BAT SPECIES ABUNDANCE AND DISTRIBUTION, THE EFFECTS OF FOREST THINNING AND BURNING ON BAT FORAGING ACTIVITY, INCIDENCE OF WEST NILE VIRIS IN BATS, AND CALCIUM WATER HOLE EXPERIMENTS AT HEIL VALLEY RANCH, 2005

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SUMMARY POINTS FOR 2004 FIELD SEASON

- 158 bats were captured and released across 60 net nights and 15 sites
- 14 *M. volans* were captured in 2005, most captures during study period
- 523 unknown sonar calls was recorded across 34 detectors nights in 2005
- Adult reproductive females *Corynorhinus townsendii* were captured at Ingersol Quarry
- First juvenile *Corynorhinus townsendii* was captured at Ingersol Quarry
- A lactating female *C. townsendii* was radio-tagged but never reacquired
- Blood was drawn from 26 bats for WNV testing, none tested positive
- *M. thysanodes* maternity roost in Geer Canyon reestablished in 2005
- Usage of artificial calcium water hole was evident, further testing necessary
- Sonar data from 2005 continue to support meadows and thinned areas as highest in bat foraging diversity

Abstract: In 2005 we conducted research at Heil Valley Ranch (HVR) to continue 1) measuring bat species abundance and distribution that was begun in 2002, 2) measuring the effects of forest thinning on bat foraging patterns, 3) measuring blood antibody levels to West Nile virus (WNV) infections. In addition, we began an experimental field test of the calcium hypothesis that females and juveniles will differentially use water holes higher in calcium content. Matching funds of $4,500 were provided by UNC for the calcium experiment portion of the study.

A total of 159 bats (50 were *M. lucifugus*, 16 *M. thysanodes*, 14 *M. volans*, 9 *M. ciliolabrum*, 3 *C. townsendii*, and 1 was *L. noctivagans* were captured. *Myotis volans* were captured in higher numbers for this species in the second sequential year. Netting at ephemeral roadway water holes exhibited relatively high capture rates (18 captures across four species). Captures would have been higher, but on the first night of netting when activity was at its peak, a cougar (*Felis concolor*) insisted that I leave the area and I complied. We captured two female, Townsend's big-eared bats (*Corynorhinus townsendii*), one lactating, the other post-lactating, and for the first time captured a subadult individual at Ingersol Quarry in September. This is the first record of a subadult *C. townsendii* at HVR. *C. townsendii* is considered an imperiled species and locating the roost site would be of considerable interest.

Blood was drawn from 26 individuals (14 *M. evotis*, 10 *M. lucifugus*; and 2 *M. thysanodes*) to test for WNV antibodies, of which none tested positive in 2005.

Sonar data collected from meadow, thinned, unthinned and burned sites at HVR continue to indicate that thinned and meadow areas support the highest bat species richness and species evenness at HVR.

As for the water hole calcium experiment, a total of 565 passes over five nights were recorded within the first hour after sunset using infra-red video recordings. Of these, 358 were at the natural water hole, whereas 207 were at the artificial calcium-treated water hole. There was no significant difference between water hole usage from recordings taken during the first hour after sunset (student t-test, $p = 0.187$). However, using Trailmaster Inc. infrared counters designed to count bat passes that I acquired in September and placed at the artificial and natural water holes showed a significant differences ($p < 0.001$) between sites with the artificial water holes having significant higher activity. These data are highly preliminary.

INTRODUCTION

Three aspects of the study of bats at Heil Valley Ranch (HVR) have evolved over the past four years, Species Abundance and Distribution, Forest Thinning and Bat Foraging Patterns, and Incidence of West Nile Virus in bats at HVR. In 2005 a new study funded by the University of Northern Colorado to test the calcium-water hole connection hypothesis (Adams, 2003) was begun.

Part I: ***Tracking Species Abundance and Distribution:*** Because bats are difficult to catch and they change their foraging patterns and areas seasonally, long-term studies of bat populations are required to ascertain presence and abundance of bat populations. In 2004, a previously undocumented eastern bat species (*Pipistrellus subflavus*) was found on OSMP property in north Boulder (Armstrong et al., 2005) In addition, because bats are susceptible to human disturbance, infectious diseases, and are responsive to climate variation, year-to-year patterns may shift and thus require long-term efforts to understand regional ecology, population dynamics and stability. In this third year of capture and release data collection, we are beginning to better understand ecological patterns of bats at HVR in Boulder County.

In 2002, we began mist netting bats at ephemeral and permanent water holes throughout HVR. In addition, radio tagging of some lactating females allowed us to locate and map maternity roost sites as well as conduct outflight counts and document emergence times of various colonies and species. These data are paramount in the management and conservation of bat species in the West. In 2005, we continued with our mist netting efforts that contributed new information on species abundance and species presence at HVR, and added ephemeral water holes located in roadways near Ingersol Quarry to our monitoring sites.

Part 2: Forest Thinning Practices: Protecting critical foraging habitats for bats is of paramount importance. Loss of critical foraging habitat can affect the stability and survivorship of bat populations. Several critical factors need be in balance. For insectivorous bats, foraging in less cluttered habitats is most energy efficient because obstacle avoidance is limited as they hunt. However, foraging in open areas has its own risks, such as predation from owls at night, or other raptors before darkness (Erickson and West, 2002).

Human impacts to foraging habitats usually come in the form of forest cutting and various other degradations. Clear-cutting practices have likely caused the loss of some bat populations, however, the overall effects will never truly be known. Studies in the West indicate bat activity is low where clear-cutting has occurred. Conversely, the less-severe practice of forest thinning may enhance bat foraging areas (Parker et al., 1996; Perdue and Steventon, 1996; Humes et al., 1999; Patriquin and Barclay, 2003). However, Tibbels and Kurta (2003) found that thinned areas of red-pine did not enhance foraging areas for bats which instead used intra-forest clearing more predominately. In 2003, we began a study to understand the effects of forest thinning practices currently underway at HVR using set 0.25 hectare plots in four habitat types. This study continued in 2005.

Part 3*: *Incidence of West Nile Virus in HVR Bat Populations: Insectivorous bats are the predominant foragers of night-flying insects, including adult mosquitoes (Gould 1955; Griffin et al. 1960; Findley, 1993; Altringham, 1996). In Colorado, myotis species consume mosquitoes in variable amounts (Adams, 2003). In Moffat County, *M. lucifugus* consumed 21% of their diet in flies and mosquitoes (Diptera), with other myotis species consuming about 10% of their diet in flies (Freeman, 1984). Diets of bats, however, differ regionally. Adams (1993, 1997) found seasonal differences in consumption of species of Diptera by *M. lucifugus*, from 28% in spring to 38% in fall. The relationship between mosquito consumption and incidence of WNV in bats remains unknown. However, some bat species have tested positive for WNV infection in New York (Marra et al., 2003; Davis et al., 2005). Because Boulder, Larimer, and Weld counties were the "hot-zone" for human cases of WNV infections in 2003, we initiated a study to document the incidence of WNV infection in *Myotis* species at HVR in 2004 and continued this monitoring in 2005.

Part 4.—Calcium water holes and bat activity: Adams (2003) showed a significant correlation between the amount of dissolved calcium in the water and visitation by reproductive female bats and their young. In 2005, Adams received $4,500 as a match grant from the University of Northern Colorado to build and analyze visitation patterns at an artificially constructed, calcium-treated water hole, in Middle Geer Canyon.

METHODS

Capture and Release: We continued mist netting bats at previously netted water holes and at previously unsampled locations throughout the park. Previously unsampled areas included ephemeral water holes that formed in spring 2005 along the 4 x 4 road north and east of Ingersol Quarry. Flash floods through Geer Canyon filled in all usable bat drinking holes. We dug a water hole at the Middle Geer Canyon site and netted there periodically throughout the summer. The other main sampling site in 2005 was Ingersol Quarry. All captures were made in mist nets, and all individuals were released within two hours of capture.

Radio-Tagging.—A radio-tag weighing 0.47g (Holohil, Inc.) was glued to the dorsum of a female, lactating Townsend's big-eared bat (*C. townsendii*) between the shoulder blades after the fur was trimmed. Attachment of transmitters was accomplished using non-toxic, surgical glue.

Bat Activity and Forest Thinning: As in 2003 and 2004, Pettersson 240x time-expansion, sonar detectors interfaced with Sony tape recorders were position in 0.25 hectare fixed plots in unthinned forest, recently thinned forest, open meadows, and a burned site in Geer Canyon. ***Null hypotheses:*** $\mathbf{H_0}$**:** There are no significant differences in bat foraging activity as measured by sonar pass recordings between unthinned, human-thinned, montane meadow, and natural burned habitats (i.e. treatment plots). $\mathbf{H_1}$**:** Bat species composition will not be significantly different between treatment plots.

Blood Sampling for West Nile Virus: Bats were captured in mist nets and anaesthetized using Isoflurane. Approximately 30 μL of blood was drawn from an artery in the interfemoral membrane by puncturing with a 25 gauge needle. Samples were collected in heparinized, glass capillary tubes (Lollar and Schmidt-French 2002; Kunz and Nagy 1988). Pressure was applied to the wound with the researcher's index finger, until blood-loss ceased. Individuals were returned to capture sacs for 20 minutes to ensure that bleeding did not reoccur. Individuals were then released. Blood samples were put on ice and later spun down using an Autocrit Ultra 2 micro-centrifuge and stabilized using Ambion, Ribopure blood kits. Samples were analyzed using a 1-step RT-PCR kit (Ambion) called Retroscript (Kauffman, et al., 2003).

Null hypothesis: $\mathbf{H_0}$**:** There will be no antibodies present for WNV in bats at HVR.

Artificial Calcium Site, Geer Canyon.—Filming with IR camcorders and auxillary IR lights was conducted at the natural water hole in Geer Canyon for three consecutive nights to establish a baseline on usage. A two meter diameter artificial water hole was constructed using a 6 x 9 reinforced plastic tarp placed up-stream from the natural water hole we have netted over for the last three years. A tarp was used to cover the natural water hole to drive the bats to the artificial water hole, acclimating them to its presence. Filming was conducted for two night after the natural water hole had been covered for two previous night. We then treated the artificial water hole with calcium in the form of hydrated lime increasing water hardness to four-times natural concentration. Water calcium load was measured as water hardness using a water quality titration test. The artificial water hole was left for use by bats in this state for four nights. After the fourth night, the tarp on the natural water hole was removed, and the bats were allowed four nights to establish use patterns among the two sites after which IR filming was conducted at both natural and artifical water holes simultaneously using two IR camera setups with lights for 1 to 1.5 hours after initial activity began on each night. In addition, in September, the PI purchased two infrared wildlife counters specialized for counting bat activity. The purpose of these counters was to allow for monitoring the water holes throughout the entire night, rather than only the first 1- 1.5 hours after activity began because bats have different usage patterns throughout the night not detected by early filming. Each counter system was placed at water level across each water hole and left running continuously. The counters record date and time of each pass. Passes that happen during the daylight by birds can then be subtracted from the total number of passes. $\mathbf{H_0}$: There will be no significant differences in bat use patterns between artificial and natural water holes.

RESULTS

Capture Data: Netting began on 7 June and continued until 13 September. Summer 2005 was climatically more normal than 2004 and numbers of bats caught was higher in 2005 than in previous years with a total of 159 bats captured (Table 1). Of these, 61 were *M. evotis*, 50 were *M. lucifugus*, 16 *M. thysanodes*, 14 *M. volans*, 9 *M. ciliolabrum*, 3 *C. townsendii*, and 1 *L. noctivagans*. Curiously, *Myotis volans* were captured in higher numbers in the second sequential year. Roadway water holes exhibited relatively high capture rates (18 captures across four species). As in 2004, we again captured two female, Townsend's big-eared bats (*Corynorhinus townsendii*), one lactating, the other post-lactating. For the first time captured a male, nonreproductive subadult individual at Ingersol Quarry in September. This is the first record of a subadult *C. townsendii* on HVR. *C. townsendii* is considered an imperiled species and locating the roost site of this colony is of interest to BCPOS.

Radio-Telemetry.—An adult, lactating female *C. townsendii* was captured, radio-tagged, and released on 28 July (Table 1). Upon release it flew north-westward, circled a few times and then went out of range of our telemetry unit (possible removing its transmitter). Attempts to reacquire the telemetry signal over the next several days and nights did not result in re-acquisition. Due to the terrain and the fact that *C. townsendii* typically roosts in underground caverns, re-acquiring the signal without air-support appeared futile.

Table 1. *Capture and release data from 2005, organized by date and capture site.*

Date	Year	Location	Species	Sex	Age	Repro	Weight	Status
7-Jun	2005	Middle Geer	*L. noctivagans*	M	A	NS	11	not bled
14-Jun	2005	Roadway Waterhole	*E. fuscus*	M	A	NS	17	not bled
14-Jun	2005	Roadway Waterhole	*E. fuscus*	M	A	NS	18	not bled
14-Jun	2005	Roadway Waterhole	*E. fuscus*	M	A	NS	NA	not bled
14-Jun	2005	Roadway Waterhole	*M. evotis*	M	A	NS	6.5	not bled
14-Jun	2005	Roadway Waterhole	*M. evotis*	F	A	P	7.8	not bled
14-Jun	2005	Roadway Waterhole	*M. evotis*	M	A	NS	7.3	not bled
14-Jun	2005	Roadway Waterhole	*M. evotis*	M	A	NS	7	not bled
14-Jun	2005	Roadway Waterhole	*M. lucifugus*	F	A	P	7.3	not bled
15-Jun	2005	Ingersol Quarry	*no captures*					not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	7.1	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled

16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	F	A	P	5.3	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	F	A	P	6.5	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	F	A	P	6.9	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	7.1	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	6.5	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	7.5	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled

16-Jun	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. volans*	F	A	P	7	not bled
16-Jun	2005	Ingersol Quarry	*M. volans*	F	A	P	8.5	not bled
16-Jun	2005	Ingersol Quarry	*M. volans*	M	A	NS	6.9	not bled
16-Jun	2005	Ingersol Quarry	*M. volans*	F	A	P	8	not bled
16-Jun	2005	Ingersol Quarry	*M. volans*	F	A	P	9.7	not bled
16-Jun	2005	Ingersol Quarry	*M. volans*	F	A	P	7.5	not bled
16-Jun	2005	Ingersol Quarry	*M. volans*	F	A	P	7.9	not bled
16-Jun	2005	Ingersol Quarry	*M. volans*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. volans*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. volans*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. volans*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. volans*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. volans*	M	A	NS	NA	not bled
16-Jun	2005	Ingersol Quarry	*M. volans*	M	A	NS	NA	not bled
18-Jun	2005	Roadway Waterhole	*E. fuscus*	M	A	NS	14	not bled
18-Jun	2005	Roadway Waterhole	*E. fuscus*	M	A	NS	14.7	not bled
18-Jun	2005	Roadway Waterhole	*E. fuscus*	M	A	NS	15	not bled
18-Jun	2005	Roadway Waterhole	*E. fuscus*	M	A	NS	15.3	not bled
18-Jun	2005	Roadway Waterhole	*E. fuscus*	M	A	NS	15.5	not bled
18-Jun	2005	Roadway Waterhole	*M. lucifugus*	M	A	NS	6.5	not bled
18-Jun	2005	Roadway Waterhole	*M. thysanodes*	F	A	P	7.6	not bled
18-Jun	2005	Roadway Waterhole	*M. thysanodes*	F	A	P	7.4	not bled
18-Jun	2005	Roadway Waterhole	*M. thysanodes*	F	A	P	8.1	not bled
18-Jun	2005	Roadway Waterhole	*M. thysanodes*	F	A	P	6.8	not bled
25-Jun	2005	Middle Geer	*no captures*					not bled
10-Jul	2005	Middle Geer	*no captures*					not bled
28-Jul	2005	Ingersol Quarry	*C. townsendii*	F	A	L	NA	**telemetried**
28-Jul	2005	Ingersol Quarry	*E. fuscus*	M	A	S	18.5	not bled
28-Jul	2005	Ingersol Quarry	*M .thysanodes*	M	A	S	9.2	not bled
28-Jul	2005	Ingersol Quarry	*M. ciliolabrum*	M	A	NS	5.5	not bled
28-Jul	2005	Ingersol Quarry	*M. evotis*	M	A	S	6.5	not bled
28-Jul	2005	Ingersol Quarry	*M. evotis*	M	A	NS	5.2	not bled
28-Jul	2005	Ingersol Quarry	*M. evotis*	F	A	L	8.5	not bled
28-Jul	2005	Ingersol Quarry	*M. evotis*	F	A	P	9.6	not bled
28-Jul	2005	Ingersol Quarry	*M. evotis*	F	A	L	9	not bled
28-Jul	2005	Ingersol Quarry	*M. evotis*	F	A	L	9.1	not bled
28-Jul	2005	Ingersol Quarry	*M. evotis*	F	A	L	8.7	not bled
28-Jul	2005	Ingersol Quarry	*M. lucifugus*	F	A	NPNL	9.7	not bled
28-Jul	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS		bled
28-Jul	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS		bled
28-Jul	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS		bled
28-Jul	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS		bled
28-Jul	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS		bled
28-Jul	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS		bled
28-Jul	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS		bled

28-Jul	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS		bled
28-Jul	2005	Ingersol Quarry	*M. lucifugus*	F	A	P	10	not bled
28-Jul	2005	Ingersol Quarry	*M. lucifugus*	F	A	L	9.6	not bled
28-Jul	2005	Ingersol Quarry	*M. lucifugus*	F	A	P	10.5	not bled
28-Jul	2005	Ingersol Quarry	*M. lucifugus*	F	J	NLNP	9.2	not bled
28-Jul	2005	Ingersol Quarry	*M. lucifugus*	F	A	L	10.8	not bled
28-Jul	2005	Ingersol Quarry	*M. thysanodes*	M	A	NS	7.5	not bled
28-Jul	2005	Ingersol Quarry	*M. thysanodes*	M	A	NS	7.5	not bled
12-Aug	2005	Middle Geer	*M. evotis*	F	J	NLNP	5.9	not bled
12-Aug	2005	Middle Geer	*M. evotis*	M	A	NS	6.2	not bled
12-Aug	2005	Middle Geer	*M. thysanodes*	F	SA	NLNP	8.1	not bled
12-Aug	2005	Middle Geer	*M. thysanodes*	F	A	Post-L	8.1	not bled
18-Aug	2005	Ingersol Quarry	*M. evotis*	M	A	NS	NA	bled
18-Aug	2005	Ingersol Quarry	*M. evotis*	M	A	S	NA	bled
18-Aug	2005	Ingersol Quarry	*M. evotis*	M	J	NS	NA	not bled
18-Aug	2005	Ingersol Quarry	*M. evotis*	M	A	S	NA	bled
18-Aug	2005	Ingersol Quarry	*M. evotis*	M	A	S	NA	bled
18-Aug	2005	Ingersol Quarry	*M. evotis*	M	J	NS	NA	not bled
18-Aug	2005	Ingersol Quarry	*M. evotis*	M	J	NS	NA	not bled
18-Aug	2005	Ingersol Quarry	*M. evotis*	M	J	NS	NA	not bled
18-Aug	2005	Ingersol Quarry	*M. evotis*	F	A	Post-L	6.3	not bled
18-Aug	2005	Ingersol Quarry	*M. evotis*	F	A	Post-L	6.5	not bled
18-Aug	2005	Ingersol Quarry	*M. evotis*	F	A	Post-L	6.1	not bled
18-Aug	2005	Ingersol Quarry	*M. evotis*	F	A	Post-L	6.1	not bled
18-Aug	2005	Ingersol Quarry	*M. lucifugus*	M	A	NS	NA	bled
18-Aug	2005	Ingersol Quarry	*M. thysanodes*	M	A	P	NA	bled
18-Aug	2005	Ingersol Quarry	*M. thysanodes*	F	A	Post-L	8	not bled
18-Aug	2005	Ingersol Quarry	*M. thysanodes*	F	A	Post-L	8.3	not bled
18-Aug	2005	Ingersol Quarry	*M. thysanodes*	F	A	Post-L	8.1	not bled
24-Aug	2005	Middle Geer	*M. ciliolabrum*	F	A	L	4.6	not bled
24-Aug	2005	Middle Geer	*M. ciliolabrum*	M	SA	NS	4.1	not bled
4-Sep	2005	Ingersol Quarry	*C. townsendii*	F	A	Post-L	NA	not bled
4-Sep	2005	Ingersol Quarry	*C. townsendii*	M	SA	NS	8	not bled
4-Sep	2005	Ingersol Quarry	*M. ciliolabrum*	M	A	S	5.1	not bled
4-Sep	2005	Ingersol Quarry	*M. ciliolabrum*	M	SA	NS	2.1	not bled
4-Sep	2005	Ingersol Quarry	*M. evotis*	M	A	S	NA	bled
4-Sep	2005	Ingersol Quarry	*M. evotis*	M	A	S	NA	bled
4-Sep	2005	Ingersol Quarry	*M. evotis*	M	A	S	NA	bled
4-Sep	2005	Ingersol Quarry	*M. evotis*	M	A	S	NA	bled
4-Sep	2005	Ingersol Quarry	*M. evotis*	M	J	NS	NA	bled
4-Sep	2005	Ingersol Quarry	*M. evotis*	F	A	NLNP	5.8	not bled
4-Sep	2005	Ingersol Quarry	*M. evotis*	F	A	NLNP	6.1	not bled
4-Sep	2005	Ingersol Quarry	*M. evotis*	F	A	Post-L	6.2	not bled
4-Sep	2005	Ingersol Quarry	*M. evotis*	F	A	NLNP	7	not bled
4-Sep	2005	Ingersol Quarry	*M. thysanodes*	F	SA	NLNP	6.3	not bled
13-Sep	2005	Middle Geer	*M. evotis*	F	A	NLNP	NA	bled

13-Sep	2005	Middle Geer	*M. evotis*	M	A	N	NA	bled
13-Sep	2005	Middle Geer	*M. evotis*	M	A	NS	NA	bled
13-Sep	2005	Middle Geer	*M. evotis*	M	A	NS	NA	bled
13-Sep	2005	Middle Geer	*M. lucifugus*	M	A	NS	NA	bled
13-Sep	2005	Middle Geer	*M. thysanodes*	M	SA	NS	7.1	not bled
13-Sep	2005	Middle Geer	*M. thysanodes*	F	A	NLNP	NA	bled

Sonar Survey Data: Total numbers of species per plot type (Fig. 1) showed that meadows supported the highest species richness with seven species captured. Shannon indices (includes evenness) for thinned versus meadow habitats also indicated that meadows (H = 1.78) were more active than thinned areas (H = 1.58).

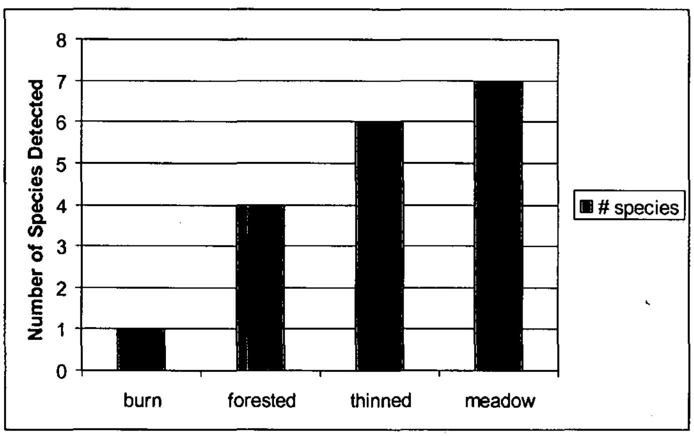

Figure 1. Plot of number of species recorded in each of the treatment plots.

The number of calls recorded in each plot adjusted for the number of detectors per plot (four detectors in burn, thinned and meadow plots versus six detectors in forest plots) shows the importance of meadow and thinned areas for bat foraging at HVR (Fig. 2). As in 2003 and 2004, both H_0 and H_1 were not supported by the 2005 data that showed significant differences among plots in bat activity patterns.

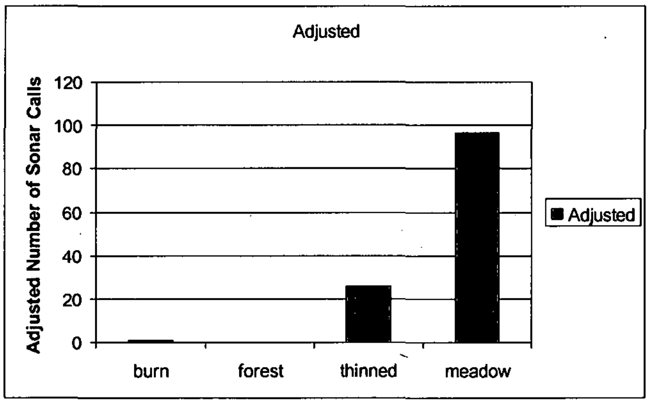

Fig. 2. Adjusted sonar numbers across plots.

West Nile Virus Data: Of the 26 individuals (14 *M. evotis*, 10 *M. lucifugus*; and 2 *M. thysanodes*) from which blood was drawn, none tested positive for West Nile virus antibodies in 2005 (Table 2). Thus, H_0 was supported by the 2005 data. Our data are supported by other studies including Davis et al. (2005) in which *E. fuscus* and Brazilian free-tailed bats (*Tadarida brasiliensis*) were inoculated with New York 99 strain of WNV in which some *E. fuscus* showed titers ranging from 10-180 plaque-forming units per milliliter of serum. Neither species, however, showed clinical signs associated with exposure to the virus. Davis et al. (2005) also tested sera from 149 bats collected in Louisiana, with two positive results.

Table 2. Results from ELISA test on blood samples for incidence of West Nile Virus inhibin response among three myotis species (Ml = *Myotis lucifugus*, ME = *M. evotis*, Mt = *M. thysanodes*). No positive responses were found to occur in an adult male *M. lucifugus* captured at Ingersol Quarry in September.

Sample	Row	No anti-WNV MAB					Row	With anti-WNV mMAb					
		Rep1	Rep2	Avg	CV			Rep1	Rep2	Avg	CV	Difference	%Inhibition
Blank	A	0.1311	0.1376	0.134	3.4		A	2.2536	2.2891	2.271	1.1	2.137	0.0
h-anti-WNV-IgG	B	0.1399	0.1751	0.158	15.8		B	0.5348	0.4733	0.504	8.6	0.347	83.8
normal dog Ig	C	0.2096	0.3165	0.263	28.7		C	2.1645	2.1822	2.173	0.6	1.910	10.6
h-anti-WNV-IgM	D	0.1541	0.1664	0.160	5.4		D	0.4964	0.4615	0.479	5.2	0.319	85.1
1	E	0.1486	0.1502	0.149	0.8		E	2.2612	2.3505	2.306	2.7	2.156	-0.9
2	F	0.1593	0.1517	0.156	3.5		F	2.2572	2.3162	2.287	1.8	2.131	0.3

3	G	0.1513	0.1834	0.167	13.6		G	2.2528	2.2787	2.266	0.8	2.098	1.8
4	H	0.1403	0.1879	0.164	20.5		H	2.1875	2.2999	2.244	3.5	2.080	2.7
5	A	0.1855	0.1977	0.192	4.5		A	2.2718	2.2683	2.270	0.1	2.078	2.7
6	B	0.1377	0.1491	0.143	5.6		B	2.1927	2.2895	2.241	3.1	2.098	1.8
7	C	0.1852	0.178	0.182	2.8		C	2.3954	2.4177	2.407	0.7	2.225	-4.1
8	D	0.1389	0.1509	0.145	5.9		D	2.3965	2.3388	2.368	1.7	2.223	-4.0
9	E	0.137	0.1728	0.155	16.3		E	2.2661	2.2694	2.268	0.1	2.113	1.1
10	F	0.1435	0.1387	0.141	2.4		F	2.2739	2.2085	2.241	2.1	2.100	1.7
11	G	0.2619	0.2362	0.249	7.3		G	2.3079	2.3142	2.311	0.2	2.062	3.5
12	H	0.1662	0.1856	0.176	7.8		H	2.2284	2.2353	2.232	0.2	2.056	3.8
13	A	0.1798	0.1233	0.152	26.4		A	2.2987	2.2391	2.269	1.9	2.117	0.9
14	B	0.1535	0.1226	0.138	15.8		B	2.2593	2.2244	2.242	1.1	2.104	1.6
15	C	0.1303	0.1484	0.139	9.2		C	2.1752	2.1475	2.161	0.9	2.022	5.4
16	D	0.1773	0.189	0.183	4.5		D	2.199	2.2214	2.210	0.7	2.027	5.1
17	E	0.1398	0.1337	0.137	3.2		E	2.3033	2.2251	2.264	2.4	2.127	0.4
18	F	0.1348	0.1474	0.141	6.3		F	2.2345	1.9571	2.096	9.4	1.955	8.5
19	G	0.1528	0.1519	0.152	0.4		G	2.1699	2.2505	2.210	2.6	2.058	3.7
20	H	0.1513	0.1324	0.142	9.4		H	2.0844	1.4429	1.764	25.7	1.622	24.1

Calcium Water Hole Experiment: A total of 565 passes over five nights were recorded within the first hour after sunset using Infra-red video recordings. Of these, 358 were at the natural water hole, whereas 207 were at the artificial calcium-treated water hole (Fig. 3). There was no significant difference based upon pooled data between the water holes in usage based upon recording taken during the first hour after sunset (student t-test, $p = 0.187$). These data supported H_0.

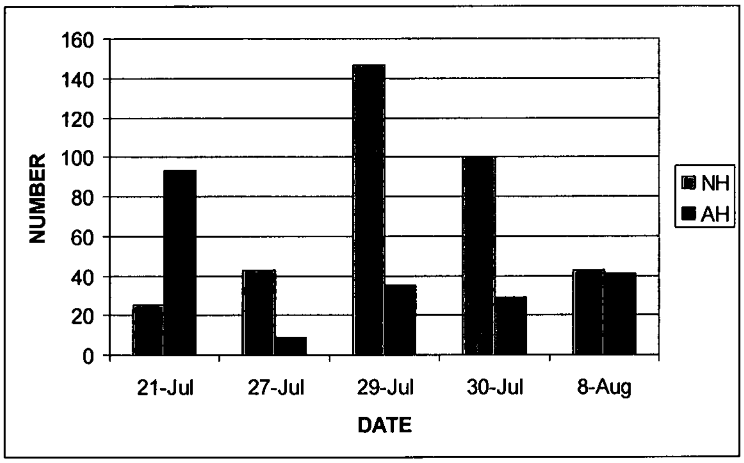

Figure 3. Number of passes of bats drinking at a natural versus artificial (calcium-treated) water holes in Geer Canyon recorded by infra-red video recorders within one hour after activity began after sunset. There were no significant differences ($p = 0.187$) between pooled totals of activity at each water hole.

Between 8 and 17 September, two sets of Trailmaster Active Infrared Counters were placed, one each, at the natural and artificial water holes. The infrared beam was placed just off the surface of the water in the flight path of drinking bats. The infrared counters ran continuously over the 10-day period, recording time of each pass triggered by an object breaking the beam. Passes recorded at times that did not correlate with nighttime bat activity were rare, but were subtracted from the total pass number. Fig. 4 shows results from these pass data.

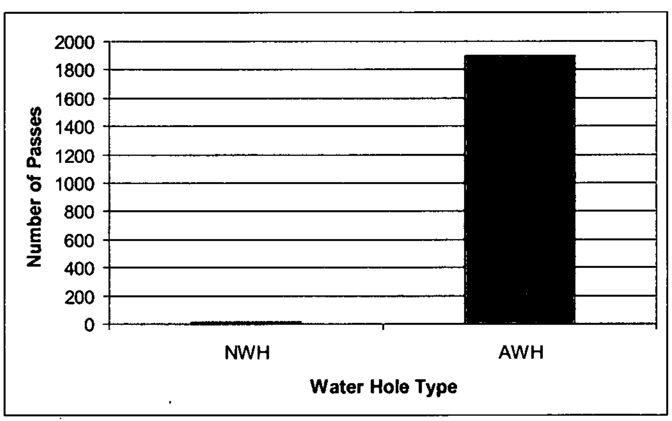

Figure 4. Pass number recorded by TrailMaster, Inc. infra-red pass detectors placed across the surface at the artificial and natural water holes. There was a significant difference ($p < 0.001$) between numbers of passes recorded at each site.

The natural water hole detectors counted 13 passes over this time period, whereas the artifical water hole calculated almost 1,900 passes during the same time frame (Fig. 4). Most of the passes were recorded between the hours of 0230 to 0400 h. There were significant differences ($p < 0.001$) between use patterns of the natural and artificial water holes, thus these data do not support H_0.

DISCUSSION

In 2005, total number of captures was much higher than in previous years, indicating that bat populations at HVR appear stable and perhaps increasing for some species (Table 1). However, a single year sample does not imply a sustainable increase. More data are necessary to document populational trends. Curiously, the record numbers of captures of *M. volans*, which were not captured at Ingersol Quarry in the first two years of the study, shows the locally dynamic nature of bat populations. In addition, the imperiled species *C. townsendii* was captured in highest abundance in 2005, and the capture of a subadult individual suggests that a maternity site is nearby Ingersol Quarry. Unfortunately, the signal from a telemetried lactating female was never reacquired during daytime and nighttime monitoring, thus the maternity site remains elusive. Because of only 11 maternity sites for this species are known in Colorado, locating this roost is important to management and protection of this species.

Comparative analyses of capture data (Table x) over the first three years indicate that, in terms of overall captures of males and females, the bat fauna at HVR trends towards increasing numbers of males and decreasing numbers of females. Totals over the four years are 134 females versus 285 males. Thus of the 420 bats captured, approximately 32% were females and 68% were males. Adjusting the capture data relative to sampling effort (BNN, bats per net per night, Table 3) over the last four years, excluding nights when nets were set and no captures occurred, indicates relatively similar capture rates over the first three years. However, in 2005 relative capture rates doubled. Of note is the fact that the increase in BNN in 2005 was the result of increased captures of males and females both of which almost doubled between 2004 and 2005.

Table 3. *Comparative capture data by male/female across four years at HVR. BNN = bats per net per night*

Species	**2002**	**2003**	**2004**	**2005**	**Total**
M. ciliolabrum	1 (♀)	7 (4♀, 3♂)	7 (1♀, 6♂)	5 (1♀, 4♂)	**20 (7♀, 13♂)**
M. evotis	21 (6♀, 11♂)	15 (9♀, 6♂)	34 (9♀, 25♂)	61 (19♀, 42♂)	**131 (43♀, 84♂)**
M. lucifugus	23 (12♀, 11♂)	14 (7♀, 7♂)	9 (1♀, 8♂)	50 (7♀, 43♂)	**96 (26♀, 69♂)**
M. thysanodes	17 (13♀, 4♂)	22 (9♀, 11♂)	14 (11♀, 3♂)	16 (11♀, 5♂)	**69 (44♀, 23♂)**
M. volans	0	1 (♀)	4 (♀)	14 (6♀, 8♂)	**19 (8♀, 11♂)**
E. fuscus	7 (♂)	38 (♂)	18 (1♀, 17♂)	9 (♂)	**72 (2♀, 62♂)**
L. cinereus	1 (♂)	0	2 (♂)	0	**3 (0♀, 3♂)**
L. noctivagans	1 (♂)	1 (♂)	2 (♂)	0	**4 (0♀, 4♂)**
C. townsendii	1 (♂)	0	2 (♀)	3 (2♀, 1♂)	**6 (4♀, 2♂)**
Total	**32♀, 36♂**	**30♀, 66♂**	**25♀, 63♂**	**46♀, 112♂**	**420 (134♀, 285♂)**
BNN	**6.8**	**5.6**	**7.3**	**15.8**	**8.57**

Age data from 2005 supported trends over the past three previous years in which very few juveniles were captured (Table 4). Most juveniles captured were *M. evotis*, the species for which juveniles have consistently been captured across years. However, a high of 10 juvenile *M. thysanodes* captured in 2003, were not repeated in 2005 even though the maternity colony of this species, absent in 2004, was present in 2005. Overall captures of juveniles in 2005 were few, composing a mere 7.6% of all captures. On the whole, juveniles compose a mere 7.8% of overall captures of bats at HVR between 2002-2005.

Table 4. *Comparative age distributions per species across years at HVR.*

Species	**2002**	**2003**	**2004**	**2005**
M. ciliolabrum	A(1) J(0)	A(3) J(2)	A(6) J(1)	A(3) J(2)
M. evotis	A(8) J(9)	A(8) J(7)	A(32) J(2)	A(55) J(6)
M. lucifugus	A(19) J(4)	A(14) J(0)	A(9) J(0)	A(49) J(1)
M. thysanodes	A(13) J(4)	A (12) J(10)	A(13) J(1)	A(13) J(3)
M. volans	A(1) J(0)	A(1) J(0)	A(4) J(0)	A(14) J(0)
E. fuscus	A(5) J(2)	A(38) J(0)	A(18) J(0)	A(9) J(0)
Total	**A(47) J(19)**	**A(76) J(19)**	**A(82) J(4)**	**A(143) J(12)**

The incidence of WNV in bats at HVR appears to be low or nonexistent. After the outbreak of WNV in 2003, there were lower population numbers of bats at HVR and one *M. lucifugus* tested positive for WNV antibodies. Since 2003, incidence of WNV in the Front Range of Colorado has been very low, and appears to have run its course. However, another outbreak such as observed in 2003, would instigate further testing of bats at HVR during the epidemic. As is, we have no idea whether or not bats were affected by WNV during the outbreak. All we can say at this point is that the test for antibodies in bats at HVR has produced little in the way of results one and two years after the 2003 outbreak.

Sonar data from 2005 showed the continued importance of meadows and thinned plots for foraging by bats. Despite the thinning efforts, *M. evotis*, a clutter specialist, continues to occur in high numbers at HVR.

The calcium experiments run in 2005 using an artificial water hole with artificially increased calcium load gave interesting results that varied by the method of data collection. A confounding component of the experimental setup was that the natural water hole was one that bats are used to using, and, in addition, is the first water hole they come into contact with as they move up the drainage after leaving the roost in the evening. Because bats lose large amounts of body water during diurnal roosting, they may drink at the most proximate water hole available and only later in the night visit water holes based upon nutrient content. Thus, the filming of bats at emergence time for 1 – 1.5 hours after sunset gave different results in visitation pattern on most nights than did data collection with active infrared pass detectors that ran throughout the night. Therefore, replicating these experiments in 2006 will be required to draw any conclusion about water hole preferences by bats at HVR.

FUTURE NEEDS

- Continue capture and release to complete 5-year data set on population dynamics
- Radio-tag several female *C. townsendii* in order to locate maternity roost site
- Continue sonar data collection from forest thinning operation, add insect collection
- Replication of calcium water hole experiments

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