CHALLENGING TIMES FOR NORTH AMERICAN BATS:

Planning for the Future of a *Myotis yumanensis* and *M. lucifugus* Maternity Colony at The Evergreen State College Organic Farmhouse

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by

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ABSTRACT

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and *M. lucifugus* Maternity Colony
at
The Evergreen State College Organic Farmhouse

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Many threats face North American bats. Highlighting the urgent need for bat conservation efforts, a microcosmic example of the current degradation of North American bat habitat exists on the campus of The Evergreen State College, in Olympia, WA. There, a hand-built, rough-timbered farmhouse has provided roosting shelter for a maternity colony of Little Brown (*Myotis lucifugus*) and Yuma Bats (*Myotis yumanensis*) for many years. The farmhouse is slated for extensive remodeling activities that will likely cause interruption of reproductive activities and abandonment of the site. During the summer of 2011, emergence counts were conducted to determine the number of bats present, reproductive success, and seasonal timing of departure from the roost. Additionally, a literature review was conducted to determine the best mitigation measures available in preparation for the farmhouse remodeling. Emergence count surveys established that the farmhouse is extensively used by the breeding bats, with two intra-colony groups that regularly change roosting locations on the building. The farmhouse offers many options for roosting locations, with roost crevices on 3 sides of the structure at varying heights. Although bat-houses have been used successfully as maternity colony roosts by Little Brown Bats, attempting to replicate the abundance of roost crevices available on the farmhouse with a bat-house would be very difficult. Installing multiple bat-houses at varying heights and exposures may offer a similar range of roost temperatures and conditions as the farmhouse does now. Not carrying out remodeling on the farmhouse would offer the greatest assurance of continued bat reproduction at the site. Out of concern for the bat colony’s uncertain future, continued monitoring should be undertaken and well-designed and placed bat-houses installed to provide roosting alternatives at the site.

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Chapter 1: Yuma Bats, Little Brown Bats, and Maternity Colonies

Bats are an integral part of Earth's ecosystems on all continents except for Antarctica. The vital roles bats play range from primary pollinators of fruit trees and cacti to insect control, sweeping many tons of insects out the air every night (Evelyn et al., 2004; Fleming et. al, 2003; O'Shea and Bogan, 2003; Tuttle, 2005). In Texas alone, Brazilian Free-Tailed Bats (*Tadarida brasiliensis*) consume an estimated two million pounds of insects nightly (Keeley, 1999). The economic value of the insect control services provided by bats to farm crops across the United States is approximately $23 billion annually (Boyles et al., 2011; Altringham, 1996).

The State of Washington is host to many bat species during the summer months. Some species are migratory, such as the Hoary Bat (*Lasiurus cinereus*), which spends only a few months in the Pacific Northwest while bearing young and then migrating to wintering grounds in Southern California and further south (Findley and Jones, 1964). Others, such as Yuma Bats (*Myotis yumanensis*) and Little Brown Bats (*Myotis lugcifugus*) migrate locally from their winter hibernacula in the Cascade Mountains, heading to the lowlands of Western Washington during the summer (Falxa, 2008).

While Little Brown Bats are distributed throughout North America, Yuma Bats are endemic to the West (Hall, 1981). Additionally, Yuma Bats are listed as a *Species of Concern*, one step below being listed as endangered under the U.S. Fish and Wildlife Service's Endangered Species Act (O'Shea and Bogan, 2003). Like other North American bats, Yumas are found in pockets; locally abundant in places, but otherwise absent, due perhaps to habitat alteration or other human influences (Evelyn et al., 2004).

Two large combined breeding colonies of Little Brown and Yuma Bats are known to exist in Thurston County, near the city of Olympia, WA. Both colonies are well-established, at times being composed of hundreds to thousands of individuals (BAOT, 2011; Falxa, 2008).

One colony is located in the Woodard Bay area, in a non-serviceable deteriorating pier over Chapman Bay on the Puget Sound. The pier structure is occupied by up to 5,000 Yuma Bats during the breeding season (BAOT, 2011). The area is under the jurisdiction of the Washington State Department of Natural Resources (WSDNR) and is monitored by staff biologists and maintained as a Natural Resource Conservation Area (WSDNR, 2002). The second colony of Yuma Bats is found in a large, older, hand-built wooden farmhouse[1] on the campus of The Evergreen State College (TESC). A 2009 species composition census found this colony to be comprised of approximately 600 Yuma Bats and Little Brown Bats, plus individual California Myotis (*Myotis californicus*), Big Brown Bats (*Eptesicus fuscus*), and Silver-Haired Bats (*Lasionycteris noctivagans*) (Davis, 2009). These large gatherings of Little Brown and Yuma Bats are known as 'maternity colonies', composed entirely of females bearing and raising young (Altringham, 1996; Davis, 2009; Falxa, 2008). The males and non-productive females of these species disperse in small groups and individually, and are not found with reproductive females at this time (Christy and West, 1993).

The Woodard Bay colony maternity roost has been recognized by the DNR as an important ecological site and the structure has been recently modified to prevent human access to the bat breeding area and is expected to receive protection for the foreseeable future (WSDNR, 2010). The colony at TESC, on the other hand, will be subject to a

[1] See Appendix A for map of Farmhouse location

major disruption in the near future. Facilities Services of TESC has proposed a remodeling project for the farmhouse, involving removal and replacement of all siding materials (Paul Smith, 2011: personal communication; Davis, 2009; Falxa, 2008). The rough-hewn, aged cedar siding that covers the building provides abundant and varied habitat for roosting bats and rearing young. The breeding bats regularly move en masse to different areas on the structure, probably due to varying temperatures within the siding, weather conditions, and other factors (Davis, 2009). A disturbance to the roost structure, even during the winter months when the bats are not present, could cause abandonment of the site, thus greatly disadvantaging several species of endemic wildlife critical to local agriculture and insect control within urban areas. English Nature, the national ecological agency for the U.K., has found that modifications to roost structures such as changes in size of roost space, changes to entrances, and changes to airflow can significantly impact bats' use of a roost and lead to desertion (Mitchell-Jones, 2004).

With the tremendous hurdles presented to the bats including habitat destruction and alteration, wind turbine developments, and the White Nose Syndrome epidemic, it is necessary that steps be taken on bats' behalf to ensure their populations do not go extinct within our lifetime. This thesis examines in-depth the current usage of the farmhouse by bats, the species using the farmhouse, as well as proposes long-term monitoring of the bats at TESC Farmhouse. In the following section, a description the biology of the bats comprising the Farmhouse's maternity colony is explored.

Chapter 2: Natural History of *Myotis yumanensis* and *M. lucifugus*

In the Pacific Northwest of North America, Little Brown Bats are similar in appearance to the more regional Yuma Bat, and can only be reliably identified either by examination in the hand or using electronic bat detectors[2] (Greg Falxa, 2010: personal communication). In areas where the bats' ranges overlap, such as the Pacific NW, the animals can be distinguished at close range by examination of the fur. Yuma Bats have glossy fur while Little Brown Bats have dull fur- though not always the most reliable method of identification, as intermediate individuals have been observed (Fenton, 1980). Most bat echolocation calls are inaudible to the human ear; however, with the use of an electronic bat detector, echolocation calls can be used to reliably identify species (Johnston, 2002).

Both species belong to the genus *Myotis*, or mouse-eared bats. Yuma Bats are of similar dimensions, sometimes a bit smaller than Little Brown Bats with total length of 37-49 cm and forearm length of 32-38 cm (Hall, 1981). Little Brown Bats are cinnamon to dark-brown on the upper parts and buffy to pale grey on the underparts. The upper parts of Yuma Bats are buffy-tawny to brown while the underparts are pale buffy to yellowish white (Fenton, 1980). Yuma Bats, occur only on the west coast of North America with six subspecies spread throughout their range. The subspecies that lives at Evergreen's farmhouse is *Myotis yumanensis saturates. Saturatus* occurs approximately from San Diego, California north along the Pacific and west of the Cascade Mountains to the northern end of Vancouver Island, British Columbia, including a population on the island itself (Hall, 1981).

[2] See Appendix D for examples of bat detectors

Behavior

As with all Pacific Northwest bats, Little Brown and Yuma Bats are nocturnal and have insectivorous diets (Christy and West, 1993; Fenton, 1980). They set out from their roost sites during an approximate one hour window from ½ hour before to ½ hour after sunset on their nightly hunting forays (Butchkowski, 2009; Kunz, 2003). The bats are opportunistic, catching and eating an array of insects on the wing. Interestingly, Little Brown Bats capture insects directly with their mouths but also by scooping a flying insect into their tail or wing membranes and then directing the insect into their mouth while flying (Saunders, 1988).

All bats extensively use echolocation calls during flight. Bats echolocate to detect insect prey, gain detail on the surface structure of the prey, and avoid obstacles (Altringham, 1996; Fenton, 1980; Gould, 1955). There is evidence that the bats additionally use echolocation calls to detect con-specifics at roost sites. The only non-echolocation calls used during flight are "honks" which Little Brown Bats use when on a collision course with another bat. The "honk" call involves lowering the end portion of their frequency modulated calls from 40 to about 25 kHz (Fenton, 1980).

Little Brown and Yuma Bats are seasonal visitors at their breeding and summer feeding sites. Although they may awaken occasionally during the winter months to forage on warmer nights, most of the cooler months are spent in hibernation (Altringham, 1996). The bats hibernate in cave areas, preferring very specific locations with certain temperature and humidity conditions (Christy and West, 1993; Davis and Hitchcock, 1965, Kunz and Reynolds, 2003). Although it is not known for certain, biologists speculate that the Olympia populations hibernate in caves on the west slope of the Cascade Mountains (Greg Falxa, 2010: personal communication). Yumas begin their summer seasonal activities by awakening from hibernation in early to late April, depending on weather trends. Upon arousal from hibernation, the female bats gather at maternity roost sites and the males disperse individually or in small groups (Altringham, 1996; Christy and West, 1993). The TESC Organic Farmhouse bats normally return to the maternity colony site in late April (Davis, 2009).

Reproductive Ecology

Many bats of temperate regions, including Yuma and Little Brown, share a mechanism for maximizing the time available during summer to rear young. The bats, male and female, gather for a mating *swarming* period during late summer and early fall to copulate and vigorously feed to put on weight for the upcoming hibernation (Altringham, 1996; Kunz and Reichard, 2010). With this strategy, the bats do not need to spend precious time in the spring mating before beginning gestation (Altringham, 1996). Females store spermatozoa throughout the winter and fertilization occurs upon arousal from hibernation in the spring (Altringham, 1996; Racey, 1979).

After a 40-50 day gestation period, females give birth to one flightless and blind pup (Altringham, 1996; Kunz and Reichard, 2010). The young remain flightless and totally reliant on their mothers until about 18 days old, at which time they fledge and can forage for insects on their own, however pups' diets are supplemented with milk until around 26 days old (Kunz and Anthony, 1996; Kunz and Reichard, 2010; Kurta et al., 1989).

The colonial strategy for rearing young provides benefits to the mothers and young alike. By participating in such a colony, the bats share body heat, easing the energetic burden of maintaining a high body temperature during gestation in order to promote rapid embryo development (Barclay, 1982). Young bats, not yet volant (capable of flight), can also benefit from colonial living. By having many nursing mothers around, nursing duties are occasionally shared by unrelated mothers in the event that young are separated from their own mother (Altringham, 1996)

During the spring and summer months, males and non-productive females disperse individually at separate sites from gestating and lactating females (Kurta and Kunz, 1988). Occasionally males are found at maternity colony sites, but in these situations the males roost separately from the females (Davis and Hitchcock, 1965).

Chapter 3: Bats in Peril- Threats to Bat Populations

In 1998, Altringham noted "there is now considerable evidence that bat populations in many parts of the world are in decline, and that the range of many species has contracted". Bat populations in North America are threatened on various fronts including continuing habitat destruction, increasing numbers of wind turbines, and very recently, a newly discovered fungus (Boyles, 2011; Tuttle et al., 2009). Aptly named White Nose Syndrome (*Geomyces destructans*), the disease is evident by a velvety white fungus found on the snout, ears, wings and other exposed skin on infected bats (Blehert et al., 2009).

White Nose Syndrome (WNS) is, at present, causing the most accelerated, precipitous decline of North American wildlife in recorded history (Bat Conservation International, 2009). WNS is a disease that was first recognized in New York State in February 2006 (Frick et al., 2010). By 2009, within three years of its discovery, WNS was confirmed to have spread to at least 9 states along the eastern seaboard, inland to Kentucky, and north to Ontario, decimating colonies of 6 species of hibernating bats along the way and in many cases causing 100% mortality (Tuttle et al. 2009; USFWS et al. 2010).

The disease alters bats' hibernation cycle and bats use up fat reserves and perish (Foley et al., 2010; Reichard, 2009). Infected bats will often take flight in mid-winter, perhaps attempting to forage and replace body fat reserves, and then often die near cave entrances or inside the hibernacula cave (Fascione, 2010; Foley et al., 2010). Little Brown Bats appear to be particularly vulnerable to White Nose Syndrome. Kunz and Reichard (2010) noted that since 2006, WNS has killed at least one million Little Brown

Bats in the Northeastern U.S. Should WNS reach the Washington State, the challenges facing Olympia's maternity colonies will be greatly increased.

Several factors put the Woodard Bay and TESC colonies at risk to catastrophic decline in population numbers. Little Brown Bats and Yuma Bat only bear one young per reproductive female per year, but these bats are long-lived with cases of individual bats living 30+ years in the wild (Keen and Hitchcock, 1980; Wilkinson and South, 2002). In optimum conditions, the bats' longevity assures that the species continues to maintain population stability despite low numbers of young reared during each breeding season, however low reproductive rates also leave bat populations vulnerable to drastic declines (Christy and West, 1993). A disease, such as WNS, could rapidly spread through a colony wiping out large numbers of bats and accordingly, disturbance or destruction of maternity roosts could have a similar effect (Frick, 2010; Williams and Brittingham, 2006). Only two colonies of Yuma and Little Brown Bats are known to exist in Thurston County. Because these colonies are composed of the only reproductive individuals known in the county, these colonies are at high risk for catastrophic impact on entire species regionally.

Chapter 4: *Myotis* at TESC Organic Farmhouse

Caretakers at the Farmhouse first noticed bats using the cedar siding for shelter in 1987 (Greg Falxa, 2010: personal communication). Since that time, members of the local community have enjoyed the summer evening emergence of the bats on the flight out to their nightly feeding grounds.

While the Farmhouse has proven to be a secure maternity roost site for many years, as demonstrated by the bats' continued fidelity to the site, it may not remain a reliable breeding location in the future. As explained by the director of Facilities Services at TESC, the Farmhouse structure is slated for a major overhaul (Paul Smith, 2011: personal communication). The remodeling project will include complete removal and replacement of all siding materials. The plans will likely not include replicating the rough, hand-split cedar siding currently on the building (Paul Smith, 2011: personal communication).

According to the Facilities Services director, construction activities could take place during the winter months while the bats are away at hibernacula sites. Additionally, measures to allow for continued bat access could possibly be incorporated into the design. However, there are no guarantees that the returning bats, in a low state of health from sustained fat-loss during hibernation, and in early stages of gestation, would recognize their historic breeding roost or find the remodeled structure suitable.

Even if the remodeled structure will allow for continued bat access, a major construction project on one of only two known *Myotis* maternity colony roosts in Thurston County holds great potential for causing reproductive interruption, possibly resulting in a catastrophic local impact on Yuma and Little Brown Bat populations

(Briggs, 2000; Evelyn et al., 2004; Mitchell-Jones, 2004). Not disturbing the farmhouse structure at all would be the best assurance that the colony continues to survive, but that does not appear to be an option (Paul Smith, 2011: personal communication).

Chapter 5: What's Known about the Farmhouse Colony- Surveys and Observations

In 2009, Davis et al. used bat detectors and SonoBat software (SonoBat, Arcata, CA) coupled with mist netting for five evenings early in the breeding season (April 16 to May 24) to determine the ratio of bat species present at TESC's Organic Farmhouse. Ms. Davis found a ratio of 6.07 : 1.04 Yuma Bats to Little Brown Bats exiting the Farmhouse roost. During Davis' acoustic sampling surveys, the lowest combined count of Yuma and Little Brown Bats emerging was 8 and the survey with the highest count resulted in 78 bats.

Bat detectors are complex however, and require that the observers be thoroughly familiar with their operations, limitations, and potential biases (Johnson, 2002; Kunz, 2003). For on-going monitoring efforts, low-tech but effective evening 'emergence counts' are the standard and most accurate method for censusing bats that depart from buildings, mine tunnels, and trees (Kunz, 2003; Kunz and Anthony, 1996; Rydell et al., 1996; Sedgeley and O'Donnell, 1998). Emergence counts consist of placing observers at strategic locations near a bat roost and counting the bats as they emerge for evening departure from the roost.

Emergence Count Protocol

Emergence counts consist of visual observations of bats exiting their roost site. In order to effectively conduct counts, observers should be assigned specific exits or fields of view (at TESC's Organic Farmhouse, the north and south sides of the building), and should be present at their stations prior to the start of emergence to ensure that the earliest departing bats are counted (Kunz, 2003). Counts should begin ½ hour before official sunset and conclude at ½ hour after official sunset following guidelines suggested by Johnson (2002) and Butchkowski (2009) for *Myotis yumanensis* and *M. lucifugus* emergence counts. If availability of observers is limited, evening emergence surveys should be conducted during at least 3 consecutive nights during periods of maximum adult colony size; for maternity colonies, this is the period of late pregnancy and early lactation- approximately the 3rd week of June (Butchkowski, 2009; Kunz, 2003).

If observers are available for ongoing emergence counts, information such as intra-colony variation in the number of bats present and seasonal change in colony size associated with reproductive activity can be garnered (Kunz, 2003; Ransome, 1990). For ongoing emergence counts, observers should conduct their first count during the last week of May and continue to survey at least every two weeks through July 31 (Butchkowski, 2009). Two or more counts on consecutive evenings should be conducted to obtain error parameters (Butchkowski, 2009). If counts are conducted after young begin to fly (approximately late June, early July), it is important to bear in mind that newly volant young may depart later in the evening than adults, thus making it necessary to extend the census period until past the time when the adults have emerged, or make visual counts of roosting young if possible (Butchkowski, 2009; Kunz, 2003; Kunz and Anthony, 1996).

Emergence Count Results 2011

In summer 2011, the author, with the help of a research assistant, conducted eight evening emergence counts at the farmhouse during the lactation and fledging period (6 July to 14 August). The counts were completed on a weekly basis except during the week of 11 July through 17 July, due to heavy rainfall. The emergence counts resulted in findings detailing the number of bats utilizing the Organic Farmhouse as well as the bats' roosting behavior at the site. The first evening emergence count on 6 July, 2011, resulted in the highest count of all the surveys. 330 bats were observed exiting the Farmhouse on that date (Table 1).

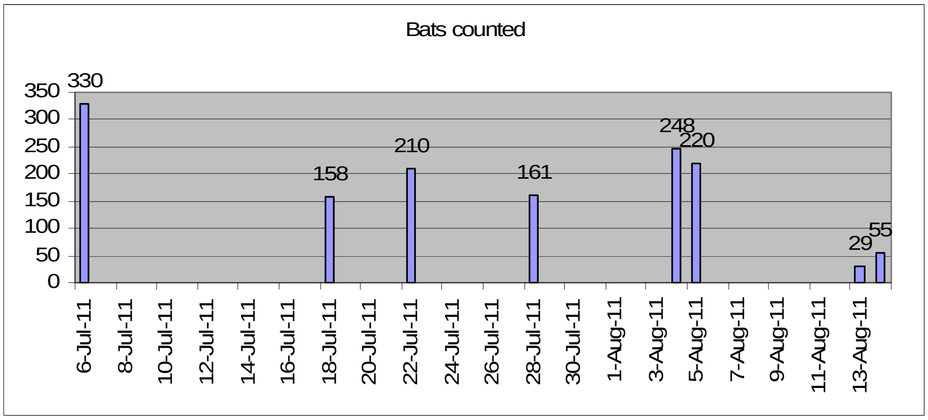

Table 1. Summary of the total number of bats counted during weekly emergence counts at TESC Organic Farmhouse 2011. The final 4 counts were paired to obtain error parameters.

The number of emerging bats counted declined over the next few weeks until 4 August, when 110 juvenile *Myotis* spp were observed roosting together underneath siding material on the west face of the Organic Farmhouse (Fig. 1). Approximately the same number of juveniles was observed at the same location the following night as well. On both nights, the juvenile bats were observed at the end of the survey period, after the departure of

Figure 1: Juve. *Myotis* observed roosting in large group in central portion west wall of farmhouse August 4&5.

On the following survey, 13 August,

the juvenile bats were not seen under the siding on the west side of the farmhouse. However, bats were observed emerging from the south side of the Farmhouse, this time from underneath metal flashing material along the edge of the roof (Fig. 2). Upon closer inspection, we determined that many juvenile bats were roosting under the flashing, but an accurate count was not possible due to obscured viewing. On the following night, 14

Figure 2. Juve. *Myotis* were observed roosting under metal roof flashing on the south side of the Farmhouse August 13.

Figure 3. Two roosting locations were observed on the north wall of the Farmhouse. The area near the roof peak was used the most frequently.

August, bats were again observed roosting under and exiting from the south side roof area.

Throughout the survey season, bats were observed emerging from several locations in addition to sites where juveniles were observed roosting. Two groups of bats were noticed during emergence counts. One group consistently emerged from the Farmhouse on the north end of the building, while another group moved en masse to several different locations on the south and west sides of the structure. The north side group emerged from the location on the lower section of the wall on the first evening survey, 6 July (Fig. 3). On all subsequent emergence counts, bats emerged from the higher location near the roof peak. The number of bats emerging from the northern wall peaked on 18 July with 130 bats and declined throughout following surveys (Table 2).

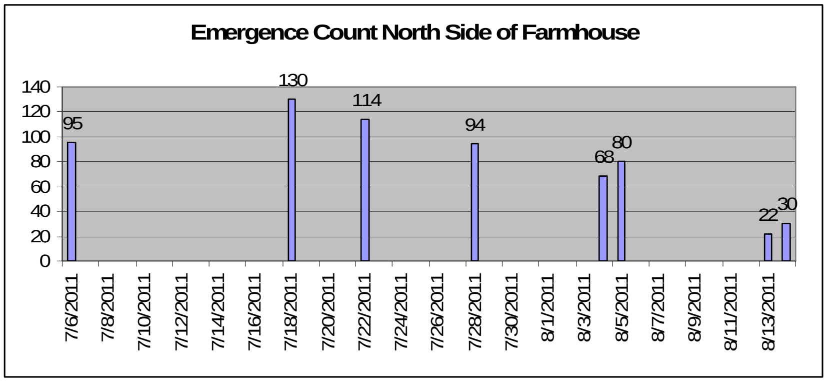

Table 2. Number of bats counted emerging from north side of TESC Organic Farmhouse 2011.

Figure 4. Roosting locations on south wall of Farmhouse on July 6, 18 & 22.

Figure 5. Roosting locations on west wall of Farmhouse on July 28, and Aug 4 & 5.

Yuma Bats that was first observed emerging from the south wall of the Farmhouse on 6 July changed roosting locations regularly throughout the surveying period. On July 6, 18 and 22, the group was observed emerging from three different locations on the south wall of the Farmhouse (Fig. 4). On 28 July and 4 & 5 August, the group was observed emerging from two different locations on the west wall of the Farmhouse (Fig. 5) and no bats were observed emerging from the south wall. As previously noted, juvenile bats were observed roosting under slats on the west wall on 4 & 5 Aug. One week later, 13 & 14 August, most bats had apparently departed for the season and the few remaining bats emerged from the north wall and the metal flashing along the roof on the south wall (Fig. 2). No bats were observed emerging from or roosting on the west wall.

The peak number of bats counted emerging from the south and west walls occurred on the first count, 6 July (Table 3). The count numbers declined greatly until 4 August when the group of approximately 110 juvenile bats was discovered on the west wall of the Farmhouse.

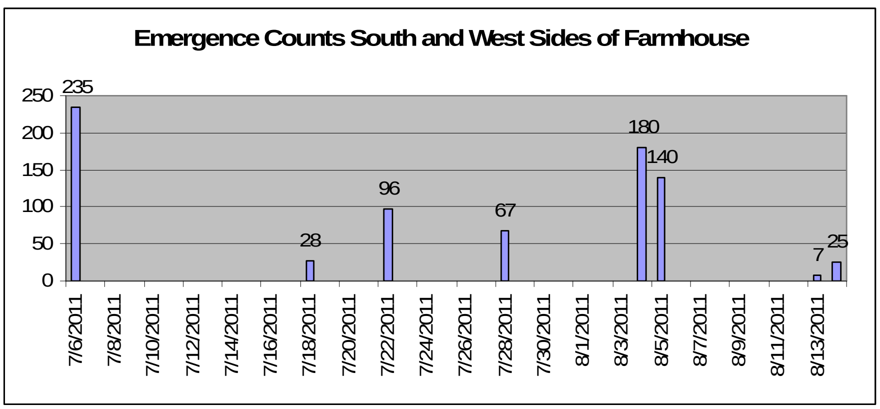

Table 3. Number of bats counted emerging from south and west sides of TESC Organic Farmhouse 2011.

Chapter 6: Conclusion and Recommendations

Observations of the TESC Organic Farmhouse colony in 2011 clearly established that the annual gathering of bats is indeed a maternity colony bearing young at the Farmhouse. Additionally, observations demonstrated that the colony is quite mobile, using many surfaces of the structure for roosting and rearing young. The bats move around to different locations often, likely due to varying roost temperatures and weather conditions (Mitchell-Jones, 2004). Frequent moves to different roosting locations may also help the bats evade parasites (Tuttle, 1993).

If TESC Facilities Services does proceed with remodeling the Farmhouse, a habitat with varied and abundant areas for *Myotis* bats to roost and raise young will be lost. Bats are notoriously selective about the habitats in which they carry out life functions such as feeding, mating, hibernating, and bearing young (Evelyn et al., 2004; Mitchell-Jones, 2004; Tatarian, 2006; Williams and Brittingham, 2006). Attempting to mimic the variety of roosts available on the Farmhouse with a structure such as a bat house would be difficult due to the wide range of nooks available for roosting on the current farmhouse structure. As observed during the 2011 emergence counts, bats can roost low to the ground in cooler areas, high up on the structure under the roof, and on three different sides of the building. The variety of roosts provides bats with a range of temperatures, humidity's, and gradient of safety from ground predators that would be very difficult to replicate.

Recommendations

As it appears inevitable that the Farmhouse structure will be remodeled, some attempt at providing the maternity colony with alternative housing should be undertaken lest the colony abandon the site, which would likely result in many casualties (Briggs, 2000; Evelyn et al., 2004; Mitchell-Jones, 2004).

In spring 2011, TESC's Facilities Services and the Center for Ecological Living and Learning (C.E.L.L.) granted the author permission to build a bat house near the Organic Farmhouse. The author plans to construct bat housing and assist students with further study of the maternity colony during summer of 2012.

Bat condos have been successfully used to provide maternity roost shelter for Little Brown Bats (Fig. 6). Little information is available about Yuma Bats using bat-house structures for maternity roosts. However, because Yuma Bats have displayed long-lasting fidelity to the Farmhouse site, one could expect that the bats may be accepting of an alternative roost structure at the same location (Evelyn et al., 2004).

Figure 6. A bat-condo intended for relocation of a colony of 10,000 Little Brown Bats near Spokane, WA 2008. http://www.wa.nrcs.usda.gov

There are many uncertainties with a bat house being the only available shelter for roosting and parturition at the site should the Farmhouse become rendered inaccessible to bats due to remodeling. The Little Brown and Yuma Bat colony may readily accept an artificial bat house and begin using it, or, only a few bats may use it, or, it may remain uninhabited. However, when a bat-house is designed specifically to meet bats' needs, with considerations such as location, exposure to sunlight, and dark-colored stain for heat retention all taken into account, occupancy rates can be greatly increased (Tuttle, 1993). Conditions such as temperature, humidity, air movement, location of the structure, and height above ground are all determining factors in whether bats will occupy a bat-house (Evelyn et al., 2004; Mitchell-Jones, 2004). A design such as that provided in the Pennsylvania Game Commission's *"Bat Condo Directions"*, by Butchkoski and Hassinger (1997), takes into consideration many of the requirements of *Myotis* bats and has been successful in attracting Little Brown Bat colonies.

Another option is the installation of several smaller sized bat houses in strategic locations near the Farmhouse (Fig. 7). While smaller bat houses typically house only 100-200 bats, their smaller size allows for more placement options including different heights, distances from buildings etc., and exposure to sunlight. Varied placements may provide the bats with enough options for roosting to replicate the abundance of roosts available at different heights and exposures on the Farmhouse. Additionally, smaller bat houses are less expensive and less labor intensive to build than a large bat condo.

Figure 7. A seven-chamber bat house from Bat Conservation and Management, Inc. Houses up to 210 *Myotis* sized bats. http://www.batmanagement.com

Further Research

Continuing study of the Organic Farmhouse colony should include temperature and humidity measurements in the bats' preferred roosting locations in order to learn more about the roosting and parturition requirements of local Little Brown and Yuma Bats. As more information is gathered about the habits of the colony, continuing the availability of optimum shelter should become more straightforward. In addition to investigating the roosting habits on the farmhouse, yearly emergence counts should be continued in order to monitor presence and fluctuations in the maternity colony population (O'Shea and Bogan, 2003).

Emergence Count Data Forms and Surveyor Information Forms specifically made for surveys at the Organic Farmhouse and Kifer Barn are available in Appendix B. Additionally; the Emergence Count Protocol section of Chapter 5 provides a proven methodology and straightforward means of carrying out seasonal monitoring of the Farmhouse bat colony. A basic database, such as a Microsoft Excel®-style format, would be very helpful for compiling yearly survey data and keeping all important information about the colony together in one format. See Appendix C for sample Excel spreadsheet summary of emergence counts for 2011.

Further research on the Farmhouse bat colony should also take into account the rapid spread of White-Nose Syndrome among North American bats and the potential that the disease may reach Washington State. As WNS appears to only be active in hibernating bats, identifying the Farmhouse colony's hibernacula site could be very helpful in taking preventative measures against WNS infection (Reichard and Kunz, 2009). It is believed that the primary means of transmission of WNS is from bat to bat, however, recreational activities in areas infected with WNS such as caving or hiking, could lead to people inadvertently transmitting the disease great distances in a short amount of time (USFWS, 2011). As a side-note, currently there is no evidence that *Geomyces destructans* is pathogenic to humans (USFWS, 2011).

If the hibernacula site for the Farmhouse bat colony can be identified, protection from disturbance by humans, possibly including cavers carrying WNS, could be established for the site. One possible method for following the colony members to their hibernacula is radio telemetry, involving attaching small transmitters to several colony members while at the Farmhouse site at then tracking them to their wintering grounds. Radio tracking a bat over long distances would require an intensive effort to maintain contact with the traveling bat, as radio telemetry transmitters have a limited effective range that is reduced substantially by vegetation and geographical features such as hills (Holland and Wikelski, 2009).

However, this is not to say that it would not be worth the effort to attempt to radio-track individuals from the Farmhouse colony to their hibernacula site; Evelyn et al. (2004) was successful in tracking 15 out of 16 radio-tagged Yuma Bats to roost sites in a suburban California residential area. Additionally, Cochran and Kjos (1985) successfully radio-tracked an individual Swainson’s Thrush (*Catharus ustulatus*) over 1,500 km, by ground vehicle. Thus, with enough perseverance, it appears that one could radio-track small bats to their hibernation sites as well. Unfortunately, as of yet, developing technology has not reduced globally-effective Position Tracking Terminal (PTT) satellite tracking transmitters to a light enough weight to use on *Myotis* sized bats (Holland and Wikelski, 2009).

Author's Note

Please feel free to contact the author with any questions about bat activity at the Farmhouse or for support such as electronic copies of field survey forms, or recommendations about setting up bat monitoring activities. Enjoy the bats!!

Noel Ferguson

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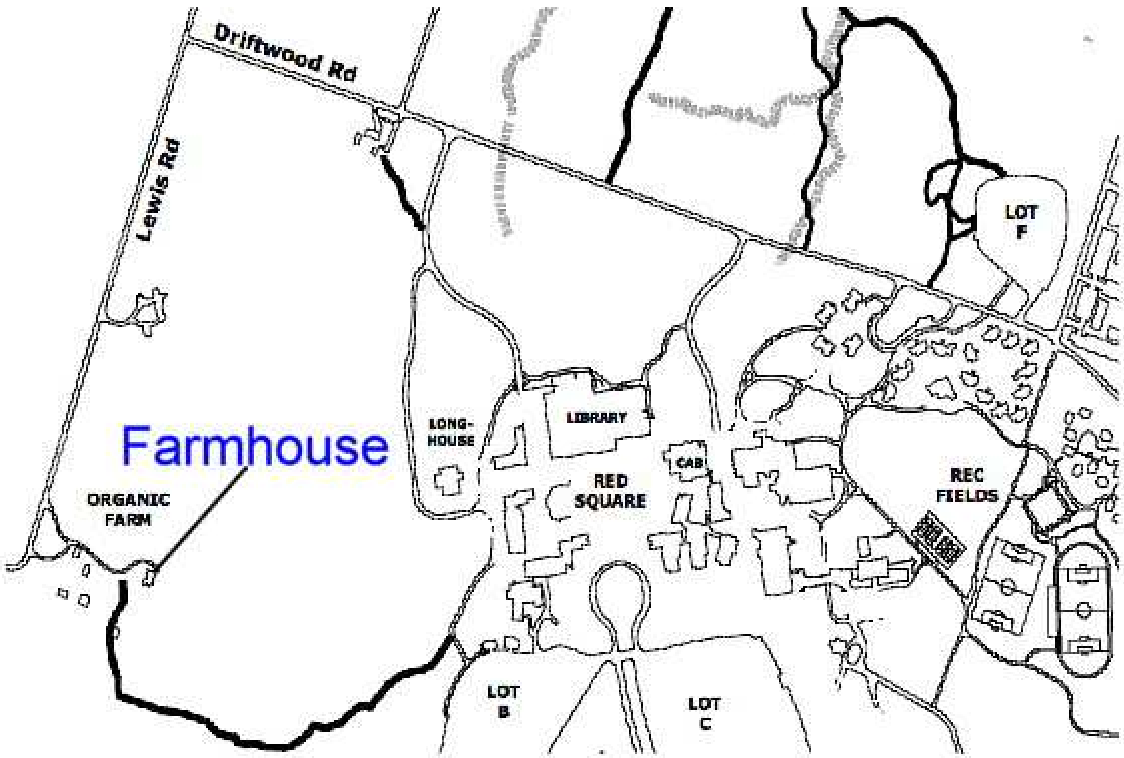
APPENDICES

Appendix A: Map of Organic Farmhouse Location



Map of The Evergreen State College, Potasnik, GIS 2006

Appendix B: Emergence Count Survey Forms

The Evergreen State College Bat Colony
Summer Maternity Roost Monitoring-EMERGENCE COUNT Data Form

SURVEYOR NAME:________________________________

(Surveyor who is responsible for reporting, and has completed a SURVEYOR INFO data form)

DATE	SKY CODE NO	WIND CODE NO	START TEMP ºF	START TIME (24 hr)	END TIME (24 hr)	TOTAL BATS COUNTED	Survey TECHNIQUE USED: VISUAL, VIDEO, or OTHER
BAT TALLY/ NOTES and COMMENTS							

SKY		WIND		
CODE	DESCRIPTION	**CODE**	DESCRIPTION	~Speed
1	Clear-Clear to a few clouds	**1**	Calm-Leaves Still	0 MPH
2	Partly Cloudy-Clouds but variable sky conditions	**2**	Slight Breeze-Leaves slightly Rustling	1-7 MPH
3	Cloudy-Mostly cloudy or overcast	**3**	Gentile Breeze-Leaves and twigs in motion	8-12 MPH
4	Drizzle-Light intermittent rain	**4**	Mod. Breeze-Small branches begin to move	13-18 MPH
5	Showers-Steady soaking rain	**5**	Windy-Small Trees or more in canopy sway	19-24+ MPH
6	Thunderstorms-Rain with thunderstorms	**6**	Not Recorded-	Not Recorded
7	Not Recorded-Not Recorded			

Sky and wind codes of 1 – 3 are best. Code of 4 is marginal. Avoid surveying if code is higher than 4.

Roost Site Surveyed:

☐ Organic Farmhouse

Check box for side(s) of Farmhouse surveyed N☐ S☐ E☐ W☐

(See photos for orientation)

☐ Kifer Barn

☐ Other:______________________________

Location on Organic Farmhouse and/or Kifer Barn where bats were observed emerging. (Mark location(s) on appropriate photos)

North

East

South

South II

West

Kifer Barn

The Evergreen State College Organic Farmhouse and Kifer Barn
Summer Maternity Roost Monitoring-SURVEYOR INFORMATION Data Form

SURVEYOR INFORMATION (CONFIDENTIAL):

NAME: ____

ADDRESS: ____

____

CITY: ________________________________ STATE: __________

ZIP: ______________

PHONE: ________________________________

EMAIL: ________________________________

SURVEYOR TYPE (circle what best describes you):

Volunteer -You are surveying as a volunteer and have limited expertise in both bat identification and ecology.

Student -You are a student studying bats with a basic expertise in both bat identification and ecology.

Researcher -You are actively involved in bat research on an academic and/or professional level.

COMMENTS: (Bat experience etc.)

____

____

____

____

____

____

____

____

Appendix C: Sample Spreadsheet for Summarizing Survey Data

Date	Surveyor Name	Location	Start Time	End Time	Sunset
7/6/2011	Arielle Pauling	Org. Farmhouse South Side	8:30	9:35	9:09
7/6/2011	Noel Ferguson	Org. Farmhouse W/N Side	8:30	9:35	9:09
7/18/2011	Arielle Pauling	Org. Farmhouse North Side	8:30	9:25	9:00
7/18/2011	Noel Ferguson	Org. Farmhouse South Side	8:30	9:25	9:00
7/22/2011	Arielle Pauling	Org. Farmhouse South Side	8:30	9:17	8:57
7/22/2011	Noel Ferguson	Org. Farmhouse North Side	8:27	9:17	8:57
7/27/2011	Arielle Pauling	Kifer Barn (observed from same location)	8:22	9:29	8:49
7/27/2011	Noel Ferguson	Kifer Barn (observed from same location)	8:22	9:29	8:51
7/28/2011	Arielle Pauling	Org. Farmhouse South Side	8:19	9:10	8:50
7/28/2011	Noel Ferguson	Org. Farmhouse North Side	8:19	9:10	8:50
8/3/2011	Arielle Pauling	Kifer Barn (observed from same location)	8:17	9:25	8:42
8/3/2011	Noel Ferguson	Kifer Barn (observed from same location)	8:17	9:25	8:42
8/4/2011	Arielle Pauling	Org. Farmhouse S/W Side	8:20	9:05	8:40
8/4/2011	Noel Ferguson	Org. Farmhouse North Side	8:20	9:05	4:40
8/5/2011	Arielle Pauling	Org. Farmhouse West Side	8:35	9:05	8:39
8/5/2011	Noel Ferguson	Org. Farmhouse North Side	8:35	9:05	8:39
8/10/2011	Arielle Pauling	Kifer Barn (observed from same location)	8:34	9:05	8:31
8/10/20111	Noel Ferguson	Kifer Barn (observed from same location)	8:34	9:05	8:31
8/13/2011	Arielle Pauling	Org. Farmhouse S/W Side	8:20	9:15	8:26
8/13/2011	Noel Ferguson	Org. Farmhouse North Side	8:21	9:15	8:26
8/14/2011	Arielle Pauling	Org. Farmhouse S/W Side	8:10	9:00	8:24
8/14/2011	Noel Ferguson	Org. Farmhouse North Side	8:10	9:00	8:24

Start Temp.	Cloud Cover %	Wind Speed/ Direction	Bats counted	
75F	0%	5 mph winds/		235
75F	0%	5 mph winds/N		95
			Total	330
60 F	0%	0 mph/S		130
60 F	0%	0 mph/S		28
			Total	158
65 F	0%	10 mph/ SE		96
65 F	0%	10 mph/ SE		114
			Total	210
65 F	70%	0 mph		5
65 F	70%	0 mph		5
			Total	5
72 F	0%	0 mph		67
72 F	0%	0 mph		94
			Total	161
75F	0%	0 mph		7
75 F	0%	0 mph		7
			Total	7
72.5 F	0%	5 mph		180
70 F	0%	5 mph/ N		68
			Total	248
60 F	60%	0 mph/ N		140
60 F	60%	0 mph/ N		80
			Total	220
65 F	0% - hazy	0 mph		5
65 F	0% - hazy	0 mph		5
			Total	5
65 F	15%	0mph		7
65 F	15%	0 mph		22
			Total	29
60 F	75%	5mph/N		25
60 F	75%	5 mph/ N		30
			Total	55

Notes

8:55 - first bat emerges. Bats emerged from lower corner of roof - far left side
9:02 - first bat emerges. Many bats returning and flying in and out of roosts

8:57 - first bat emerges.
9:03 - first bat emerges. Same few bats that emerge fly back and forth.

9:00Bats are observed emerging from large slat previously unoccupied on last S. side count. Investigated
8:49 - first bat emerges.

9:15 - walked to area on North side and saw bats exiting from open doorway in barn
" "

9:00 Discovered new major roosting area on the West side; never noted them here previously
8:44 first bat emerges.

not many bats tonight.Most must roost at the Org. farmhouse
" "

8:45 - first bat emerges. None were seen coming from S. side just W. side. Observed many juvenile bats
8:41 - first bat emerges, briefly pursued by dragonfly. Many bats returning shortly after emerging

8:36 - bats already emerging when I arrived. Counted about 110 still in roost slat above window on W side
8:36 - first bats emerge. A few unsteady flyers doing short loops off the side and back are observed.

8:34 - first bat observed, flew into the barn through narrow doorway on back.

8:40 first bat emerges and bumps into window. W side is completely abandoned. Only the narrow roofing
8:33 - first bat emerges.

8:34 - first bat emerges from corner of roof on S side. New roosting spot.
8:20 - first bat emerges from roof peak. 1 lone bat repeatedly lands on the siding near peak after flying in

Appendix D: Examples of Bat Detectors

Pettersson Elektronik

"The D1000X is a professional ultrasound detector, based on the latest technology. The detector has heterodyne, frequency division and time expansion systems and also a built-in 16-bit recording system using a Compact Flash card as storage medium. It is equipped with our well-known, high-quality capacitance microphone which has been further improved to give lower noise, wider dynamic range and lower distortion." www.batsound.com last accessed 9-14-11 Approx $6,000

"The D 500X is an ultrasound recording unit intended for long-term, unattended recording of bat calls. In contrast to time expansion bat detectors, the D500X records full-spectrum ultrasound in real time with virtually no gaps between recordings. The recorder is equipped with four slots for CF cards, which typically makes it possible to leave the unit in the field for more than a month. The triggering system allows the device to automatically start recording as a sound is detected." www.batsound.com last accessed 9-14-11 Approx $2,400