ROOST FIDELITY OF TOWNSEND'S BIG-EARED BAT IN UTAH AND NEVADA

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ABSTRACT: The biological importance and degree of expression of roost fidelity in Townsend's big-eared bat (*Corynorhinus townsendii*) remains largely unknown. While reports of movement among and between roosts have been noted, it is unclear whether these movements were a result of human disturbance or part of some unknown, but normal, pattern of bat behavior. Current management and conservation strategies assume that *C. townsendii* exhibits strong roost fidelity across space and through time. We investigated the validity of this assumption at roosts throughout the Great Basin. Movement among roosts was common throughout the study area, with a high degree of intra/inter-seasonal variation observed. However, at larger temporal scales (i.e., across years), patterns of use became apparent. Differences in lability were noted between roost types, with use of caves more static (through space and time) than use of mines. The implications of these findings on management and conservation efforts are discussed.

Key words: abandoned mines, fidelity, caves, habitat use, *Corynorhinus townsendii*.

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INTRODUCTION

When attempting to manage and maintain populations of wild organisms, a basic understanding of how individuals and groups use their habitat is essential. A key component of this understanding, is recognizing the range of inherent variability of both spatial and temporal use of habitat. Management decisions are often made without a clear understanding of how much variability is exhibited in the system of interest. Possible ramifications of this paucity of data include misinterpretation of population trends (Cockrum and Petryszyn 1991, Steidl et. al. 1997, Strayer 1999), incorrect inference of habitat specialization (Pierson and Rainey 1998), and artificial simplification of complex systems (Channell and Lomolino 2000).

While temporal variation in use of foraging habitat by bats has been recognized (Hayes 1997), some have attributed nightly variation to researcher-induced disturbance from mist-netting and subsequent handling of individuals (Kunz 1982). However, recent studies using echolocation-monitoring (Hayes 1997), and radio-telemetry techniques (Brigham 1991, Wethington et al. 1996) have confirmed that temporal variation in use of foraging habitat is common in bat populations. As echolocation-monitoring and radio-telemetry techniques do not involve the repeated capture and handling of individuals, it is likely that this temporal variation is a natural phenomenon and is not an artifact of data collection methods.

Temporal variation in the use of roosts by cavern-dwelling bats has also been recognized (Tuttle 1976). This variation has been considered seasonal, with bats seeking refuge from ambient conditions that vary throughout the year. For example, roost requirements for an individual hibernating in January are different than those required during the reproductive period, when warmer sites are preferred. As seasons vary somewhat predictably among years, it has long been assumed that seasonal use is static, with bats moving among a subset of available roosts as seasons change (Hill and Smith 1984).

Recent reviews regarding roost fidelity in bats (Kunz 1982, Lewis 1995) suggest several general patterns. Species using more permanent, less abundant types of roosts should exhibit greater roost fidelity than those using more abundant, ephemeral roosts. For example, foliage-roosting bats would be expected to exhibit higher lability relative to cavernicolous species. Many of the studies upon which these assumptions are based, were conducted over a limited period of time, with little attention paid to fidelity among years. However, some researchers have described variation in long-term roost fidelity (Humphrey 1975, Tuttle 1976). Tuttle (1976) suggested that observed lability may be a result of a paucity of data regarding species use of available roosts.

The general supposition that cavern-roosting species exhibit pronounced roost fidelity has, in part, led to the general assumption that Townsend's big-eared bat (*Corynorhinus townsendii*), an obligate cave-roosting species (Kunz 1982, Humphrey and Kunz 1976), is sedentary, with movements between roosts largely limited to inter-seasonal migration. This assumption of high roost fidelity has been supported by observations that maternity colonies tend to use the same roosts over the course of years (Humphrey and Kunz 1976, Pearson et al. 1952)

and even decades (Sherwin, in litt.). Although, several cases of *C. townsendii* "abandoning" roosts have been reported (Humphrey and Kunz 1976), these movements have been largely attributed to disturbance from humans, and have not generally been acknowledged as normal patterns of behavior (Tuttle and Taylor 1994). For example, reports of arousal and inter/intra-roost movements in south-east Idaho (Bosworth 1994, Doering 1996) have been dismissed as the data collection techniques used in these studies make it impossible to determine if these movements were natural or were a direct response to inappropriate data-collection techniques. However, in a recent study, Sherwin et al. (2000) report intra-seasonal roost switching by both maternity and bachelor colonies in northern Utah, with roost switching behavior more common for colonies that used abandoned mines than caves.

The purpose of this study was to investigate roost fidelity in *C. townsendii* across temporal and spatial scales. As *C. townsendii* is the most common bat species observed in mines in the Great Basin (Sherwin et al. 2000), it is at possible risk from abandoned mine reclamation programs. Currently, several hundred abandoned mines that provide potential habitat for this species are reclaimed each year (Sherwin et al. 2000). In most cases, pre-closure biological surveys are conducted, however, these surveys are generally limited to a single visit per season (summer and winter), for one year. This single-year protocol assumes that there is no temporal variation either within seasons and/or among years. Herein, we test the assumption of maintained fidelity, and make recommendations regarding the amount of effort needed to make satisfactory inference into use of roosts by *C. townsendii*.

METHODS

Study area

We collected data at abandoned mines and caves located within lands managed by the U.S. Forest Service, Bureau of Land Management, Utah Department of Transportation, National Park Service, Utah Division of Parks and Recreation, and private lands in nine counties in northern Utah and three counties in Nevada. The area ranged in elevation from 1,350 to 3,600 m and included a complex suite of geologic provinces. Valley floors were dominated by Great Basin Shrub Grassland, whereas higher elevations varied from mountain-brush communities to alpine meadows and krumholtz associations.

We surveyed 1200 abandoned mines and 43 caves for bats and associated sign (e.g., guano, staining, insect parts, and odor). Each site was surveyed multiple times during warm and cold seasons for a minimum of two years, between 1994 and 2000. Interiors of mines and caves were surveyed following protocols modified from Altenbach and Milford (1995) and Sherwin et al. (2000).

Abandoned mines were located by reviewing government patent and claim records, topographic maps, and extensive surveys in the field. Caves were located by contacting management agencies and local caving groups and examining records from museum collections for specimens collected in caves.

Mine and cave surveys

Due to hazards posed by abandoned mines, safety was a primary concern. An air monitor (Passport, Mine Safety Appliances, Pittsburgh, Pennsylvania) that continuously measured oxygen, carbon monoxide, methane, and particulate levels was used during internal surveys. At least two people entered each mine while a third remained outside and in constant radio contact. Standard safety equipment was worn at all times (Altenbach and Milford 1995).

To minimize disturbance to day-roosting bats, they were neither handled nor captured within roosts. We recorded presence, number, location, and identity of species. Internal surveys were terminated if bats were noticeably disturbed by the surveyors' presence or if conditions did not meet requirements for human safety.

Collection of data

Abandoned mines and caves were internally surveyed, and the presence and location of bats within the roost were recorded. Each roost was categorized by type of use (hibernation, fall migratory, spring migratory, swarming, summer bachelor, summer maternity). It was possible for a single roost to qualify for several categories.

In an effort to minimize disturbance, internal surveys (during that season) of actual roosts were curtailed and subsequent surveys were limited to external exit counts. Exit surveys were generally limited to non-invasive observation using low light binoculars and night vision equipment. In addition, mist nets were set across entrances of a subset of sites, with nets in place $\geq$0.5 h before sunset. Nets were constantly monitored, and bats were removed immediately upon capture. Total time for processing each individual was kept to a minimum. If a possible change in the type of roost use was noted, an internal survey was initiated. Sites at which no bats were observed were revisited as often as possible to maximize the likelihood of detecting use.

Analysis

All sites that were found to be actual roosts were pooled and effort curves were generated for each site by graphing the cumulative distribution of the number of visits required before *C. townsendii* was observed. The variability of site occupancy was measured by comparing the number of surveys needed before effort curve reached an asymptote at 90% probability of correctly iden-

tifying non-roosts. Curves were generated for: 1) general use (all roost types, across all seasons); 2) seasonal use (among all roost types); 3) seasonal use of caves; 4) seasonal use of mines; and 5) variation across years.

RESULTS

Of the 1243 sites surveyed, 473 (437/1200 mines, 36/43 caves) were used as day roosts by *C. townsendii* (Table 1). Of the 437 identified mine roosts, the majority (311/437, 71.2%) were used discontinuously within seasons and/or across years. However, this pattern was not observed in caves, as only 5 of 36 (13.9%) cave roosts were used discontinuously within seasons and among years.

It took an average of 8.3 surveys (during a single season) before a given mine could be eliminated as an actual roost (90% Probability - Figure 1). It took an average of 3.2 surveys at a single cave before that site could be eliminated as an actual roost (90% Probability).

A minimum of 3.4 surveys were required before a mine could be eliminated as a maternity roost (90% Probability - Figure 2). Maternity colonies in mines moved an average of 2.3 times (range, 0-5) during the maternity period, using an average of three discrete roosts (range, 1-6). Maternity colonies in caves exhibited strong fidelity, typically using a single cave for the entire maternity season (range, 1-2.2). The use of these caves was maintained among years.

An average of 7.6 surveys was required before a site could be eliminated as a hibernation roost. Higher fidelity was exhibited in large colonies in mines (>5 individuals) than in small colonies in mines (≤5 individuals - Figure 3). Use of caves as hibernation roosts was not sensitive to colony size, as only one of 23 caves was used discontinuously during the winter season. All other cave-wintering roosts were occupied throughout the duration of the winter period during all years of data collection.

DISCUSSION

A tremendous amount of variation was observed in the relative fidelity of *C. townsendii* to individual roosts. Despite this variability, some pronounced patterns were observed. Bachelor colonies in mines exhibited a surprising amount of variability in their fidelity to individual roosts within seasons, with individuals commonly moving among roosts. However, when compared across years, patterns of fidelity were clearly observed, as individuals moved among a predictable group of mines during each year. Bachelor colonies in caves were much less labile, with individuals using a limited number of roosts in a more predictable manner. When compared across years, use of caves remained constant, with individuals occupying a sub-set of roosts in a predictable pattern.

Maternity colonies in mines were more stable than were bachelor colonies in mines, yet still exhibited higher frequencies of intra-seasonal movements than has previously been reported. Hibernating groups were also found to be highly labile with individuals commonly moving among different roosts within a single hibernation season. When colonies in mines were divided by size (small: < 5 individuals; large: > 5 individuals), an interesting pattern was observed. Higher fidelity was exhibited in large colonies than in small colonies. Large colonies in mines exhibited similar levels of roost fidelity to colonies of all sizes in caves. They tended to occupy a single hibernation roost continuously throughout a single hibernation period predictably among years (use was relatively constant, but colony sizes fluctuated throughout a given winter season). However, mines that were used as hibernation roosts by small colonies were occupied discontinuously, with multiple surveys (nine) required to correctly identify non-roosts.

The degree of roost fidelity expressed by *C. townsendii* proved to be both spatially and temporally variable with individuals often moving among a subset of sites during both summer and winter seasons. Expressed fidelity differed markedly throughout the study area with some populations exhibiting strong fidelity to specific roosts while others expressed fidelity to groups of roosts, but not to any single site. While the proximate and ultimate causes of these movements are not yet understood, the large

Table 1. Results of surveys of roosts of *Corynorhinus townsendii* conducted throughout the Great Basin between 1994 and 2000. The number of identified maternity roosts does not reflect the actual number of maternity colonies observed. Use of roost types was not mutually exclusive, therefore, the number of used sites is less than the sum of roost types.

Type of Roost	Number Surveyed	Number Used	Hibernation Roosts	Maternity Roosts	Bachelor Roosts
Combined	1243	473	153	37	348
Mines	1200	437	130	31	316
Caves	43	43	23	6	32

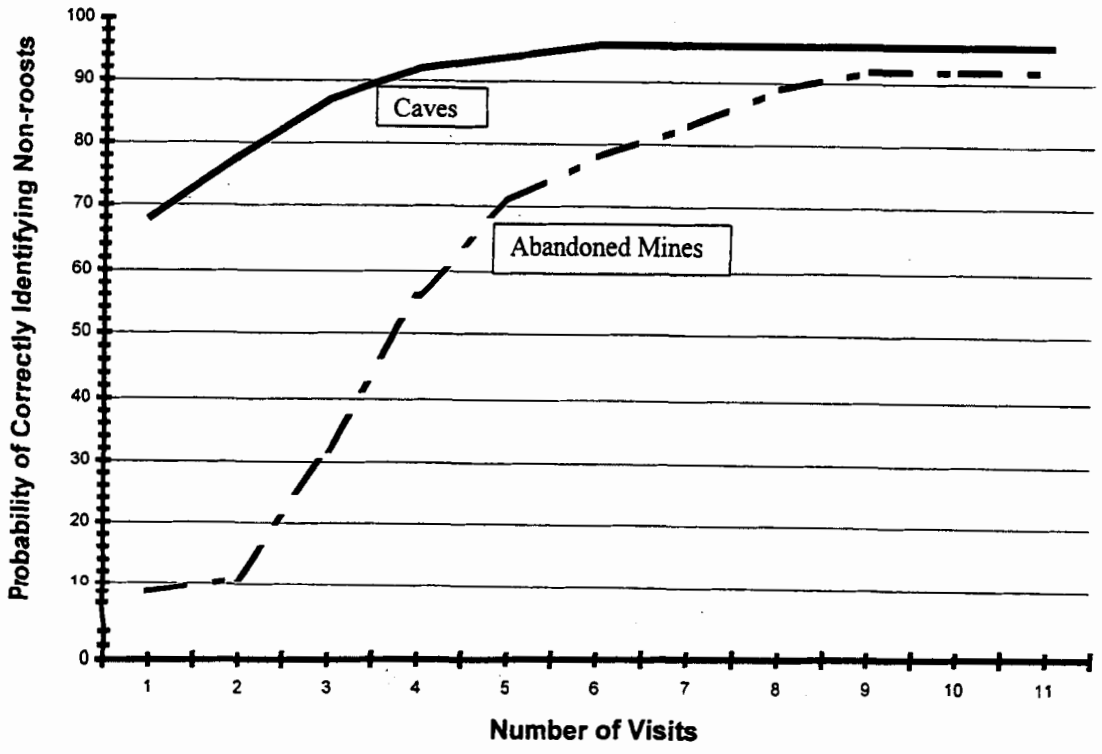

Figure 1. *Corynorhinus townsendii* bachelor roosts in caves and mines. Caves (solid line) have a higher probability than abandoned mines (dot-dashed line) of being correctly identified as non-roosts with fewer visits (about four visits for caves). Abandoned mines are visited approximately eight times before reaching a 90% probability of correctly being identified as a non-bachelor roost.

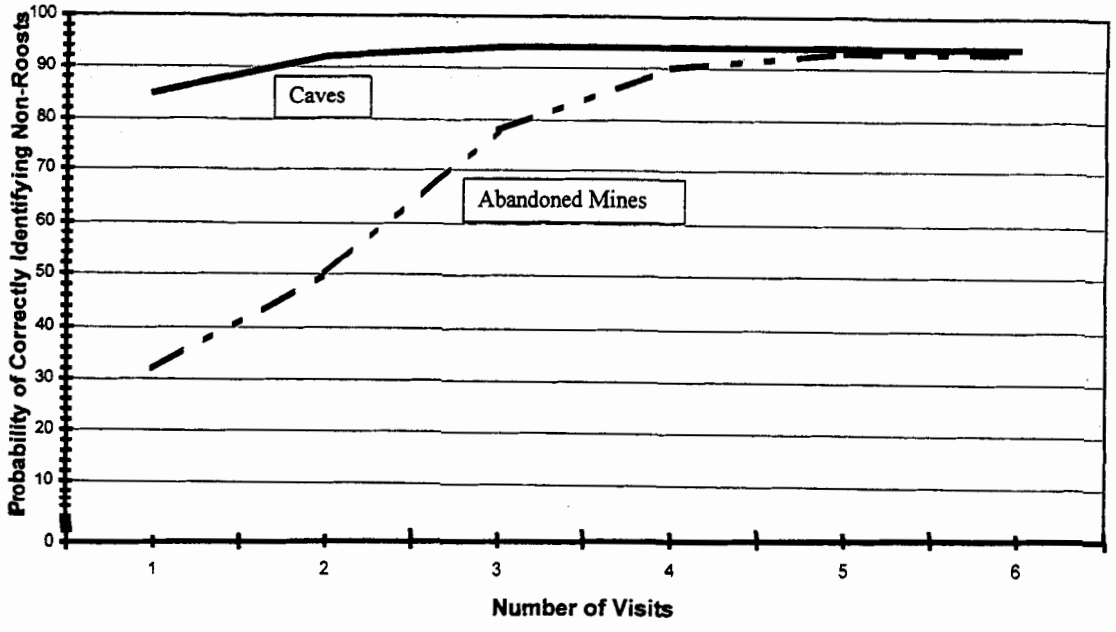

Figure 2. *Corynorhinus townsendii* maternity roosts in caves and mines. Caves (solid line) have a 90% probability of being correctly identified as non-roosts after only two visits over time, as compared with the need to visit abandoned mines (dot-dashed line) four times to make the same determination.

degree of variation in expressed fidelity throughout the study area suggests that different populations are somehow buffered from these forces, or are responding to local factors that are not expressed equally throughout the study area.

Levels of fidelity differed markedly in colonies using mines compared to those using caves, with higher fidelity noted in use of caves over mines. It is unknown whether these expressions of fidelity reflect differential quality of roost type, or is correlated with some other, yet unknown, variable. However, these data support Sherwin et al. (2000), who report that mine-based colonies are smaller and less spatially stable than those using caves. Further, we show greater lability among colonies using caves. Regardless of causality, higher rates of fidelity were expressed in use of caves during all use periods and during all years of data collection.

It has been proposed that human disturbance has significant negative impacts upon this species, with populations abandoning roosts as a direct result of human disturbance (Tuttle and Taylor 1994). In fact, human disturbance (including disturbance by researchers) has been suggested as a key constraint on the entire system, with local patterns of distribution and even roost selection being a direct reflection of this disturbance (Tuttle and Taylor 1994). While human disturbance certainly plays a role in the short-term dynamics of local populations, and may even result in local extirpations, it is unlikely that disturbance is the ultimate constraint on the system (i.e., patterns of distribution, population dynamics). We propose that, in some cases, what has been interpreted as site "abandonment" may actually be normal movement patterns of relatively labile colonies.

As *C. townsendii* is commonly found in abandoned mines, it is critical that management agencies understand how this species utilizes these roosts. Currently, hundreds of abandoned mines are reclaimed annually, with pre-closure biological surveys typically limited to a single visit during the summer and winter seasons. When selecting mitigation roosts, or attempting to protect actual roosts, it is important that managers account for the potentially dynamic nature of the use of roosts, as it is possible that critical roosts may not be continuously occupied. The data presented in this study are based solely on the actual occupancy of roosts by *C. townsendii*, and do not include analyses regarding "sign" of use (guano,

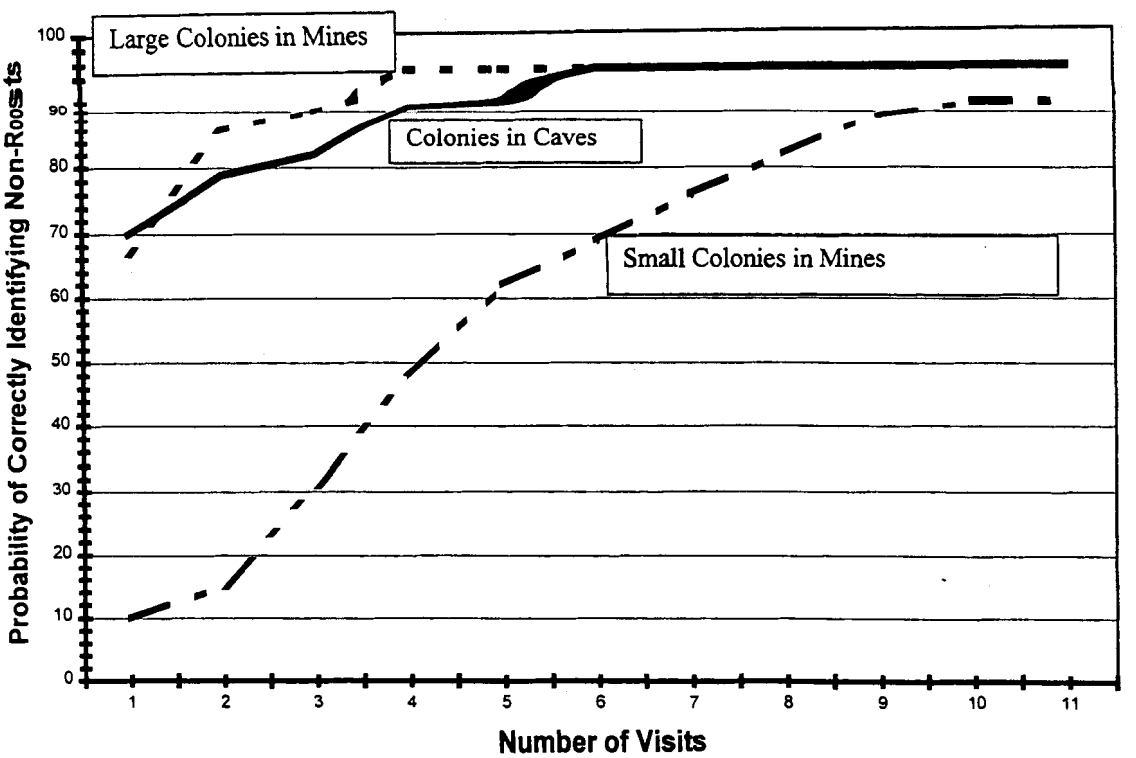

Figure 3. Presence of hibernation colony of *Corynorhinus townsendii* in caves and mines. Caves (solid line) have a higher probability than abandoned mines (dot-dashed line) of being correctly identified as a non-hibernation roosts with fewer visits (about four visits for caves, nine for abandoned mines) than for small hibernation colonies in mines (dashed line). However, colonies that are large (greater than 50 individuals) are most easily detected with the fewest visits to abandoned mines (dashed line).

discarded insect parts, etc). In most cases, sites that proved to be actual roosts contained signs of use (guano, discarded moth wings, etc.) by this species, therefore, we propose that researchers should be willing to protect sites based solely on "sign" of use and not use "occupancy at time of survey" as the only gauge of site importance. This would impose a certain minimum level of experience on researchers and exclude as unreliable those surveys conducted by inexperienced researchers.

In recent years, management decisions have been made that assume *C. townsendii* exhibits high roost fidelity. Since the early 1990's, approximately 250 abandoned mines in the Great Basin have been closed with bat gates (H. Milford, Pers. Comm.). These sites were gated based on occupancy only, without considering potential variability in the use of roosts, and no published data are available to allow an assessment of the relative success of these protection efforts. As these protection measures were made assuming static use of roosts, it is critical that data be collected regarding the relative success of these conservation efforts.

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