Glacier National Park Bat Assessment Project

Bats in Buildings: Assessing Human Structures as Roost Sites in Glacier National Park

Photo: Cheyenne Stirling

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Introduction

Bats comprise 25% of mammalian species worldwide and represent the only mammals that have developed true flight (OBC 2015). Bats are an integral component of ecosystems, as they feed on insects in both forest and agricultural systems, pollinate plants, disseminate seeds, and are considered a keystone species in caves (BCI 2015a). Without bats, the agriculture industry in the United States could lose as much as $3.7 billion a year due to crop loss and the need for pesticides (Boyles et al. 2011). Loss of bat populations would send rippling effects throughout many ecological communities with potentially serious impacts. Recent developments such as white-nose syndrome (WNS), however, have made it even more critical that we begin to learn about bats before we risk losing populations or entire species.

In 2006, a white powdery fungus was found growing on the noses of infected bats in a cave in New York. Scientists have since learned that the cold-loving fungus, *Pseudogymnoascus destructans,* causes WNS which infects bats during hibernation (BCI 2015b). The disease kills bats by upsetting a bat's homeostasis, causing the animal to arouse from hibernation more frequently. This process causes bats to deplete their fat stores before spring, resulting in death by starvation or freezing. Mortality rates in some areas are nearly 100 percent. WNS has spread to 28 states, confirmed in four additional states, and five provinces, killing an estimated 7 million bats, and recently has reached the west coast (WNS 2016a).

In 2011, an emergency petition was submitted to the US Fish and Wildlife Service to list the Little Brown Bat (*Myotis lucifugus*) as federally endangered due to a rapid decline in their populations (Frick et al. 2010). This species was once the most common and widely distributed bat in the eastern United States. In 2012, an emergency assessment subcommittee of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) concluded that along with the Little Brown Bat, both the Tri-colored Bat (*Perimyotis subflavus*) and Northern Myotis (*Myotis septentrionalis*) were assessed as endangered (EC 2014) due to the ongoing spread of WNS and bat mortalities associated with the disease.

Of all bats found in Montana, the Little Brown Bat is highly susceptible to WNS (Kunz and Reichard 2010, BCI 2015b) and is the species most strongly associated with human structures for roosting (Foresman 2012). As buildings age, they deteriorate due to the constant swelling and shrinking associated with wet/dry and cold/hot weather conditions. This swelling/shrinking cycle often results in small openings forming in walls, roofs, and attics, which provide roost sites where bats are protected from weather and predators. Little Brown Bats can gain entry into holes < 1.3 cm in size (BCI 2011). They also will use bat houses as roost sites (Figure 1).

Bats are difficult species to study, in part because they are nocturnal and they roost during the day. A few bat species are solitary, but most bats roost in groups or colonies (BCI 2011). At dusk, bats will exit the roost sites for the night to find night-flying insects, which provide the majority of food needed (Adams 2003, Foresman 2012). This flight timing at dusk is referred to as emergence. Bats also may congregate when they hibernate in the winter months. In the eastern US, bats hibernate in huge colonies that often number in the tens of thousands (Tuttle 2003). In Montana, the largest known hibernaculum supports 1757 bats and the smallest known hibernaculum supports only four individuals (MNHP, B. Maxell, pers. comm).

Until recently, knowledge about bats in Glacier National Park (GNP) was nearly nonexistent because no formal studies had ever been conducted (Bate 2015). Initially, wildlife biologists only had visual confirmation of four bat species in GNP, and presence of one species was documented based on only a single road-killed individual. Two other species were documented only through acoustic surveys (MNHP 2015). Of 11 potential species in GNP, six are Montana species of concern (SOC) or potential SOC (MNHP 2015) (Table 1). Since 2011, the GNP Bat Inventory and Monitoring Project has confirmed the presence of nine bat species in GNP including: Long-eared Bat (*Myotis evotis*), Silver-haired Bat (*Lasionycteris noctivagans*), California Myotis (*M. californicus*), Yuma Myotis (*M. yumanensis*), Little Brown Bat (*M. lucifugus*), Long-legged Bat (*M. volans*), Eastern Red Bat (*Lasiurus borealis),* Big Brown Bat (*Eptesicus fuscus*), and the Hoary Bat (*Lasiurus cinereus*) (Bate 2015). As a result of these surveys, three new species were added to GNP's mammal list: California, and Yuma Myotis, and the Eastern Red Bat. The findings also contributed to range expansions for each of these new species (MNHP 2015).

Two of the bat species in GNP are known to be susceptible to WNS: Little Brown and Big Brown Bats (BCI 2015b). Two other bat species, the Silver-haired and Eastern Red Bats, are known vectors of the disease without showing signs of WNS (BCI 2015). In the east, *Myotis* species appear most likely to contract WNS, but it is unknown whether the other *Myotis* species in GNP are susceptible to WNS (BCI 2015).

Six of the nine bats confirmed in GNP are considered year-round residents that hibernate in caves, mines and/or buildings to survive the winter (MFG 2015). During the warm season months, bats roost in natural shelters, such as caves, hollow trees, snags, and under the sloughing bark of large trees (Adams 2003, Foresman 2012). Roosting bats are also found in attics, spaces between building walls and under siding and roofing, and in bat houses (MFG 2015). Conservation and protection of roosts are important long-term management activities for many North American bat species (Sheffield et al. 1992). Information about bat roost sites from GNP is so lacking that it is considered a "black hole" of data in Montana (MNHP, B. Maxell, pers.

comm.). Prior to this study, only 25 structures (buildings and bridges) in GNP had been assessed for roosting bats (Bate 2015). Understanding which structures bats use for roosting could provide necessary information to develop measures to protect bats. I sought to document the locations, characteristics, and types of roost sites occurring in human structures throughout GNP. Information on day, night, and maternity roosts for bats is critical to collect before the potential arrival of WNS in GNP (MNHP 2015).

Study Area

Glacier National Park is located in the northwestern corner of Montana and comprises over one million acres. To the north, GNP is bordered on the east side of the Continental Divide by Waterton Lakes National Park in Alberta. The Continental Divide bisects GNP into two regions, typically referred to as the east and west sides of the park, with elevations ranging from approximately 950 to 3200 m. Vegetation communities are diverse, varied in successional stages, and include: riparian areas, wetlands, grasslands, shrub fields, montane deciduous and coniferous forests, burned forests, sub-alpine and alpine environments, lakes, and rock and glacier environments.

Throughout GNP, there are clusters of 733 buildings, currently owned by the National Park Service (GNP data files). The number of structures in GNP exceeds 900 after including buildings on private in-holdings. Building types include hotels, visitor centers, office space, residential housing, garages, ranger stations, patrol cabins, barns, and sheds. Many buildings in GNP are considered historic, with the oldest building dating back to 1912, and many are in need of refurbishing due their age and the harsh climate of GNP.

Methods

In the summer of 2015, I received a dataset of all the buildings contained within the boundary of GNP. Maps of all buildings in the park were made by the GNP mapping staff in ArcMap. Each map focused on an individual portion of the park and included the buildings as red blocks, and building numbers that corresponded with data about each of the individual buildings (Figure 2). I used these maps to locate each building, verify building numbers and ensure all buildings were surveyed once.

I conducted daytime inspections of buildings and bat boxes. Internal inspections were only conducted in the case of sheds, barns, attics, cabins and houses where I suspected bats were entering or where residents reported hearing or seeing bats, with permission of the people who worked or lived there. At each structure, I looked with a high powered flashlight and listened for bats and recorded signs of guano or urine as I walked around each building. Bat guano is distinctly different than rodent droppings: it is tapered, has silver flecks from the insects that they eat, and is friable (falls apart easily). I also recorded whether there were potential roost areas on each structure or entry access to attics or human use areas (Figure 3).

For all roosts, I determined whether or not the structure was being used as a day, night, and/or maternity roost. A day roost was any roost where bats were either seen or heard during the day. A night roost was any sign of bat use (bat feces and/or urine) without the presence of bats. A maternity roost was where both adult female and juvenile (pups) bats were found. Maternity roosts were identified by grabbing individuals out of the roosts and looking for pups and females nursing. If pups were found anywhere near the roost (i.e. on the ground, in the attic, or reported dead near the roost) that roost was decidedly a maternity roost. I also recorded roost features (e.g., wall, roof, eaves, etc.), which were the characteristics of the specific areas on buildings where the roost was detected. For each building, I recorded construction date and materials (e.g., wood, tin, log, etc.), roof type, and whether the building had roosts, or potential roost sites. Finally, I photographed all sides of the building to help with later analysis.

I entered data into a relational database in Access comprised of four tables: site overview, site info, roost info, and incidental species. In each table, the data were categorized in specific columns. The site overview table included survey ID, observer, habitat comments, time, date, return visit, remodel assessment, roost potential, tin roof, tin siding, cement, log, wood, masonry, porch, bat house, eaves, number of bats observed, and general comments. The roost info table included survey ID, roost type, material comments, roost feature, roost materials, entrance comments, roost human risk, number of bats, dropping scale (per Montana Natural Heritage Program standards), number of entrances (<5, 5-25, 25-50, 50>), roost orientation, and any other comments. I linked each photo to the corresponding building number and characteristics in the database.

I summarized characteristics of roosts and roost features and created frequency histograms. I used logistic regression to compare buildings with and without roosts and determine if bats were preferentially selecting certain building characteristics for roost sites.

Results

General - From June to August 2015, I inspected 579 buildings during 31 survey days. I found 451 roost sites in 249 buildings of which 83% were night roosts (Figure 4). There were five maternity roosts found in the buildings surveyed, although more likely occur. Of the 451 roosts, 398 (88%) did not have any actual bats present at the time of the survey. For roosts where I did observe bats (n = 53), the majority of these were day roosts, yet a few were night roosts.

Roost characteristics - Most roosts were on or in walls (39%) or under eaves (27%) (Figure 5). Roosts mainly were comprised of wood (77%) or logs (35%, Figure 6). Most roosts had fewer than 5 entrances (95%), a few roosts (4%) had 5-25 entrances, and <1% of roosts had 25-50 entrances. I found no difference in orientation among roost sites (Table 2).

Building characteristics - Night roosts were two times more likely to be in buildings with masonry present than those without (Table 3), even though relatively few buildings were comprised of masonry (~3.3%). Most (68%) of these masonry buildings were used by bats as night roosts. Night roosts were three times more likely to be found in buildings without tin siding compared to those with tin siding (Table 3). Relatively few buildings had tin siding (~3%, 17/578) and only 2 of these 17 buildings were used by bats as night roosts. I did not detect strong preferences for locations of night roosts related to tin roofs, cement, logs, wood, bat houses, or area (backcountry/frontcountry, Table 3). In some cases, the lack of preferences may be due to relatively small sample sizes. For example, I surveyed only 17 buildings in the backcountry, compared to 557 buildings in the frontcountry.

Day roosts were six times more likely to be on buildings with a bat house than those without (Table 3). Only 8 buildings (of 578, ~1%) had associated bat houses, but 5 of these were used by bats as day roosts. I did not detect strong preferences for locations of day roosts related to tin roofs, tin siding, cement, logs, wood, masonry, or area (backcountry/frontcountry, Table 3).

Discussion

Results from this study demonstrate the importance of older, wooden buildings for bats roosting in GNP. Three-fourths of all bat roost sites (n = 451) that I found were in the wooden portion of buildings. The bat houses put up on buildings by the park have also proven to be important to roosting bats, as 10 out of 11 were occupied. Bat houses were placed only on buildings where bats had been gaining entry and coming into contact with humans; the houses were intended to mitigate the loss of bat roost habitat when the building was sealed up. In the St. Mary dorm, however, I still found bats roosting in the attic even though the building had several bat houses on it.

Although bats did not use buildings with tin siding, they did use buildings with tin roofing, where they were found underneath the ridges of the tin. This was most common in roofing where the foam plugs had fallen out. I recommend that if managers want to prevent bats from roosting under the tin, to check the foam plugs annually.

It is important for the park to conduct emergence counts where there is evidence of large numbers of bats in a structure. This is necessary because most bats in a roost are not visible during daytime inspections. For example, in a building in the St. Mary area, I estimated that 25 bats were roosting during the day behind loose siding on an older building. When I conducted an emergence count that night, however, I counted 979 bats leaving the roost. Emergence counts before and after the arrival of WNS will be critical in helping biologists understand the impacts of this disease.

I recommend that park staff use these data to help expedite the compliance review process for projects that seek to remodel, restore, or repair buildings by informing managers about whether the structure is, or has been, occupied by bats. If bats are using a structure, this study would provide park staff with the necessary information to develop mitigation measures to protect bats. The park managers would also know where specifically on the building bats have previously been roosting, which would allow the process to move along quickly as further inspections might not be necessary.

This information is especially important in the case of maternity roosts where construction has to wait until the pups are volant and have left the roost. It was hard to know exactly where all the maternity roosts were; a lot of the information about maternity roosts were based on previous knowledge of the roosts or because dead pups were found near the roost. Wherever possible, it is important to inspect the bats in a roost to identify species, sex, and age to help locate additional maternity roost sites. If a building needs to exclude bats entirely due to human safety concerns, I recommend that the work be conducted in spring before the bats arrive, or in the fall after the bats have left, to minimize impacts. Other mitigation steps would be prevention or control techniques. Most bat species tend to leave buildings in the winter, so if a building has a known bat colony inside, the best time to exclude them would be to wait until the bats have left for the winter before sealing up all possible entrance points. Other mitigation options should include using bat houses or bat condos in areas where roost habitat is eliminated.

Baseline data from this project will contribute to the first ever bat roost database in Montana. Furthermore, locations and numbers of bat roosts will allow biologists to better assess potential impacts of WNS, should it arrive in Montana.

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Table 1: Bat species in Glacier National Park that are species of concern or potential species of concern in Montana.

Species	Scientific Name
Little Brown Myotis	*Myotis lucifugus*
Hoary Bat	*Lasiurus cinereus*
Silver-haired Bat	*Lasionycteris noctivagans*
Yuma Myotis	*Myotis yumanensis*
Eastern Red Bat	*Lasiurus borealis*

Table 2. Specific orientation of roosts on buildings, summer 2015, GNP, MT.

Orientation	Number of roosts	% of roosts
North	94	20.8
South	94	20.8
East	93	20.6
West	66	14.6
SW, SE, NW, or NE	63	14.1
All directions (i.e. attics)	41	9.1
TOTAL	451	100.0

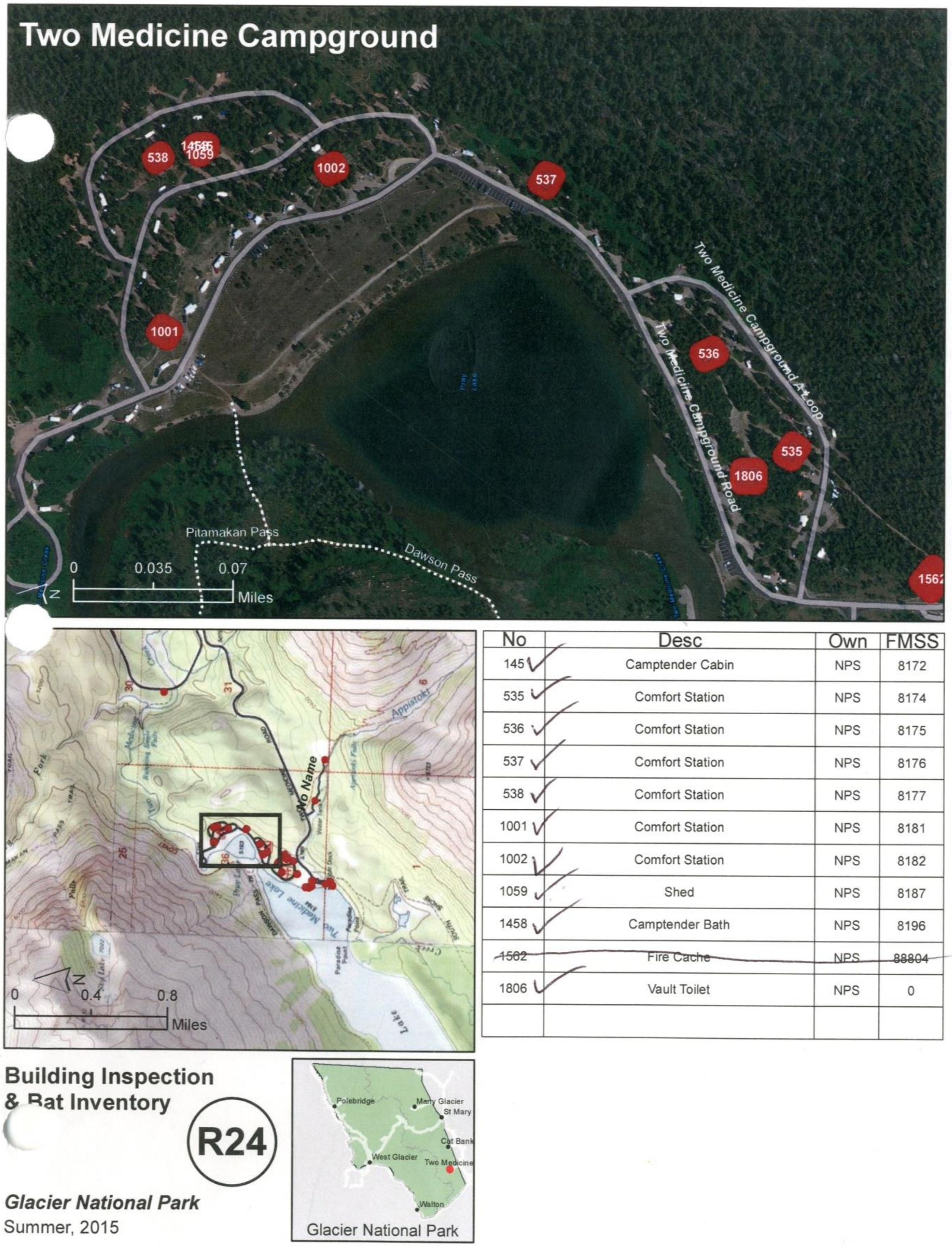
Table 3. Predicted probabilities of use with and without the building characteristic (and 95% CIs), test statistics, and P-values from logistic regression comparing buildings with and without roosts, summer 2015, GNP, MT. Bats showed some preference for characteristics listed in bold. Bats were more likely to roost in older buildings; I provide an estimate of the decrease in the odds of use of a building for each 1-yr increase in "year built".

Building Characteristic	Predicted Probability of Use		95% CI	$F_{1, 576}$*	*P*
Night Roosts					
Tin Roof	With	0.36	0.31 - 0.42	0.00	0.967
	Without	0.36	0.31 - 0.42		
Tin Siding	With	0.12	0.03 - 0.37	3.77	0.053
	Without	**0.37**	**0.33 - 0.41**		
Cement	With	0.41	0.24 - 0.60	0.28	0.599
	Without	0.36	0.32 - 0.40		
Log	With	0.43	0.33 - 0.54	2.12	0.146
	Without	0.35	0.31 - 0.39		
Wood	With	0.36	0.32 - 0.41	0.22	0.64
	Without	0.34	0.25 - 0.44		
Masonry	**With**	**0.68**	**0.45 - 0.85**	7.76	0.006
	Without	0.35	0.31 - 0.39		
Bat House	With	0.63	0.28 - 0.87	2.25	0.134
	Without	0.36	0.32 - 0.40		
Area	Backcountry	0.24	0.09 - 0.49	1.19	0.276
	Frontcountry	0.37	0.33 - 0.41		
Year Built		-0.007	-0.014 - 0.001	2.82	0.094
Day Roosts					
Tin Roof	With	0.08	0.06 - 0.12	2.03	0.155
	Without	0.05	0.03 - 0.09		
Tin Siding	With	0.06	0.01 - 0.32	0.03	0.864
	Without	0.07	0.05 - 0.09		

Cement	With	0.00	0.00 - 1.00	0.00	0.978
	Without	0.07	0.05 - 0.10		
Log	With	0.11	0.06 - 0.20	2.50	0.115
	Without	0.06	0.04 - 0.09		
Wood	With	0.07	0.05 - 0.09	0.88	0.349
	Without	0.09	0.05 - 0.18		
Masonry	With	0.00	0.00 - 1.00	0.00	0.971
	Without	0.07	0.05 - 0.10		
Bat House	**With**	**0.38**	**0.13 - 0.72**	8.27	0.004
	Without	0.06	0.05 - 0.09		
Area	Backcountry	0.06	0.01 - 0.32	0.02	0.901
	Frontcountry	0.07	0.05 - 0.09		
Year Built		-0.016	-0.031 - 0.00	3.91	0.049

* For comparisons of buildings in the front and backcountry, the F-statistic has *df* = 1, 572 because I did not have area designations for 4 buildings. For comparisons based on the year that the building was built, the F-statistic has *df* = 1, 421 because I did not have this information for all buildings.

Figure 1: Bat house on a pole away from a building, which was being used as a roost site. Photo: Cheyenne Stirling



No	Desc	Own	FMSS
145	Camptender Cabin	NPS	8172
535	Comfort Station	NPS	8174
536	Comfort Station	NPS	8175
537	Comfort Station	NPS	8176
538	Comfort Station	NPS	8177
1001	Comfort Station	NPS	8181
1002	Comfort Station	NPS	8182
1059	Shed	NPS	8187
1458	Camptender Bath	NPS	8196
~~1562~~	~~Fire Cache~~	~~NPS~~	~~88804~~
1806	Vault Toilet	NPS	0

Figure 2: Example of a map used for building inspections provided by Glacier National Park. Each red square represents an individual building that needed to be surveyed.

Figure 3: Types of bat roosts in buildings and bridges (clockwise from upper left): bats roosting under siding of historic building, in a bat house, in a barn loft, and a maternity roost under a bridge. Photos: Glacier National Park.

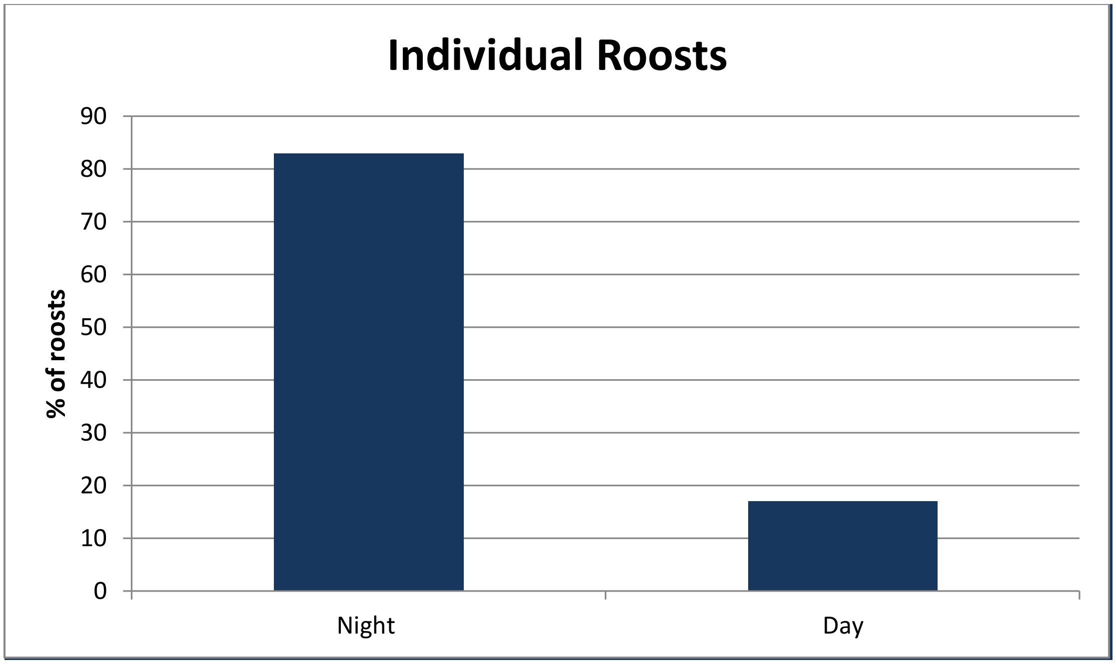


Figure 4: Frequency of day and night roosts found while surveying, summer 2015, GNP, MT.

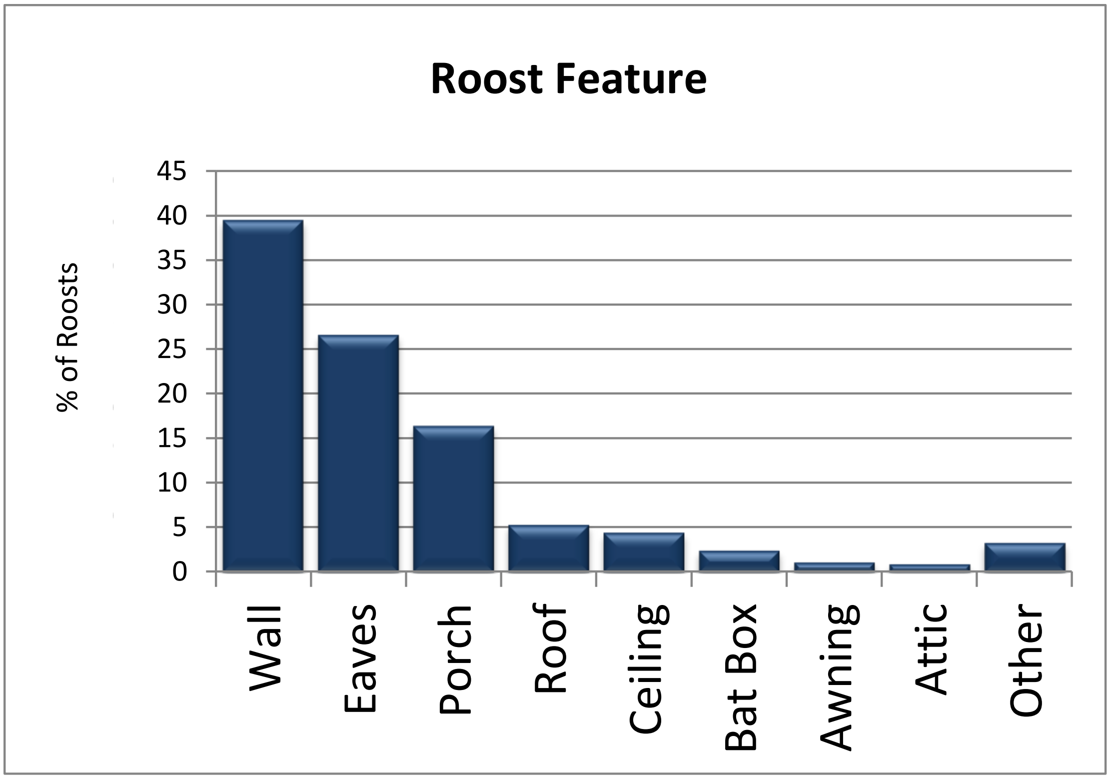


Figure 5: Frequency of active roosts (bat use based on either sign or sightings) with each roost feature, summer 2015, GNP, MT.

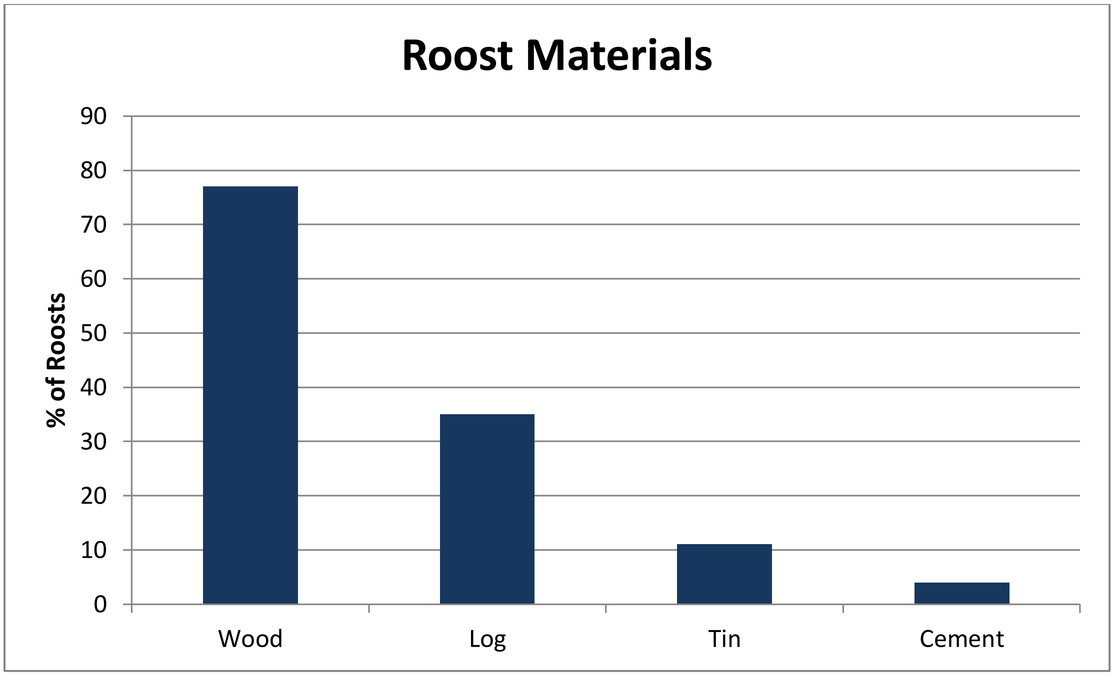


Figure 6: Composition of individual roosts, summer 2015, GNP, MT. Total exceeds 100% because some of the roosts had two types of materials (13 combinations).