
**Fort Lewis
2009
Townsend's big-eared
Bat Study**



prepared for
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and
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Introduction and Summary

The Townsend's big-eared bat (*Corynorhinus townsendii*) is a federal *species of concern*, and a Washington state *candidate species* for listing as threatened or endangered. Although found across Washington state, the number of known nursery colonies is limited to approximately 20, each with 20 – 200 bats. This species is the only Washington bat known to form nursery colonies in caves; however half of the known colonies utilize buildings.¹ Compared to other species, these bats are particularly sensitive to human disturbance at day roost sites. A thorough review of Townsend's big-eared bat colony structure and their susceptibility to disturbance is found in a 1998 status review of Townsend's in California, by Pierson and Rainey.²

A 1990 report by Perkins³ estimated the known population of Townsend's big-eared bats in Washington State as 600 (not all colonies are known and documented), indicating Townsend's numbers are in decline in the Pacific Northwest. Forest management practices are likely responsible for some of these declines,⁴ as is loss of roosting habitat. Disturbance from human activity (research, mineral extraction, and recreational activities), removal of old buildings, and bat exclusion efforts are responsible for the extirpation of many historic Townsend's colonies.⁵ Removal of older trees and snags, the dominance of even age forests, and use of chemical treatments in forests are likely impacting the foraging habitat.

Bats in the genus *Corynorhinus* are difficult to detect during surveys. They have very quiet echolocation calls that are seldom documented in recordings made during acoustical bat surveys, even in areas they are known to occupy.^{6,7,8} They are also adept at avoiding mist nets used in bat surveys.⁹

Townsend's big-eared bats prey primarily on medium size moths (average 5 cm wingspan) but will take larger prey, such as Sphinx moths.¹⁰ Their distribution appears to be associated with mature conifer stands, like those found on the Fort Lewis Military Reservation. The flight and echolocation style of this species is well adapted for foraging along mature forest canopy.¹¹ Their strategy of feeding on moths in the forest canopy likely contributes to healthy forests. Studies indicate that their diet includes forest pests such as the tussock moth.¹² Prey studies for Townsend's bats in the western states have not been conducted, and their contribution to Northwest ecology may be undervalued.

Documentation of Townsend's big-eared bats on Fort Lewis is spotty. During a 1992 Fort Lewis bat survey, a single adult female Townsend's was captured, radio-tagged, and subsequently tracked to two sites in the nearby town of Roy.¹³ This effort did not document a maternity colony, but a small number of Townsend's bats were found roosting in a building in the town of Roy. After a few days, the bats moved to nearby shed, and then disappeared. Follow-up inspections at one of the roost sites indicated the presence of a colony for a period during the 1990s, but monitoring has been intermittent. The building manger made repeated attempts to eradicate the bats in the building's attic, which may have been successful; in 2005, the WDFW district biologist reported that the colony had not been at the site for some years, and its fate was unknown.¹⁴

In the mid-1990s, there was also a report of a single Townsend's big-eared bat found in a construction office trailer in the Rainier Training Area (RTA), but no details on this animal are in

the records. A targeted study was conducted in 1996 to determine if these bats of federal and state concern were present on Fort Lewis, but none were found.¹⁵ Until the 2008 Fort Lewis bat survey, no known documentation of Townsend's bats has occurred on or nearby Fort Lewis for a number of years. In September, 2008, on the final day of a comprehensive bat inventory conducted on Fort Lewis by Cascadia Research, the first Townsend's big-eared bat was encountered, day-roosting in a concrete culvert adjacent to Bower Woods.

The bat was radio-tagged and tracked during evening foraging for 6 nights, and a search image for the type of preferred night-roosting structure was developed. Using this information we were able to document 2 more Townsend's bats by the end of September--a post-lactating adult female, and a juvenile male (a 'young of the year'). The adult female was tagged and tracked for 7 days, documenting that both of the tagged bats foraged in forests on the military installation during the early autumn season.

Given these encounters, Fort Lewis Fish and Wildlife, The Nature Conservancy, and Cascadia Research all realized that this elusive species may actually be present in the Fort's diverse lowland wooded areas, and that these recent encounters might indicate a maternity colony was located nearby. However, since many bats disperse away from maternity colonies after the reproductive season, occurrences in late September did not necessarily indicate that a maternity colony resided in the area.¹⁶

Between 17 June and 29 September, 2009, 22 Townsend's big-eared bats were visually sighted or captured. Six of these were fitted with radio-tags and tracked. Additionally, 2 reproductive female Long-eared myotis bats (*Myotis evotis*) were tagged and tracked, which were found to use similar habitat as the Townsend's bats. This report contains a discussion of what we learned during this follow-up study targeting Townsend's big-eared bats, performed during the summer of 2009.

An important conclusion from the tracking effort is that the Townsend's bats forage in stands of large conifers, typically with open and complex canopy structure, and they would travel between isolated stands of this type. Most of the tracked bats would travel up to several miles between stands, revisiting some of the same locations each night. Although much of the foraging occurred deep within Fort Lewis, such as in the Central Impact Area (CIA), no maternity roosts were located within the boundaries of the installation. A small complex of Townsend's nursery roost sites were located 0.5 km (0.36 mile) off the Fort, in the town of Roy, which appeared to collectively house one maternity colony.

In addition to the Townsend's discoveries, two radio-tagged long-eared myotis bats were tracked to roost trees, including a snag in Training Area 5, which housed over 40 bats in June, a positive indication of a maternity colony roost. Genetic test results from long-eared myotis bats sampled in this same area during 2008 indicated that some of these bats are the cryptic *Myotis keenii*, a species of concern. During this field work, several other bat nursery colonies were discovered in undeveloped areas of the Fort, boosting the opportunities for bat conservation on the installation. These are discussed in *Recommendations*.

Project Goals

The project goals were to study the Townsend's big-eared bats, verified on Fort Lewis in September 2008, to better understand:

- Foraging habitat
- Preferred roosting locations & roost structure characteristics.

Better understanding of these variables will help inform conservation efforts and possibly forestry practices. These goals were accomplished by radio-tagging and tracking six adult female Townsend's big-eared bats, and two reproductive female Western Long-eared bats, between 17 June and 15 October, 2009. We performed detailed radio-tracking of foraging movements on 30 nights, and on 32 days searched for, or verified, day roost locations. The detailed behavioral data has helped to interpret the locational data.

Strategies and Methods

Capture strategy

To accomplish the project goals with the limited funding available, we proposed to investigate foraging habitat preferences by radio-tagging at least five Townsend's big-eared bats, then track each individual for an average of two nights. We also budgeted four days per tagged bat to perform daytime tracking to locate day roosts. If we failed to capture enough Townsend's bats, we planned to tag and track Western long-eared myotis bats, encountered during the 2008 surveys, as they used similar forest habitats on the installation, and past experience showed that these could be captured.

We tracked foraging bats for a total of 30 nights, and tracked bats to day roosts on 32 days (Table 1). Tracking was performed in continuous sessions rather than switching between multiple bats, in an attempt to collect stand-level foraging habitat data rather than home range data, where periodic sampling is preferred. Since Townsend's bats are believed to be roost limited, finding roost sites, and more importantly, locating maternity roosts was a study priority. Roost switching has been observed with most forest bats, so locating day-roosting bats for multiple days was incorporated in the study plan.

Capture effort was constrained to limit the amount of disturbance to the roost sites. Two sites suspected to shelter maternity colonies were not inspected when adults were present. The primary site was not entered until nursery activities were believed to be completed for the season. Infrared cameras and bat detectors were used to investigate roost sites, modified to improve their performance with Townsend's echolocation calls, which are of such low volume that this species has earned the nickname "*the whispering bat*".

Considerable effort was expended searching for and capturing Townsend's bats at night roosts scattered throughout the foraging habitat on Fort Lewis. This strategy was chosen given the lack of knowledge of day roost locations, and then continued after day roosts were identified because other studies have indicated that bats are more tolerant of disturbance at night roosts than at maternity sites.¹⁷ These strategies were successful for both achieving our data collection goals and for the conservation goal of not displacing bats from day roost sites. A verification of success in this regard was the netting near a maternity roost which had no detectable negative consequences.

Table 1. Tracking effort for Townsend 's Big-eared bats (*Coto*), Summer 2009.
 T= tracking during foraging performed, DR = the day roost located for this date.

Date	Coto-1		Coto-2		Coto-3		Coto-4		Coto-5		Coto-6	
	Forage	Roost	Forage	Roost	Forage	Roost	Forage	Roost	Forage	Roost	Forage	Roost
6/17/09	T											
6/18/09	T	DR1										
6/19/09	T	DR1										
6/20/09	no effort	DR2										
6/21/09		DR2										
6/22/09	T	DR2										
6/23/09	no effort											
6/24/09	T	DR2										
6/25/09	T	DR1										
6/29/09			T									
6/30/09			T	DR1								
7/01/09			T	DR1								
7/02/09			T	DR1								
7/03/09			T	DR1								
7/05/09					T							
7/06/09					no effort	DR1						
7/07/09					T	DR1	T	DR1				
7/08/09					no effort	DR1	T	DR1				
7/09/09					T	DR1	T	DR1				
7/10/09							no effort	DR1				
7/11/09							T	no effort				
7/12/09							rain	DR1				
7/13/09							T	no effort				
8/11/09									T			
8/12/09									T	DR1		
8/13/09									T	DR1		
8/14/09									T	DR1		
8/15/09									T	DR1		
8/16/09									T	DR1		
8/17/09										no effort		
8/18/09										DR1		
9/29/09												DR1
9/30/09											no effort	
10/01/09											no effort	
10/02/09											T	DR2
10/03/09											T	DR2
10/04/09											no effort	
10/05/09											T	DR2
10/06/09											T	DR2
10/07/09											T	DR3
10/08/09												DR4
Days of effort:	6	7	5	4	3	4	5	5	6	6	5	6

Tracking effort summary:

	Foraging		Day roosting	
Totals days of effort:	30		32	
Average days per bat:	5		5.3	

Capture effort was constrained to limit the amount of disturbance to the roost sites. For instance, a site suspected to shelter a maternity roost was not inspected when adults were been observed leaving via multiple routes. At a distance of approximately 30 meters from the structure a mist net was erected along one of the flight paths. We captured 5 Townsend's bats (out of an estimated 20-30 bats roosting there), and tagged one non-reproductive female who returned to that structure each of the 8 days her tag was attached. Had there been only one exit, or if all of the bats followed a constrained route, this may not have been an appropriate location for a net.

Tracking strategy

Generally, only one bat was radio-tagged at any given time. The collection of foraging data requires constant observation, which was accomplished by following these wide-ranging, fast-moving flying animals, whose movements were not constrained to roads. Compounding this standard problem encountered in bat foraging studies was the access restrictions to various training areas that the bats traveled through or foraged in. At times this interrupted tracking led to subsequent loss of the animal's location. This occurred when a bat would utilize the Central Impact Area, which five of the six radio tagged Townsend's bats did during the tracking period.

Tracking data was recorded on digital voice recorders (Olympus VN-960PC), allowing the observer to take detailed notes without interrupting tracking effort. Observation date and time is retained when the notes are downloaded to a computer for transcription. This produced a higher quality of data than written notes during night-time tracking. At the time of transcription, tracking and location data was entered into a custom database program GTM 2.35 (Sartell, Missouri Dept. of Conservation),¹⁸ which is a map-based digitizing application which populates Microsoft Access database tables, creating a fairly universal data structure. The program was written to satisfy the specific data entry needs for radio tracking studies, and included built-in modules to run HomeRange module (Ackerman, et al, 1985)¹⁹ and KernelHR (Seaman & Powell, 1998)²⁰ which were used for creating range and utilization polygons, discussed in the results.

Results and discussion

Results

Six Townsend's big-eared bats were located and radio tagged to meet our study goals. Survey effort consisted of 32 dedicated days of search/capture effort and 30 days and nights of radio tracking effort. Tracking nights typically included opportunistic search effort, such as checking for bats while tracking in the vicinity of a known or possible night roost, or setting up bat detectors in the area of operations. During these searches, there were 24 separate Townsend's big-eared bat encounters (visual observation, acoustic recording, or capture & release). Acoustic encounters (echolocation calls) were only counted as a distinct individual when it was clearly not a recording of the Townsend's bat being radio-tracked.

Six Townsend's big-eared bats were tracked during foraging activities (Table 1) on an average of 5 nights apiece (range: 3 – 6 nights). During the day roost investigations, tagged bats were located each day, for an average of 5.3 days (range: 4 – 7 days). Additionally, the two groups of reproductive Townsend's believed to collectively comprise the local Roy colony were monitored. The radio tagged Townsend's bats foraged primarily on Fort Lewis, utilizing conifer stands on the installation between 70 and 100% of their feeding time. Focal feeding areas were generally north or west of Roy, and 5 of the bats spent some time foraging in the middle of the Central Impact Area, approximately 8 km from their day roosts in Roy. Excluding the day they were captured, all six bats day-roosted exclusively in buildings located outside the installation boundary. Four bats tracked during the core reproductive period (mid-June through mid-August) roosted in the Roy maternity colony roosts, less than 600 meters from the Fort boundary. The final bat tagged (*Coto-6*, tagged 29 October 2009) foraged exclusively within Fort Lewis, but day roosted in the Spanaway area and at the edge of the Nisqually River delta, at opposite ends of her foraging area. These two successive day roosts were separated by 17 km.

A total of nine day roosts were located. Two were in buildings within 200 meters of each other in the town of Roy, and were occupied by maternity colonies, likely a related social group. Four of the six bats radio tagged and tracked in 2009, and the single female Townsend's tracked in September 2008, roosted at least some of the time in one of these two structures.

Two structures southwest of the town of Roy (1.2km and 1.9 km from maternity roost), housed the first tagged Townsend's bat, along with a few others. One was a two-story garage (split-level) and horse stable, the other an abandoned log house. The garage/stable had signs of previous use by Townsend's bats, in the form of accumulated guano. The first tagged bat made use of both the upstairs garage, and then two different rooms in the downstairs horse stable. One was an abandoned log house 1 km south of Roy, which also sheltered several other day-roosting Townsend's bats, discovered on days that the tagged bats were not occupying this location.

Throughout this study, several different single Townsend's bats were located in a concrete culvert near Range 26, including the final tagged bat (*Coto-6*) which day-roosted in three different off-base residential structures. This last bat was captured at the east edge of the CIA, but day-roosted as far north as Military Rd. at Spanaway Loop Rd., and to the south at an abandoned house between Mounts Rd. and the Nisqually Delta. In 2008, a single female Townsend's big-eared bat was found day-roosting in a barn at the west edge of Roy, at a property adjacent to Muck Creek.

Maternity roosts

The largest group of Townsend's bats formed a maternity colony in the town of Roy, at a site that has probably been occupied intermittently for many years. 52 bats were counted during a count at this larger maternity roost structure (Site 2) on 17 September 2009. This was more than we expected, especially so long past the time the young would normally be weaned. Bats often disperse to other roost sites after nursery activities are completed. At the smaller roost site (Site 1), 8-10 young were observed in a single cluster on 13 July 2009. To minimize disturbance and detrimental impact to these bats, no direct observations were made during daylight hours, when the adults were present. It would be normal to have more adult females at a roost site than there are juveniles, since adult females do not reproduce every year. Recent studies have found that Townsend's regularly shift maternity colonies between sites, both between years, and in some scenarios, during a summer. There is evidence that this may have been the pattern for this colony, but insufficient and discontinuous documentation exists on historic usage of roosts.

A female Townsend's bat (*Coto-5*) was netted mid-evening on August 15, while she entered the stables located nearby the larger roost. All of the daytime locations for her were in the attic of a building that had historic records for Townsend's big-eared bats from the 1990s. This bat was still lactating, so this confirmed suspicion that this structure sheltered a maternity colony, in addition to the fact that there were several earlier Townsend's bat observations in the general vicinity of this structure. The poor lighting conditions combined with the elevated entrance hindered precise observations, and we had not directly observed bats leaving the structure. The current building manager had stated that he did not believe bats were currently present, but had knowledge of prior occupation. When discovered in 1992, the structure was reported to have 12 – 15 Townsend's bats, but it was believed to have been vacated, either from the exclusion efforts or other human disturbance.²¹

The property manager was cooperative, and eventually access to the upper areas of the structure was obtained, and on 17-September infrared video cameras documented over 52 bats in the attic. One camera was aimed at a small opening that had been overlooked during bat proofing efforts, and 47 bats were observed exiting through this passage. After it appeared all of the bats had exited, an inspection of the attic found five Townsend's and one Big brown bat remaining. The location of the current roost was an addition to the main building which forms a secluded, compartmentalized area. This is the same section of the building described as occupied in the 1992 report, yet the accumulation of guano did not appear adequate to indicate continuous use over this entire period.

Some favorable characteristics of this roost site (#2) are seclusion from humans and other animals, and a dark, open attic space. Townsend's bats hang from open surfaces in clusters, rather than squeeze into crevices like many bat species do. This makes them more vulnerable to disturbance and predation, which may be why this species is easily driven out of roost sites. This type of roosting habitat appears to be absent at the preferred feeding areas consisting of older and more complex stands of conifers on Fort Lewis.

The one radio tagged lactating bat foraged in closest proximity to the roost site, a behavior consistent with many studies of bat colonies. Bats will travel longer distances from maternity roosts to foraging grounds if the availability of these two needs are not in close proximity, although this may be a less successful life history strategy.²²

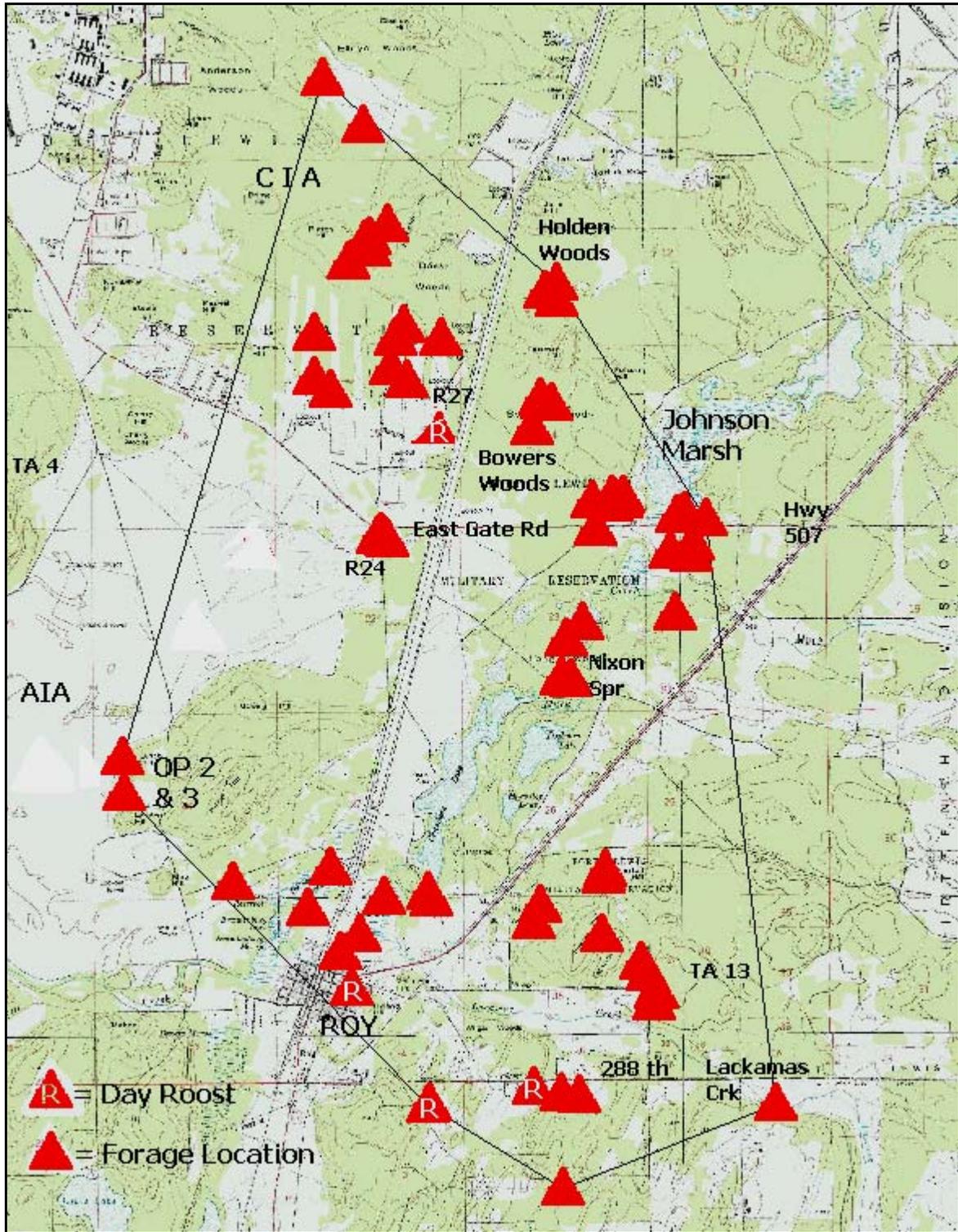


Figure 1. Core activity area for all five Townsend's big-eared bats tracked during the maternity season. Symbols indicate significant foraging locations used multiple occasions or by multiple bats.

Foraging habitat

The shared characteristic in the most-visited foraging habitat were large diameter conifers with complex branch structure typically found in more mature trees (>60 to 80 years), along forest edges. Individual bats would travel between very specific patches of this forest type, visiting the same small patches night after night. The typical foraging focal areas were more park-like, with wider tree spacing and a more open canopy (50 to 70% cover) than other stands which were passed over by these bats. The edges of Douglas-fir stands with uneven tops are the features which attracted the most usage from tagged bats.

Large conifers with an open and complex canopy structure attracted this species of bat. Some focal areas for foraging were isolated stands of 10-12 large trees, or openings in an otherwise more closed forest structure. All of the stands of trees that were foraged by multiple Townsend's bats either had some trees of the largest sizes found in the area, 150 – 180cm DBH (59 – 70 inches), or the majority of trees were 90 – 120 cm DBH (35 - 46 inches). These focal areas had more open canopy, larger diameter trees, and more complex, uneven tops. In many cases there was a nearby shelter to night roost in, but presumably those may be scattered throughout the entire area, not just nearby these larger trees. A 2003 study of bat activity levels in western Washington showed that stand-level variables were the significant predictors of bat activity with landscape-level variables having little or no effect on bat activity.²³

One isolated stand of 12 Douglas-fir (figure 2), with trees averaging 100 cm DBH (43 in.), was used by two different tagged Townsend's bats from the Roy colony, and additional acoustic calls from non-tagged Townsend's were recorded there as well. This was the only off-installation focal area located in this study, located southwest of Roy near Lacamas Creek, on 48th Ave So. This stand was remarkable in that the bats traveled to this location, then returned back to the focal areas on Fort Lewis. Not only did two tagged bats make repeated visits to this stand, but other unmarked Townsend's bats were recorded at this location on acoustic bat detectors. This helps illustrate that unique features attract Townsend's bats, and because this stand is surrounded by pasture on all sides, it made characterizing this popular stand more certain than ones surrounded by forest. The aerial photo below shows this stand of 10 Douglas-fir, all but two were between 100 and 120 cm DBH (43 - 48 in.).



Figure 2. Example of isolated Douglas-fir stand that attracted multiple foraging Townsend's big-eared bats from the Fort Lewis maternity colony. 10 of the 12 trees were between 100 and 120 cm DBH (43 - 48 in.).

Discussion of foraging behavior

The behavior and foraging preferences of this group of Townsend's big-eared bats are consistent with other *Corynorhinus* investigations, although the available tree species are not the same as in other parts of the country where these studies have been conducted. Foraging in forest canopy, individuals' fidelity to specific stands, and showing little association with water features were found here and during a similar study in northern coastal California.²⁴

At times a bat would travel between several of these preferred locations more than once in an evening of foraging, spending from 15 – 20 minutes, up to a couple of hours at each site. Occasionally a bat made return trips to a subset of the first round of locations visited on the evening's route. This was especially evident with the first two tagged bats, possibly because of the greater amount of location data, and their tendency to visit a greater number of sites. One bat, the

still-lactating Coto-5, was repeatedly tracked to one small area, primarily the trees between Observation Posts 2 and 3. This area has some more savanna-like habitat, and was fairly close (2.5 km) to this bat's day roost in Roy, where she would return during the night, presumably to feed her pup, then head out again to forage.

There was a large variation in distances that these bats would travel during a night, although individuals would generally follow similar foraging routines each night, re-visiting the same sites. The one lactating bat, *Coto-5* traveled the shortest distance of 2.6 km, while *Coto-6*, a post-reproductive female made the largest single-night movements: 17 km between successive day roosts, and 17.6 km between a day roost and a foraging area. There is not a standard in bat research for describing these distances. Some report farthest distance from day roost, some total 'loop' distances, obtained by adding up each leg of the night's journey between the documented foraging areas, and various hybrids of these. There are attempts at calculating home ranges using various means, such as the kernel methods which produce utilization probability polygons to show preferred habitat, or the *minimum convex polygon* (MCP), a polygon encompassing all of the data points, as in a series of line segments connecting all of the 'outside' locations. The map shown in Figure 1 is an example of why the kernel method fails to provide useful information for use in conservation decisions for animals which pick and choose small patches of habitat over a wide area.

The data is shown graphically using a combination of methods. There is little value in calculating home range (kernel methods) in terms of area densities when the species is picking specific patches of habitat over a wide area. It is believed that Townsend's big-eared bat occupation is not limited by total area of undeveloped habitat, but by availability of specific features in the habitat, in particular the large, complex tree structures, even if they occur in isolated patches.

Figure 1 depicts a minimum convex polygon of the area used by the five Townsend's bats in the 2009 maternity months of June through August. The locations for the two Townsend's bats tracked during 2008 all fall within this polygon as well. These bats primarily foraged the CIA-to-Johnson Marsh-to-Roy area, plus the forested area southeast of Roy which is contiguous with Training Area 13. They never entered nearby Training Area 16 to the southwest. The expansive travels of post-reproductive bat *Coto-6* show that these individuals are familiar with a wider range than indicated by the first five Townsend's bats that were tagged and tracked in 2009. Why the area toward Lewis Lake or the Nisqually River was not utilized is unknown, and it remains possible that some bats from the Roy group may actually forage there as well.

A search for abandoned shelters that might provide similar shelter as the abandoned latrines in Bower Woods and Holden Woods (training areas 6 and 10) was performed. Several additional latrines were located and reported by Fort Lewis Fish & Wildlife staff, but follow-up inspections found none with indications of bat use (i.e., guano). No additional wooden structures similar to these were located in any of the training areas. Possibly the lack of structures available for night roosting limits the suitability of the area.

Foraging in the Central Impact Area

Although four Townsend's bats foraged in the Central Impact Area, it was not accessible for radio-tracking. Because of this, all of the locations indicated in Figure 3 are approximate, and are based on triangulation from paved perimeter roads. The values indicated by the adaptive kernel utilization contours have more limited value than in areas where specific trees and stands could be identified.

The outer contours (95% utilization density) shown are the areas in the CIA where the tagged bats are suspected to have foraged during the 2009 study. The inner contour is the 67% utilization density area, or where an animal might be expected to be encountered foraging 67% of time when in the CIA. Repeated locations for the same bat were eliminated to reduce possible over-representing an area that may have been estimated incorrectly. Although bats were never tracked foraging in the CIA farther north than Range 29, *Coto-6* foraged to the north of the CIA in Training Area 7S. This bat was captured day-roosting near Range 26 at the east edge of the CIA. Given very weak signals from the locations behind R29, bats traveling in the interior beyond Range 29 may not have been detectable from the perimeter roads.

After the field work was completed, an opportunity to enter the CIA occurred, and foraging areas that were estimated by earlier triangulation were visited. The areas previously mapped behind ranges 25 – 29 were found to contain large diameter conifers which exhibited the loose tree spacing and complex canopy structure used by Townsend's foraging in other areas. It appeared that the Central Impact Area contained substantial reserves of older trees which appear to be the type targeted by foraging Townsend's big-eared bats.

In Figure 3 below, southeast Johnson Marsh and the burned out Ponderosa Pine area north of East Gate Rd are in the lower right corner. Large smoothing values were used for this map in KernelHR, to help connect the widely spaced foraging points.

Winter observations

This species is not known to forage in this area during the winter months,²⁵ however no surveys have been done that would target this species. It is not known where Townsend's bats from this area spend the winter months, but it is assumed they travel to a suitable hibernation site with colder average daily temperatures, which would promote torpor and greater energy savings. Significant numbers of Townsend's bats are found hibernating in lava tubes around Mt. St. Helens, but it is not known if the Fort Lewis group is included.

Recommendations

If adequate late-seral and complex conifer stands remain available as a foraging resource, the success of the Townsend's big-eared bats at Fort Lewis is likely limited by secure and suitable roosting structures. Natural roost sites have been found elsewhere in basal cavities in old-growth redwood trees, or in caves or mines, features absent from this study area. Human made structures appear to be the only available roost habitat, and protecting and enhancing this resource would help secure long-term viability for these bats. The retention of the complex older stands of conifers, in patches of at least a dozen trees, would help ensure the availability of preferred foraging habitat. Open areas in managed forest may offer edge habitat with the favored complex canopy features. The favored conifer stands were more loosely spaced than found in commercial stands, and resembled a park-like configuration. Careful thinning of mid-seral stands may help accelerate the development of the desired complex canopy structure .

Dedicated roost structures located close to the foraging areas would be the single greatest enhancement to promote long-term survival of the known Townsend's colony. The two structures currently housing the colony are old and require maintenance that would likely disturb the bats. One is not secure from humans, and there is known human activity within the structure, although the building owner is supportive of maintaining the bats there. The larger group is in the attic of an ideal structure for these bats, except that it is occupied and the bats could pose a problem for the building managers in the future.

Two or three artificial roost structures on Fort Lewis property could provide a secure nursery designed to meet a colony's reproductive needs. Several designs have been successful for housing Townsend's bats in other regions of the country, and some experimentation could lead to attracting the colony from private and un-securable structures in Roy, to secure structures on public land. Locations that might prove best for a maternity bat structure include the corridor between the Central Impact Area and training areas 10 & 12, and the prairie areas adjacent to Muck Creek, bordering the town of Roy.

Monitoring the condition and status of the colony would be much easier with the colony housed in a specialized structure on the installation, and features to facilitate inspection with minimal disturbance to the bats could be incorporated in the design.



Figure 3. Five of the six Townsend's bats tracked in 2009 foraged in the Central Impact Area. Three of these were captured in a culvert adjacent to the CIA near Range 27, as were 2 additional Townsend's, and several Myotis bats. The male bat tracked in Sept. 2008 foraged primarily in the CIA.

Other bats observed during this study

Concurrent with the Townsend's investigation, several maternity roosts for other species were located on the installation. Two new Big brown bat colonies were located while doing associated field work, and two day roosts for long-eared myotis bats were located by tracking tagged bats.

On 27-June and 11-August long-eared myotis bats (presumed Western long-eared bats, *Myotis evotis*) were captured at night roosts at the east edge of Training Area 5. Presumed to be Western long-eared myotis (*Myotis evotis*), but upon completion of the study we received results from DNA tests that indicated that three long-eared myotis bats captured in 2008 at these same night roosts were actually Keen's myotis (*Myotis keenii*), a state candidate for listing as threatened or endangered. Morphologically very similar, the reliable methods to ID these two species are genetic testing or skull examination of voucher specimens. The range of Keen's myotis has been considered limited to the Olympic Peninsula, but these and an earlier genetic-ID of a single Keen's captured in Mt. Rainier National Park indicate otherwise. Therefore, the two long-eared myotis bats tracked this year (2009) at the edge of TA 5 could have been either of these two species, and genetic sampling will need to be done in the future to resolve the species question.

The two radio-tagged long-eared myotis bats were tracked to locate day roosts. The first tagged bat used a 5 meter tall Ponderosa pine broken snag, which had over 40 bats exit during an evening count. Since this was a pregnant bat, and it was the third week of June, it is safe to characterize this location a maternity roost. This snag was similar to a typical roost structure type found in western Oregon by Ormsbee,²⁶ during a Western long-eared bat study. Another day roost used by this individual, approximately 1 km to the south of this one with 40 bats, was not located, and may have been another maternity roost site. Tree roosting bat colonies typically move among a set of roosts. A follow-up visit to the known maternity tree roost in July indicated that this colony had relocated, likely in this general area, where there were still suitable snags for colonial roosting.

Conclusion

Townsend's big-eared bats and other forest-obligate bats utilize the wooded areas of Fort Lewis in patterns that are probably reminiscent of more historic bat populations. The nearly complete removal of mature conifer forests in the Puget Sound lowlands has no doubt modified the distribution and behavior of the resident bats in this region. Still, the general lack of very old, large decadent trees has forced many bats to use human-made structures for maternity colonies. This jeopardizes their long-term success, as these structures are removed, bats are eradicated, and urbanization forces more separation between forage and roost habitat. Protection and regeneration of Townsend's big-eared foraging habitat could be partially achieved through strict adherence to *the letter* and *the spirit* of the Fort Lewis Forest Stewardship Council certification document (SCS-FM/COC-096N).²⁷

Bats in the Fort Lewis region would greatly benefit from a concerted effort to improve and preserve roosting habitat, especially natural and artificial structures for colonial bats.

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Tables and Figures

Table 2. Bat species found in western Washington state:

Scientific name	Common name	Federal conserv. status	State conserv. status	NatureServ ranking	Presence on Fort Lewis ¹
<i>Corynorhinus townsendii</i>	Townsend's Big-eared Bat	Species of Concern	Candidate species	S3	Yes
<i>Lasionycteris noctivagans</i>	Silver-haired Bat	-	-	S3S4	Yes
<i>Lasiurus cinereus</i>	Hoary Bat	-	-	S4	Yes
<i>Eptesicus fuscus</i>	Big Brown Bat	-	-	S5	Yes
<i>Myotis californicus</i>	California Myotis	-	-	S5	Yes
<i>Myotis evotis</i>	Long-eared Myotis	Species of Concern	-	S4	Yes
<i>Myotis keenii</i>	Keen's Myotis	Species of Concern	Candidate species	S1	Yes
<i>Myotis lucifugus</i>	Little Brown Myotis	-	-	S5	Yes
<i>Myotis volans</i>	Long-legged Myotis	Species of Concern	-	S3S4	Yes
<i>Myotis yumanensis</i>	Yuma Myotis	Species of Concern		S5	Yes

¹Based on 2008 and 2009 survey data collected by Cascadia Research.

² *M. Keenii* : It is now known that their range includes the study area; previously the closest known populations were on the Olympic Peninsula. DNA test results for biopsy samples taken in 2008 from 3 long-eared myotis (forested areas bordering the Artillery Impact Area) were confirmed as *Myotis keenii*.

Table 3. Townsend's big-eared bats roosting locations identified on Fort Lewis in 2008 & 2009, with other species noted.

ID	Type	UTM-E	UTM-N	Species	Construct.	Comments
Bower-Latrine	NR	536891	5211751	Coto	wood	Coto-3? NR in & west middle latrine in N Bower Woods
DeBalon-Latrine	NR+DR	537246	5213480	Coto	wood	DeBalon latrine - 2008 Coto-M both DR & NR
JM-Latrine	NR	537494	5210891	Coto	wood	NR in latrine next to Johnson Marsh Rd; guano
OP2	NR	532969	5207230	Coto Epfu Myca Myke Mylu	concrete	OP2; NR for Myca Coto Myke Mylu Epfu
OP3	NR	533038	5207638	Coto Myca Myev Mylu Myke	concrete	OP3; NR for Myca Coto Mylu
OP3-Latrine	NR	533119	5207692	Coto Myca Myev	wood	OP3 latrine; NR Coto Myca Myev; Feb09 Myca NR
R20-Bldg	NR	534869	5210112	Coto		R20; NR Coto (male-08) & unk. guano in open lower room
R26-Drainpipe	NR+DR	536179	5211541	Coto Myca Myev	concrete	R26 DR & NR for multiple Coto & Myca - DR Myev

Table 4. Roosting locations for all other bat species (non-Coto) on Fort Lewis in 2008 & 2009.

ID	Type	UTM-E	UTM-N	Species	Construction	Comments
507Ruins	DR	541308	5212447	Myotis	wood	507 Ruins; Unk Myotis Spp DR in 'uncle george' bat box
8thAve-RR-Brdg	DR	542271	5212325	Epfu	concrete	EPFU colony in middle joint of 8th Ave3 So bridge over RR
E-Gate-Rocket-BB	DR	537753	5209597	Mylu Unk	wood	Rocket had multi myotis DR 2009
E-Gate-UG-BB	DR	537759	5209549	Myev	wood	Uncle George box had DR Myev 2008 & 09 .
EPFU-DR-PSME	DR	530557	5208618	Epfu	live tree	EPFU maternity colony obs. Early July-09 in PSME
Hatchery-NR	NR	525217	5208353	Myca Mylu Myyu	wood	Hatchery bldg many NR myotis at tops of posts
MYEV2-DR1	DR	532031	5208947	Myev	dead tree	MYEV-2 DR in AIA snag; recent PSME die-off
MYEV-DR1	DR	530587	5208581	Myev	dead tree	MYEV colony in PIPO snag; 40+ bats exited 25 June 09
NoName Lk-UG-BB	RTA	520864	5198192	Myvo	wood	DR in 'uncle george' bat box
OP10	NR	527314	5209155	Myca	concrete	OP10 NR for Myca
OP11	NR	526102	5209736	Myca	concrete	OP11 NR for Myca
OP7	NR	531760	5209273	Myev	concrete	OP7; MYEV2-NR1 capture & recapture; other Myev-juv.
OP8	DR	530380	5208161	Epfu Myca Myev Myke	concrete	OP8 many NR Myev Myca Epfu
OP9	NR	529169	5208236	Epfu Myca Myev	concrete	OP9 many NR Myev Myca Epfu
Pipeline-UG-BB	RTA	517328	5197884	Unk. Myotis spp.	wood	unk in 'uncle george' bat box
R22-Latrine	NR	535364	5209827	Myotis	wood	R22 Latrine NR myotis& guano
Museum	DR	529204	5216048	Epfu	wood	Attic of Military Museum, historic Big brown bat nursery
Span-Marsh-UG-BB	DR	540616	5215493	Myotis	wood	DR unk Myotis in UG & Rocket boxes- Upper Span. Marsh
Triangle-UG-BB	DR	543456	5206868	Myotis and Unk.	wood	DR in 'uncle george' bat box; Triangle Prairie

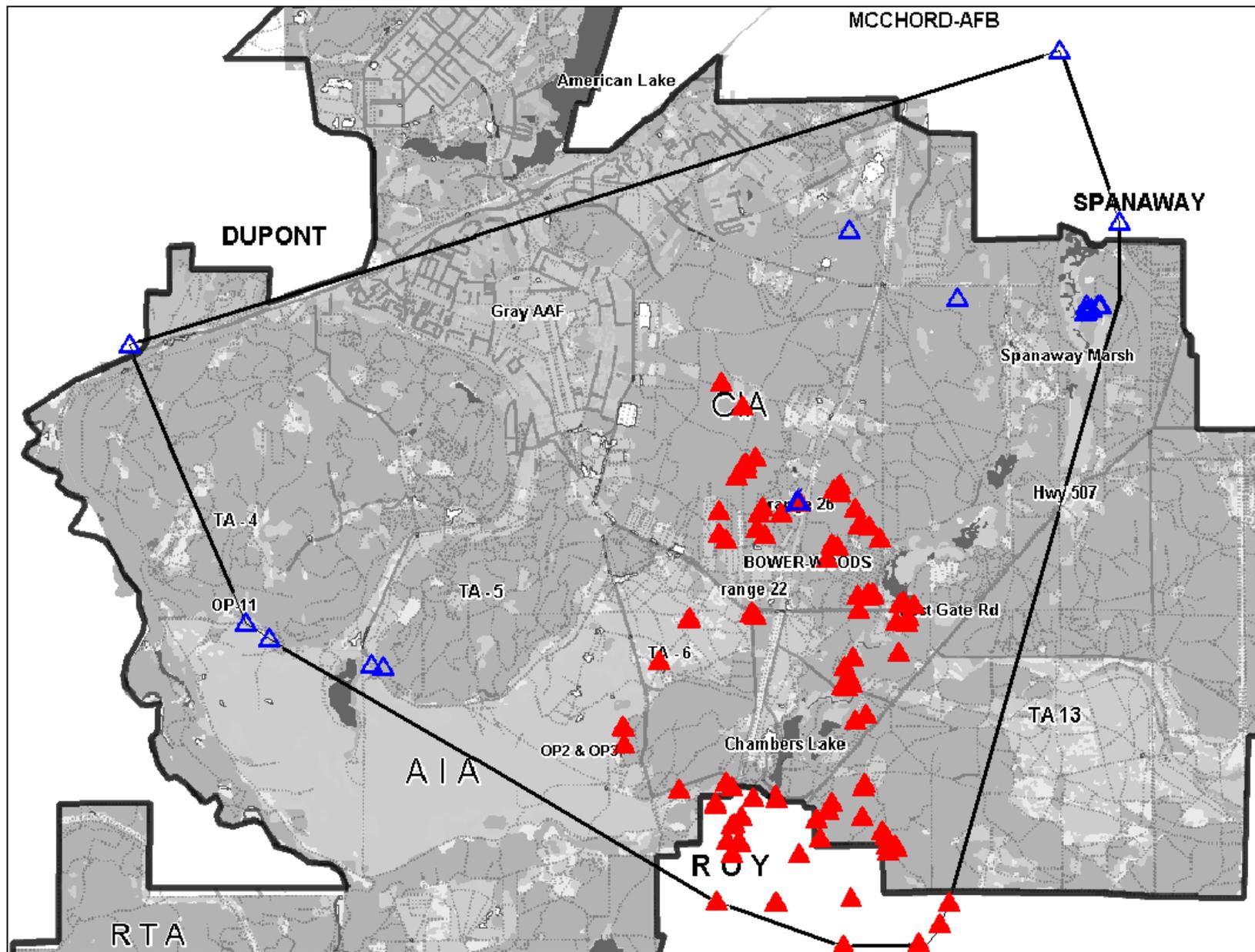


Figure 4. *Minimum convex polygon (MCP) for all of the tracked Townsend's big-eared bats. Red (filled) triangles are forage and roost locations for 5 bats during maternity season, blue (open) triangles are the Coto-6, tracked in October, 2009. Blue (open triangle) sites outside the installation boundary are all day roosts for Coto-6.*

Key to Townsend's bat *focal foraging area* map (Figure 5)

Point	UTM Easting	UTM Northing	Notes
1	526376	5209399	<i>Coto-6 only</i> , other Townsend's was recorded at the trees along road
2	528713	5208731	<i>Coto-6</i> , other Townsend's, & long-eared bats detected (Keen's myotis in this area)
3	532691	5210043	Male <i>COTO</i> tracked here & other Townsend's detected here acoustically in Sept., 2008
4	533059	5207431	Multiple Townsend's bats detected here concurrently in both 2008 & 2009
5	535187	5212255	Approximate, possibly larger area (inaccessible to tracking)- large trees in this area
6	534926	5211310	Approximate, possibly larger area (CIA inaccessible to tracking)
7	535323	5209604	<i>Coto-1</i> only, foraged here every night, sometimes twice a night
8	536786	5210791	Campsite area, thinned & open canopy, park-like landscape
9	537209	5211169	Multiple Townsend's; largest trees in Bower Woods, up to 166 cm DBH (65 inches)
10	537369	5209964	Multiple tagged Townsend's foraged here, other <i>Coto</i> bats detected acoustically
11	537980	5209823	Both sides of East Gate Rd, more on north, where DBH up to 1.8 meters (71 inches)
12	536952	5208400	Multiple <i>Coto</i> tracked here, primarily in trees on west side of Nixon Springs & north to Shaver
13	537778	5205608	Exact point in TA13 unknown, but very close to this
14	538482	5204126	Multiple tracked bats, add'l Townsend's recorded at this isolated stand on 48 th Ave.
15	541373	5214989	<i>Coto-6 only</i> , long foraging bouts 3 consecutive nights; one 2008 acoustic detection nearby

All UTM coordinates are in Zone 10.

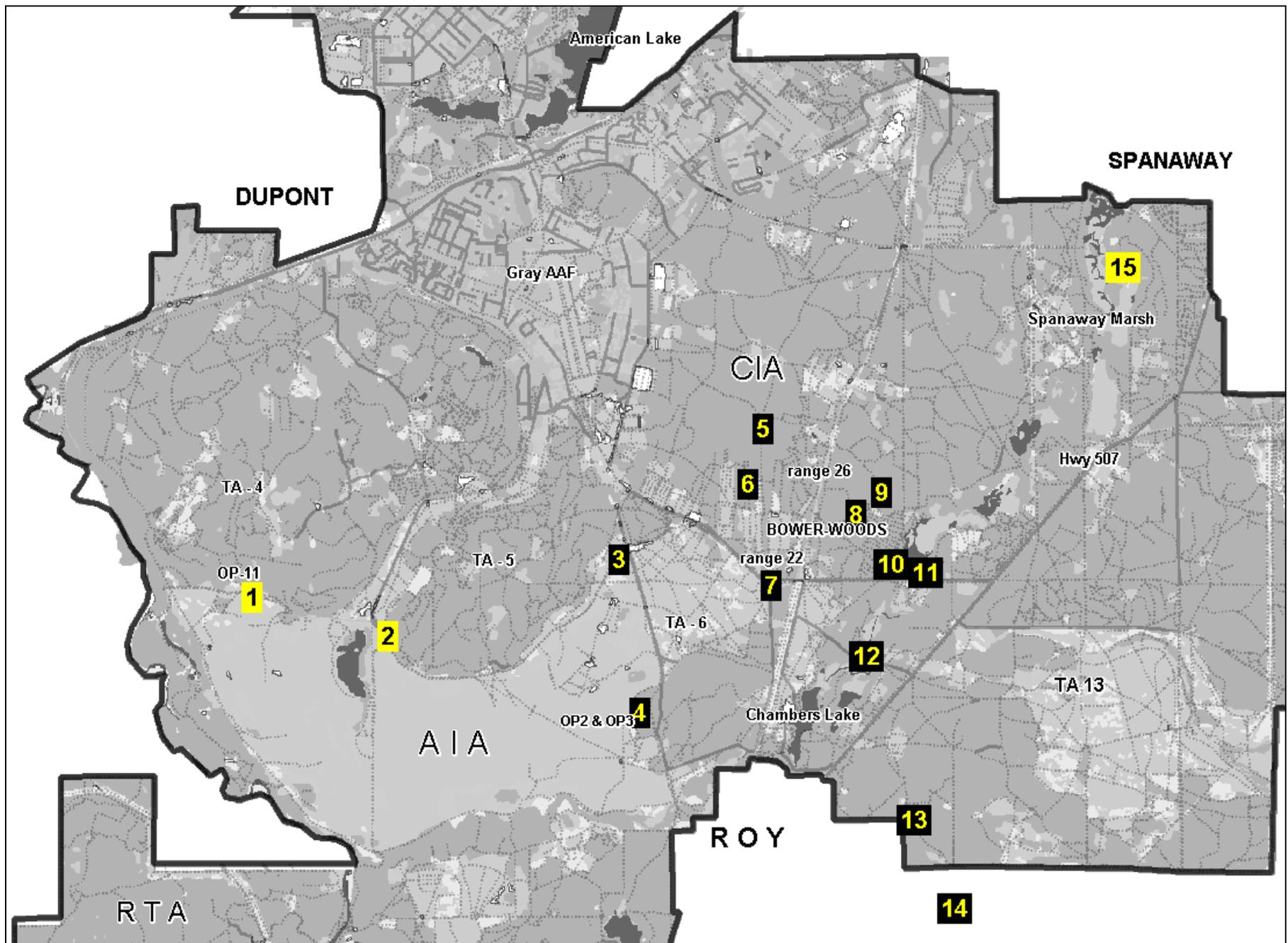


Figure 5. Foraging focal areas--locations where multiple Townsend's big-eared bats foraged, 2008 & 2009 data (see key to sites, above).

