male was easy to identify because he had very dark, mottled fur and two prominent white dots above each eye. We had a few observations in October and November of this male traveling, with his tail held high in dominant fashion, with VO84 while all other

pack members trailed behind.

By late Fall 2023, an adult female had also joined the pack. This subordinate female looked very similar to a subordinate female observed in the Cranberry Bay Pack in December 2022 shortly before the pack split up. We suspect, though cannot say with certainty, that this female is VO84's daughter who re-joined the pack.

In October 2023, we had several observations of 10 wolves in the pack—Wolf VO84, the new dominant male (CB_BM2), the new subordinate female, another subordinate (likely female), and 6 pups. We surmise the other subordinate wolf in the pack was likely the pup in the pack in Winter 2022-2023. We observed all 10 of these wolves, or combinations of these 10 wolves traveling together throughout late October and November 2023.

However, in late November 2023, Wolf VO84 was usurped from her role as breeding female and was likely forced out of the pack. Our last observation of VO84 with the Cranberry Bay Pack was November 22, 2023. The adult subordinate female that



Several members of the Cranberry Bay Pack in Fall 2023.



1 One of the last observations of Wolf V084, the long-time breeding female of the Cranberry Bay Pack, in the Cranberry Bay Pack territory before she was usurped by another female in late November 2023. **2** The breeding male of Cranberry Bay, Wolf CB_BM2, during most of Winter 2023-2024 before he appeared to be replaced by another male.



The breeding female of the Cranberry Bay Pack (Wolf CB_BF) scent-rolling in March 2024.

joined the pack sometime in late summer or fall quickly assumed the role as the pack's dominant/breeding female (her ID is now CB_BF). We have observations of this female in early December traveling around as a dominant wolf with her tail-raised, a posture she did not have earlier in Fall 2023 when VO84 was the dominant wolf. We suspect this female overthrew VO84 in late November 2023 and chased her out of the pack/territory. Intriguingly, we did not have any observations of VO84 on any camera after that November 22 observation. On March 8, 2024, we were contacted by a trapper in Ontario who said he legally caught and killed VO84 on March 6, 2024 just north of Voyageurs National Park in Ontario.

By mid-to-late winter, the Cranberry Bay Pack had dwindled to 7 wolves—the newly established breeding pair (Wolves CB_BF and CB_BM2) and 5 pups. From what we can tell, the dominant male with the prominent white dots above his eyes was the mate of the new breeding female that usurped VO84. We have an observation

on February 23, 2024 where this male was standing tall and dominant while Wolf CB_BF and a pup licked his face vigorously. However, by April 2024, there was yet again a new dominant male traveling around with the new breeding female (CB_BF), who clearly was nursing pups based on her distended nipples. This new male clearly was a different male than the dominant male in the winter as he had lighter colored fur, no white dots above his eyes, and had distinctive black streaks around and between his eyes. We do not recognize this male, and can only speculate as to what must have occurred for him to become the dominant male.

Regardless, there were 7 wolves in the Cranberry Bay Pack as we had 6 independent observations of 7 wolves together throughout the winter, including observations in December, February, March, and April. Additionally, we observed 2 or more Cranberry Bay Pack members together during the winter on 34 occasions, which provided us with some helpful footage for assessing pack composition.

One interesting note: Cranberry Bay is the westernmost pack on the Kabetogama Peninsula, and the pack has historically occupied the western third of the peninsula, including much of the Chain of Lakes. But all our remote camera footage indicates that the territory has changed. Indeed, we did not observe Cranberry Bay Pack members on any remote cameras on the Chain of Lakes portages (Locator-War Club, War Club-Quill, or Quill-Locator). In the past, most if not all of these portages were in the Cranberry Bay territory and we typically captured several observations of the pack at these locations. We surmise that the Cranberry Bay territory has either decreased in size or shifted to include more territory south of Gold Portage. This change in territory is likely due, in part, to the Nashata and Mithrandir Packs taking over the eastern portions of the former Cranberry Bay territory—we captured both packs on the Chain of Lakes Portages frequently throughout the winter.

HALF-MOON

We have struggled to get a substantial number of observations of the Half-Moon Pack over the past few years. Often, we had just enough observations to determine the number of wolves in the pack, but rarely have we had an abundance of remote camera footage of these wolves. Fortunately, that was not the case this past winter. We increased the number of remote cameras we had in the pack's territory and put cameras in some different areas than we had before. In total, we observed 2 or more Half-Moon Pack members together 83 times during the winter survey period—an average of one observation every 1.6 days during the winter. Of those observations, we had 20 independent observations—observations on different days— of 7 wolves in the pack.

The abundance of footage made it easy to determine the composition of the pack, which consisted of a breeding pair (V094 and Pup2217—a 6-year old female), a yearling male (Wolf O6C), a subordinate female (likely a yearling), and 3 pups. This winter was the second winter where V094 and Pup2217 were the breeding pair of the

pack. The pair produced a litter of 7 pups in Spring 2023. Of those 7 pups, 3 (43%) survived.

Surprisingly, we did not observe Pup2217 traveling with V094 or other pack members very often during the winter. For instance, we had many observations of all pack members, except Pup2217, traveling together. Because we still saw Pup2217 with the pack periodically, we assumed observations of the other 6 pack members without Pup2217 were for all intents and purposes observations of 7 wolves because we knew she clearly was still the breeding female. Nonetheless, it is odd for a breeding female to not travel with the pack, and especially the breeding male, for substantial portions of the winter. Further, all evidence we have collected so far this summer suggests the Half-Moon Pack did not produce pups this spring for the first time since the pack formed in late 2019. Assuming we are correct in our assessment, we do not know whether the lack of reproduction is because of a shift in social dynamics or some other reason.

A Half-Moon Pack pup in November 2023.





1 Wolf V094, the breeding male of the Half-Moon Pack. **2** Wolf O6C, a yearling male in the Half-Moon Pack. **3** Pup 2217, the breeding female of the Half-Moon Pack.

LIGHTFOOT

Because the Lightfoot Pack was only a breeding female (Wolf LF_BF) and her 2 adult offspring in Winter 2022-2023, the pack did not produce pups in Spring 2023. In fact, the last time the Lightfoot Pack produced pups was in Spring 2021 when they successfully reared 4 pups. However, the breeding male of the pack at that time, Wolf VO71, was killed by other wolves in January 2022 before he had a chance to mate with the female. Thus, the pack did not produce pups in Spring 2022. For some reason the female did not find a mate during the ensuing year and so the pack did not produce pups again in Spring 2023.

For most of Summer 2023, the Lightfoot Pack consisted of the breeding female (LF_BF) and her 2 year old daughter (Wolf B3S). The breeding female's 2-year-old son, Wolf Y4D, who we collared in May 2023, came and went from the territory throughout the summer before dispersing from the pack for good in late summer.

The Lightfoot breeding female finally found a mate in Fall 2023, when we noticed a large male wolf (dubbed "Wolf LF_BF") traveling around with her and B3S. The pack remained these 3 wolves for the duration of winter as we had 23 independent observations (observations on different days) of 3 wolves during the winter survey period. The addition of the breeding male led to the pack producing pups in Spring 2024. We do know how many pups the pack had but we have clear video footage in early May of the breeding female who was clearly lactating and nursing pups.

1 Wolf B3S, an almost 3 year old subordinate female in the Lightfoot Pack crossing the ice on a frozen beaver pond. **2** Wolf B3S (left) and Wolf LF_BM, the new breeding male (right) of the Lightfoot Pack.

3 Wolf B3S in Fall 2023.



LISTENING POINT

The Listening Point Pack occupies the central and eastern portions of the Kabetogama Peninsula, an area that is remote, relatively inaccessible, and has very few linear features. As such, we have had challenges getting sufficient footage of the pack in this area for many years. Additionally, we have struggled to readily identify each individual wolf in the pack because we have had so few observations. To overcome this, we increased the number of remote cameras deployed in this area, and varied the areas we deployed cameras to increase our odds of observing the pack. This included putting cameras on hiking trails, snowmobile trails, beaver dams and ponds, and random wildlife trails. Fortunately, this varied approach was successful and we had excellent data on the Listening Point Pack this winter for the first time.

The Listening Point Pack was 5 wolves in Winter 2023-2024—the breeding pair (Wolves LP_BF and LP_BM), a subordinate male (Wolf LP_SM), and two pups—and we had 27 independent observations of the pack at that size and a total of 85 observations of 2 or more pack members together during the winter survey period. We suspect that the 3 adult wolves in the pack are the same 3 adults that comprised the pack in Winter 2022-2023. The breeding pair is clearly the same pair as last year and we suspect the subordinate male is also the same.

The pack produced its first litter of pups in Spring 2023 after taking over the territory from the Shoepack Lake Pack in Summer/Fall 2022. The breeding female of the pack was clearly pregnant in early April 2024 so it appears the pack produced pups for a second year in a row.



1 The breeding male of the Listening Point Pack, Wolf LP_BM, carrying a deer leg from a nearby kill in early 2024. **2** The subordinate ~3–4 year old male in the Listening Point Pack (Wolf LP_SM) in early 2024.

The Listening Point Pack territory appears to be the largest territory on the Kabetogama Peninsula currently based on remote camera footage. Indeed, on several occasions we observed the pack as far west as Loiten Lake and as far east as Johnson Bay/Weir Lake, indicating their territory includes about half of the Kabetogama Peninsula. On the eastern edge of their territory near Mica Bay, the Listening Point Pack clearly overlaps with the Blackstone Pack. Notably, we did not observe Listening Point on a camera northeast of Mica Island, where we observed the Blackstone Pack on 8 occasions, indicating that the territory does not extend that far east. Similarly, Listening Point has substantial overlap on the western edge of their territory, near Shoepack Lake, with the Mithrandir Pack whose territory appears to be roughly from Shoepack Lake westward to Quill Lake/Warclub Lake.

1 The two Listening Point pups in late March 2024 **2** Three Listening Point wolves: the two pups and the subordinate ~3-4 yr old male (Wolf LP_SM).



MITHRANDIR/NASHATA

The strange saga of the Mithrandir and Nashata Packs continued this past year. In Winter 2022-2023, the Nashata Pack consisted of the breeding female (NS_BF) and two male wolves. We suspect these males were subordinates from the Cranberry Bay Pack who joined the Nashata Pack after the Cranberry Bay Pack split in December 2022. The original breeding male of the Nashata Pack disappeared (likely died) in December 2022, shortly before these two males joined the pack.

The splitting of the Cranberry Bay Pack caused the breeding male of Cranberry Bay, Wolf VO83, to leave the pack and form the Mithrandir Pack in December 2022 which consisted of two wolves: Wolf VO83 and a yearling female from the Nashata Pack (Wolf NS_SF) who is the daughter of the breeding female of the Nashata Pack. Importantly, the Nashata and Mithrandir Packs appeared to be separate social groups that largely shared a single territory in Winter 2022-2023, or at least both packs had territories that overlapped extensively during this time.

We observed the two wolves of the Mithrandir Pack, Wolves VO83 and NS_SF, on camera frequently together during Spring-Fall 2023, and it is clear the pack did not produce pups in Spring 2023 as the female in the pack was never lactating. The Nashata Pack continued to be 3 adult wolves into Summer 2023, producing a litter of pups in Spring 2023.

But both these packs experienced sizable change in late 2023. By late fall, there was a third wolf, an adult male, traveling with the Mithrandir Pack. Our impression was that this third wolf looked like one of the two adult males that joined the Nashata Pack in December 2022. Regardless, by late November, VO83 was no longer a part of the Mithrandir Pack. Instead, Mithrandir consisted of Wolf NS_SF, the 2.5 year old female originally from Nashata (Wolf NS_SF), and this other male (dubbed “Wolf

MI_BM”). In total, we had 80 observations of the Mithrandir Pack during winter and in all but one (see below) the pack was just the two wolves (i.e., a breeding pair).

Some way or another, Wolf VO83 left the Mithrandir Pack in late November 2023 and quickly joined the Nashata Pack as the breeding male. Indeed, we have two observations of VO83, the breeding female of Nashata (NS_BF), and a pup on December 7, 2023, and then several more observations of all 3 wolves throughout December. During the winter survey period, we had 27 independent observations of these 3 wolves in the Nashata territory and never had any observations larger than 3 wolves.

VO83 and the breeding female of Nashata mated in Winter 2023-2024, and spring footage demonstrated the pack had pups in Spring 2024.

We do not fully understand what the interactions were like between the Mithrandir and Nashata Packs, though we suspect they are largely amicable.

Wolf NS_SF, the breeding female of the Mithrandir Pack, in March 2024.

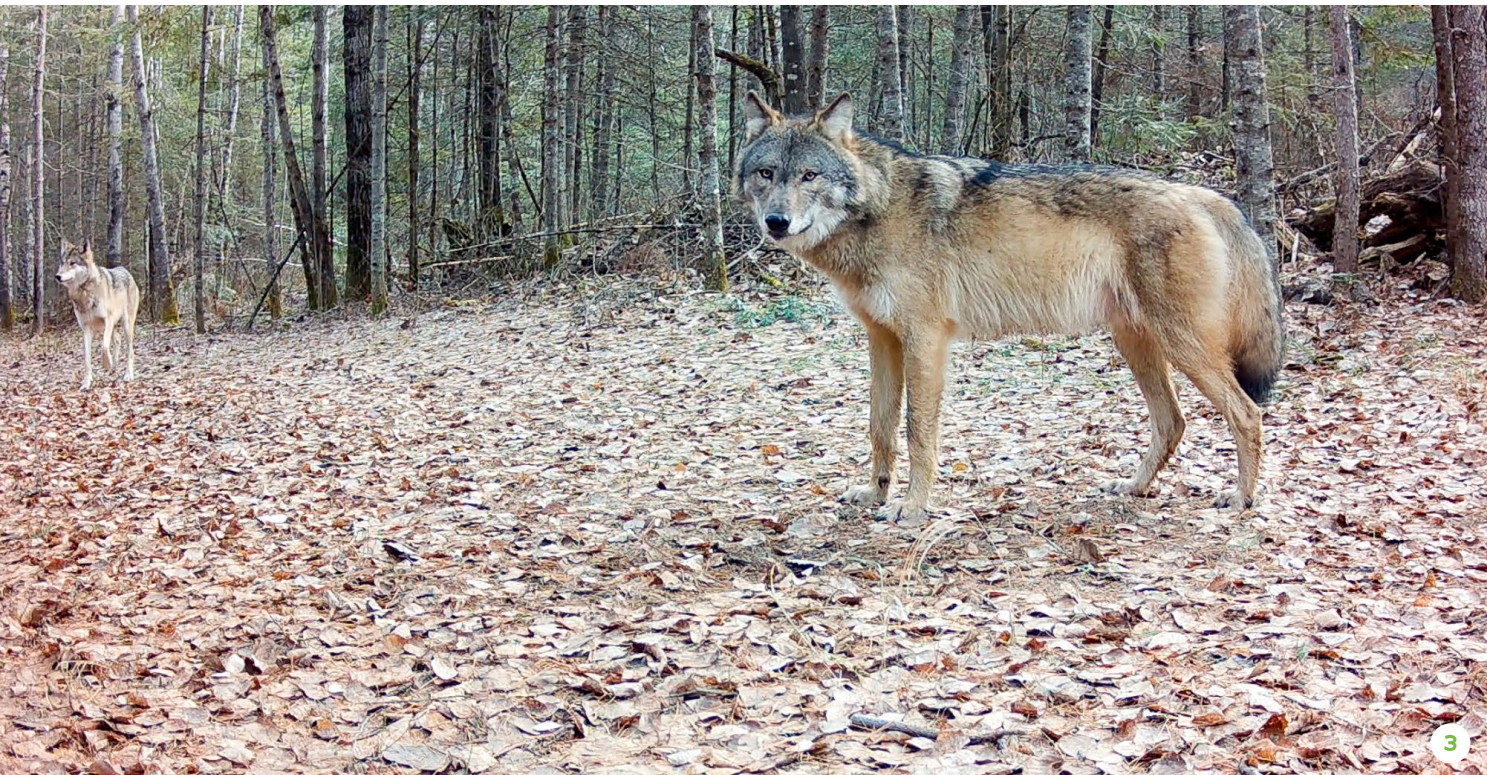


For example, we had one observation on February 24, 2024 of Wolf VO83 traveling with Mithrandir, his former pack. We know that the breeding females in each pack are related (mother-daughter), and we know that VO83 has been the mate of each of these females.

Further, we think it also possible, if not likely, that the mate of the Mithrandir female, Wolf MI_BM, was part of the Nashata Pack up until Fall 2023. In other words, most if not all of these wolves know each other well.

We suspect this familiarity and relatedness explains why the packs have substantially overlapping territories. We frequently observed both packs on remote cameras on all Chain of Lakes portages as well as several cameras around Nashata Point, Clyde's

1 Wolf MI_BM, the breeding male of the Mithrandir Pack **2** Wolf MI_BM, the breeding male of the Mithrandir Pack **3** The Mithrandir Pack in early December. The breeding male, Wolf MI_BM, is to the right and the breeding female, Wolf NS_SF, to the left.





The breeding female of the Mithrandir Pack in December 2023.

Creek, and Ellsworth Rock Gardens. Based on these data, we think it possible that the two packs share >30-40 km² of territory, which is a rare occurrence in the Greater Voyageurs Ecosystem.

However, there do appear to be some areas that are used either exclusively or disproportionately by one or the other of these packs. For example, the Mithrandir Pack territory appears to include the central portion of the Kabetogama Peninsula (in and around Shoepack Lake), an area we did not detect the Nashata Pack in. Similarly, the area near LaBounty Bay and Locator Lake appears to be largely the Nashata Pack territory as we had several more observations of Nashata in this area than the Mithrandir Pack. We are certainly interested to see how this saga continues to unfold over the next year.

One fascinating observation from remote cameras this winter was the behavior of Wolf VO83. For most of the winter, VO83

remained with the Nashata Pack. However, we had clear observations of VO83 traveling with the Cranberry Bay Pack on February 19, 2024, the Mithrandir Pack on February 24, 2024, and the Listening Point Pack on April 3, 2024. In other words, VO83 was observed peaceably traveling with wolves in each of the 3 neighboring packs. The observation with Cranberry Bay is not entirely surprising as it is possible that the breeding female is VO83's daughter from when he was the breeding male of the Cranberry Bay Pack. The observation of VO83 with the Listening Point Pack is more perplexing because we are not aware of any connection between VO83 and that pack. However, there is much we do not know and understand about the history and relatedness of wolves in many packs and we cannot rule out the possibility that VO83 is related to wolves in the Listening Point Pack.



1 The Nashata Pack in March 2024. The breeding male, Wolf V083, is in front, and the breeding female, Wolf NS_BF, is in the back.



2 The Nashata Pack in March 2024. The breeding male, Wolf V083, is closest to the camera, and the breeding female, Wolf NS_BF, is furthest away.



3 Wolf V083, the breeding male of the Nashata Pack.

PARADISE

The Paradise Pack was two wolves, a breeding pair, in Winter 2023-2024. The pair consisted of Wolf V077, the breeding male of the Paradise Pack since the pack formed in 2020, and Wolf V090, the new breeding female of the pack.

In late March 2023, Wolf V085, the breeding female of the pack for 3 years, disappeared shortly before she was due to give birth to another litter of pups. We suspect she died as it is highly-abnormal for a pregnant breeding female to leave her pack voluntarily just days before she is to give birth, or for her to get replaced by another breeding animal in late March. In fact, we have yet to document this occurring in the GVE. Although we are not certain what happened to V085, we do know that she was not usurped by another female as we had numerous observations of the three other Paradise Pack members—V077, a yearling male (Wolf W2L), and a pup— in April and early May 2023, and they were not traveling with wolves outside of pack members.

However, by mid-to-late May and early June 2023, we began observing V077 traveling with Wolf V090, who had been a lone wolf in the GVE since we collared her in 2020. Interestingly, despite being a lone wolf, V090 gave birth to pups in April 2023 and we had numerous observations of her with distended nipples from nursing pups. We do not know who the father of the pups was because we never observed V090 with another wolf in Winter 2022-2023. Further, V090 did not seem to be maintaining a territory, before or after she had pups. In early-to-mid May, for instance, we observed her on remote cameras in a large area that included Sheep Ranch Road, Nine Mile Road, Ulland Pit Road, and Camp 90 Road. Regardless, V090's pups did not survive long and we never observed V090 traveling with any pups in Summer 2023 or Fall 2023.

We did, though, have dozens of observations of Wolves V077 and V090 traveling together in the Summer and Fall



1 Wolf V077 (front) being playfully chased by his mate Wolf V090 (back). **2** The Paradise Pack in Winter 2023-2024. The breeding male, Wolf V077, is the wolf to the right and the breeding female, Wolf V090, is the wolf to the left.



2023, a pattern that continued through winter when we had 125 observations of the pair together—that is almost one observation per day of the pair from December 1 to April 10. We never observed other wolves in the Paradise Pack during winter, which is not surprising. Wolf W2L, the subordinate male who was collared through mid-Summer, dispersed from the pack in late May 2023, and the pup from the winter likely dispersed by mid-Summer 2023.

The Paradise Pack territory appears to have expanded southward to Sheep Ranch Road in 2023-2024 and in doing so, took over some of the Windsong Pack territory. For example, the Paradise Pack territory now includes the location where the Windsong Pack dened in Spring 2023. We know, based on remote camera footage, that the pack produced pups this spring.



1 Wolf V090, the breeding female of the Paradise Pack. **2** The Paradise Pack in March 2024. Wolf V090, the breeding female, is on the right and Wolf V077, the breeding male, is on the left.

PEATLANDS

The Peatlands Pack, which occupies the former Leatherleaf Pack territory and some of the former Borealis Pack territory, consisted of 10 wolves in Winter 2023-2024—a breeding pair, three subordinate adults, and 5 pups. We consider the Peatlands Pack a “new” pack because the pack has an entirely different breeding pair than the Leatherleaf Pack, who occupied the territory until mid-to-late 2023, and the Borealis Pack who occupied the territory southerly adjacent to Leatherleaf Pack territory. We surmise the transition to a new pack was related to the death of the Leatherleaf breeding female (Wolf LL_BF) who was hit by a car on Highway 53 in July 2023.

We strongly suspect that many of these pups and subordinate adults in Peatlands are either from the Leatherleaf or Borealis Pack. Further, we cannot rule out the possibility that one of the breeding wolves in the Peatlands Pack was not a subordinate in the Leatherleaf or Borealis Packs. We suspect the members of the Peatlands Pack are somehow related/connected to either members of the Leatherleaf or Borealis Packs because we think it highly unlikely that a nomadic pack of 10 wolves simply moved in and quickly took over the Leatherleaf territory. We do know that both the Leatherleaf and Borealis Packs had pups in Spring 2023, and several pups were alive in Borealis as of late summer 2023. We do not have any information on the pups in Leatherleaf during summer.

Unfortunately, what transpired over the past year in the Borealis, Leatherleaf, and Peatlands Packs is unclear and we likely will not know exactly what occurred. Much of this is because we had not put out a substantial number of cameras in this area of the GVE up until the past year. Thus, unlike most packs in the GVE, we had a poor understanding of all the individuals who were in these territories prior to the

formation of the Peatlands Pack.

We had 31 observations (two or more pack members together) in the Peatlands Pack in 2023-2024. Most of the observations of wolves in this territory were of smaller groups within the pack traveling together. For instance, we had one observation of 9 wolves, two of 8 wolves, 3 of 7 wolves, and 3 of 6 wolves. However, we had 3 independent observations of 10 wolves together in February, so we conclude the pack was 10 wolves in Winter 2023-2024. We observed the breeding female of the Peatlands Pack (Wolf PL_BF) in most observations of the Peatlands Pack during Winter 2023-2024. The female has a golf ball-sized chunk of flesh dangling off her front left leg which allows her to be identified easily.

A Peatlands Pack subordinate wolf in early 2024.



1 Wolf PL_BF, the breeding female of the Peatlands Pack. You can see the large chunk of flesh dangling from her front leg. **2** A Peatlands Pack pup in mid-winter. **3** Five members of the Peatlands Pack in early 2024.



REDHORSE RIVER

The Redhorse River Pack is the pack to the east of the Whiskey Point Pack. The vast majority of the pack's territory is almost certainly in Ontario on the east side of Sand Point Lake, and all of the observations of this pack are likely due to the pack making brief forays into the GVE. For instance, we observed the pack on the western side of Sand Point Lake near the Namakan Narrows and Mukooda Lake in a few instances. We even had one observation of this pack near Vermilion River Falls, but that was likely a brief exploratory foray outside of their territory.

The pack is easy to identify because the breeding male of the pack, Wolf RR_BM, has a distinctive appearance: he is a big wolf, has short fur on his body but longer hair around his neck and face, and has unique

coloration on his face, especially around his eyes. In total, we had 6 observations of the pack in Winter 2023-2024. The breeding pair were alone in 4 of the 6 observations and in the other two observations 4 wolves were together, the breeding pair and two pups. Although we would have preferred to have more data, we think 4 wolves is a good estimate for this pack.

Like the Boulder Bed Rapids Pack, the Redhorse River Pack only overlaps the Greater Voyageurs Ecosystem by a small margin, we do not anticipate spending any additional effort to study the pack, and the only data we will likely have on this pack moving forward is when they periodically venture into the GVE and are captured on remote cameras.

1 The breeding pair of the Redhorse River Pack. The breeding male (Wolf RR_BM) is the larger wolf to the right.
2 The distinctive breeding male of the Redhorse River Pack (Wolf RR_BM).



STUB-TAIL

In Fall 2023 and early December 2023, the Stub-tail Pack was 8 pack members—the breeding pair, a subordinate male and female, and 4 pups. However, by mid-December 2023 the subordinate male was no longer traveling with the pack, and we think he most likely dispersed. The pack then decreased to 7 wolves and remained 7 wolves for the duration of the winter. The breeding pair of the Stub-tail Pack remained the same as Winter 2022-2023 (Wolves ST_BF and B11D; the breeding male who was formerly ‘Wolf ST_BM’ but given a new ID when we collared him in June 2024). The remaining female subordinate was Wolf B9T, a yearling female, who we collared in Summer 2023. All 4 pups observed in the fall survived through winter, and we collared two of these four pups in Summer 2024, a male dubbed Wolf W7D and a female dubbed Wolf B10E. In total, we had 7 independent observations of the pack at 7 wolves during the winter survey period, and a total of 53 observations of two or more pack members together.

For much of the year, the Stub-tail Pack primarily occupied a territory in and around the Wento Road just south of Ray, Minnesota. However, in Winter 2023-2024, the pack shifted south, several miles down the Haney Road. The pack was spending much of their time in and around large cedar forest complexes where deer appeared to be yarding for the winter. Once winter ended, the pack shifted pack north and began occupying their primary territory. Changes in movements between summer and winter are not uncommon for wolves in the GVE but it is less common for packs to spend a substantial proportion of the winter a sizable distance outside of their primary territory.



1 Two Stub-tail pups in mid-winter. 2 A Stub-tail pup scent-rolling.



1 Wolf B11D, the breeding male (left) of the Stub-tail Pack with two pups.



2 A subordinate male wolf that was part of the Stub-tail Pack through December or so. We did not observe this wolf with the pack after December indicating he likely dispersed.



3 Wolf ST_BF, the breeding female of the Stub-tail Pack. Her distinctive short, 'stub-tail' can easily be seen from this angle.

THUJA

We started studying the Thuja Pack in Fall 2023 when Wolf O3S, a yearling wolf from the Windsong Pack, joined the Thuja Pack in September 2023. We collared O3S in the Windsong Pack territory in May 2023, and for a decent portion of the spring and summer he either remained in the Windsong territory, occasionally traveling with other pack members like Wolves O4D (his mother) and B7D (his brother), or wandering around the GVE as a lone wolf.

Interestingly, when O3S joined the Thuja Pack, the pack was 10 wolves strong—a very large pack for the GVE—with O3S becoming the 11th member. We had one nice observation of all 11 wolves on October 26, 2023 where you can see the pack consisted of Wolf O3S, a breeding female (Wolf TJ_BF), two other adults, and 7 pups. One of the two adults was likely the breeding male. Yet, the Thuja Pack changed substantially and quickly after this observation.

Although we had many observations of the Thuja Pack in fall and winter, we never observed 11 wolves together again. Instead, we observed 7 wolves—O3S, the breeding female (Wolf TJ_BF), and 5 pups. We then had a handful of observations of 4-6 wolves together in the pack in December 2023 and early January. However, after early January 2024, we never observed more than 5 wolves together except once on February 4, when we observed O3S, TJ_BF, and 4 pups together. By comparison, we had 6 independent observations from mid-January until early April of 5 wolves together: O3S, TJ_BF, and 3 pups. Based on all of this, we considered the pack to be 5 wolves because all evidence indicates the pack was 5 wolves for the majority of the winter survey period.

The rapid decrease in the size of the Thuja Pack is likely due to a combination of events. The first is that Wolf O3S almost certainly usurped the former breeding



Wolf O3S, the breeding male of the Thuja Pack, chasing a coyote.



male of the pack in late Fall 2023. In doing so, the former breeding male was likely removed from the pack by force. The new breeding pair was then O3S and the original breeding female (TJ_BF). The second is that several pups likely died during late fall or early winter. The largest number of pups any pack ($n=76$ packs) has successfully recruited in the GVE during 2015-2024 was 5 pups. Therefore, it seems largely inevitable that some of the 7 living pups in October would not survive to winter. Third, the pack had another subordinate wolf when O3S joined. We suspect that wolf likely dispersed as is common for young wolves in fall or early winter based on our GPS-collar and remote camera data. The combination of these 3 factors would explain how the pack precipitously declined from 11 wolves in late October 2023 to 5 wolves in late January 2024.

1 Wolf TJ_BF, the breeding female of the Thuja Pack in March 2024. **2** The breeding female of the Thuja Pack, Wolf TJ_BF, with a pup following her. **3** Two Thuja pups in Fall 2023.



TILSON CREEK

The Tilson Creek Pack was simply a breeding pair (Wolves TC_BM and TC_BF) in Winter 2023-2024. In total, we had 10 independent observations of the Tilson Creek Pack during the winter survey period. We did have 5 observations during the survey period of a third wolf traveling with the Tilson Creek Pair. We suspect this was likely a yearling wolf that was born into the Tilson Creek Pack in Spring 2022. Despite this 3rd wolf associating with the pack at times, we concluded that the pack was two wolves because the majority of our observations of the pack were simply the breeding pair.

The 3rd wolf appeared to be only loosely associated with the pack, indicating that for the majority of the winter this 3rd wolf would have been a lone wolf. This kind of behavior is not uncommon for young wolves in the GVE.

The Tilson Creek breeding pair was the same as in Winter 2022-2023 but unlike 2022-2023 when the pair successfully reared two pups, the pair did not successfully rear any pups in 2023-2024. We do not know if this is because the pack did not produce any pups in Spring 2023 or because the pups that were produced did not survive.

1 Wolf TC_BF, the breeding female of the Tilson Creek Pack. **2** Wolf TC_BF, the breeding female of the Tilson Creek Pack. **3** The breeding male of the Tilson Creek Pack, Wolf TC_BM, carrying a beaver in May 2024. **4** Wolf TC_BM, the breeding male of the Tilson Creek Pack.





VERMILION RIVER

The Vermilion River Pack was 6 wolves in Winter 2023-2024. The pack consisted of the breeding pair (Wolves B2L and Y7S, the latter of which was collared in Summer 2024), a subordinate adult male (Wolf VR_SUB1), and 3 pups. We had 65 observations of 2 or more Vermilion River Pack members together during the winter survey period, and 14 of which were independent observations of 6 wolves together.

The pack was larger at the end of fall and beginning of winter when the pack was 7 wolves—breeding pair, a subordinate adult male, and 4 pups. Indeed, we had observations of 7 on November 22 and 24 as well as December 5, 19, 21, and 27. However, one of the pups likely died at the end of December or early January because we only observed 3 pups in the pack during January-

April 2024. The Vermilion River Pack only had 4 pups in Spring 2023 so 75% survived their first year which is above average.

Notably, the Vermilion River Pack had a lice infestation in mid-Winter 2023-2024 that affected all pack members. Wolves in the pack were likely scratching themselves or rubbing their bodies against various objects in response to the lice. As a result, most wolves in the pack looked in rough shape with ragged fur and some areas with almost no fur. Although the lack of fur made the wolves appear sickly and diseased, the wolves were almost certainly just fine. Lice infestations are generally just an annoyance for wolves and not a serious issue or indication of larger health problems.

Wolf B2L, the breeding male of the Vermilion River Pack.



1 The breeding pair of the Vermilion River Pack. Wolf Y7S, the breeding female, is on the left, and Wolf B2L, the breeding male is on the right. **2** The 2-3 year old subordinate male (Wolf VR_SUB1) in the Vermilion River Pack. Much of his fur has been rubbed off because of the lice infestation that affected most pack members. Further, he is quite thin for winter, a period when he should be in peak physical condition. **3** Five of the 6 Vermilion River Pack members. The wolf on the far right is Wolf B2L, the breeding male. He is followed by three pups and a ~2-3 year old subordinate male (Wolf VR_SUB1).

WANDERING PINES

Winter 2023-2024 was the first year we studied wolves in the Wandering Pines Pack territory, which is to the east/southeast of Elephant Lake. We generally have not studied wolves in this area because wolves in this territory have only overlapped the GVE by a small amount. However, our expanded boundary of the GVE—the southeastern boundary of which is the Pelican and Vermilion Rivers—now includes much of the Wandering Pines Pack territory.

The Wandering Pines Pack was 3 wolves in Winter 2023-2024. The pack consisted of a breeding pair and a subordinate adult wolf. We observed members of the pack

together 18 times during the winter survey period, and we had a total of 9 independent observations (observations on different days) of the 3 pack members together. In February 2024, we also observed all three members of the Wandering Pines Pack consuming a freshly-killed adult deer on the ice of Elephant Lake. The pack did not recruit any pups in 2023-2024. We do not know if this is because the pack did not produce any pups in Spring 2023 or because the pups that were produced did not survive.

The breeding female of the Wandering Pines Pack.



WHISKEY POINT

The Whiskey Point Pack had a turnover of their breeding female in 2023-2024. The original breeding female (Wolf WP_BF) had a litter of pups in Spring 2023 and was spotted on remote cameras periodically during Summer 2023 but then disappeared around October 2023. Indeed, all observations of the pack from October 2023 through January 2024 were of the breeding male (Wolf WP_BM) and 4-5 pups. Five pups survived through October 2023 but by November 2023 there were only 4 surviving pups as we had several independent observations of the breeding male with these four pups from November 2023 to early January 2024. We suspect that the breeding female likely died sometime in the fall. We think it is unlikely she was usurped by another wolf because we did not observe another adult wolf with the Whiskey Point Pack for several months after her disappearance (i.e., another wolf did not simply force out this female and assume her breeding role), and we never observed her on any remote cameras in the GVE during Fall 2023 or Winter 2024 after she disappeared.

The vacancy left by the breeding female's disappearance was relatively short-lived. By mid-January 2024, a lone female we observed several times in Fall 2023 and early Winter 2024 in the Whiskey Point/Wiyapka Lake territories, joined the Whiskey Point Pack, mated with the breeding male, and became the new breeding female (now dubbed Wolf WP_BF2) of the Whiskey Point Pack. The first observation we have of her in the Whiskey Point Pack was on January 18, 2024.

Interestingly, we only observed a maximum of 5 wolves, and perhaps more importantly, never observed more than 3 pups in the Whiskey Point Pack after the female joined the pack. This pattern suggests that a pup died sometime in early to mid-January 2024, but we cannot say for certain. What we can say for certain is that 3 pups survived to adulthood as we observed all 3 pups in April 2024.



Two Whiskey Point Pack pups.

Given all of this, we conclude that the Whiskey Point Pack was 5 wolves during the majority of the winter survey period: a breeding pair and 3 pups. In total, we had 39 observations of 2 or more Whiskey Point Pack members together during the winter survey period, and 6 independent observations of 5 wolves together.

Although we have not had a GPS-collared wolf in the Whiskey Point Pack recently, remote camera observations have been helpful for understanding roughly where the territory boundaries are. Namakan Lake is clearly the northern boundary of the territory and Sand Point Lake is the eastern boundary. The southern boundary of the territory appears to be somewhere around Mukooda Lake, Staeger Bay, and Johnson Lake. The territory almost certainly includes Spring Lake and the northern shoreline of Little Johnson Lake. We suspect the Little Johnson River is likely the western edge of the territory. The Wiyapka Lake Pack and Whiskey Point Pack use the Net Lake Portage on the southern tip of Junction Bay extensively indicating that the Whiskey Point Pack very likely extends a bit further west than the portage.



1 The breeding male of the Whiskey Point Pack (Wolf WP_BM). **2** The new breeding female, Wolf WP_BF2, of the Whiskey Point Pack. **3** Two Whiskey Point pups playing with the strap used to secure our camera. **4** The new breeding female of the Whiskey Point Pack, Wolf WP_BF2.

WINDSONG

The Windsong Pack was only two wolves in Winter 2023-2024: Wolf V087, the breeding male, and Wolf O4D, the breeding female. We had 33 independent observations of these two wolves, and we never observed more than two wolves together in the pack. The pack did produce pups in Spring 2023 but we do not know how many. All evidence indicates the pups did not survive long as Wolf O4D, the mother of the pups, did not spend time localizing at a den or rendezvous site in late May or early June. We did have one interesting observation of Wolf V087, the father of the pups, traveling with a very small pup in late spring. We never observed any pups in the pack after that observation.

In contrast with Winter 2023-2024, the Windsong Pack was quite large in Winter 2022-2023 at 7 wolves—the breeding pair and 5 pups. In Spring/Summer 2023, we collared 3 of the 5 pups, who were now yearlings. Two of these yearlings, Wolves B7D and O7T, died by Fall 2023 due to human-causes, and the third, Wolf O3S, dispersed from the pack and eventually joined the Thuja Pack. We also found the skeletal remains of another young wolf in the Windsong Pack territory in Summer 2023, whom we suspect is likely a yearling wolf from the Windsong Pack (we need to confirm via genetic analysis). In other words, we know that most of the yearlings in the pack either died or dispersed over the past year, leaving only the breeding pair in the pack by Winter 2023-2024.



1 Wolf O4D, the breeding female of the Windsong Pack. **2** Wolf V087, the breeding male of the Windsong Pack.

WIYAPKA LAKE

The long-term breeding female of the Wiyapka Lake Pack, Wolf VO76, was usurped by another female in late Summer or early Fall 2023. This new female was observed traveling with the Wiyapka Lake breeding male and two pups on several occasions during fall, indicating that the transition from VO76 to this new female occurred quickly. Wolf VO76's tenure as the dominant female of the Wiyapka Lake Pack was 5 years (2019-2023) and she produced pups each of those years.

We collared this new breeding female, now dubbed Wolf R7S, this spring, and when doing so learned that she was actually VO76's daughter who we had tagged as a pup in Spring 2021. This female was not part of the pack in 2022-2023 indicating she must have traveled back to the territory and then taken over the breeding position sometime in Summer 2023. We are fairly certain the breeding male of Wiyapka Lake Pack changed in 2022 (i.e., the first breeding male's tenure was ~2019-2021, and the second breeding male's tenure was ~2022-2024) indicating that the breeding male (dubbed Wolf R8E, formerly known as WL_BM, after we collared him in Spring 2024) in 2023-2024 was almost certainly unrelated to R7S. In other words, she was not mating with her father.

As mentioned above, we did have several observations of R7S, R8E, and two pups together in Fall 2023. However, both pups likely died in late fall as we did not have any observations of more than two wolves—the breeding pair—in the pack from December 2023 to April 2024. In total, we had 36 independent observations of two wolves in the pack, which equates to an observation every 3.7 days.

Interestingly, for a 2-3 month period in Fall 2023 and early Winter 2024, the Bluebird Lake Pack appeared poised to take over the Wiyapka Lake territory. Starting in late September, Wolf B6T and her mate,

Wolf BL_BM, left their territory, which was southerly adjacent to Wiyapka Lake, and began traveling extensively throughout the Wiyapka Lake territory. They would return periodically to their original territory but most of their time in October and November 2023 was in Wiyapka territory, and it seemed a takeover was imminent.

Yet, somehow, the Wiyapka Lake Pack was able to defend their territory and stave off the Bluebird Lake Pack. By early 2024, the Bluebird Lake Pack was largely residing in their original territory, even though they still made occasional forays northward into the Wiyapka Lake territory. Nonetheless, Wiyapka Lake and Bluebird Lake did seem to have sizable overlap in their territories around the Amundsen Lake and Gannon Creek areas.

Wolf R8E, the breeding of the Wiyapka Lake Pack.





METHODS

Pack Size

We estimated pack size using remote trail cameras during our winter monitoring period which we defined as December 1 to April 10. We considered the end of the winter monitoring period as April 11 because that is average parturition date for wolves in the GVE and when we would generally expect packs to stop traveling as a cohesive social group. Our objective was to get repeated independent observations of the same pack at the same size during the monitoring period. We considered observations to be independent if they were on a different day than any other observations of that pack. Multiple independent observations of the same size for each pack provides highly-reliable and accurate pack size estimates.

Estimating home ranges

To estimate home ranges, we caught wolves via rubber-padded foothold traps and fit them with GPS-collars. All capture and handling of wolves was approved by the National Park Service's and University of Minnesota's Institutional Animal Care and Use Committee (protocols: UMN 1905-37051A).

We primarily estimated home range size for wolf packs using GPS-collar data from May 1 to October 31. Wolf pack home ranges in the GVE appear more stable in summer (the ice-free period) than they are in winter. During winter, wolf home ranges in the GVE are prone to small shifts and changes and are less stable than they are in the summer, likely because wolf movements change based on where deer congregate and on intraspecific pressures from neighboring packs. Wolf home ranges appear to stabilize during spring to fall because deer are likely more dispersed across their territory and intraspecific competition is lowest during the summer (Mech and Barber-Meyer 2017).

Furthermore, most wolves studied during summer were fitted with GPS-collars that took locations every 20 minutes during the summer period before the collars switch to taking 6 hour locations. Wolves fitted with collars that took 20-min fixes yielded high-resolution GPS-collar data on wolf movements during summer, which was ideal for estimating home ranges and certainly superior to using longer fix-interval GPS data from the winter. That said, GPS-location data was limited for some wolves during summer for a variety of reasons including fall capture dates and collars with sustained low fix rates (1-6 hr). In these scenarios, we estimated home ranges using winter locations or a combination of summer and winter locations.

We used locations from GPS-collared wolves to estimate kernel home ranges for each pack (Fig. 2). More specifically, we used 99% kernel home ranges for wolves with 20-min-fix-interval GPS-collars and then 95% kernel home ranges for wolves with GPS-collars that had longer fix intervals (1-6 hr fix-interval collars). We calculated home ranges differently because the data from wolves with 20-min-fix-intervals had substantially higher resolution than collars with longer fix intervals. Thus, the periphery of territories was much clearer because of the amount of GPS-location data (~2,180 locations/month). As a result, kernel density home ranges fit the location data exceptionally well and a 99% kernel home range was more representative than a 95% home range. With longer fix-intervals, however, there was more uncertainty due to substantially fewer GPS-locations and we decided a 95% kernel home range was more appropriate. We removed locations associated with extra-territorial forays prior to developing kernel density home ranges (Burch et al. 2005, Powell and Mitchell 2012, Mancinelli and Ciucci 2018).

We removed the area of kernel home ranges that overlapped the 4 large lakes—Kabetogama, Rainy, Namakan, and Sand Point—in the Greater Voyageurs Ecosystem (Fig. 2). Wolves do not use the large lakes as part of their home range during the ice-free periods (~April to November) and rarely, if ever, swim out to the islands in these large lakes. Thus, these lakes are hard territorial boundaries for most of these packs for the majority of the year (~April to November). Even when ice forms, wolves spend relatively little time out on the ice with most activity on the ice near the shorelines of these major lakes or on the small islands close to the mainland. As such, removing any territory overlap with these major lakes seems more logical than including territory that overlaps the lakes. Notably, we did not remove the area of smaller lakes that were entirely contained within pack territories.



Quantifying home range overlap

Although wolves are highly territorial, wolf pack home ranges frequently overlap to some extent (Fig 2). When using metrics such as mean pack and home range size to estimate density, quantifying home range overlap is necessary to avoid underestimating density (Erb and Humpal 2020). However, for most wolf pack home ranges, we only had partial knowledge of neighboring packs (i.e., we did not have current home range data for each pack every year) so we used an approach that allowed us to account for overlap when estimating density without having perfect knowledge of all home range overlap in our study area (Gable et al. 2022).

Our approach consisted of calculating the average spatial overlap of one home range on another using all available home range data for a given year (we refer to this metric as ‘pack-on-pack overlap’ hereafter). We then estimated the number of neighbors that known wolf pack home ranges likely had using a combination of known and historical wolf pack territory locations. We then multiplied pack-on-pack overlap by the average number of neighboring packs to yield the average home range area that a typical wolf pack overlaps with other wolf packs. To incorporate this into density estimates, we divided the spatial overlap by two (i.e., because two packs shared the area of overlap) and subtracted the result from the average home range size (see equation below). In a few instances, 3 pack home ranges overlapped but the area of the overlap was minor (<1-2 km²) so we were not concerned about incorporating this into our estimates as it would have little-to-no effect (Fig. 2).

Calculating density

We calculated wolf density (wolves/1000 km²) using data on pack size, home range size, and pack-on-pack overlap. Specifically, we used the following equation:

$$Density = \frac{PS \div \left(HR - \left(\frac{Ovlp * Nb}{2} \right) \right)}{0.85} * 1000$$

where PS is mean pack size, HR is mean home range size, Ovlp is mean pack-on-pack overlap, and Nb is the mean estimated number of neighboring packs that a typical wolf pack has. We estimated that lone wolves constituted 20.7% of the population (see detailed discussion above) and thus divided the density of pack wolves (which is calculated via the numerator in the equation above) by 0.804 to yield overall wolf density (Gogan et al. 2004, Erb and Humpal 2020).

We used a non-parametric bootstrapping approach to obtain 95% confidence intervals for our density estimates (Fieberg et al. 2020). To do this, we generated 1,000 plausible values, given the data collected, for each parameter (HR, PS, Ovlp, Nb) by doing 1,000 bootstrapping iterations (i.e., resampling with replacement). We calculated density using the values generated during each bootstrap iteration to yield 1,000 plausible density estimates. We then selected the 2.5% and 97.5% highest density values for our 95% confidence interval (Gable et al. 2020).



REFERENCES

- Burch, J. W., L. G. Adams, E. H. Follmann, and E. A. Rexstad. 2005. Evaluation of wolf density estimation from radiotelemetry data. *Wildlife Society Bulletin* 33:1225–1236.
- Erb, J. D., and C. Humpal. 2020. Minnesota wolf population update 2020. Minnesota Department of Natural Resources.
- Erb, J., and C. Humpal. 2022. Minnesota wolf population update 2022. Minnesota Department of Natural Resources.
- Ethier, D., and J. Sayers. 2008. Estimating abundance and distribution of gray wolves using winter track surveys. *Voyageurs National Park Report*.
- Fieberg, J. R., K. Vitense, and D. H. Johnson. 2020. Resampling-based methods for biologists. *PeerJ* 8:e9089.
- Fox, J. 2006. Gray wolf winter tracking survey 2004-05; Voyageurs National Park, Minnesota. *Voyageurs National Park Report* 5.
- Fox, J., R. O. Peterson, and T. Drummer. 2001. Gray wolf biology research in Voyageurs National Park, 1998-2001. Natural Resource Preservation Program Project #197 1–73.
- Fuller, T. K. 1989. Population dynamics of wolves in North-central Minnesota. *Wildlife Monographs* 105:3–41.
- Gable, T. D., S. M. Johnson-Bice, A. T. Homkes, S. K. Windels, and J. K. Bump. 2020. Outsized effect of predation: Wolves alter wetland creation and recolonization by killing ecosystem engineers. *Science Advances* 6:eabc5439.
- Gable, T., A. Homkes, and J. Bump. 2022. 2021-2022 Greater Voyageurs Ecosystem wolf pack and population size report. University of Minnesota Digital Conservancy. <https://hdl.handle.net/11299/250487>.
- Gable, T., A. Homkes, and J. Bump. 2023. 2022-2023 Greater Voyageurs Ecosystem wolf population report. University of Minnesota Digital Conservancy. <https://hdl.handle.net/11299/256914>.
- Gogan, P. J. P., W. T. Route, E. M. Olexa, N. Thomas, D. Kuehn, and K. M. Podruzny. 2004. Gray wolves in and adjacent to Voyageurs National Park, Minnesota : research and synthesis, 1987-1991. Omaha, Neb. : U.S. Dept. of the Interior, National Park Service, Midwest Regional Office.
- Hardwig, J. T. 1978. Timber wolf (*Canis lupus*) food habits in Voyageurs National Park, 1977-1978. U.S. National Park Service Contract No. PX-6000-7-0921, Biology Department, Rainy River Community College, International Falls, MN 31.
- Mancinelli, S., and P. Ciucci. 2018. Beyond home: preliminary data on wolf extraterritorial forays and dispersal in Central Italy. *Mammalian Biology* 93:51–55.
- Mech, L. D., and S. Barber-Meyer. 2015. Yellowstone wolf (*Canis lupus*) density predicted by elk (*Cervus elaphus*) biomass. *Canadian Journal of Zoology* 93:499–502.
- Mech, L. D., and S. M. Barber-Meyer. 2017. Seasonality of intraspecific mortality by gray wolves. *Journal of Mammalogy* 98:1538–1546.
- Powell, R. A., and M. S. Mitchell. 2012. What is a home range? *Journal of Mammalogy* 93:948–958.

