Ecology of the Great Blue Heron (*Ardea herodias*) on the Slate River in Crested Butte, Colorado: Phenology, demography, behavior and impacts of river recreation

2019

Ecology of the Great Blue Heron (*Ardea herodias*) on the Slate River in Crested Butte, Colorado: Phenology, demography, behavior and impacts of river recreation 2019

Final Report prepared for
the Crested Butte Land Trust and the Slate River Working Group

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"I only know this bird by a name we've wrapped him in"

T. Alan Broughton

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Executive Summary

Great Blue Herons (*Ardea herodias*) are the largest North American heron and two defining characteristics of this species are its year-round, solitary, patient and laborious hunting style contrasting with its gregarious, colonial nesting strategy whereby they occupy nearly permanent rookeries. Their lives are intertwined with fish and sticks. Because rookeries are used across generations of herons, they represent focal points in the landscape for conservation planning of this species.

The Great Blue Heron population in the Slate River valley adjacent to Crested Butte, Colorado inhabits a unique high elevation wetland complex. The Slate River Valley is also an increasingly popular playground. In the last few years, recreationists using stand-up-paddle (SUP) boards, kayaks, rubber duckies, and small rafts enjoy a float through the Upper Slate River. The purpose of this study was to determine if human recreation on the Slate River impacted heron nesting. We documented Great Blue Heron breeding phenology and population demography and quantified heron activities at the nests, recorded human disturbances, and documented heron responses to human activities.

We studied Great Blue Heron breeding season phenology by making nest and bird counts beginning with the first heron arriving at the colony and continuing until the final fledgling departed the valley. We documented spring arrival dates of herons, nest building and courtship events, copulation, timing of egg laying and incubation, hatch dates, nestling stage, fledging dates, and post-fledging dispersal. We conducted a systematic scan of all the nests and counted the number of adults, the number of nests with incubating adults (indicating presence of eggs), the number of successful nests (proportion of nests with at least one successful hatched chick – nest success), the number of chicks produced (brood size), the number of nests that successfully fledged at least one chick (fledging success), and the number of chicks that fledged (fledgling success). We quantified heron activities approximately 4-6 days each week, rotating observation time between morning (sunrise – 1000), day (1000-1500), and evening (1500 – dark), and we quantified human activities within 400 m of the heronry through one-hour long observation bouts. Disturbances included: car/truck, other vehicles (snowmobiles, all-terrain vehicles, trailers), bikers/runners, bird watchers, miscellaneous (skiers, police sirens), and river floaters. We recorded the number of herons exhibiting disturbance behaviors which included alert posture, hunkering, and/or flushing from the nest.

In 2019, the Slate River heronry consisted of 20 active nests in two small stands of lodgepole pine (*Pinus contorta*) along the banks of the Slate River. The 2019 colony occupancy lasted 169 days (24 weeks). The first heron arrived on 17 March, 13 of 20 pairs arrived by 31 March, and 4 more initiated nests before 13 April. The remaining 3 heron pairs initiated nests on 26 April, 7 May, and 18 May. Incubation started on 12 April and the last pair started incubation on 1 June. The first chicks hatched on 10 May and the last hatching event occurred on 5 July. The first fledging included chicks from 3 separate nests on 7 July. The chick rearing period ranged from 45-63 days (6.4-9 weeks), with a mean of 56.2 days (8 weeks). For 50 days (18 May to 7 July) all 19 successful nests were occupied. By 15 July (the median date of chick fledging), 13 nests (65%) remained occupied/active. By 1 August, only 3 nests (15%) remained active in the colony. The final nest was completed on 2 September.

We assumed that each of the 20 active nests had a unique adult pair, for a total breeding population of 40 adult herons. One nest failed to produce any young. The remaining 19 nests were successful (95% nest success) and produced 47 chicks. Brood size varied among nests from 1-4 chicks with the average brood size of 2.5 ± 1.0 chicks. Total nestling period required by adults to fledge the entire brood ranged

from 46-68 days. The estimated nestling development period for individual chicks ranged from 45-63 days with an average of 56.2±4.6 days per chick. Of the 20 active nests, 19 fledged at least 1 chick (95% fledging success). Of the 47 chicks produced, 41 fledged (89% fledgling success). The mean number of fledglings produced for all initiated nests was 2.05, and the mean number of fledglings per successful nest was 2.15.

According to scan sampling data, adults and chicks overwhelming spent time in the nest conducting comfort or maintenance activities, such as feather care, stretching, or in other maintenance behaviors. They also spent time in non-descript posture behaviors either standing, sitting or lying in the nest. Overall, herons spent 93% of their time in these two behaviors. Focal sampling resulted in similar results with over 90% of time spent in maintenance and postural behaviors.

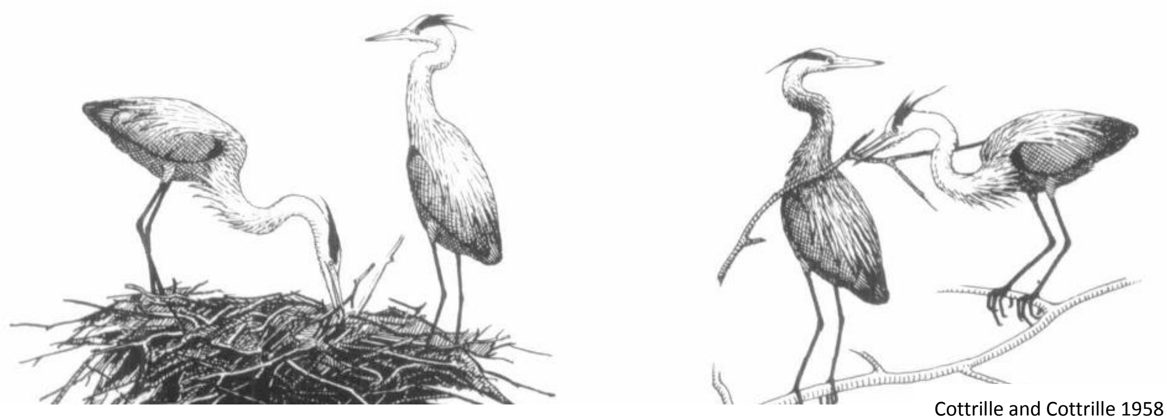
We recorded 7,095 human activities and the large majority occurred on the Slate River Road including 5,675 cars and trucks representing 80% of total activities. The second most abundant human activity included 1,088 bicyclists, runners, and hikers, and accounting for 15% of all activities. We observed a total of 59 watercraft on the Slate River during the surveys, representing less than 1% of total documented activities. Of the 7,095 events, 176 led to possible heron behavior disturbances. Human activity varied by time of day with the fewest activities in the morning (mean of 43.6 events per hour from 545-1000) compared to the peak in the middle of the day (44.1 events per hour from 1000-1500) and activity remained fairly constant through the late afternoon and evening (43.2 events per hour from 1500-1858). Generally, runners and hikers had their highest activity in the morning, bicyclists peaked at midday, car traffic increased from morning to mid-day and stayed high through most of the early evening, and river recreation was not observed before 10 am and peaked at midday. The rate (#/hr) of human activities in the Slate River valley peaked on the 3rd weekend of July 2019 and river recreation was only observed in July and August.

The 43 groups of floaters consisted of 104 watercrafts including 84 SUP boards, 9 kayaks, 8 duckies, and 3 rafts. A minimum of 123 people floated the colony stretch, with groups ranging in size from 1-6 floaters. We observed groups of 5 or more people on nine occasions. Of these, seven were associated with a noise event, five had a stopping event under the colony, and 59 were associated with a heron behavior change. The earliest group floated through the colony at 1057 and the latest floaters arrived at the colony at 2010 (near dark). The mean float time was 1425. Whereas river recreation accounted for less than 1% of all human activities in the Slate River valley, this recreation type was tied to 68-100% of heron disturbances, including 71% of adult heron alert, 68% of chick heron alert, 100% of chick hunkering, and 100% of heron flushes.

We documented 40 adult heron and 20 active nests. The colony size threshold of 20 nests is a key population monitoring metric to assess productivity and likelihood of persistence in the Slate River valley into the future. Our study suggests that river recreation by SUP boards, kayaks, duckies, and rafts result in disturbance behavior more than 9 times out of 10. River recreation occurs directly below the heronry, providing a small spatial buffer (40 feet or 12 m). Effective spatial buffers that separate human activity from heron nests usually exceed 250-300 m. However, not all river recreation has equal impact on herons. Our observations indicate that large (≥4 crafts), loud groups with upright floaters who pause and cluster through the colony section create more disturbance to the herons. Continuation of a voluntary no float period and bolstered efforts to educate floaters on river etiquette would likely reduce disturbances to the heron colony.

Introduction

Great Blue Herons (*Ardea herodias*) are the largest North American heron and have waded the waters of this continent for nearly 2 million years (Butler 1997, Vennesland and Butler 2011, Schulenberg 2019). They reside in a variety of freshwater and marine habitats and are highly adaptable (Vennesland and Butler 2011). Two defining characteristics of this species are its year-round, solitary, patient and laborious hunting style contrasting with its gregarious, colonial nesting strategy whereby they occupy nearly permanent rookeries, some exceeding 1,000 nests (Witt 2006). Their lives are intertwined with fish and sticks. On lanky legs, they awkwardly balance in the crowns of tall trees grasping thin branches with their four long toes and flapping outstretched wings (Butler 1997). In their spear-like bills they carry sticks gathered from the ground, usurped from woody plants, or robbed from neighboring nests (Mock 1976). These sticks become gifts to their mate and play an integral ceremonial role in courtship and an important structural role when assembling their lofty nests (Cottrille and Cottrille 1958).



Cottrille and Cottrille 1958

Because the rookeries are used for many years and across generations of herons, they represent focal points in the landscape for conservation planning of this species. Colony location and size are determined by a complexity of local and landscape scale factors (Kelly et al. 2007), including presence of high quality foraging habitat, intra-seasonal variations in food availability, food competition among colony members, costs of foraging, nest habitat availability, presence of adjacent colonies, road density, amount of human disturbance, and predator risk, among other factors (Gibbs et al. 1987, Butler 1991, Gibbs 1991, Kelley et al. 2007, Knight 2010, Butler and Vennesland 2011). The colony location represents a complexity of dynamic temporal factors that change over multiple spatial scales, as well as crucial trade-offs in heron choices that include minimizing predation/disturbance threats and optimizing nutritional and energetic resources. The total number of suitable colony sites is limited and heron occupancy depends on combinations of multiple factors. For example, Great Blue Herons occasionally form colonies where human activity is relatively high, if the trade-off includes a highly profitable foraging habitat (Knight 2010). Once a colony is established, its persistence depends on the size of the colony and land use stability. Large colonies with over 20 nests have relatively robust persistence (Kelly et al. 2007), and where colonies remain buffered from human disturbances or other land use changes, they are more likely to persist (Vennesland and Butler 2011).

At the turn of the 20th Century, the millinery industry heavily exploited herons and led to the demise of many Great Blue Heron rookeries (Merchant 1984). Heroic efforts, by numerous conservationists, most notably many passionate women whose efforts were tied both to the creation of the Audubon Society and the passage of the Migratory Bird Treaty Act (Moore-Colyer 2000), curbed the precipitous decline of these elaborately plumed birds. Today the Great Blue Heron has robust populations across much of its range (Vennesland and Butler 2011, Sauer et al. 2017a). Surveywide, the species has a slight positive (statistically significant) trend (+0.44% per year growth) over the last 50 years and in the Southern Rockies they exhibit strong significant growth (+1.91% per year) (Sauer et al. 2017b). In Colorado, the Breeding Bird Survey population is stable (confidence intervals overlap zero) and the Colorado Breeding Bird Atlas found an increasing trend (Brown and Dexter 2016), however, the Western Breeding Bird Survey region shows a statistically significant decline (-0.79% per year) since 1966 (Sauer et al. 2017b) (Figure 1). The current continental population estimate for Great Blue Herons is 124,000 (Sauer et al. 2017). These relatively positive heron population projections indicate that the species is mostly doing well at regional scales. However, local populations are vulnerable.

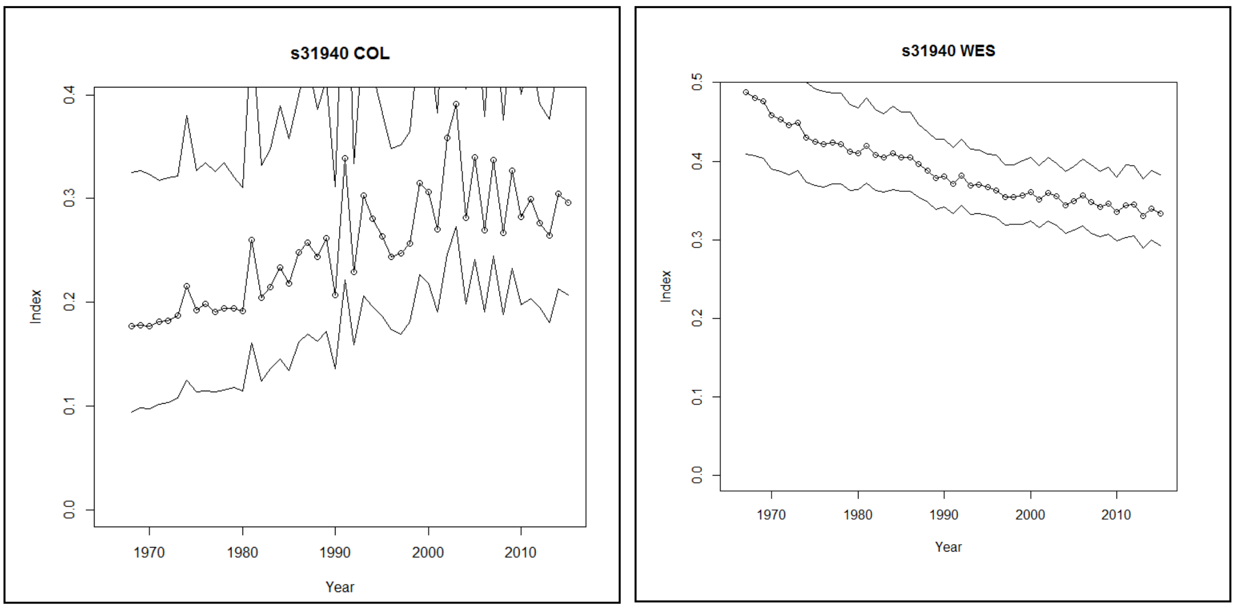


Figure 1. Breeding Bird Survey (BBS) "Relative Abundance" (RA) index for Great Blue Herons in Colorado (left) and the Western BBS region (right). The RA index compares the annual population estimate to the population size in 1988. From Sauer et al. 2017b.

The Great Blue Heron population in the Slate River valley adjacent to Crested Butte, Colorado inhabits a unique high elevation wetland complex. Herons occupy more than 20 nests located in conifer trees along the Slate River and have done so for over 20 years. The Slate River Valley is also an increasingly popular playground for bikers, runners, hikers, campers, and other outdoor enthusiasts, including river floaters (Lieberman 2016). In the last few years, recreationists using stand-up-paddle (SUP) boards, kayaks, rubber duckies, and small rafts enjoy a picturesque float through the wild and biologically diverse Slate River wetlands from the Gunsight Bridge to the Crested Butte recreation path (Slate River Working Group 2019). The heron colony is potentially vulnerable to river recreation as floaters pass directly under the nesting trees.

Great Blue Heron Biology and Vulnerability
Great Blue herons, like all species, have a unique life history (Figure 2), and certain features of their annual cycle make these birds particularly vulnerable to human disturbances. As migrants to the

Crested Butte area (Hyde 1979, Ryder et al. 1979, Brown and Dexter 2016), they lack the vulnerability that accompanies resident species. Nonetheless, when they arrive in late winter, they are faced with the collective challenges of molting, courting, mating, nest building and surviving, simultaneously, in an environment where minimum temperatures average 10 F and much of their foraging habitat is frozen or blanketed in snow. Further, these "income egg layers" must acquire nutritional resources from their environment daily for the production of eggs (Drent and Daan 1980), meaning that they do not carry on-board stored resources to dedicate to egg production. Further, their colonial nature and use of nearly permanent colonies (at least where colonies are persistent) constrain their spatial adaptability (Vennesland and Butler 2011). Species with high site fidelity may lack flexibility in adjusting nesting locations due to their programmed faithfulness to a breeding location (Carrasco et al. 2017, Feng et al. 2019). Further, a regional population occupies a single site and houses all of its eggs in one basket or at least a few trees in one specific location. In addition, the lengthy breeding season prescribes that the adults are tied to one location for 5-6 months and the chicks are nest bound for one month in the egg stage and 8+ weeks in the nestling stage (Vennesland and Butler 2011). Thus, colony sites become intensely susceptible to environmental changes or alterations in land use and human activity. Potential threats include changes in availability and quality of food resources and foraging habitats. If wetlands in the vicinity of a colony are impacted by changing land uses, this could impact the capacity of the site to nutritionally support the colony (Gibbs 1991). In addition to food, nest trees must be available and over time trees may die as a result of disease or lightning strikes, they may be removed by humans through development pressures, or herons may degrade the health of their own trees through defecation (Julin 1986). These normally solitary predators are vulnerable to human activities near their colonial nests and are prone to abandon sites.

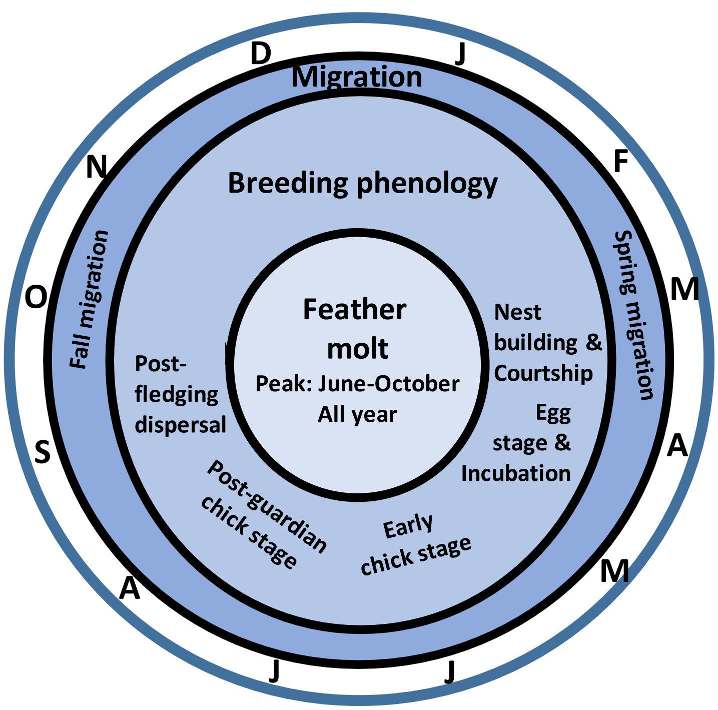
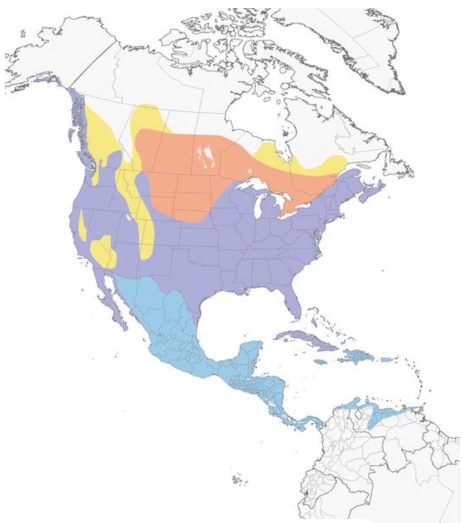


Figure 2. Annual cycle of the Great Blue Heron (*Ardea herodias*).

In addition to several factors that make herons especially vulnerable at nest sites, they also have a challenging prospect of gaining sufficient food, not only to feed themselves, but also a brood of up to 6 rapidly growing chicks that reach adult weight in 8 weeks (Butler 1997). These birds wade slowly and often stand for prolonged periods in a form of stealth hunting (Schulenberg 2019). They typically feed on fish but also consume amphibians and small mammals among other delicacies (Vennesland and Butler 2011). Besides the protracted time requirement for acquiring food, they also fly significant distances between foraging grounds and nests repeatedly throughout the long days of the nesting season. Food availability may change throughout this time period and the unpredictability of food resources drives down their optimal use of time and energy (Kelly et al. 2007). The success of a Great Blue Heron in raising one or more fledglings is a function of multiple trade-offs between nest tree characteristics, a dynamic food supply, risk of predation, and frequency and magnitude of human disturbances. In heron conservation, the most feasible component of this equation to address is human activity and potential disturbances, especially in relatively rural and wild landscapes.



Species range of Great Blue Heron

Human Disturbance

Human activities like biking, running, hiking, birding, river floating, and may other recreation activities potentially have negative effects on wildlife abundance, occupancy, reproductive success, behavior, stress level, and ability to raise young (Ikuta and Blumstein 2003). Several studies have documented these impacts on nesting Great Blue Herons (Parker 1980, Taylor et al. 1981, Vos et al. 1985, Hockin et al. 1992, Klein 1993, Corley-Martinez 1995, Carlson and McLean 1996, Vennesland 2000, Rodgers and Schwikert 2002, Vennesland and Butler 2004, Vennesland 2010). The impacts of human activity on herons is dependent on type, timing, frequency, and the magnitude of the disturbance as well as site factors, although impacts do not always translate into population-level impacts (Nisbet 2000). Human activities have been correlated with reduction in Great Blue Heron reproductive success (Carlson and McLean 1996, Vennesland 2000, and Vennesland Butler 2004). Specifically, human disturbances disrupted nesting behaviors and foraging, and increased vulnerability of eggs and hatchlings to potential predation and weather events (Vos et al. 1985, Parnell et al. 1988, Klein 1993) and have resulted in higher egg and nestling mortality, slow growth, reduced body mass, premature fledging, and even in some cases nest abandonment (Vos et al. 1985, Rodgers and Smith 1995, Machmer and Steeger 2004). Outside of the nest, human disturbances can result in reduced foraging time and efficiency (Machmer and Steeger 2004). The early nesting period is when herons are most vulnerable to disturbance and thus are more likely to abandon a site at this time (Parnell et al. 1988, Vennesland 2000). In Montana, a colony of herons were displaced 16 km to more isolated locations after being heavily disturbed by river recreation including, in one case, 150 canoeists paddling by on a single day (Parker 1980). Tolerance of human disturbances have been reported, but this habituation to non-threatening human disturbance typically occurs later in the nesting cycle or when disturbances are distant from the colony (Hockin et al. 1992).

Outdoor recreation takes diverse forms and has increased substantially in the last decade in the Upper Slate River valley (Lieberman 2016). A significant increase in river recreation has also been observed with approximately 10 floaters in 2012 and over 100 floaters in 2017 (Tim Szurgot, personal communication). The Crested Butte Land Trust is a key stewardship organization in the Upper Slate River and they have been a leader in developing a collaborative stakeholder group to address the complex issues of protecting natural resources, managing diverse land uses, and providing access to their lands for recreational benefit. Balancing these diverse and sometimes competing values presents an increasingly common challenge across the world (Gill 2007), especially in local areas that become discovered for their recreational values. The purpose of this study was to determine the impact of human recreation on the Slate River Great Blue Heron colony to inform proper management by the Slate River Working Group and the CBLT in safeguarding the herons.

Research Objectives

The purpose and scope of this study was to observe and document the breeding phenology and population demography of the Great Blue Heron colony at the Slate River rookery in Crested Butte, Colorado. We quantified heron activities at the nests, recorded human disturbances, and documented heron responses to human activities. Specifically we addressed the following research objectives:

Phenology of Great Blue Heron breeding activities
We documented the annual cycle phenology from spring arrival to fall departure of Great Blue Herons. We produced a detailed phenology based on observations taken 4-6 days per week for most for the 2019 breeding season. We determined the timing and duration of the following annual cycle events:

Spring migration arrival to nest colony
Nest selection and building
Courtship and mating
Egg laying and incubation
Nestling and post-guardian stages
Fledging
Post-fledge dispersal from colony site

Demographic characteristics of Great Blue Heron breeding
We identified basic demographic characteristics of the Slate River heronry including:

Number of nests, number of active/occupied nests, and comparative nest use among years
Number of adult herons and pairs
Number of active nests with eggs (incubation)
Number of successful nests (at least one egg hatched)
Number of chicks produced
Number of chicks fledged

Great Blue Heron behavior within the colony and in foraging habitats
We documented adult heron activity patterns from initiation of courtship to chick fledging and we quantified chick behaviors throughout the nestling stage. We also documented attendance at the colony, directions of adult movements, and locations of adult herons away from the nest and in foraging sites. We quantified behavior using scan sampling to successively document the behavior of each bird in the colony at one time and focal sampling to detail behaviors of randomly selected adults in and out of nests and chicks within nests. We assessed adult and chick behavior relative to time of day and season.

Human activities and colony disturbances
We conducted 1-hour observation bouts to document human activities in the vicinity of the Great Blue Heron rookery on the Slate River. In addition, we observed and recorded heron responses to each activity to assess potential disturbances. In addition to random 1-hr bouts, we collected targeted observations to quantify and characterize river recreation and determine heron responses.

Great Blue Heron colony site factors
After post-fledging dispersal, we measured habitat characteristics associated with the rookery, including GPS locations of nest trees, nest tree structural data, and we collected heron fecal and feather samples from under the nests.

"*How many of us can stand stock-still for more than three minutes, much less an hour? How many of us can **exert the kind of patience** the heron does in waiting, watching, being ready for our reward? How many of us are prepared to take immediate action and strike in the instant our opportunity swims by? I don't know how many of us can do these things… but I do know the heron can help us achieve this kind of intense tranquility.*" Avia Venefica

The Heron Totem
Calm
Grace
Solitude
Patience
Longevity
Versatility
Tranquility
Good Luck
Partnership
Intelligence
Domesticity
Being Present
Determination
Independence
Resourcefulness

John Williams

Methods

Study Area

Great Blue Herons nest in a colony (heronry or rookery) along the Upper Slate River adjacent to Crested Butte, in Gunnison County, Colorado (Figure 3). This rookery resides on land owned and managed by the Crested Butte Land Trust (CBLT) (0326280E 43069133N) who's mission focuses on protection of open lands for viewing, ecological resources, ranching culture, and recreational access. From its high elevation headwaters among craggy peaks in the Elk Mountain Range, the Slate River drops precipitously for 23.7 miles to its confluence with the East River near Crested Butte South. Outdoor enthusiasts have travelled to this valley for many years for hiking, running, biking, camping, fishing, class V kayaking, and increasingly for more moderate river floating (especially on SUP boards) (Lieberman 2016). The confluence with Coal Creek approximately marks the lower end of the Upper Slate River which winds through a high elevation glacial valley at 8,900 feet m.s.l. This valley is characterized by a mosaic of landowners including the CBLT, Bureau of Land Management (BLM), the USDA Forest Service (USFS), private property owners with conservation easements (held by CBLT and the town of Crested Butte), small sub-divisions including the Wildbird Community, and other private lands (Slate River Working Group 2019). Above the heronry, Gunsight Bridge, owned by the CBLT with an easement held by the Town of Crested Butte, and the Oh-Be-Joyful campground, managed by the BLM, allow access to the Slate River for river recreation (Slate River Working Group 2019). Watercrafts float from these put-ins through the Upper Slate River reach and under the heronry (Figure 3).

Figure 3. Slate River and wetlands with Great Blue Heron colony. Inset: Gunnison County in red; Crested Butte located at blue dot. Green tree symbols represent the Upper and Lower heron colonies, pink balloons are observation points, sailboats indicate heronry floating stretch, swimmers represent challenging curves, and fish heads indicate potential heron foraging sites.

The heronry has been occupied for at least 20 years (although historic records are lacking) in two stands of conifer trees. Many of the trees are partially or fully dead (Figure 4). The trees in the Upper Colony have experienced greater mortality than those in the Lower Colony. Tree mortality results from heron occupancy and the deposition of feces and prey remains raining down from the nests, which inhibits photosynthesis (Julin 1986). In high precipitation regions (e.g., Pacific Northwest) colony trees are less vulnerable to mortality due to rain cleansing the trees of heron feces (Butler 1997). The colony trees hover along the banks of the Slate River which meanders across the valley bottom and over time has created a diverse wetland complex characterized by the active stream channel, historic channels, oxbow lakes, and beaver ponds (Cooper 1993). These diverse aquatic habitats provide potential foraging areas for Great Blue Herons. In addition to the riparian trees, vegetation includes a mix of woody (especially willow) and herbaceous wetland plant species (Cooper 1993).

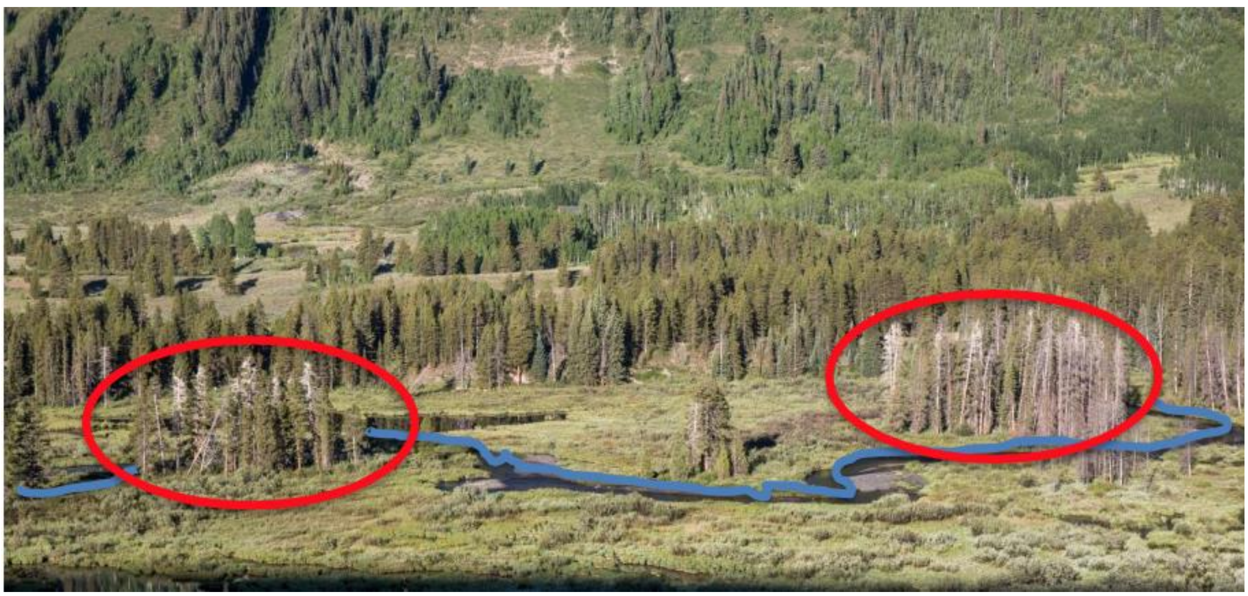


Figure 4. The Slate River (indicated by blue line) flows from right to left in the photograph with the Upper Colony circled on the right and the Lower Colony is circled on the left. Both Great Blue Heron colonies are directly adjacent to the Slate River. Photo by Carly Clegg.

Study Design and Data Collection

Phenology

We documented Great Blue Heron breeding season phenology by making nest and bird counts beginning 17 March and ending 4 September 2019. Detailed observations began after the first heron arrived at the colony and continued until the final fledgling departed the valley. We observed the heronry from one of three observation sites: east of the colony on Smith Hill Road from a private property pull out which was elevated above the Slate River wetlands and afforded an aerial view of the colony from 300 m away, on the Slate River Road about 200 m east of the colony and level with the valley bottom, and on Wildbird Ridge slightly less than 200 m west of the colony and slightly elevated above the valley bottom (Figure 3). At all observation sites we sat in lawn chairs with a spotting scope and made very little motion or noise. At Wildbird, we were concealed in conifer trees, but at the other two locations we were exposed with no hiding cover present. Our presence did not seem to be noticed by the herons. We observed the herons approximately 4-6 days per week rotating between the Wildbird and Slate River Road observation points. In June we gained access to the Smith Hill observation point (on private property) and due to its superb vantage point, we conducted most observations from this point for much of the summer. We spent 2-4 hours per observation period and recorded time, date, weather, presence and number of herons (adults and chicks), and heron behaviors that indicated annual cycle event (e.g., courtship, incubation, chick rearing). We documented spring arrival dates of herons, nest building and courtship events, copulation, timing of egg laying and incubation (based on the presence of herons sitting low in the nest for extended periods of time), hatch dates (observations of chicks in nests), nestling stage, fledging dates (dates chicks departed the nest), and post-fledging dispersal. We back-dated hatch dates to determine date of initiation of egg laying and incubation based on reported incubation length of 27-29 days (Vennesland and Butler 2011).

Nesting demographics

We gathered demographic data on each individual nest in the colony. In 2018, we used photographs of the nest trees to label each nest by number and documented a total of 26 nests in both the Upper and Lower colonies (Figure 5). We used the same nest numbers in 2019, and three new nests were built (we labeled these nests 27, 28, and 29) and a few 2018 nests were not occupied by herons in 2019. During our observations of the colony we conducted a systematic scan of all the nests and counted the number of adults, the number of nests with incubating adults (indicating presence of eggs), the number of successful nests (proportion of nests with at least one successful hatched chick – nest success), the number of chicks produced (brood size), the number of nests that successfully fledged at least one chick (fledging success), and the number of chicks that fledged (fledgling success).

Time activity budgets

Using scan and focal time budget sampling, we recorded behaviors of Great Blue Herons (Altman 1974). From nest building and courtship stage to fledging, we quantified heron activities approximately 4-6 days each week, rotating observation time between morning (sunrise – 1000), day (1000-1500), and evening (1500 – dark). We attempted to sample these times evenly throughout the season.

We performed scan sampling to record behavior of every adult heron and chick present at the rookery and quantified the proportion of the colony engaged in each behavior at one moment in time. We began our scan at one end of the colony and systematically viewed each nest recording the number of adults and chicks in the nest and an associated behavior code for each bird. We recorded chick behavior during the nestling period. We conducted multiple scans per sampling day.

We conducted focal time budgets on randomly selected herons (adults and chicks) using a random number generator. We did not perform focal time budgets on non-active nests, as was done in 2018 to assess nest occupancy rates. The randomly selected heron was observed for 20 minutes and a behavior recorded every 30 seconds. A timer was used to indicate intervals and end time, allowing the researcher to continuously observe the focal heron. In addition to adults and chicks in nests, we observed herons in the wetland habitats when a bird was present. We selected from 35 potential heron behaviors in 9 categories to characterize each heron's behavior (Table 1). These behaviors were conceptualized in 2018, and in 2019 we added three posture codes to better describe heron activity in nests (laying down, sitting upright, standing). For example, a heron may appear to be doing nothing at all and we could record this as standing or sitting. We conducted 3 or more focal time budgets per sampling day.

Table 1. Nine behavior categories used to quantify Great Blue Heron time activity budgets at the Slate River heronry, Crested Butte, Colorado in 2019.

Behavior Category	Behaviors	Description of Behavior
Foraging	5 foraging behaviors	All activities associated with catching, handling and consuming food
Locomotion	2 locomotion behaviors	Walking and flying
Self-Maintenance	5 self-maintenance behaviors	Preening, stretching, sun-bathing, thermal control, sleeping, roosting, nest maintenance
Agnostic	5 agnostic behaviors	Intra- or interspecific aggression
Courtship and mating	11 courtship behaviors	Male to male, or male to female communication during pair formation and nest building. Behaviors may continue for the duration of the nesting season
Alert/vigilant	1 vigilant behavior	Heron responding to external stimuli indicating heightened awareness
Incubation	1 incubation behavior	Adult males and females take turns incubating eggs
Brooding	2 brooding behaviors	Adults attend to and feed chicks
Posture	3 postures	Standing in nest, sitting upright in nest, laying in nest

Nest tree height and girth

After all herons departed the colony in fall 2019, we entered the heronry site and measured the nest trees to determine tree height using a rangefinder and tree girth using a DBH tape. We also recorded the UTMs of each nest tree using a Garmin Montana 600 GPS unit (NAD83 datum) and we marked the perimeter of the colony with the GPS.

Tissue samples

In addition to taking tree measurements, when we entered the colony site, we collected heron fecal samples and feathers from the base of nest trees. Tissue samples were collected with gloves and for fecal samples we took the entire substrate that supported the feces. These samples were placed in Ziploc bags and labeled with date, location and content. UTM locations were recorded using a GPS unit for each sample. These samples were collected for possible use in future studies, but will not be discussed further in this report.

Human activity and heron disturbance

We quantified human activities within 400 m of the heronry through one-hour long observation bouts. During this time we recorded all human activities and other potential heron disturbances (presence of predators) on the Slate River Road, on other roads and trails, in the aerial environment, in the wetlands, and on the Slate River. Disturbances were categorized into the following categories: car/truck, other vehicles (snowmobiles, all-terrain vehicles, trailers), bikers/runners, bird watchers, miscellaneous (skiers, police sirens), and river floaters. We recorded the location and duration of human activity, the number of people associated with each event when possible, and heron behavior prior to and during the disturbance event. To do this we scanned the colony prior to the disturbance event to assess baseline behavior and scanned again during the human activity. We recorded the number of herons exhibiting disturbance behaviors which included alert posture, hunkering, and/or flushing from the nest.

We documented all of the above forms of human activity in the Slate River Valley during the one-hour long monitoring sessions, and the focus of the study was on the effects of river recreationists on the Great Blue Herons at the Slate River colony. Most disturbance observations were made from the Smith Hill observation point (Figure 3), which afforded an "aerial" view of the river valley and provided an excellent vantage of the heronry and the river above and below the heronry. From this vantage we could see watercraft prior to their arrival at the heronry and thus had a short amount of time to assess pre-floater heron behavior. Once the floaters arrived at the Upper Colony we started timing them through the heronry stretch which ended at the gravel bar past the second curve below the Lower Colony (Figure 3). Further, we recorded the number and type of crafts (SUP boards, kayaks, rafts, duckies), the number of people in the group (and whether pets were present), whether they wore PFDs, we could hear them, they were bunched together or spread out, they were standing or had a low profile, and whether they continued floating or stopped within the heronry stretch.

In addition to one-hour disturbance monitoring, we conducted targeted observations on rivercraft when we observed them outside of the hour-long sampling bouts. Some observations of river recreation events were facilitated by two-way radio (generously loaned by the Monarch Ski Patrol) communication with CBLT employee Cheryl Cwelich who was conducting a river user study. Cheryl greeted floaters at the Gunsight Bridge put-in and provided information about the heronry and tips on proper river etiquette. She radioed our observer on Smith Hill when the floaters put on the river and described the type of watercrafts, the number of people and pets, whether they wore personal floatation devices and whether they carried coolers.

Data Analyses

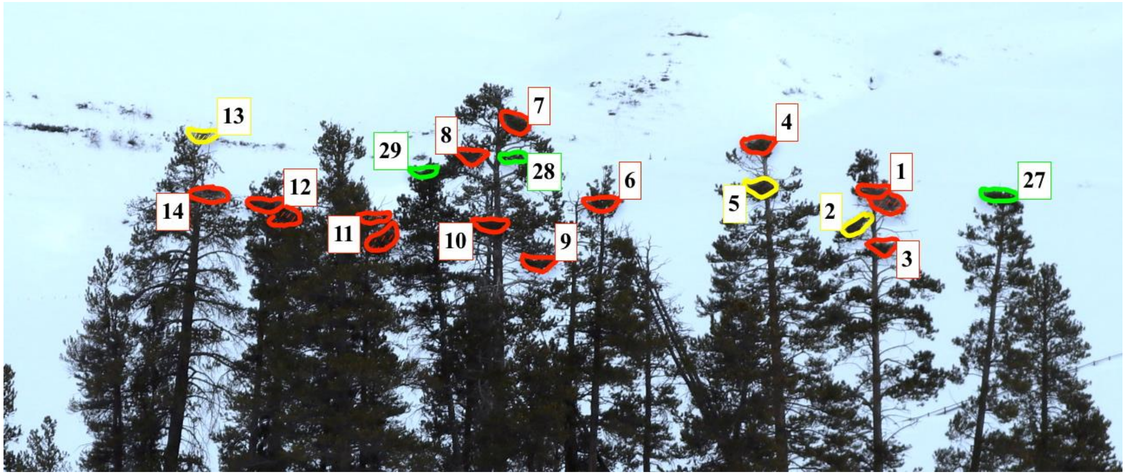
This observational study was primarily qualitative and we employed descriptive statistics to quantify heron phenology, nesting demography and time activity budgets. We compared heron activity budgets with inferential tests (ANOVA for three-way comparisons and t-test for two-way comparisons) using Microsoft Excel. For these hypothesis tests we used an alpha value of 0.05 to judge statistical significance. We conducted ANOVA to compare behaviors among morning, day, and evening periods. T-tests were used to compare behaviors for wetland versus nest, adult versus chicks, and incubation versus nestling stage.

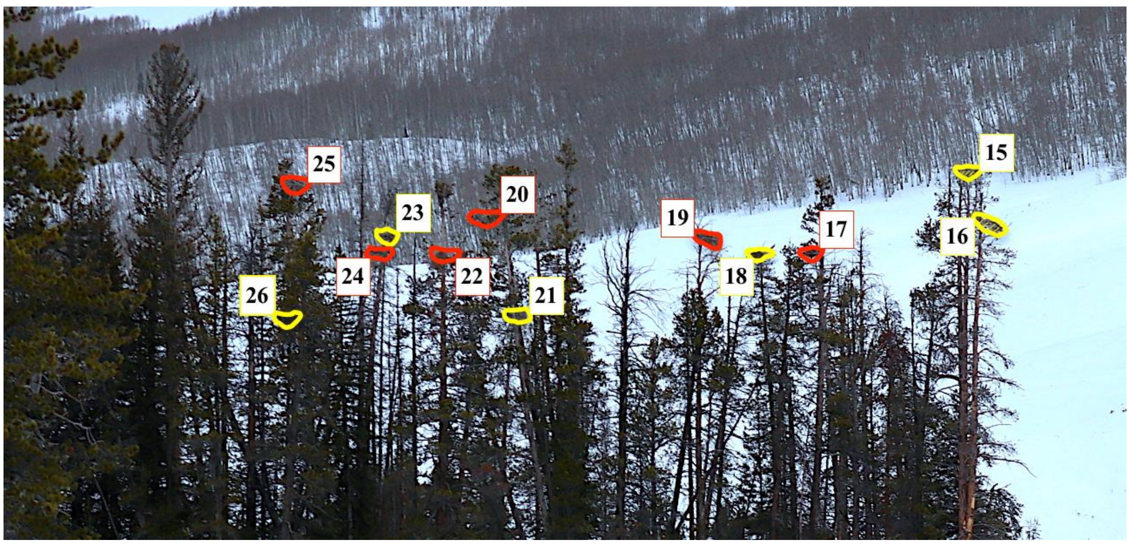
Results

We observed the Slate River Great Blue Heron colony on 120 days during the 169 day heron occupancy period from 17 March to 4 September 2019. Our effort focused from April to September (153 days). During this period Ellie Orr observed the colony on 53 days, Jake Bartholomew observed 57 days, and Pat Magee added 5 days. We spent nearly 400 hours observing herons and commuted 6,900 miles.

Great Blue Heron nest identification and nest tree characteristics

At the start of the season we identified 26 nests in two sub-colonies. Each nest was numbered in 2018. In 2019, 3 new nests (27, 28, and 29) were numbered successively from the 2018 scheme (Figure 5). Nine of the 2018 nests were inactive and two of these (13 and 18) were dismantled for sticks (Table 2). The occupancy and fate of each nest was individually monitored throughout the 2019 breeding season.





- Red nests = used in 2018 and 2019
- Red nests with hashing = in 2019 these nests were reused but mostly rebuilt in a slightly new location
- Green nests = new nests in 2019
- Yellow nests = present in 2018 and 2019 but not used in 2019 (nest 23 was the only inactive nest in 2018)
- Yellow nests with hashing = nests present in 2018 but by late April 2019 they were disassembled as a stick source for 2019 active nests

Figure 5. Slate River Great Blue Heron rookery from Wildbird Ridge (west of colony). Lower Colony (top) and Upper Colony (bottom). Nests 1, 11, and 12 were mostly rebuilt in 2019 on top of or adjacent to the 2018 location. Nest 9 was also completed rebuilt in 2019 at 2018 location. Nests 27, 28, and 29 were new in 2019. Nests 13, 15, and 16 were dismantled by late April 2019.

Table 2. Height (m) and girth (cm) of Great Blue Heron nest trees at the Slate River colony near Crested Butte, Colorado in 2019. Nest numbers in ( ) were present at beginning of 2019 but were pulled apart by heron as a source for sticks. Active nests in 2019 are in bold font.

Colony	Tree Number	Nests	DBH (cm)	HT (m)
Lower Colony	1	**27**	19	10.7
	2	**1**, 2, **3**	18.5	11.3
	3	**4**, 5	20.9	12
	4	**6**	19.6	11
	5	**7**, **8**, **9**, **10**, **28**	23	13
	6	**29**	13.2	11.3
	7	**11**	12.1	12
	8	**12**	15.7	12.2
	9	(13), **14**	25.5	13
Upper Colony	10	(15), (16)	No data	No data
	11	**17**, (18)	12.5	14
	12	**19**	14.7	15.4
	13	**20**, 21	19.1	13.7
	14	**22**	20.3	14.5
	15	23, **24**	17.3	13.7
	16	**25**	17	17
	17	26	16.9	11.6
Summary Statistics	Mean		17.8	12.9
	SD		3.7	1.7
	Range		13.4	6.3
	Minimum		12.1	10.7
	Maximum		25.5	17.0
	Sample Size		16	16

The Slate River heronry is situated in two small stands of lodgepole pine (*Pinus contorta*) along the banks of the Slate River. In 2019, heron nesting occurred in 15 lodgepole pine trees (nest 26 in tree 17 was present but inactive in 2019, and tree 10 contained two nests -- 15 and 16 -- in 2018 but neither nest was present in 2019). The Lower Colony consisted of 9 nest trees and the Upper Colony had 6 trees with active nests. Of these 15 trees, 13 had a single active nest. One tree had two active nests and one tree in the Lower Colony held five active nests. The diameter of nest trees ranged from 4.7-9.8 inches (12.1-25.2 cm) with a mean girth of 7 inches (17.8 cm). Nest tree height averaged 42.3 feet (12.9 m) with the lowest nest tree at 35.1 feet (10.7 m) and the tallest nest tree at 55.8 feet (17.0 m) (Table 2). The 9 trees in the Lower Colony had slightly larger diameters (18.6±4.4 cm) compared to 7 measured trees in the Upper Colony (16.8±2.6 cm), while the Upper Colony nest trees were slightly taller (14.3±1.7 m Upper vs. 11.8±0.8 m Lower). Great Blue Herons at the Slate River colony nest in the crowns of conifer trees (Figure 5). We did not measure the height of nests, but 11 of the 20 active nests in 2019 were on the very top of their nest tree and average general nest height was around 40 feet. All nine nest trees in the Lower Colony had robust crown growth, whereas all nest trees in the Upper Colony had some live branches but most had extensive dead foliage (Figure 5). This might suggest that the Upper Colony has been in use by herons for a longer duration and suitability may be declining (the Upper Colony declined from 12 active nests in 2018 to 6, while the Lower Colony lost 4 nests and gained 3 new nests in 2019).

Nest Status

The Slate River Great Blue Heron colony showed dynamic occupancy between 2018 and 2019. In 2018 we monitored 25 active nests and in 2019 we observed 20 active nests (Table 3).

Table 3. Active status of Great Blue Heron nests in 2018 and 2019 at the Slate River heronry in Crested Butte, CO. x = active, N = inactive, R = removed, YR = year (2018, 2019), numbers across the top of table indicate heron nest number (see Figure 5). Nests 27, 28, and 29 were new in 2019.

YR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
18	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	N	x	x	x			
19	x	N	x	x	N	x	x	x	x	x	x	x	R	x	R	R	x	N	x	x	N	x	N	x	x	N	x	x	x

Phenology of Great Blue Heron breeding activities

The first Great Blue Heron arrived at the Slate River colony on 17 March 2019, 13 of 20 pairs arrived by 31 March 2019, and 4 more initiated nests before 13 April 2019 (Tables 4 and 5). The Slate River and associated wetlands were still mostly frozen and 1-2 foot snow pillows covered most of the nests through the end of March (Appendix A for 2019 weather). The snow depth in Crested Butte on 17 March 2019 was 36", declined to 23" on 31 March, and was 0" on 16 April (https://www.ncdc.noaa.gov/cdo-web/quickdata). Snowfall measured 53" in March, 4" in April, and 16" in May 2019 (https://www.ncdc.noaa.gov/cdo-web/quickdata). The remaining 3 heron pairs initiated nests on 26 April, 7 May, and 18 May (this last nest #29 started 2 months after the first herons arrived) (Tables 4 and 5, Figure 6). There was no evidence of re-nesting in this late nest. Nest #9 was initiated on 7 May, after the nest had been almost completely dismantled by neighboring herons and rebuilt by a later arriving pair. Herons occupied nests immediately after arriving in late March and began nest refurbishing. Luscious heron plumes were flagrantly displayed along with a variety of stretches, bill duels, circle flights, twig shakes and vocalizations. Nest prospecting, courtship, and pair formation overlapped in sequence and occurred rapidly after spring arrival. By the end of March and in early April, we observed herons copulating.

The 27-29 day incubation period started on 12 April and, by 21 April, 9 pairs were incubating eggs. The last pair started incubation on 1 June 2019 (Tables 4 and 5, Figure 6). While Great Blue Heron nesting chronology is often synchronized (Butler 1997), individual variation in timing of breeding events was observed in our study. The pair that constructed Nest #29 began egg laying and incubation on 18 May, approximately 6 weeks after the first eggs were laid in the colony.

The first chicks hatched on 10 May 2019 and, by the end of May, 85% of chicks in the colony had hatched, but the last hatching event occurred on 5 July 2019, 35 days later (Tables 4 and 6, Figure 6).

Table 4. Great Blue Heron breeding season phenology at the Slate River heronry, Crested Butte, Colorado in 2019. While the last nest was initiated by 18 May, herons continued to contribute new nesting materials through 14 June 2019.

Life cycle event	2019 Dates
Spring arrival	17 March – 18 May (62 days)
Nest building	17 March – 14 June (89 days)
Incubation	12 April – 5 July (84 days)
Hatching	10 May – 5 July (56 days)
Chick rearing	10 May – 2 September (115 days)
Fledging	7 July – 2 September (57 days)
Post-fledging dispersal	Most chicks departed soon after fledging

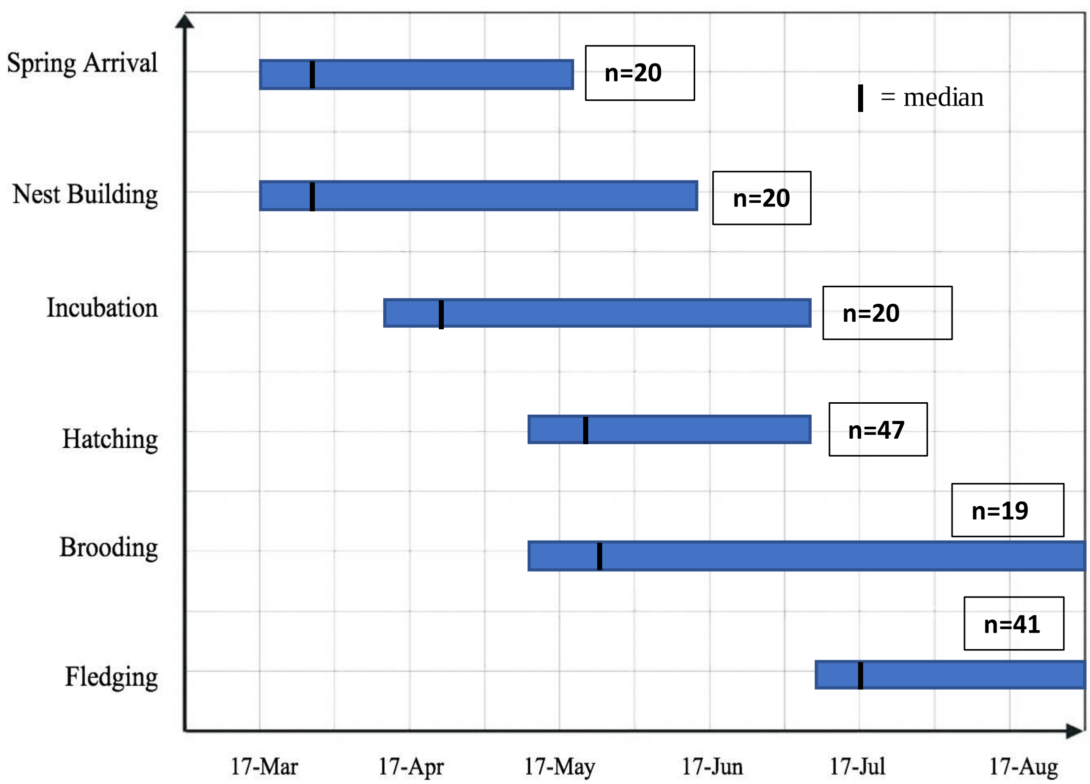


Figure 6. Great Blue Heron breeding phenology at the Slate River colony near Crested Butte, Colorado in 2019.

Table 5. Great Blue Heron 2019 nest occupancy, date of initiation of incubation, and nest success at the Slate River rookery. A successful nest contains at least one successfully hatched egg.

	Nest Number	Occupation Date	Incubation Date	Successful nest?
Lower Colony	**27**	28 March	18 April	Y
	1	17 March	12 April	Y
	2 inactive	N/A	N/A	N/A
	3*	28 March	12 April	N
	4	28 March	20 April	Y
	5 inactive	N/A	N/A	N/A
	6	19 March	25 April	Y
	7	19 March	15 April	Y
	28	26 April	16 May	Y
	8	28 March	14 April	Y
	9 rebuilt/reused	7 May	29 May	Y
	10	20 March	16 April	Y
	29	18 May	1 June	Y
	11	5 April	27 April	Y
	12	28 March	16 April	Y
	13 no nest by 4/21	**		
	14	19 March	15 April	Y
Upper Colony	15 no nest by 4/18	**		
	16 no nest by 4/25	**		
	17	20 March	3 May	Y
	18 inactive	N/A	N/A	N/A
	19	31 March	27 April	Y
	20	13 April	27 April	Y
	21 inactive	N/A	N/A	N/A
	22	13 April	27 April	Y
	23 inactive	N/A	N/A	N/A
	24	2 April	24 April	Y
	25	20 March	3 May	Y
	26 inactive	N/A	N/A	N/A

**Nest 3 was occupied on 28 March and remained occupied until 16 July, but no chicks were ever observed. Two "adult" herons were observed in Nest 3 on two occasions and incubation behavior was observed. Therefore, we discerned that the nesting pair laid eggs and incubated, but no eggs hatched. This was the lone unsuccessful nest.*

***Nests 13, 15, and 16 were dismantled by herons and sticks were recycled into other nests*

Table 6. Great Blue Heron hatch dates and number of chicks per nest at the Slate River heronry near Crested Butte, Colorado in 2019. Multiple hatch dates correspond to each chick.

	Nest Number	Number of Chicks	Hatch Dates
Lower Colony	27 (new nest)	2	1) 16 May 2) 18 May
	1	4	1) 10 May 2) 12 May 3) 14 May 4) 16 May
	2 (inactive)	N/A	N/A
	3	0	No chicks hatched
	4	4	1) 18 May 2) 20 May 3) 22 May 4) 24 May
	5 (inactive)	N/A	N/A
	6	3	1) 23 May 2) 25 May 3) 27 May
	7	3	1) 13 May 2) 15 May 3) 17 May
	28 (new nest)	1	1) 13 June
	8	3	1) 12 May 2) 14 May 3) 16 May
	9	2	1) 26 June 2) 28 June
	10	2	1) 14 May 2) 16 May
	29 (new nest)	4	1) 29 June 2) 1 July 3) 3 July 4) 5 July
	11	2	1) 25 May 2) 27 May
	12	2	1) 14 May 2) 16 May
	13 (no nest)		
	14	3	1) 13 May 2) 15 May 3) 17 May
Upper Colony	15 (no nest)		
	16 (no nest)		
	17	1	1) 31 May
	18 (inactive)	N/A	N/A
	19	2	1) 25 May 2) 27 May
	20	2	1) 25 May 2) 27 May
	21 (inactive)	N/A	N/A
	22	2	1) 25 May 2) 27 May
	23 (inactive)	N/A	N/A
	24	4	1) 22 May 2) 24 May 3) 26 May 4) 28 May
	25	1	1) 31 May
	26 (inactive)	N/A	N/A

Table 7. Fledge dates, number of fledged chicks, and fledging success of Great Blue Herons at the Slate River colony near Crested Butte, Colorado in 2019.

	Nest Number	Number of Fledglings	Fledge Date	Number of Days to Fledge	Fledge Success
Lower Colony	27	2	1) 15 July 2) 17 July	1) 60 2) 61	2:2
	1	4	1) 10 July 2) 12 July 3) 14 July 4) 17 July	1) 61 2) 61 3) 61 4) 62	4:4
	2	Inactive			
	3	0			
	4	3	1) 17 July 2) 20 July 3) 24 July	1) 61 2) 61 3) 63	3:4
	5	Inactive			
	6	3	1) 17 July 2) 17 July 3) 17 July	1) 55 2) 53 3) 51	3:3
	7	1	1) 7 July	1) 55	1:3
	28	1	1) 4 August	1) 52	1:1
	8	3	1) 7 July 2) 12 July 3) 13 July	1) 56 2) 59 3) 60	3:3
	9	2	1) 16 August 2) 18 August	1) 51 2) 51	2:2
	10	1	1) 12 July	1) 59	1:2
	29	4	1) 29 August 2) 31 August 3) 1 September 4) 2 September	1) 60 2) 61 3) 60 4) 59	4:4
	11	2	1) 24 July 2) 27 July	1) 60 2) 61	2:2
	12	2	1) 8 July 2) 11 July	1) 55 2) 56	2:2
	13	No nest			
	14	3	1) 7 July 2) 8 July 3) 12 July	1) 55 2) 54 3) 56	3:3
Upper Colony	15	No nest			
	16	No nest			
	17	1	1) 16 July	1) 46	1:1
	18	Inactive			
	19	2	1) 15 July 2) 18 July	1) 51 2) 52	2:2
	20	2	1) 18 July 2) 23 July	1) 54 2) 57	2:2
	21	Inactive			
	22	1	1) 21 July	1) 57	1:2
	23	Inactive			
	24	3	1) 12 July 2) 14 July 3) 14 July	1) 51 2) 51 3) 49	3:4
	25	1	1) 15 July	1) 45	1:1
	26	Inactive			

Chick rearing began on 10 May and the first fledging included chicks from 3 separate nests on 7 July 2019. The chick rearing period ranged from 45-63 days (6.4-9 weeks), with a mean of 56.2 days (8 weeks). The last heron chick ledged on 2 September 2019. Few birds remained in the vicinity of the colony during the post-fledging period (Table 4, Figure 6). The 2019 Great Blue Heron breeding season and colony occupancy lasted 169 days (24 weeks), compared to 155 days in 2018. The 2019 season started 4 days later and ended 18 days later than in 2018.

We recorded the initial dates of nest occupancy (Table 5) and tracked number of adults and chicks in occupied/active nests (Figure 7). The first nest was occupied on 17 March and the 20th nest was occupied on 18 May. The first fully fledged nest was on 7 July, followed by other nests being completed on 11 and 12 July. For 50 days (18 May to 7 July) all 19 successful nests were occupied. By 15 July (the median date of chick fledging), 13 nests (65%) remained occupied/active (Figure 8). By 1 August, only 3 nests (15%) remained active in the colony. Of the three active nests, one reached completion on 4 August, a second on 18 August, and the final nest was completed on 2 September (Figure 8). The last nest (#29) initiated egg laying 11 days after the next latest nest (#9 which was reconstructed) and chicks fledged 15 days behind nest #9. Nest #29 fledged 4 chicks in an average of 60 days per chick, whereas the nest #9 adults raised 2 chicks in 51 days per chick (Table 7). After fledging, some juveniles and adults were observed in the Slate River wetlands and we observed some chicks return to nests. However, most herons (juveniles and adults) did not remain in the vicinity of the colony. Those herons that foraged in wetlands around the colony behaved differently from the herons in 2018 which were not observed in the Slate River wetlands in the post-fledge dispersal period.

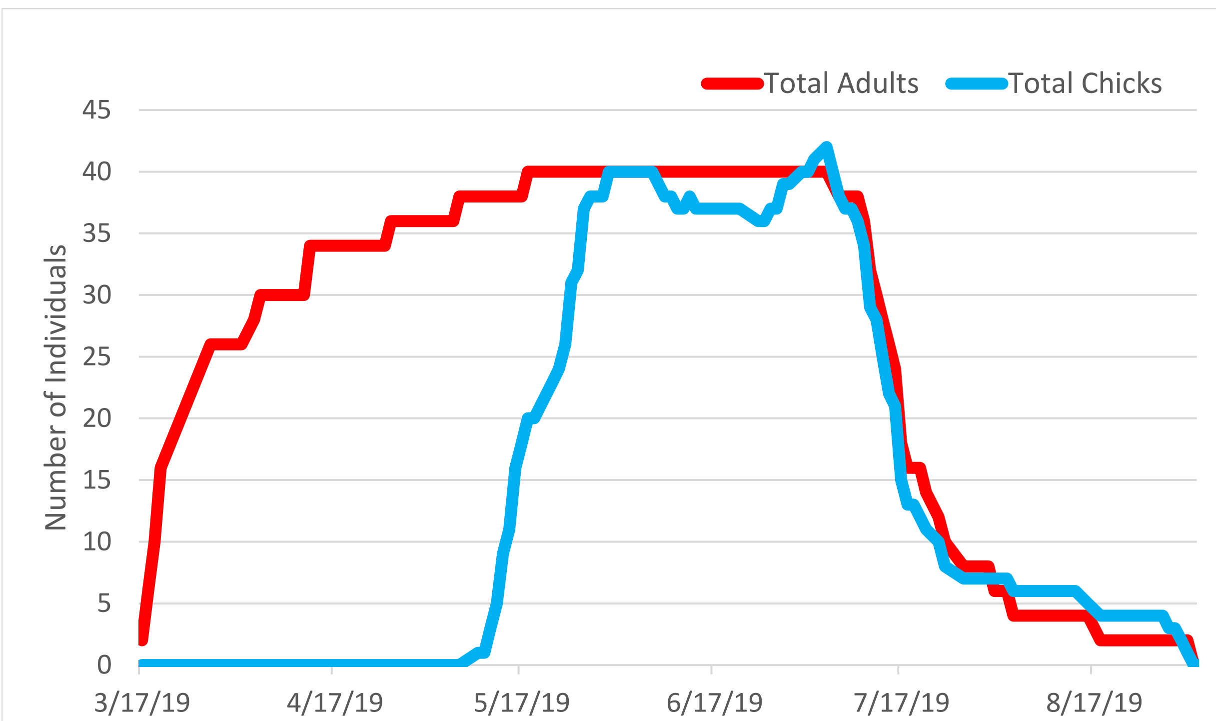


Figure 7. Total number of adult herons and heron chicks at the Slate River colony in Crested Butte, Colorado during the 2019 breeding season. Adults arrived beginning in mid-March and occupied and/or built nests, the first chicks hatched on 10 May and their numbers rapidly increased to a peak just before fledging started in early July. By 2 September the colony was empty and few herons remained in the Slate River wetlands.

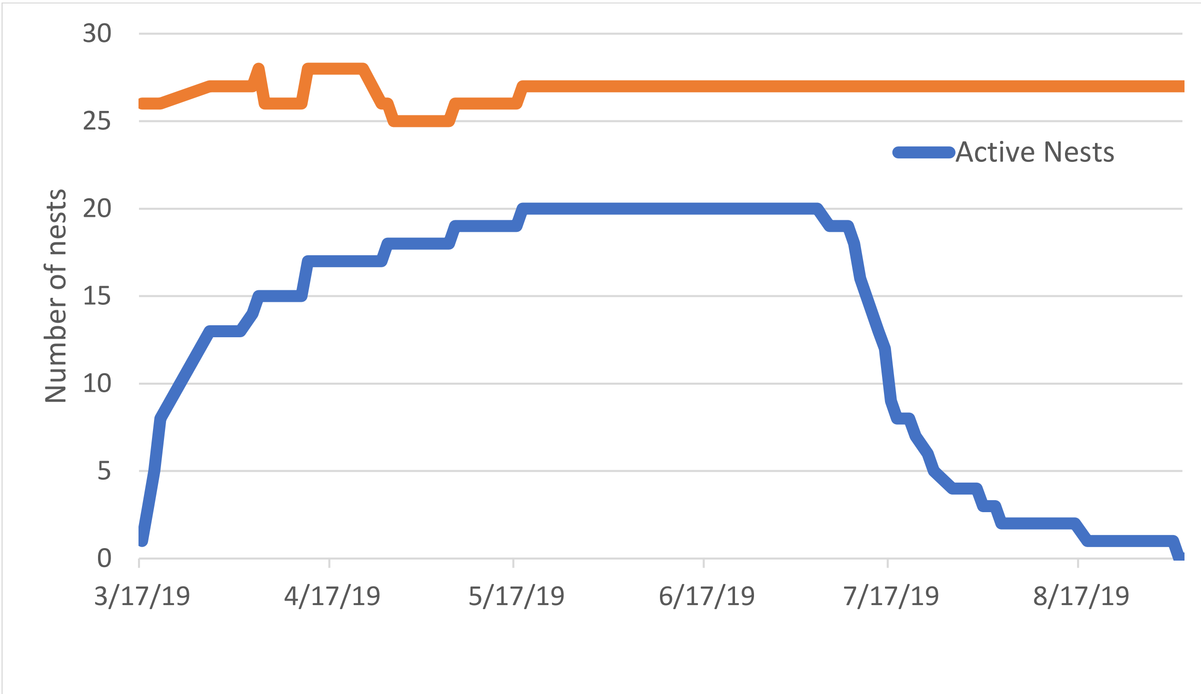


Figure 8. Total number of nests and active nests at the Slate River colony in Crested Butte, Colorado during the 2019 breeding season. All successful nests were occupied from 18 May to 7 July 2019. By 15 July, 65% of nests were still active at the colony. By 1 August only 3 nests were active (15%) in the colony.

Nesting demography of Great Blue Herons

We assumed that each of the 20 active nests had a unique adult pair, for a total breeding population of 40 adult herons. We did not observe unpaired, non-breeding adult or yearling herons. One nest (#3) failed to produce any young (Table 6). This nest was occupied on 28 March and incubation behavior was observed on 12 April. Herons continued to be observed in Nest #3 until 16 July, but no chicks were ever observed. The remaining 19 nests were successful (95% nest success) and produced 47 chicks (Table 6).

The number of eggs (clutch size) was unknown as we only observed nests at a distance and could only visually observe the number of chicks (brood size) in the nest. The 47 chicks were distributed across 19 nests. Brood size varied among nests from 1-4 chicks with the average brood size of 2.5$\pm$1.0 chicks (Figure 9). Four nesting pairs had 4-chick broods, four nests had 3-chick broods, eight nests had 2-chick broods, and three heron pairs raised 1 chick each. Total nestling period required by adults to fledge the entire brood ranged from 46-68 days (Table 8). The estimated nestling development period for individual chicks ranged from 45-63 days with an average of 56.2$\pm$4.6 days per chick (n=41). Four-chick broods had a mean nestling period of 58.6 days (n=14), three-chick broods averaged 55.4 days (n=10), two-chick broods took 56.1 days (n=14), and one-chick broods required 47.6 days/chick (n=3) to fledge (Figure 10).

Of the 20 active nests, 19 fledged at least 1 chick (95% fledging success). Of the 47 chicks produced, 41 fledged (89% fledgling success). In nests 4, 7, 10, 22, and 24 each nest failed to fledge one of the young in the brood (Tables 7 and 8). The mean number of fledglings produced for all initiated nests was 2.05, and the mean number of fledglings per successful nest was 2.15.

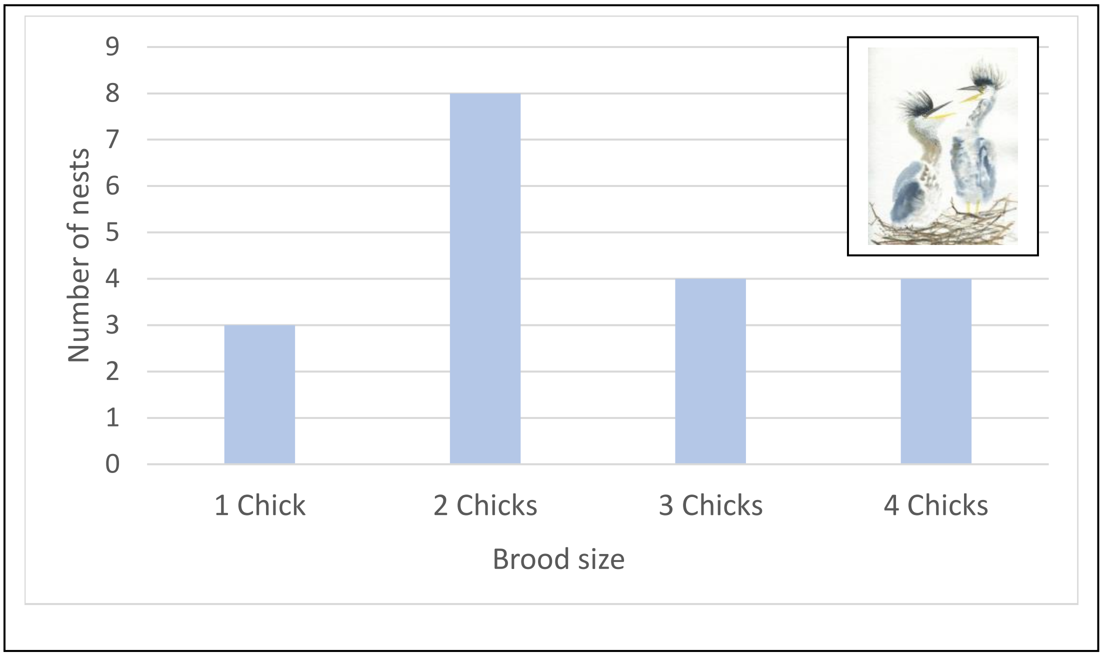


Figure 9. Frequency histogram representing Great Blue Heron brood size in relation to number of nests at the Slate River heronry in 2019. The most common brood size was 2 chicks with 8 total nests. The average brood size was 2.5 ± 1 chick (n=19). Art graphic by Wenfrei Tong.

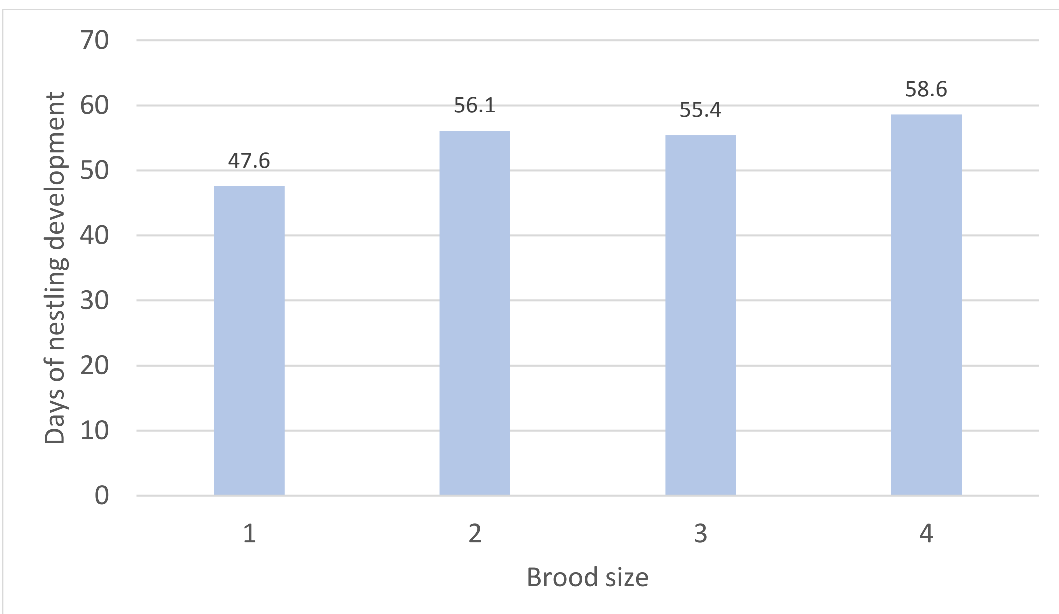


Figure 10. Great Blue Heron chick development time to reach fledging relative to brood size at the Slate River heronry in 2019. Development time is number of days per chick. Herons from 1-chick broods reached fledging 11 days earlier than herons from 4-chick broods.

Table 8. Great Blue Heron nestling period for each of the 19 successful nests (at least one chick hatched from egg). Each of these nests also successfully fledged at least one heron chick. The nestling period starts from the date the first chick in a nest was hatched to the date that the last chick in a nest fledged. Nests numbered by length of nestling period.

Nest	Brood size (# of chicks fledged)	Range of dates with chicks in nest	~Peak energy requirements (3-5 weeks post hatch)	Nestling Period (Days)
25	1	31 May – 15 July	21 June – 5 July	46
17	1	31 May – 16 July	21 June – 5 July	47
28	1	13 June – 4 August	4 July – 18 July	52
9	2	26 June – 18 August	17 July – 31 July	53
24	4 (3)	22 May – 14 July	12 June – 26 June	53
19	2	25 May – 18 July	15 June – 29 June	54
6	3	23 May – 17 July	13 June – 27 June	55
7	3(1)	13 May – 7 July	2 June – 16 June	55
22	2(1)	25 May – 21 July	15 June – 29 June	57
12	2	14 May – 11 July	3 June – 17 June	58
10	2(1)	14 May – 12 July	3 June – 17 June	59
20	2	25 May – 23 July	15 June – 29 June	59
14	3	13 May – 12 July	2 June – 16 June	60
8	3	12 May – 13 July	1 June – 15 June	62
27	2	16 May – 17 July	5 June – 19 June	62
11	2	25 May – 27 July	15 June – 29 June	63
29	4	29 June – 2 September	20 July – 3 August	66
1	4	10 May – 17 July	31 May – 14 June	68
4	4(3)	1 May – 24 July	22 May – 5 June	68

Great Blue Heron behavior

Scan Sampling

We conducted 242 scan samples of the heron colony, which summed to 2,299 minutes of data collection. Every scan included herons present in at least one nest. Of the 242 scan surveys, 39 were done in the morning, 137 during the day, and 66 in the evening. The number of herons present at the colony differed significantly by time of day ($p=0.009$, $F=4.8$, $N = 242$) (Figure 11).

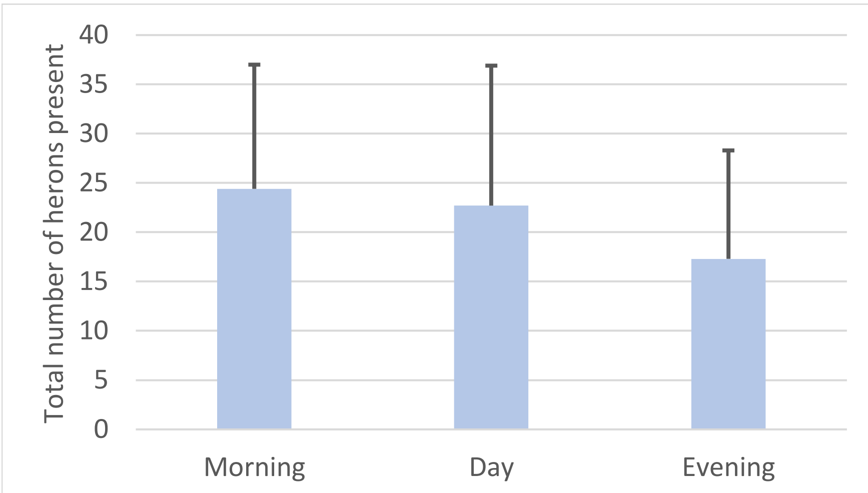


Figure 11. Total number of herons present at Slate River colony during morning, day, and evening sampling bouts. Fewer herons were present during evening than the other two time periods. Standard deviations are large pointing to the high variability of heron numbers because of the movement of adults in and out of the colony and due to the changing numbers of chicks in nests through the season.

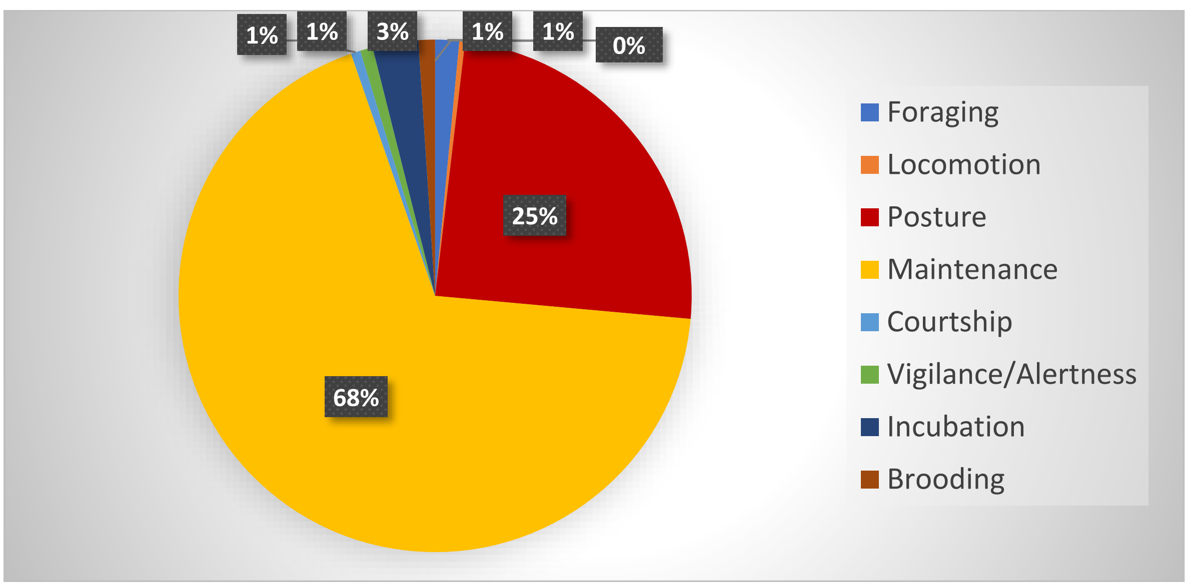
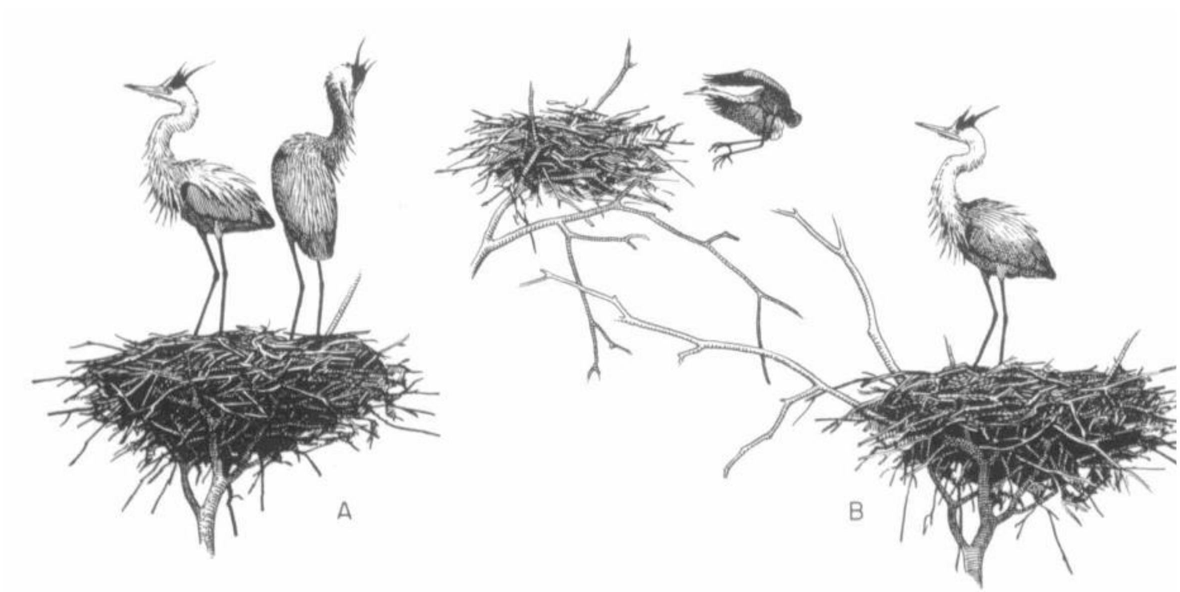


Figure 12. Great Blue Heron activity budget based on scan samples of adult herons in their nests from May through August 2019 at the Slate River heronry in Crested Butte, Colorado. Posture describes heron behavior when not engaged in any other noticeable behavior but is standing, sitting or lying in nest.

Of the 35 possible behaviors, we observed 18 behaviors in all nine of the broader categories using scan sampling at the nests. Great Blue Herons spent the majority of their time in two primary activities during the breeding season from April until the end of August. Adults and chicks overwhelming spent time in the nest conducting comfort or maintenance activities, such as feather care. Herons spent 68% of their time preening feathers, stretching, or in other maintenance behaviors (Figure 12). They also spent 25% of their time in a still position (posture) either standing, sitting or lying in the nest not engaged in another behavior (Figure 12). Overall, herons spent 93% of their time in these two behaviors. Additionally, adult herons spent 1.25% of their time brooding young and 3.47% of their time incubating eggs (Figure 12). Herons spent 0.95% of their time being vigilant, courting (0.73%), and foraging (1.82%).

The two primary heron behaviors differed significantly among times of day (Table 9). Maintenance behaviors significantly increased from 37.9% in the morning to 59.1% in the day time to 65.1% in the evening (p=0.006, F=5.065, N=220). In contrast, and in the opposite trend, posture (no distinct behavior other than lying, sitting or standing in nest) decreased significantly from morning (50.8%) to day (26.6%) and evening (22.4%) (p=0.001, F=7.183, N=220).



Great Blue Heron post-copulatory displays (Cottrille and Cottrille 1958).

Focal Sampling
We conducted 257 focal time budget samples on individual herons. These individual heron observations summed to 5,140 minutes or 86 hours of effort. Of these focal time budgets, 54 were conducted in the morning, 142 during the day, and 61 in the evening. The 257 surveys were divided into adults (n=142) and chicks (n= 103). The location (at nest or outside of the nest) was recorded for each sample.

Table 9. Great Blue Heron time budget from scan sampling in relation to time of day. Data are percent time spent in behaviors and were collected at the Slate River heronry from May to the end of August 2019.

Behavior	Morning	Day	Evening	p	F	Sample Size
Foraging	1.3	0.5	0	NA	NA	220
Locomotion	0.2	0.4	0	NA	NA	220
Posture	37.1	27.9	24.4	0.24	1.42	220
Maintenance	52.7	58.3	65.8	0.27	1.29	220
Courtship	0.8	0.5	0.5	0.56	0.58	220
Vigilance/Alertness	1.5	1.1	1.4	0.36	1.03	220
Incubation	4.3	9.2	6.3	0.43	0.84	220
Brooding	0.5	1.8	0.8	0.291	1.23	220
Total	99.4	99.8	99.2			

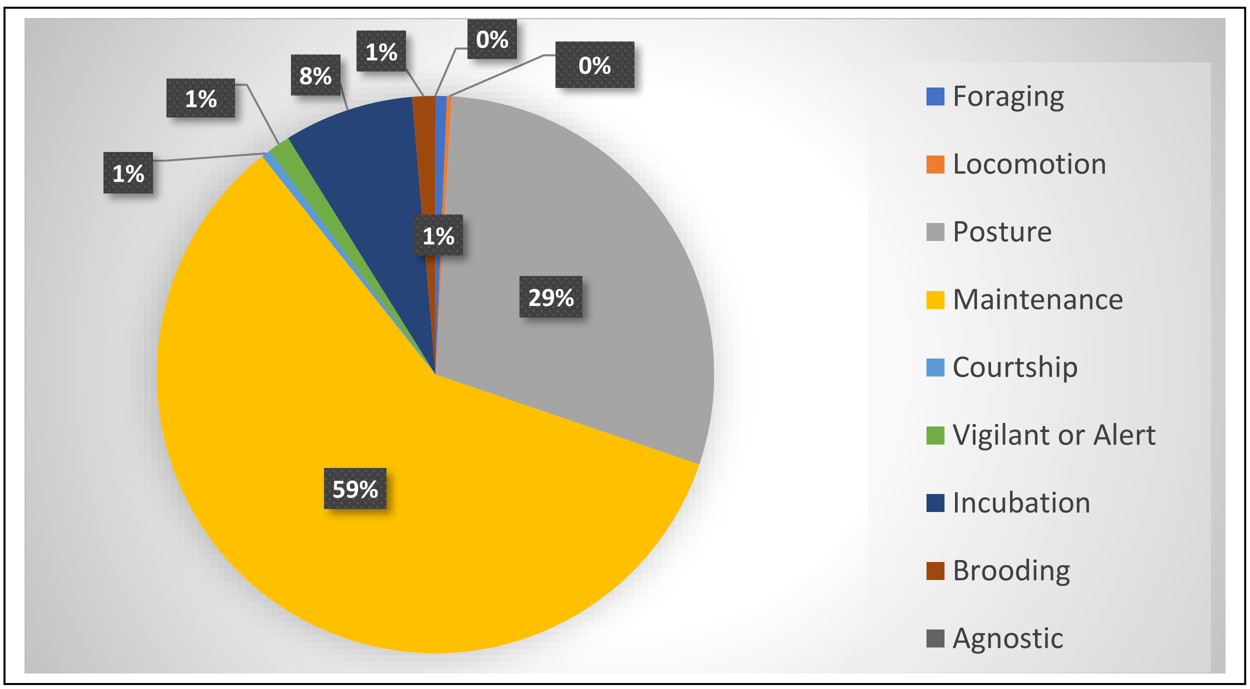


Figure 14. Focal time budget of Great Blue Herons at the Slate River colony in Crested Butte, Colorado from early May to the end of August 2019.

Photo by Jake Bartholomew

Overall, from 2 April to 2 September, 98.8% of our observations were of Great Blue Herons within their nests. They spent the largest proportion of their time in self-maintenance activities (59%), especially preening and stretching. Herons spent 29% of their time performing a posture with no associated behavior (standing upright, sitting in the nest, or laying in the nest). Brooding behaviors (primarily attending to the chicks) occupied 1.1% of their time, while herons spent 8% of their time incubating eggs. In our observations, again mostly of herons at the nest, they spent less than 1% of their time foraging or in locomotion (moving through the wetlands or flying). They were vigilant or alert for 1% of their time and courtship and agnostic behaviors accounted for 1% of their behaviors at the nest (Figure 14).

Focal activity budgets of adult Great Blue Herons and chicks

Adult herons spent more of their time incubating eggs and brooding young, in contrast to chicks. Chicks spent 64.1% of their time in self-maintenance behaviors and less than 1% of their time being vigilant or alert in the nest (Table 10).

Table 10. Adult and juvenile Great Blue Heron focal time budgets (% time spent in activities). Total observations of adult birds was 142 compared to 103 juveniles.

Behavior	Adult	Chick	p	t	Sample Size
Foraging	0.2	1.2	0.06	-1.90	246
Locomotion	0.2	1.1	0.61	-0.55	246
Posture	27.0	32.0	0.32	-0.988	246
Maintenance	54.9	64.1	0.17	-1.37	246
Courtship	0.8	0.2	0.05	1.99	246
Vigilant/Alert	1.6	0.8	0.07	1.82	246
Incubation	12.6	0.00	NA	NA	NA
Brooding	2.2	0.00	NA	NA	NA
Agnostic	0.00	0.1	0.18	-1.35	246
Total (% time spent in behaviors)	99.5	100			

Seasonal differences in Great Blue Heron behaviors
Adult heron behaviors were compared between the egg stage (incubation) and the nestling stage (brood rearing). These comparisons are more seasonal in nature than they are specific to the life cycle event, as breeding stages could not be assessed for each individual since we did not have marked herons. The nesting stage is defined by the period up to the last hatch nest (5 July). Maintenance behavior was the dominant activity during both incubation (55.4%) and nestling (57.5%). Time allotted to maintenance and posture (greater than 90% of time budget) reflects the importance of these behaviors and the low flexibility of behaviors when constrained by nesting, as well the strong association of adults to the nest throughout April to July (Table 11). Foraging and locomotion accounted for less than 1% of the behaviors during both incubation and nestling (again most of these observation were of herons in their nests). Importantly, low percentage behaviors do not represent unimportant behaviors such as vigilance which might be directly tied to survival.

Table 11. Adult Great Blue Heron focal time budgets (% time spent in behaviors) in incubation stage and nestling stage.

Behavior	Incuba -tion	Nest-ling	p	t	Sample Size
Foraging	0.8	0.5	0.81	0.24	142
Locomotion	0.6	0.2	0.61	-0.54	142
Posture	40.1	26.7	0.11	1.58	142
Maintenance	55.4	57.5	0.60	-0.53	142
Courtship	0	0.8			
Vigilant/Alert	1.4	1.1	0.60	-0.55	142
Incubation	0	11.3			
Brooding	0.8	1.4	0.54	0.61	142
Agnostic	0	0			
Total (% time spent in behaviors)	99.2	99.7			

Great Blue Heron behavior relative to time of day
Time spent in behaviors did not differ significantly for adult Great Blue Herons in relation to time of day (Table 12). We observed very little brooding behavior in the morning (0.46%) and it tended to be higher during the day (1.8%), but these apportionments did not differ significantly ($p=0.29$, $F=1.23$, $N=142$). Incubation also tended to be higher in the day time (9.3%) compared to morning (4.3%) and evening (1.2%) (Table 12).

Table 12. Adult Great Blue Heron focal time budget (% time spent in behaviors) comparing behaviors by time of day.

Behavior	Morning	Day	Evening	p	F	Sample Size
Foraging	1.3	0.5	0			
Locomotion	0.2	0.4	0			
Posture	37.1	27.9	24.4	0.242	1.42	142
Maintenance	52.7	58.3	65.8	0.27	1.29	142
Courtship	0.8	0.5	0.4	0.56	0.57	142
Vigilant/Alert	1.5	1.1	1.4	0.357	1.03	142
Incubation	4.3	9.2	1.2	0.43	0.84	142
Brooding	0.5	1.8	1.2	0.29	1.23	142
Agnostic	0.1	0.02	0.1			
Total (% time spent in behaviors)	98.6	99.6	94.5*			

*5.3 out of view

Human activities and potential disturbances to the Great Blue Heron colony

General disturbances

On 105 days we conducted 136, 1-hour observation bouts to sample potential disturbances around the heron colony from 4 April until 4 September 2019. Data were collected from 0545-1858. We recorded 7,095 human activities on the Slate River Road, trails, the sky above, and the Slate River (Table 13). The large majority of human activities documented in the Slate River valley occurred on the Slate River Road. We documented 5,675 cars and trucks representing 80% of total activities (Figure 15). The second most abundant human activity included bicyclists, runners, and hikers, and we documented 1,088 (15%) of these activities. We observed a total of 59 watercrafts on the Slate River during the surveys, representing less than 1% of total documented activities (Table 13).

Of the 7,095 events, 176 led to possible heron behavior disturbances. Herons responded in four ways to human activities and other potential disturbances: no noticeable behavior change, change to alert behavior in the nest (21 adult herons, 70 chicks), hunkering or getting low in the nest (73 adults or chicks), or flush (fly from the nest, 12 adults). Four of the 10 types of human activities did not elicit a heron disturbance behavior (heron observers, bicycles, trailers/campers, and snowmobiles) (Table 13). Chick alert behavior was observed during 70 (40% of the 176) of the disturbance events, adult alert behavior was observed 21 times (12%), chick hunkering was observed 73 times (41%), and heron flushes were recorded 12 times (7%). Of the total disturbance events recorded, 54 included loud noises (0.01%), including a chainsaw that was running at 1900 and 5 chicks, already in roosting behavior became alert.

Table 13. Human activities and other potential disturbances adjacent to the Slate River Great Blue Heron colony and potential disturbance related to types of human events. Data was collect from May through the end of August 2019 in 136 1-hr sampling bouts.

Human Activity	Number of disturbances	Percent of total disturbances	Number of noise events	Number of people	Adult herons alert	Heron Chicks alert	Chick hunkering	Heron flushes
Car and Trucks	**5,675**	**80.0**	**3**	**5,675**	**6**	**12**	**0**	**0**
Other Vehicles	**202**	**2.8**	**7**	**202**	**0**	**3**	**0**	**0**
Snowmobile	1	0.01	0	1	0	0	0	0
Trailer/Campers	91	1.3	0	91	0	0	0	0
Motorcycles/Dirt bikes	110	1.5	7	110	0	3	0	0
Bikes and Runners/Walkers	**1,088**	**15.3**	**1**	**1,088**	**0**	**3**	**0**	**0**
Bikes	984	13.9	0	984	0	0	0	0
Runners/Walkers	104	1.5	1	104	0	3	0	0
Heron watchers	**32**	**0.4**	**0**	**32**	**0**	**0**	**0**	**0**
Miscellaneous	**37**	**0.52**	**30**	**12**	**1**	**14**	**0**	**0**
XC Skiers	**2**	**0.03**	**2**	**2**	**2**	**0**	**0**	**0**
River watercraft	**59**	**0.8**	**11**	**68**	**12**	**38**	**73**	**12**
Total	**7,095**	**100.0**	**54**	**7,079**	**21**	**70**	**73**	**12**

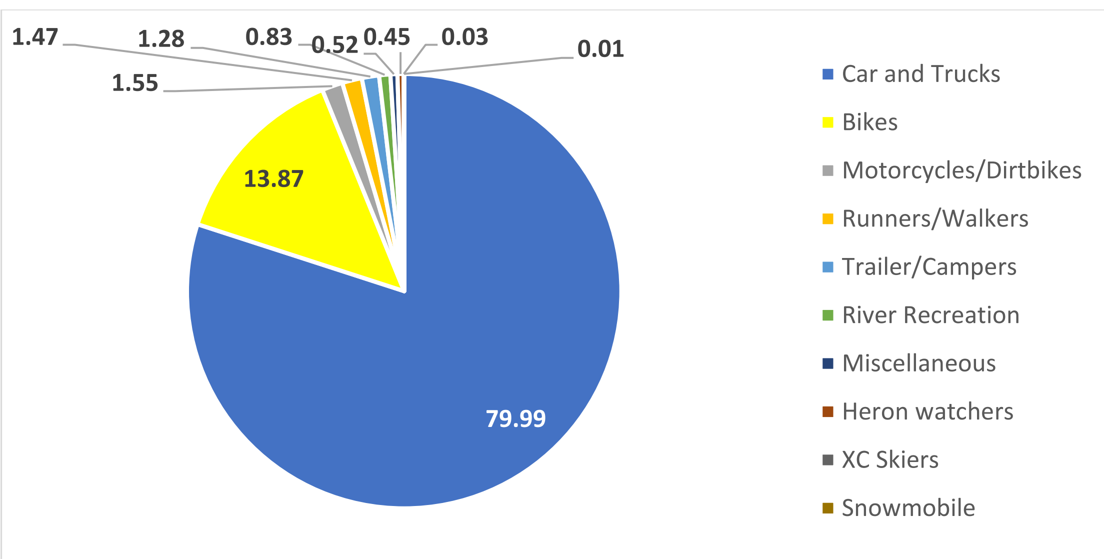


Figure 15. Human activities recorded in 1-hr observation bouts in the vicinity of the Slate River heronry represented as percentages.

Based on the 136 disturbance sampling bouts, the mean number of human activities per hour at the Slate River colony was 52.2 events per hour. This included 41.7 cars/trucks per hour, 7.2 bicyclists per hour, 0.8 runners/hikers per hour, 0.8 motorcycles/dirt bikes per hour, and 0.7 campers/trailers per hour. Watercraft accounted for 0.4 events per hour. Other activities accounted for less than 0.1 event per hour (Table 14).

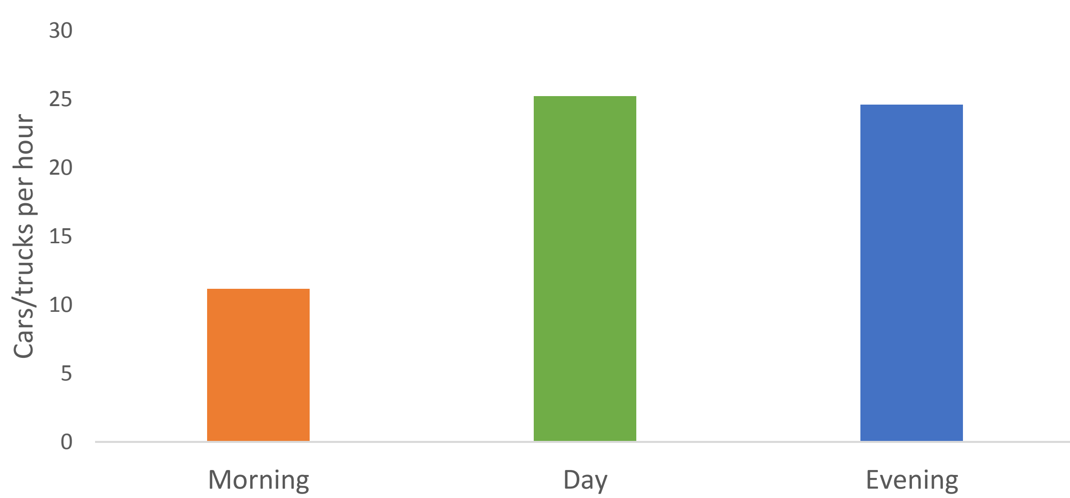
Table 14. The rates of human activity per hour in the Slate River valley.

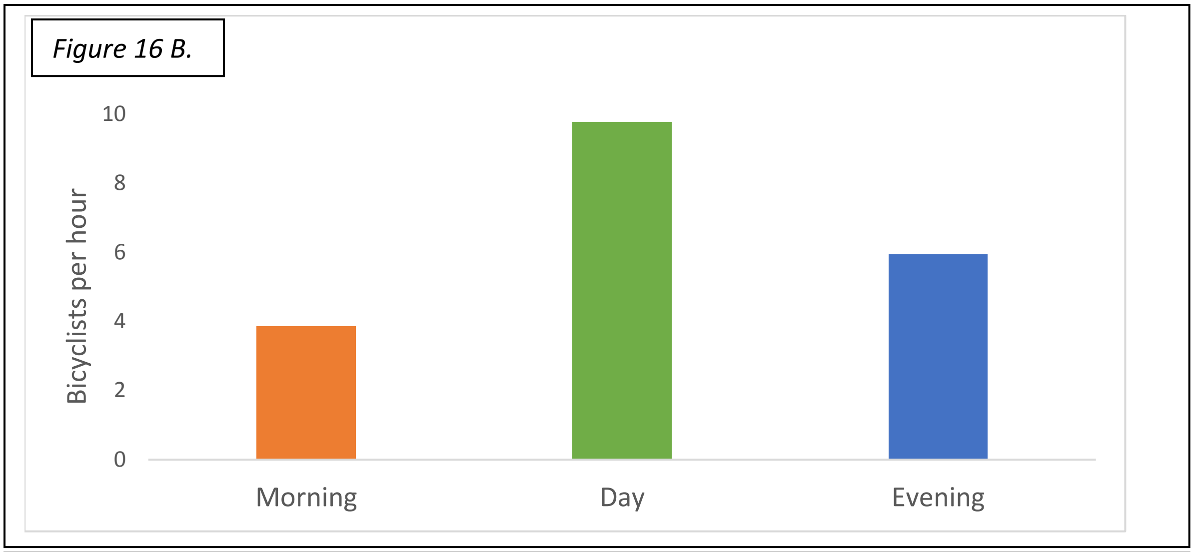
Disturbance type	Events/hour
Cars and trucks	41.7
Bicycles	7.2
Hikers and runners	0.8
Motorcycles	0.8
Campers and trailers	0.7
River recreation (floaters)	0.4
Total	52.2

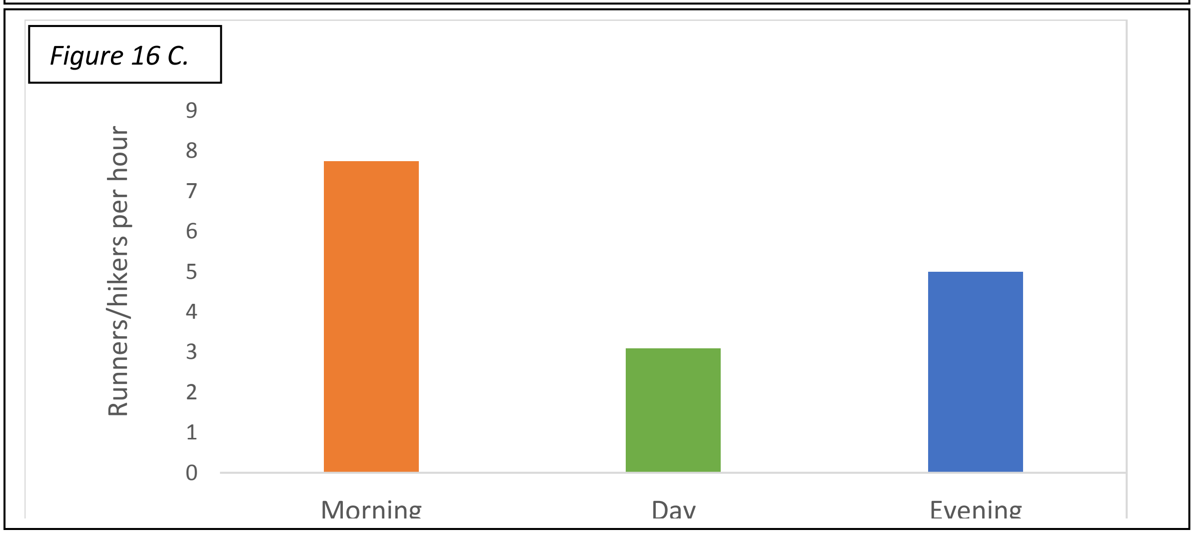
Disturbance by time of day

Human activity varied by time of day with the fewest activities in the morning (mean of 43.6 events per hour from 545-1000) compared to the peak in the middle of the day (44.1 events per hour from 1000-1500) and activity remained fairly constant through the late afternoon and evening (43.2 events per hour from 1500-1858) (Figure 16). Generally, runners and hikers had their highest activity in the morning (especially on Slate River Road), bicyclists peaked at midday (on both Slate River Road and Smith Hill Road). Car traffic increased from morning to mid-day and stayed high through most of the early evening. River recreation was not observed before 10 am and peaked at midday (Figure 16).

Figure 16 A.







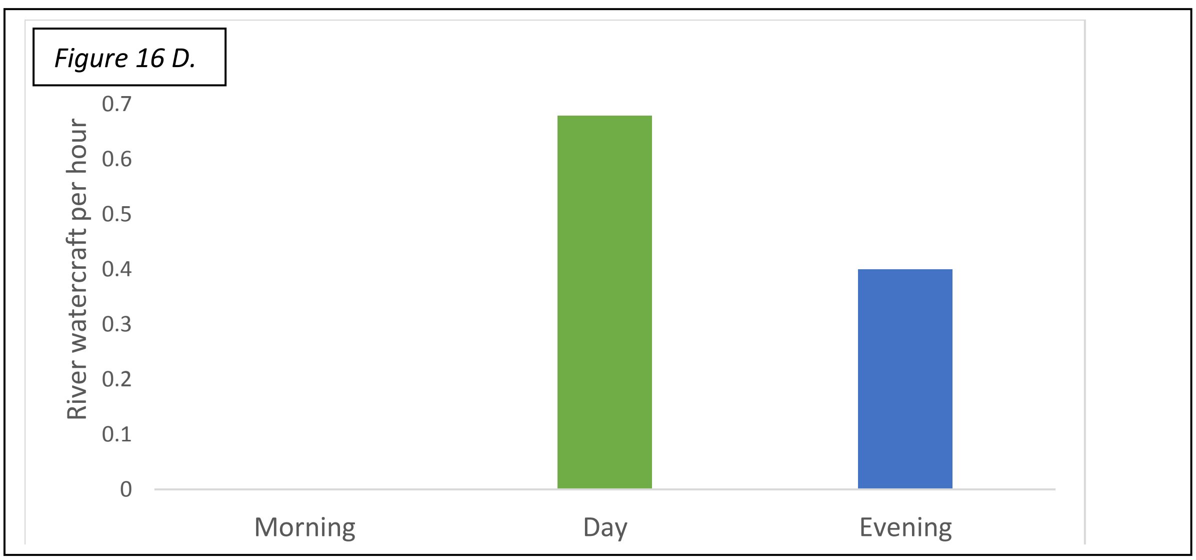


Figure 16 A-D. Rates of human activities in vicinity of Slate River Great Blue Heron rookery in relation to time of day during 2019.

Disturbance by month

The rate (#/hr) of human activities in the Slate River valley peaked on the 3rd weekend of July 2019 (Figure 17). Two cross country skiers were observed (on 14 and 18 April) and one of these led to two herons becoming alert. A total of 32 people stopped at the Great Blue Heron observation pull-off on the Slate River Road in July and August; the presence of these observers was not associated with any heron disturbance behaviors. River recreation was only observed in July and August (Figure 17).

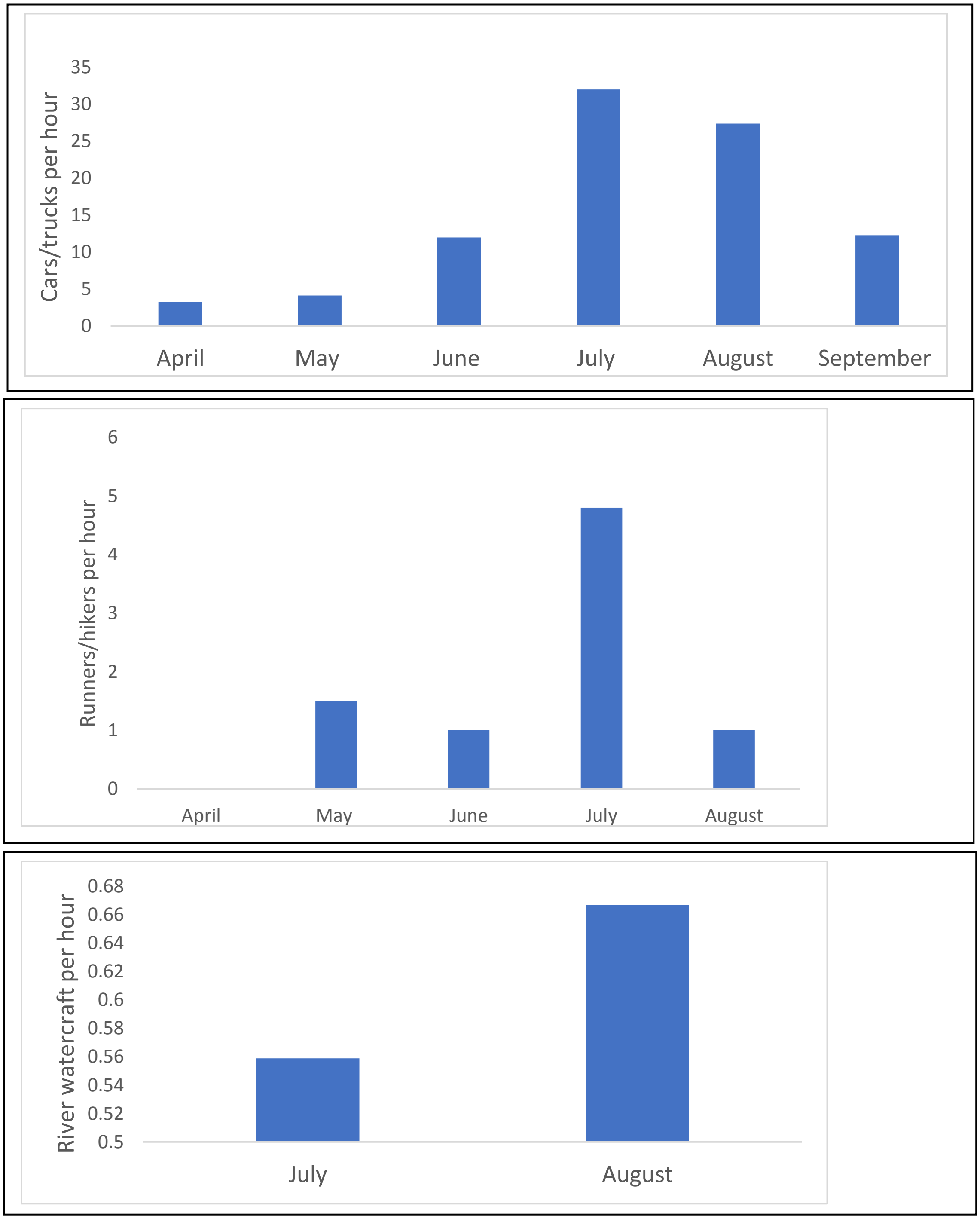


Figure 17. Seasonal human activity in the upper Slate River valley from April-September 2019.

River recreation
In addition to documenting 59 watercraft during the 1-hr observation bouts, we also conducted targeted observations of floaters to better assess relationships between floating and heron responses. We observed 44 additional floaters during these targeted observations. Using both methods, from 14 July to 10 August we recorded 45 events (groups of floaters) on 15 days where watercrafts floated the Slate River through the heron colony reach. No river recreation was recorded during our sampling times prior to 14 July. The river was closed by Gunnison County from 6 June to 14 July for safety reasons due to high water flows and the Slate River Working Group instigated a voluntary closure for 2019 from mid-March to 15 July. We did not observe any floater recreation after 10 August 2019. River flows were low at this date and the Slate River Working Group has recommended no floating after the river reached these low (bony) flows (110 cfs).

The 43 groups of floaters consisted of 104 water crafts including 84 SUP boards, 9 kayaks, 8 duckies, and 3 rafts (Table 15, Figure 18). A minimum of 123 people floated the colony stretch, with groups ranging in size from 1 floater (n=6) to 6 floaters (n=2). The most common group size was 2 (n=18). We observed groups of 5 or more people on nine occasions. Of these nine large events seven were associated with a noise event, five of these nine events had a stopping event under the colony, and 59 heron behavior changes were associated with these nine large events. The earliest group floated through the colony at 1057 and the latest floaters arrived at the colony at 2010 (near dark). The mean float time was 1425.

Table 15. Summary of river recreation by craft type.

Craft Type	Total Crafts	Percent of Total	Number of Noise Events	Heron Alert	Heron Hunkering	Chick Alert	Chick Hunkering	Heron Flush
SUPS	84	80.8	17	15	0	64	104	22
Duckies	8	7.7	4	2	0	13	6	6
Rafts	3	2.9	1	3	0	1	4	2
Kayaks	9	8.6	2	6	0	5	4	1
Total	**104**	**100.0**	**24**	**26**	**0**	**83**	**118**	**31**

Of the 104 watercraft, 16 stopped in the heron stretch. Twenty watercraft users could be heard from 300 m or more away from the colony. Eight adult herons and 35 chicks became alert when floaters were loud. Furthermore 17 heron chicks hunkered in their nests and 2 herons flushed during loud floats. The shortest flush duration was 0.5 minutes and the longest was 39 minutes; there were at least six events where a heron flushed and never returned during that observation period.

Watercraft events accounted for 71% of adult heron alert, 68% of chick heron alert (Figure 19), 100% of chick hunkering, and 100% of heron flushes when accounting for all types of human activity. Zero non-watercraft events triggered heron flushing and while river recreation accounted for less than 1% of all human activities in the Slate River valley (Figure 15), this recreation type was tied to 68-100% of heron disturbances.

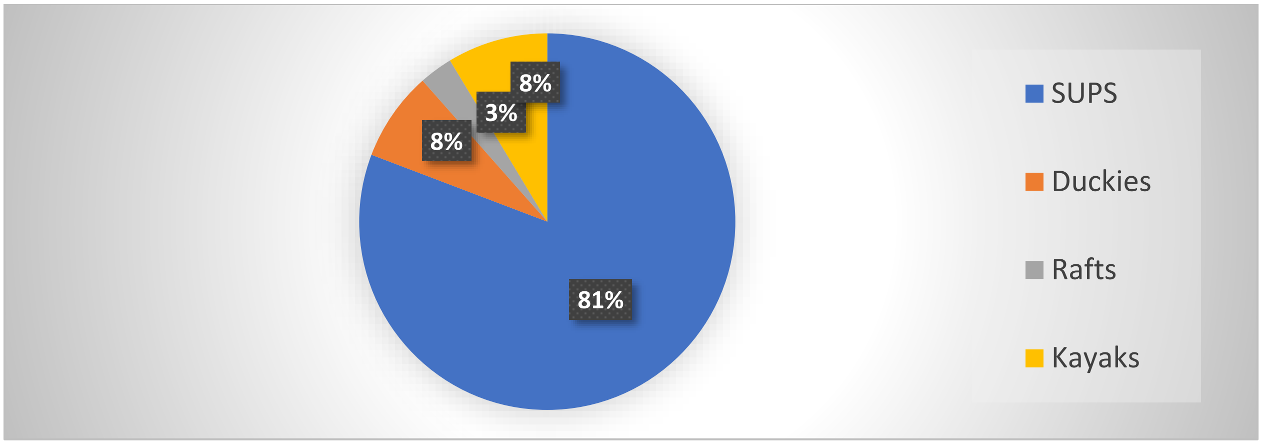


Figure 18. River recreation on the Slate River consisted of various watercraft and stand-up-paddle (SUP) boards were the most numerous.

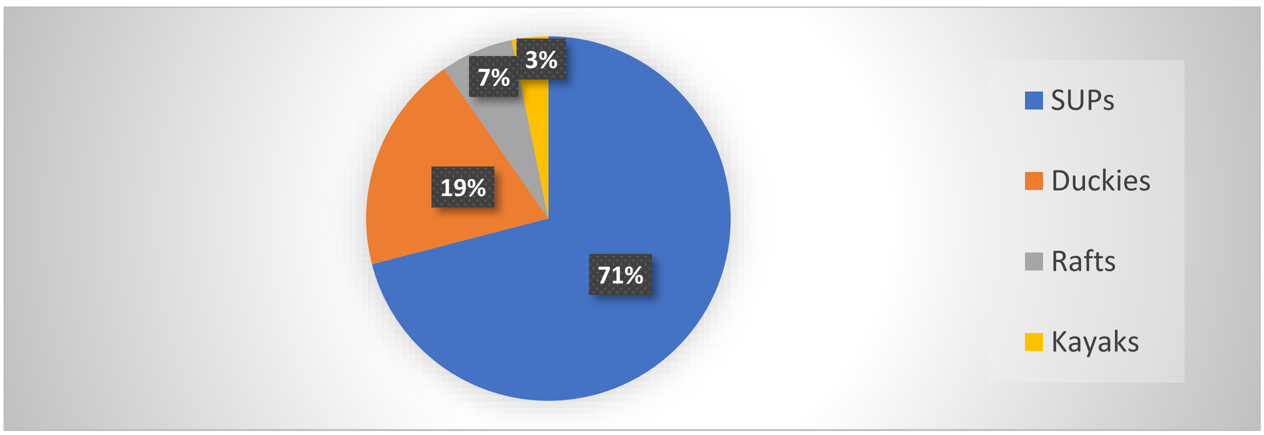


Figure 19. Adult heron flushes compared to craft type.

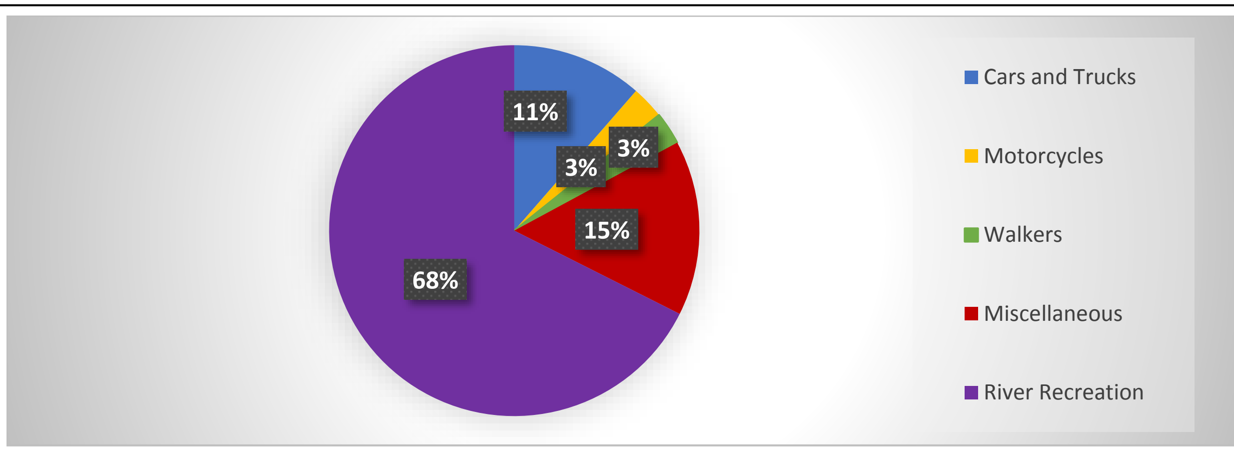


Figure 20. Percent chick alert behaviors associated with various human activities at the Slate River heronry in 2019.

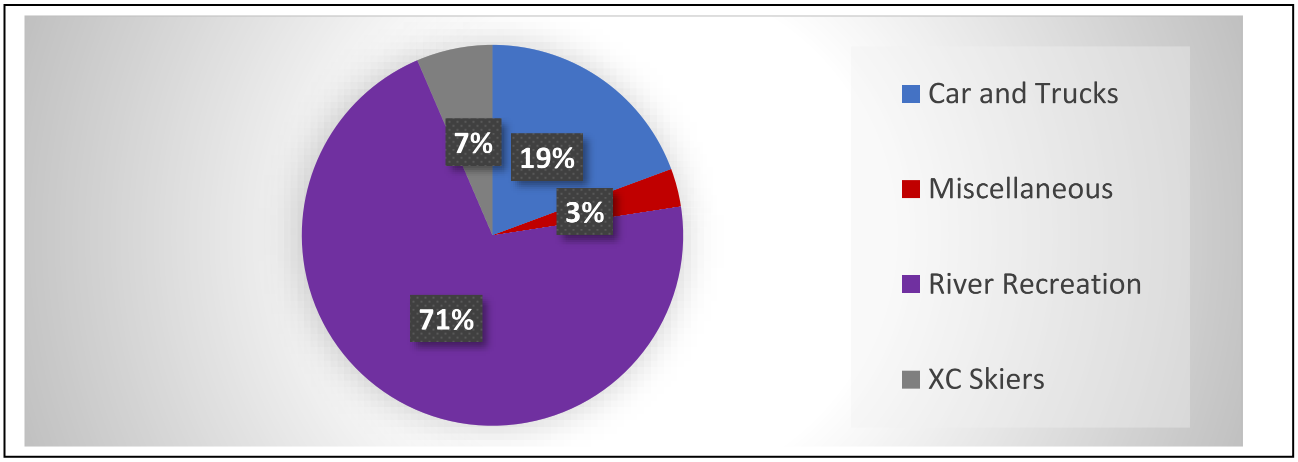


Figure 21. Percent adult heron alert behaviors associated with various human activities at the Slate River heronry in 2019.

Aircraft and non-human disturbances

We did not consistently record aircraft during 2019, but from 21-26 July one observer recorded 23 aircraft, all of which were classified as noise events. Despite the potential for disturbance, these plane events were linked to just 2 chick alert behaviors. On the other hand, an osprey was observed flying close to the heronry and 4 chicks became highly alert on 25 July, when only 4 nests were active with 8 resident chicks. The chicks remained in high alert for 2 minutes. Interestingly, a turkey vulture flew over the colony that same afternoon and did not elicit a response by herons, although the bird was at a much higher altitude. A red-tailed hawk was observed on 28 August, when only one nest remained active. Three of the four chicks became fully alert.

Discussion

Phenology and nesting demography

Our study provides basic phenology data for breeding Great Blue Herons at the Slate River rookery in 2018 and 2019 (Table 16). Phenology was similar among years except that the birds arrived slightly later (4 days) in 2019 and breeding activities extended 18 days longer in 2019 with the last heron chick fledging in early September. Spring arrival was on 17 March 2019, compared to 13 March 2018. In 2018, nests were clear of snow and Crested Butte had 8" of snowpack on arrival date, whereas snowpack was 36" (ncdc.noaa.gov) and nests were covered with 1-2 foot snow pillows on arrival date in 2019. Herons occupied nests (or at least the edges of nest platforms) despite the snow cover. With the Slate River frozen and the valley blanketed in three feet of snow and the snowpack persisting until 16 April, it is interesting to think about the juxtaposition and availability of food and foraging habitats in relation to the timing of arrival at the colony. In 2019, foraging habitats were not available in the local wetlands around the colony at least until early April and herons were required to make longer flights or acquire fewer meals. An advantage of arriving early to the colony is to obtain valuable nest sites (which are costly in time and energy and challenging to build) and early breeders tend to produce more fledglings (Vennesland and Butler 2011). However, a trade-off of early arrival could be reduced reproductive success if food is scarce or requires more effort to obtain. Because the location of a colony is partly dictated by surrounding foraging habitats and adequate availability of food (Gibbs et al. 1987, Gibbs 1991, Vennesland and Butler 2011) reduction in food availability in some years could have fitness consequences (clutch size or fledgling success reduction) or limit colony size (Gibbs et al. 1987).

Table 16. Phenology of Great Blue Herons breeding activities at the Slate River rookery in 2018 and 2019 compared to other studies. Phenological data for herons from the Birds of North America account (Vennesland and Butler 2011) and otherwise more specific citations are provided.

Life cycle event	Slate River Heronry 2018	Slate River Heronry 2019	Birds of North America (Vennesland and Butler 2011)
Spring migration Arrival	13 March	17 March – 18 May (8.7 weeks)	Varies from early February to early May across North America
Gathering Grounds	Not observed	Not observed	In some locations herons gather in flocks before entering colony site
Courtship and pair formation	No data	17 March – early May (8.4 weeks)	Late March in Alberta (Vermeer 1969) and British Columbia (Butler et al. 1986)
Nest building	13 March – ?, No data	17 March – 14 June (12.6 weeks)	3 day to 2 weeks
Egg laying	9 April – 21 May (6 weeks)	12 April – 7 June (7.9 weeks)	3rd week of March in Idaho (Collazo 1981) Late April in Alberta (Vermeer 1969)
Incubation Egg Stage	9 April – 23 June (10 weeks)	12 April – 5 July (12 weeks)	Males and females incubate for 27-29 days; Males incubate for 10 hr/day, females incubate for 3.5 hr/day and at night (Brandman 1976) Adults incubate for 54 min/hr (Pratt 1970)
Hatching	7 May – 23 June (7 weeks)	10 May – 5 July (8 weeks)	Eggs hatch 1.5-2.0 days apart (Mock 1978) or on same day (Pratt 1970)
Brooding Nestling Stage	7 May – 15 August (14.2 weeks)	10 May – 2 September (16.4 weeks)	Begins immediately after hatching and lasts 3-4 weeks. Peak provisioning occurs at 29 days and chicks fed regurgitated food until day 30. Two day old chicks fed 10 times in 13 hours and 65 day old chicks fed twice in 15 hours (Pratt 1970).
Fledging	3 July – 15 August (7 weeks)	7 July – 2 September (8.1 weeks)	Occurs 7-8 weeks post-hatch (Werschkul et al. 1977, Quinney and Smith 1979). First flight at 52 days in Alberta (Vermeer 1969), 81 days in California.
Post-fledging dispersal	Fledglings largely disappeared immediately after fledging	Fledglings disappeared after fledging; some returned to nest or lingered in wetlands	Fledglings may return to nest for up to 3 weeks post-fledge and be fed by adults (Quinney and Smith 1979) or return by themselves (Butler 1997).
Second Broods	None observed	None observed	Occurs in locations with long nesting period. Some herons choose a new mate especially if first brood failed.
Fall migration Departure	No data on timing or locations	No data on timing or locations	Mid-September to late-October, November in Alberta and December in Ontario.

Timing of nesting differed somewhat in 2019 from 2018 (Table 16). Our data were employed by the Slate River Working Group after the 2018 nesting season to recommend dates for voluntary river recreation closure from mid-March to 15 July. In 2018, 50% of active nests were completed by 15 July, whereas in 2019 only 35% were completed, but by 17 July 55% had fledged all chicks (Figure 8). By 1 August 2019, 17 nests (85%) had fledged. The last fledgling left the nest on 2 September in 2019, 18 days after the last chick fledged in 2018. In 2018, only one nest was active in August, whereas three nests were active in August 2019. These data indicate that nesting dates are variable across years, but even in two years with different environmental conditions and possible differences in food accessibility, the general phenological pattern shifted by a few days to 2 weeks. That timing of heron nesting varies among years should be considered in making management recommendations that attempt to minimize human disturbances at the colony.

Most fledged chicks (now called fledglings or juveniles) apparently departed the Slate River valley soon after fledging. Similarly, in another study, within a few days juveniles dispersed 20-60 km from their colony (Erwin et al. 1996). Commonly, though, juvenile herons forage and roost in habitats adjacent to nests and often return to the nests (Vennesland and Bulter 2011). In 2019, we observed more of this "staying" behavior than in 2018. A few chicks returned to nests several days after fledging and we observed a few fledglings in beaver ponds and oxbows below the nest sites. Adults seemed to leave the local wetlands and nesting colony soon after the last chick fledged.

We documented 40 adults in 20 active nests in the Slate River Great Blue Heron colony in 2019. Only one active nest failed to produce chicks. Nest #3 was occupied and the adults exhibited signs of incubation, however, not a single chick was produced despite the adults occupying the nest until 16 July. The other 19 nests produced 47 chicks, 41 of these fledged. We documented 27 total nests, 20 of which were active in 2019. In 2018, 25 active nest were documented. Great Blue Heron rookeries can contain 500-1,000 nests (Witt 2006), however in Colorado heronries with greater than 20 nests are considered large colonies (Brown and Dexter 2016). Colonies with more than 20 nests have greater productivity (Vennesland and Butler 2011) and persist longer (Kelly et al. 2007). The colony size threshold is a key population monitoring metric to assess productivity and likelihood of persistence in the Slate River valley into the future. When the colony was established by herons (perhaps 30 years ago) many site factors differed including the amount of human development and activity in the valley. The question is how resilient are the herons in the face of a complexly changing colony site?

Photo by Ellie Orr

We did not document clutch size due to the difficulty of seeing into the nest, but generally Great Blue Herons lay a clutch of 1-6 eggs and produce 1.5-3.3 fledglings per successful nest (Vennesland and Butler 2011). Brood sizes for the Slate River colony ranged from 1-5 in 2018 with an average of 2.7 ± 1.2 chicks per nest and 2.7 successful fledglings (100%) per nest (Magee and Zareba 2019). In 2019, brood sizes ranged from 1-4 chicks with a mean of 2.5 ± 1 chicks per nest and 95% fledging success. The mean number of fledglings produced for all initiated nests was 2.05, and the mean number of fledglings per successful nest was 2.15. In other studies, total fledglings per initiated nest ranged from 0.5-2.7 and total fledglings produced per successful nest was 1.5-3.3 (Vennesland and Butler 2011). No 5-chick broods were observed in 2019 and this could represent diminished food resources. We also observed 6 chick mortalities (89% fledgling success) compared to no mortalities in 2018. Our brood sizes were in the mid-range of clutch sizes reported for other studies (1-6) with means usually over 3 eggs per nest (Vennesland and Butler 2011). The variation in clutch size is partly explained by geography with clutch size increasing with latitude (Rubolini and Fasola 2008). Our mean brood size of 2.5 chicks per nest is probably on par with averages for other studies when accounting for survival from egg stage (clutch size) to chick stage (brood size). But it could be somewhat low for this population especially if high elevation demography parallels high latitudes. Lower reproductive performance could indicate low food availability or impacts such as human disturbance leading to stress and slower weight gain and growth.

The Slate River heronry had high nest success in 2018 (100%) and 2019 (95%) and high fledging success of 100% in 2018 and 95% in 2019. In 2018, no brood size reduction was observed (100% fledgling success) but in 2019, 6 chicks apparently died during the nestling stage and failed to fledge (89% fledgling success). We observed red-tailed hawks, osprey, eagles, and turkey vultures near the rookery, but no depredations were detected. It is possible that some chicks perished near fledging time when they were large and there was limited room for movement in the nest. The potential for smaller chicks in a larger brood being pushed out of the nest is possible but was not seen during our sampling periods. While we typically observed the nests 5-6 days per week, we didn't observe every fledging event and we made the assumption that chicks fledged successfully if they were large and ready to fledge one day and were gone the next observation day. Most brood reduction occurs before week 5 of chick rearing (Pratt 1970, Pratt and Winkler 1985) when chicks are much smaller (incapable of thermoregulation and at-risk of predation) and when they are the most vulnerable due to nutritional and energetic demands and competition with siblings (Butler 1997). The post-guardian stage begins around week 5 when adults spend much less time at the nest (Butler 1997) leaving the youngest chicks with distinct survival disadvantages. With the high fledgling success at the Slate River, adult herons apparently have adequate food supplies but little is known where these birds forage and what prey they consume. Further, more knowledge of the seasonal dynamics of their food supply in the context of ice cover, snowmelt, river flows, beaver activity, distribution of foraging habitats and distances traveled to feed, among other factors, would help elucidate the import role of food in this heron population.

We attempted to gain further knowledge of the early season nesting activities of the Great Blue Herons at the Slate River rookery, as only a few observations were conducted before May in 2018. We documented nesting behaviors beginning in April 2019 with some observations beginning on 17 March. We gained further insight on nest site selection, nest building, courtship, pairing, mating, and nest initiation through our early season observations. This study also documented the dynamic nature of nest destruction and construction. In 2019, nests 9, 13, 15, and 16 were completely dismantled, mostly by herons pirating sticks for their nests. Of these, Nest #9 was completely rebuilt in the same location and occupied late in the season (7 May). The other nests no longer exist. Nests 1, 11, and 12 were also largely rebuilt adjacent to their 2018 location. Nests 27, 28, and 29 were newly constructed in the Lower Colony. Numbering nests is critical to documenting nesting demographics and in some cases it can be difficult to observe every nest due to obstructed views through dense vegetation from the varying vantage points we used. The Wildbird Ridge observation point (Figure 3) provided the closet range and allowed for the observation of what we considered the backside of the colonies. A few nests were easier to observe from the east side location rather than from the Wildbird (west) side. Multiple perspectives are required to obtain accurate counts and observations of heron behaviors, therefore we rotated the locations from which we observed. Continuation of nest numbering and recording seasonal changes in individual nest persistence and use is recommended.

We have no information on heron nest fidelity at Slate River. In 2018, 26 nests were present and 25 were active. In 2019, 27 nests occurred throughout the season and 20 were active. It is unknown whether the same breeding adult herons from 2018 returned to the colony in 2019 or whether new recruits bred in Slate River in 2019. It is also unknown if returning herons used their previous nest or claimed a new nest. In one study, 13 of 14 marked herons that returned to their previous colony used different nests (Simpson 1984). It is likely that many Slate River adults herons return from year to year as the colony appears to be somewhat stable and has persisted for at least 20 years. But how many of the chicks from previous years recruit to the colony or prospect for new breeding locations? What is the role of yearlings (hatched one year ago) who are non-breeders in heron populations? Are they present at the Slate River colony? We have no direct evidence of yearlings observed in our study.

Time Activity Budgets

Our study documented Great Blue Heron adult and chick activities from May to early September within the nests and relatively few samples of herons in the vicinity of the wetlands surrounding the colony. Nest behaviors of adults and chicks showed that maintenance and non-distinct behaviors of standing, sitting or lying in the nest, accounted for more than 90% of the time at the nest. It is important to emphasize that amount of time spent in a behavior is not necessarily an indication of the importance of the activity. For example, adult herons and chicks never spent more than 2% of their time being alert or vigilant. While this is a small percentage of time, it may be one of the most important behaviors related to survival. Foraging time was not accurately represented due to the majority of the observations being conducted in the nest and we only observed feeding when adult herons brought food to the nest. Further analyses of behavior data will be done after the 2020 season and we also intend to add an energetics component to the study. This would provide insight into the time and energy budgets of herons at the Slate River rookery. This will also include a more concerted effort to document behaviors outside of the nests and to identify important foraging habitats used by the Slate River herons. In addition, we will attempt to identify heron gender, which is challenging but bill length can be used to differentiate sexes (Butler 1997). Also, in the next field season we will attempt to better differentiate age classes. For clarity, age classes include: chicks – young in nest; juveniles – fledged young until following breeding season; yearlings – from 1-2 years old, non-breeders; and adults – 2+ years old, potentially breeding (Butler 1997). These age-classes can be differentiated by plumage, although distinguishing yearlings and adults can be challenging (Butler 1997).

Human Disturbance

Summer recreation in the Slate River valley overlaps with nesting and brood rearing events of the Great Blue Heron colony, leading to the disruption of life cycle events. Researchers have documented negative impacts of human activities in proximity to Great Blue Heron rookeries including colony abandonment, reduced survival, and lowered reproductive success (Kelsall and Simpson 1979, Parker 1980, Drapeau et al. 1984, Forbes et al. 1985b, Leonard 1985, Vos et al. 1985, Parnell et al. 1988, Butler 1992, Hockin et al. 1992, Corley- Martinez 1995, Carlson and McLean 1996, Vennesland 2000, Gebauer and Moul 2001, Machmer and Steeger 2004, Vennesland and Butler 2004, Vennesland 2010). A few studies suggest habituation of herons to human activity is possible, especially when generous food sources are available (Thompson 1977, Butler 1997, Nisbet 2000, Vennesland 2000). Human activities in the Slate River valley are relatively low in frequency and abundance from March through May, and peak in July. Our results suggest that 99% of human activities have little behavioral impact on the herons, but less than 1% of activities, represented by river recreation, accounted for 71% of adult heron alert behavior, 68% of chick heron alert behavior, 100% of chick hunkering behavior, and 100% of heron flushes. In the context of the Slate River heron population, currently only river floating represents a threat to the stability and persistence of the heronry.

Great Blue Herons are especially vulnerable to human disturbance early in the nesting season (Vos et al 1985, Butler 1995, Vennesland 2010), when they are more likely to abandon a nest during pair formation, nest building, and egg laying (Machmer and Steeger 2004). After the eggs hatch the probability of nest abandonment declines (Vos et al. 1985, Parnell 1988, Vennesland 2010), but the first 3-5 weeks of chick rearing coincide with the highest levels of brood reduction (Butler 1997). After the 5th week, nestlings in this post-guardian stage may be less vulnerable to predation and starvation (Butler 1997). Nevertheless, chicks are still highly vulnerable to human disturbance and impacts to their growth to fledge stage. During late incubation and throughout the nestling stage adult herons flush less frequently due to the large investment in the nesting effort (Vennesland 2000). This decrease in flushing is not necessarily associated with lower disturbance. At this time adults must increase their foraging effort to provide for their young and face the highest daily energy demands during this period (require 4,264 ± 764 KJ/day; Butler 1991). Disturbance of foraging adults could lead to a loss of feeding time and efficiency, and negative consequences, especially to the young (Machmer and Steeger 2004). For example, during one floating event an adult heron landed on the nest to feed its 4-chick brood and immediately flushed when a group of river recreationists entered the colony. The heron was interrupted before completing the feeding and did not return for the remainder of the observation period.

We first observed river recreation on the Slate River starting 14 July. Prior to this date, the Slate River was under legal closure due to high water and thus overlapped with the voluntary no float period (mid-March to 15 July). No floaters were observed at any time until a SUP board holding two people floated through the colony section one day before (14 July) the voluntary closure period ended. After this first observation, 42 other floating events involving 103 watercraft floated the heron section between 15 July and 10 August. By 10 August river flows were low (≤110 cfs) and floating was not recommended. The float season lasted 25 days in 2019. No floating disturbance occurred for the entirety of the incubation period (the last chick hatched on 5 July ending the incubation period) or during any of the nesting activities prior to incubation. Floating only coincided with the nestling stage for 25 of the 115 day period and much of this occurred during the post-guardian stage when chicks are less vulnerable to mortality (Table 8).

Most human activities in the Slate River valley occur at distances greater than 300 m from nests. River recreation, on the other hand, occurs directly below the heronry, providing no horizontal spatial buffer. While the nests, positioned in the crowns of lodgepole pines above the river bank, are high above the floaters, their height does not provide a sufficient buffer (approximately 40 feet or 12.2 m). Effective spatial buffers that separate human activity from heron nests should exceed 250-300 m (Buckley and Buckley 1978, Parker 1980, Taylor et al. 1981, Bowman and Siderius 1984, Vos et al. 1985, Quinn and Milner 1999, Machmer and Steeger 2004, Vennesland and Butler 2004). Our study suggests that river recreation by SUP boards, kayaks, duckies, and rafts result in disturbance behavior more than 9 times out of 10. However, not all river recreation has equal impact on herons. The way in which recreationists float the river impacts the level of disturbance. Other researchers reported that timing, frequency and magnitude influence the sensitivity of herons to disturbances (Vos et al. 1985, Vennesland and Butler 2004, Vennesland 2000, Vennesland 2010). After chicks have hatched herons may be especially sensitive to loud noises (Vennesland 2000). Factors such as loudness, group size, floater posture (standing vs. sitting or kneeling), time required to float through the colony, floater pauses, and the level of clustering potentially impact herons to various degrees. Our observations indicate that large (≥4 crafts), loud groups with upright floaters who pause and cluster through the colony section create more disturbance to the herons. We are developing a Floater Ethics Index to quantify floater behavior (group size, volume, speed, group density, posture) and associated heron response.

Management Implications

The location of a Great Blue Heron colony represents a unique convergence of physical, ecological, and intrinsic population factors at multiple spatial scales (Gibbs et al. 1987). These factors include adequate nesting habitat (mature relatively tall nest trees), adjacent foraging habitat supporting an energetically profitable food supply within a reasonable distance from the nest (Dowd and Flake 1985, Gibbs 1991), relative isolation from roads (Gibbs and Kinkel 1997) and human disturbances (Watts and Bradshaw 1994) or if human developments are nearby adequate disturbance buffers such as forest or water (Carlson and McLean 1996), and low risk of predation (Vennesland and Butler 2011). Further, nesting location can be influenced by previous nesting success at a specific colony (Butler 1997). Herons tend to have a low threshold for human or predator disturbance resulting in the potential abandonment of colonies (Parker 1980, Pratt and Winkler 1985, Vennesland 2000). Combinations of factors such as infrequent pedestrian travel in a colony site where bald eagle predation risk is high can lead to widespread nest failures (Vennesland and Butler 2004). Each colony site has a unique combination of site factors and limited appropriate heronry locations exist across the landscape. The Slate River rookery is unique in that it is relatively large (>20 nests), it occurs in a high elevation montane ecosystem in the crowns of lodgepole pines (only 5% of Colorado's colonies are in conifers; Brown and Dexter 2016), and it has persisted for over 20 years. Great Blue Heron colonies have been recorded at over 8,000 feet in Colorado's mountain parks (Cooke 1900, Sclater 1912), but colonies near 9,000 feet have not been documented. The Slate river colony is at 8,900 feet. It is unclear how long the heronry has existed but it is likely that the colony has been in its current location for at least 25 years. Significant tree mortality, especially in the Upper Colony, suggests long residence time as heron occupancy of crown nests leads to tree mortality due to fecal and food droppings (Julin 1986, Brown and Dexter 2016). The Upper Colony was likely inhabited first and the herons have been slowly moving toward the Lower Colony that has healthier trees with more live foliage. As the trees begin to die and fall, the heronry faces an uncertain future. That the nest trees are lodgepole pine may be problematic for long-term survival, as lodgepole pines are not specifically adapted to floodplain soils and hydrology. While the Slate River colony may be 25 years old or more, the longest persistence of a colony was 71 years (Kelly et al. 2007). The bottom line is that heron choice of a nesting site matters, in fact, is crucial to its survival and reproductive success. That herons occupy nearly permanent nest sites (persistent colonies) suggests that the right combination of nesting requirements only comes together in a few places and even these crucial nesting sites may vary in annual conditions and thus annual productivity.

Many of Colorado's Great Blue Heron colonies are highly transient (Miller and Graul 1987, Levad and Leukering 2002) and many experience large fluctuations from year to year (Levad and Leukering 2002). The Slate River colony had 25 active nests in 2018 and 20 in 2019. A large, long-lived colony likely contributes significantly to population stability over a regional landscape, as larger colonies tend to have higher productivity (Vennesland and Butler 2011) and are less prone to human disturbance and abandonment (Kelly et al. 2007). Annual monitoring of the Slate River colony and other sites in the Gunnison Basin would provide a better understanding of local temporal dynamics, population movements, and colony stability. It is likely that herons from the Slate River colony interact with birds from other colonies in the region and that population fluctuations among years are the result of varying juvenile survival in winter (Butler 1997), changes in adult distribution and recruitment to new colonies, and the capacity of the site to support a specific number of herons. Food competition among nesting adults limits colony size, while food competition among herons from neighboring colonies dictates colony distribution (Gibbs et al. 1987)

Spatial buffers have been useful in dampening disturbance effects in landscapes with significant human activity. In one study, however, the size of the buffer zone had no significant effect on heron fledge success (Carlson and McLean 1996). The Vermont Fish and Wildlife Department suggested restriction of all recreational activities within 200 m of rookeries (Vermont Fish and Wildlife Department 2002). In most cases recommended buffers range from 100-300 m. Great Blue Herons especially respond to activities at close range within their line of sight (Taylor et al 1981) and to novel or loud disturbances (Vennesland and Butler 2004).

In shared landscapes herons are able to habituate to peripheral human activities that occur greater than 500 m from colonies or in some cases at closer range when food bonanzas occur, but they rarely habituate to disturbances that occur closer than 300 m from nesting sites (Taylor et al. 1981, Corley-Martinez 1995, Parnell et al. 1988, Vennesland 2000). The vast majority of human activities occurring in the Slate River valley do not elicit a heron response, likely because they occur at distances greater than 250-300 m from the nests. River recreation, on the other hand, occurs directly beneath the colony and was associated with 100% of heron flushes and chick hunkering events, 71% of adult alertness, and 68% of chick alertness. In the Slate River valley, river recreation is the only human activity that occurs within the prescribed buffer distance. On one occasion we observed anglers that approached the colony from the Slate River Road. One of our observers interacted with the anglers before they accessed the wetlands and asked them to retreat due to the vulnerability of the herons. They retreated and the herons did not react to their presence. We also observed two cross-country skiers on the Lower Loop Nordic trail on two days in early April that elicited heron responses suggesting that the herons are vulnerable to this type of pedestrian traffic. A third skier was observed down in the river bottom.

The Slate River Working Group, a collaborative stakeholders group, has not proposed a floating closure on the Slate River to protect the herons through their breeding season (mid-March through August). A river closure would provide the spatial buffer and the highest level of protection for the heronry. Closing the river to recreational use is a complex issue and contentious among many stakeholders. A mandatory closure would likely trigger legal battles. Alternatively, in 2019, the Slate River Working Group proposed a voluntary seasonal closure on the Slate River from mid-March to 15 July. This compromise provided full protection for the heronry in the early season when nests are most vulnerable to abandonment and, based on our phenology and demographic data from 2018, by 15 July over 50% of nests were unoccupied due to nest completion by that date. Part of the purpose of our 2019 study was to assess compliance with the voluntary close. We only observed a single floating event on 14 July (one day before the end of the voluntary closure) in 2019. However, the big water year of 2019 led to a legal river closure for safety reasons (county sheriff's department) from 7 June to 14 July. As soon as the legal closure was lifted at least one watercraft floated the heron reach. In the absence of the legal river closure in 2019, it is unclear how effective the voluntary closure would have been in preventing floating during the early season for the herons.

Based on our heron nesting phenology data in 2019, the date when herons reached 50% nest occupancy was on 17 July and at that time 9 nests were still active. By 1 August only 3 nests (15%) were active. The nestling stage from 3-5 weeks is the most demanding period energetically for herons (Butler 1997). Adults are feeding themselves (requiring 2,000 KJ/day) and provisioning up to 4 chicks (each requiring about 2000 KJ/day). They require a total of about 10,000 KJ/day of energy to survive and fledge their young (Butler 1997). The average length of nestling development in 2019 was 56.2 days (just under 8 weeks) and of the 19 active Slate River heron nests with chicks all but thee had progressed through the 3-5 week critical period for energy provisioning by 15 July, but 18 of 19 were through this key period by 1 August and all 19 had completed the critical energy provisions by 3 August (Table 8). These estimates are conservative because they represent the 3-5 week period after the first chick was hatched, so the highest energy demand for several chicks in the nest would have been up to a week later. To minimize heron disturbance at the Slate River colony, the maximum protection would include a full river closure from mid-March (heron arrival) to early September (last fledge). Alternatively, a mid-March to 15 July closure provides significant protection and a 1 August end date would extend protection for most nests through the most vulnerable stages of the nesting season. In years with high snowfall and deep snowpack (36 inches on 15 March), the dates may be adjusted to 1 August, but in years with less snowpack (12 inches on 15 March) a 15 July lift of the river closure might be reasonable.

The CBLT hired a person to meet floaters at the put-in and engage them in conversation about the presence of the heronry, the voluntary no float period, and the proper floating etiquette to minimize disturbance to the birds. The Slate River Working Group envisioned this float as a scenic/wildlife viewing opportunity. Despite the effort to educate floaters, our observations of river use revealed that many floaters did not follow river etiquette guidelines. Many floaters did not wear PFDs. Many floaters envisioned the float as a "party float" and carried alcohol and made loud noises. Many groups fell off their SUP boards near the heronry and walked in the water through the colony section. Many stopped under the nest trees and groups often convened below river curve 2 (Figure 3) on a gravel bar that was still very close to the nests. We also observed groups that had one or two people who floated quickly and quietly through the colony and created relatively little disturbance. If river recreation continues on the heron reach of the Upper Slate River, educating users about the float culture (scenic/wildlife) and best practices for minimizing heron disturbances should be emphasized. Also, highly respected local river recreation community leaders could serve as heron ambassadors for the user group. The presence of a CBLT employee or other person/volunteer provides an active communication approach compared to just passive signage.

A series of signs was installed by CBLT and other stakeholders after the 2018 season. Signage is likely most effective in a coordinated approach with all entities engaged. Consistent messaging and thematic signs create a unified communications strategy. Based on our observations we offer a few suggested changes in the location of signs and messaging. We recommend the presence of 5 signs with two occurring above the Upper Colony that warn floaters they are approaching the colony (Figure 22). Another sign could be placed at the location of the Upper Colony and a fourth at the location of the Lower Colony. A fifth sign could inform floaters that they are leaving the colony and entering private lands. Our observations and understanding from discussions with the CBLT employee suggest that most floaters do not know the location of the colonies and their level of floating etiquette compliance could improve if they had a clearer understanding of where they were in relation to the colony. In addition to the signs serving as "You are here" beacons and herons are right here too, messaging could include reminders of beneficial behaviors such as sitting or kneeling, being quiet, floating quickly, and not pausing.

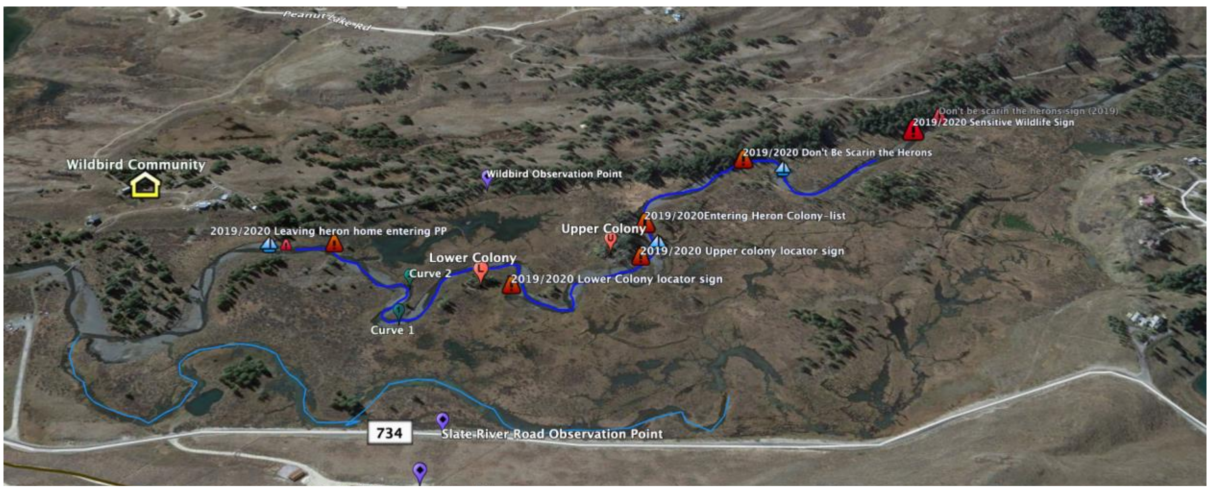


Figure 22. Proposed heron sign locations for 2020 floating season.

Research Needs

Continued monitoring of heron phenology and demography will provide insights into inter-annual variations in breeding events and reproductive success. Long-term monitoring of the Slate River heron rookery will allow CBLT and partners to assess the long-term health of the colony in relation to land-use, climate change, stream flows, and other factors vital to understanding the future of this colony. A key metric to follow is colony size and a threshold of 20 nests may be important as an indicator of potential productivity and persistence.

The Slate River Working Group Management Plan is an adaptive plan that attempts to balance land uses and human recreation in the Upper Slate River. Continued monitoring of the heron colony and the effects of human activities, particularly river recreation, on the heronry will allow the working group to make management decisions in the context of science and data. In 2019, the mandatory high flow river closure provided protection of the herons at the colony, but it also prevented us from assessing the effectiveness of a voluntary closure. Additional data are needed to gauge the success of management strategies. In 2019, we introduced the concept of Floater Ethics Index (FEI) to floater behavior. We hope to gather more data pertinent to the FEI (group size, float duration, noise level, density, posture, and other factors) in 2020 and analyze these results to inform management regarding the least impactful modes of floating through the heronry. We also consider the approach of evaluating human behaviors while floating though an experimental study, but we are cautious in doing this in a way that would generate additional disturbances and violate our research ethics.

Information on heron colony site selection in the context of local and landscape conditions may be point to key features to address in conservation planning and in implementing management practices. Herons are likely keyed into varying features of their foraging habitat when selecting colony sites. These foraging sites need to be within a certain distance of the colony to allow for efficient food provisioning and they need to have bountiful food resources. What do the herons in the Slate River colony eat, where do the obtain these foods, how does food availability change seasonally and in relation to the changing nutritional needs of herons across the breeding season? Do herons use the same foraging habits and prey during spring arrival and throughout the summer? How does river flow and hydrology affect foraging habitat availability? How do food acquisition and energetics impact the number of fledged young? We intend to observe patterns of local aquatic habitat use and extent of flights to foraging locations in 2020 in part by observing directions of herons leaving the colony and by implementing a citizen science heron observation database in the Crested Butte area. A previous collaboration by Western Colorado University and BLM along Tomichi Creek used fish pit tags to discern magnitude of heron predation on brown trout and distance that herons moved to acquire tagged fish from known locations. Additional efforts in the Upper Slate River to tag fish could provide information about prey selected by herons and distances herons are moving to foraging grounds.

We know almost nothing about where the Slate River herons migrate from and where they disperse during the post-fledge stage and when and where they migrate in fall. Further, we know little about movements from the colony within the nesting season. Marking birds would be helpful, but due to logistical constraints and the desire to minimize research impacts on the colony, we do not currently have a good way to mark the local herons. A potential method is deploying cameras to capture movement directions of herons in and out of the nests. Then, visits by researchers as well as positioning game cameras in potential foraging areas could determine whether herons are using these sites. We still wouldn't know if herons present are the same birds nesting in the colony. Working with stakeholders we may be able to install a wide-angle camera that surveys the colony throughout the season.

A deeper understanding of the ecology and biodiversity housed in the Slate River valley could involve the addition of avian point counts and developing a bird banding station. Small mammal trapping, invertebrate surveys, and floral sampling would provide a deeper understanding of the complexity of this system.

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"Truthfully, it took me 40 years to finally *understand what "stillness" and "presence" was all about – thanks to my great teacher: The Great Blue Heron.…the Great Blue Heron is the MASTER of patience!"*
Heidi Farmer

"…any of us can be, if only briefly, large against the sky."
Ginny Lowe Connors

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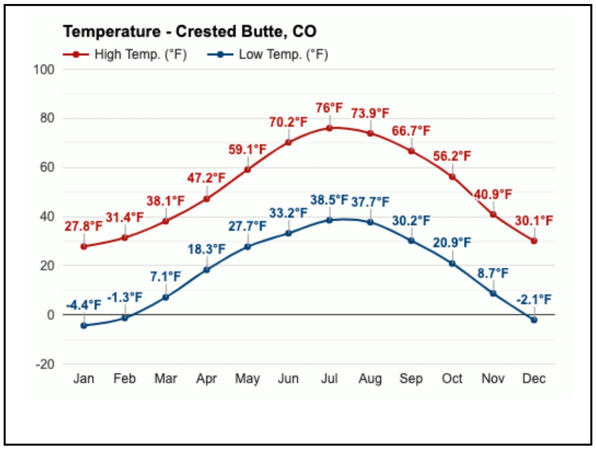
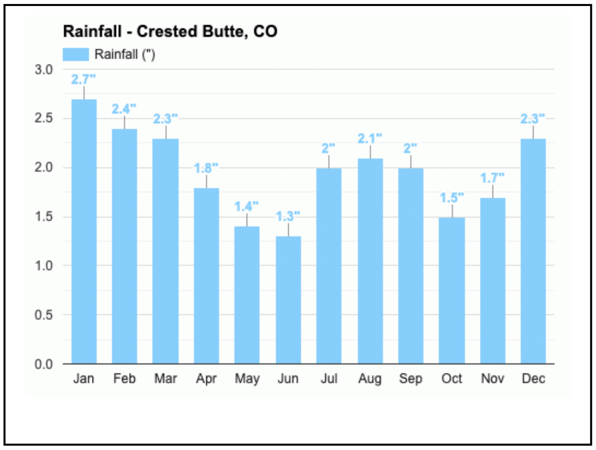
Appendix A

Crested Butte, Colorado 2019 temperature and precipitation data





https://www.weather-us.com/en/colorado-usa/crested-butte-climate

https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?co1959

Etymology of the Great Blue Heron

Ardea = heron

Herodias = song or legend of the hero;
ode to the hero