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Bat Habitat Research

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Research Task 1. Monitoring bat habitation of caves on the INEL to determine species present, numbers, and season of use.

Winter populations

Cave mapping was completed by the Idaho Cave Survey Team, under the direction of Scott Earl. Results are presented in a separate notebook, and will be needed to conduct future surveys.

To determine the densities and species composition of hibernating bat colonies, we conducted systematic surveys of INEL caves from September, 1992 through May, 1993. Hibernating bats begin to appear in INEL caves during the last week of September but do not amass in appreciable numbers until mid-November (Fig 1). Townsend's big-eared bat, *Plecotus townsendii*, is the dominant hibernating species. Though present in eleven of the thirteen caves surveyed, West Rattlesnake Cave, West Aviator Cave and Middle Butte North Cave are the only caves serving as significant hibernacula for this species (Table 1).

The eastern small-footed myotis, *Myotis leibii*, is encountered at low numbers but is present in five caves (Table 1). Prior to our study, no big brown bats (*Eptesicus fuscus*) were encountered as hibernators and were assumed to be migratory (Genter, 1986; Wackenhut, 1990). They have now been noted in two caves. As early as 1990, this species was discovered hibernating in West Rattlesnake Cave and has been documented infrequently in each subsequent winter. On 1 Nov 1992, a mating pair of big brown bats was observed in Middle Butte North Cave.

The estimation of relative abundance of hibernating bats is influenced by roosting behavior. *M. leibii* and *E. fuscus* infrequently roost in exposed areas; typically these species are encountered roosting in small "blisters", cracks in the cave wall or other highly recessed spaces. This roosting behavior makes obtaining accurate estimates of population size difficult and possibly explains the inconsistencies in our assessment of hibernating population size for these two species. Potentially, their numbers during hibernation have been underestimated because large numbers may be obscured from view deep within cracks. Big-eared bats have a strong tendency to roost on open, exposed surfaces of cave interiors. Only rarely are they found behind overhangs and in some of the larger "blisters" in the cave wall. For this reason, obtaining accurate counts of hibernating individuals of this species is feasible.

During the winter of 1992/1993 a study was conducted to examine movement and behavior patterns of *P. townsendii* through the hibernation season. In addition to periodic counts, we recorded the locations of individuals banded by us and by previous researchers. These data have resulted in several significant findings. Fluctuations in population counts of this species cannot be explained simply by sampling error. It was discovered that individual bats may disappear from the hibernating population for varying periods of time; in one case a bat disappeared for three months before reappearing. All evidence indicates that these bats leave the hibernaculum, but it remains unclear where they go. This has important implications for the determination of the absolute

Fig 1. Counts of big-eared bats during hibernation at West Rattlesnake Cave

Table 1. Number of bats found hibernating in INEL caves from September 17, 1992 to February 14, 1993.

CAVE	SPECIES	SURVEY INTERVAL														
		Sept 27- Oct 3	Oct 11- Oct 17	Oct 25- Oct 31	Nov 1- Nov 7	Nov 8- Nov 14	Nov 15- Nov 21	Nov 22- Nov 28	Nov 29- Dec 5	Dec 6- Dec 12	Dec 13- Dec 19	Jan 3- Jan 9	Jan 10- Jan 16	Jan 17- Jan 23	Jan 31- Feb 6	Feb 7- Feb 14
College Cave	<i>Eptesicus fuscus</i>	0			0											
	<i>Myotis leibii</i>	0			0											
	<i>Plecotus townsendii</i>	0			0											
East Aviator Cave	<i>Eptesicus fuscus</i>															
	<i>Myotis leibii</i>															
	<i>Plecotus townsendii</i>															
East Rattlesnake	<i>Eptesicus fuscus</i>	0			0					0						
	<i>Myotis leibii</i>	0			0					0						
	<i>Plecotus townsendii</i>	0			0					0						
EBR II Cave III	<i>Eptesicus fuscus</i>						0									
	<i>Myotis leibii</i>						0									
	<i>Plecotus townsendii</i>						3									
EBR II Cave I	<i>Eptesicus fuscus</i>															
	<i>Myotis leibii</i>															
	<i>Plecotus townsendii</i>															
Lost Cave	<i>Eptesicus fuscus</i>															0
	<i>Myotis leibii</i>															0
	<i>Plecotus townsendii</i>															0
Middle Butte I	<i>Eptesicus fuscus</i>	0	0		2									0	0	
	<i>Myotis leibii</i>	0	0		0									2	4	
	<i>Plecotus townsendii</i>	32	54		94									93	102	
Middle Butte II	<i>Eptesicus fuscus</i>				0										0	
	<i>Myotis leibii</i>				0										1	
	<i>Plecotus townsendii</i>				3										4	
Middle Butte III	<i>Eptesicus fuscus</i>	0														
	<i>Myotis leibii</i>	0														
	<i>Plecotus townsendii</i>	1														
Moonshiner's	<i>Eptesicus fuscus</i>						0									
	<i>Myotis leibii</i>						0									
	<i>Plecotus townsendii</i>						2									
North Tower	<i>Eptesicus fuscus</i>						0									
	<i>Myotis leibii</i>						0									
	<i>Plecotus townsendii</i>						4									
West Aviator Cav	<i>Eptesicus fuscus</i>															
	<i>Myotis leibii</i>															
	<i>Plecotus townsendii</i>															
West Rattlesnake	<i>Eptesicus fuscus</i>	1		0	0	0		0	0	1	1	0	0		0	1
	<i>Myotis leibii</i>	0		2	4	6		3	4	11	10	13	10		14	23
	<i>Plecotus townsendii</i>	17		109	142	140		143	151	143	146	141	145		143	134

Table 1 (con't). Number of bats found hibernating in INEL caves from February 15, 1993 to May 19, 1993.

CAVE	SPECIES	SURVEY INTERVAL											
		Feb 15- Feb 22	Feb 23- Mar 2	Mar 3- Mar 10	Mar 11- Mar 18	Mar 19- Mar 26	Mar 27- Apr 2	Apr 3- Apr 10	Apr 11- Apr 18	Apr 19- Apr 26	Apr 27- May 3	May 4- May 11	May 12- May 19
College Cave	<i>Eptesicus fu</i> <i>Myotis leibii</i> <i>Plecotus tow</i>												
East Aviator Cave	<i>Eptesicus fu</i> <i>Myotis leibii</i> <i>Plecotus tow</i>				0 0 4								
East Rattlesnake	<i>Eptesicus fu</i> <i>Myotis leibii</i> <i>Plecotus tow</i>			0 0 10					0 1 9				
EBR II Cave III	<i>Eptesicus fu</i> <i>Myotis leibii</i> <i>Plecotus tow</i>												
EBR II Cave I	<i>Eptesicus fu</i> <i>Myotis leibii</i> <i>Plecotus tow</i>												
Lost Cave	<i>Eptesicus fu</i> <i>Myotis leibii</i> <i>Plecotus tow</i>												
Middle Butte I	<i>Eptesicus fu</i> <i>Myotis leibii</i> <i>Plecotus tow</i>			0 3 92								0 2 33	
Middle Butte II	<i>Eptesicus fu</i> <i>Myotis leibii</i> <i>Plecotus tow</i>												
Middle Butte III	<i>Eptesicus fu</i> <i>Myotis leibii</i> <i>Plecotus tow</i>												
Moonshiner's	<i>Eptesicus fu</i> <i>Myotis leibii</i> <i>Plecotus tow</i>							0 0 3					
North Tower	<i>Eptesicus fu</i> <i>Myotis leibii</i> <i>Plecotus tow</i>												
West Aviator Cav	<i>Eptesicus fu</i> <i>Myotis leibii</i> <i>Plecotus tow</i>				0 1 59								
West Rattlesnake	<i>Eptesicus fu</i> <i>Myotis leibii</i> <i>Plecotus tow</i>		1 24 142	2 28 139	2 20 139		0 15 136	0 14 131	0 15 105	0 11 57	0 5 43	0 4 18	0 1 0

number of bats utilizing these caves as hibernacula. Some degree of cave exchange has been documented between East Rattlesnake Cave and West Rattlesnake Cave, but this has been limited to a few individuals. Bats banded by previous researchers have appeared in hibernacula other than where they were originally banded. This demonstrates that more than one hibernaculum may be important for individual bats.

Hibernating bats have been located in all INEL caves except Lost Cave and Barricade Cave. It appears that during the hibernation period, temperatures in Lost Cave are inappropriately high and temperatures in Barricade Cave are too low (see Research Task 4).

Spring to fall populations

Population levels of hibernating colonies begin to destabilize as early as the beginning of March when winter conditions still predominate (i.e. water sources are frozen, insects are unavailable and temperatures are low). In April, numbers begin to drop dramatically and by the second week of May hibernating colonies have completely dispersed. In our study, day-roosting bats were encountered rarely and detected activity during the post-hibernation period of 1993 was extremely low. During this period, small populations of *M. leibii* were encountered using West Rattlesnake Cave and Middle Butte North Cave as day roosts, and foraging occurred during the early evening. *Plecotus* was found roosting in very low numbers. Evening road driving resulted in the occasional bat (species unknown) observed flying over the sagebrush. Activity in no way reflected known winter populations. This low level persisted until mid-July.

Our research results indicate that after this early period, cave complexes may support substantial summer populations. This finding contradicts earlier work. Previously it was believed that once hibernation ended, caves were completely abandoned and most bats left the INEL until hibernating populations reassembled in the fall (Genter, 1986; Wackenhut, 1990). Counts of roosting bats do not accurately reflect cave use by summer populations, but our research efforts resulted in only sporadic sightings of bats in the lava tubes during summer months. Using ultrasonic detection equipment and mist-netting techniques, we were able to document increased densities of foraging bats around three INEL lava tubes (Table 2). *P. townsendii*, *M. leibii* and *E. fuscus* were captured in appreciable numbers. Most *Plecotus* appear to be using the caves as night roosts. Nearly all captures of this species occurred late in the evening; these bats appeared to be entering the cave area rather than emerging. *Myotis* and *Eptesicus*, in contrast, were active at the cave mouth shortly after sunset. This would indicate day roosting behavior. On one occasion, a *M. leibii* was observed leaving a crevice near the mouth of a cave.

Lasiorycterus noctivagans, the silver-haired bat, and *Myotis evotis*, the long-eared myotis, are migratory species (Kunz, 1982; Manning and Jones, 1989). *Myotis evotis*, has been captured in significant numbers on the periphery of the INEL and one individual

Table 2. Summary of summer bat survey data at caves. Net meter hours is a measure of mist-net sampling effort and is calculated as the total length of the mist nets multiplied by the number of hours sampled. Activity level is a subjective measure of the intensity of overall bat activity at a given sampling area. The activity level was ranked on a scale of zero to ten.

LOCATION	DATE	NET METER HOURS	ACTIVITY LEVEL	SPECIES CAPTURED OR DETECTED (*)					
				<i>Eptesicus fuscus</i>	<i>Myotis leibii</i>	<i>Myotis evotis</i>	<i>Plecotus townsendii</i>	<i>Lasionycteris noctivagans</i>	<i>Myotis spp.</i>
MIDDLE BUTTE CAVE	20AUG92	192	9	5	6		4		
	07SEPT92	288	3				5	1	
	17MAY93	0	2	*					*
	16JUN93	0	0						
	08JUL93	168	6	1			4		*
	10SEPT93	192	7	1	5	1	6	1	
RATTLESNAKE CAVE	21AUG92	192	5						
	11MAY93	0	4				*		*
	12MAY93	0	3				*		*
	15MAY93	0	3				*		*
	02JUN93	0	3						*
AVIATOR CAVE	27SEPT92	0	3						
	28SEPT92	144	2				3		

has been captured at a cave entrance this fall (Middle Butte North Cave) (Table 2). Little is known about the migratory patterns and hibernaculum requirements of this species (Manning and Jones, 1989). A silver-haired bat was collected in September 1992. A second silver-haired bat and the long-eared myotis were captured in September 1993. These bats all attempted to enter a cave between 2300 and 0100. Both of these species typically inhabit forested areas and their presence in brushy habitat is atypical (Kunz, 1982; Manning and Jones, 1989). Their capture during the fall provides evidence that INEL caves may be of broad importance for Idaho bat populations by supporting migrating species as well as resident populations. An intensive study of cave use during fall migration of bats has not been proposed as a special research task. We recommend that a study is needed to provide further information for a final management plan for species using INEL caves.

Of those that were captured at caves during the summer mist netting, several will be prepared as voucher specimens (two *E. fuscus*, two *M. leibii*, two *P. townsendii* and two *L. noctivagans*) for deposit in the Idaho Museum of Natural History. The remainder were banded and released. None of those banded by us were recaptured during subsequent mist netting. We have captured bats during the summer that had been banded by previous researchers during hibernation. Several banded individuals originally captured by us during the summer at Middle Butte Cave have been found hibernating in both Middle Butte North Cave and Middle Butte Southeast Cave. These banding data indicate that caves are of circannual importance to individual bats.

Research Task 2. Monitor bat use of man-made ponds at the INEL to determine species present and the rates of use of these waters.

Bat census techniques yield the best results where bat densities are likely to be high (Kunz and Kurta, 1988). The presence of water often results in increased densities because bats usually drink upon exiting day roosts and also because concentrations of the insects on which bats feed are generally increased near water. Though activity seems to be greatest around the large INEL caves, use of man-made ponds by resident bat populations is apparent. Three facilities with impounded water were surveyed using a combination of ultrasonic detection equipment and mist nets. Mist netting was conducted on several occasions at the sewage ponds of Argonne National Laboratories West, Idaho Chemical Processing Plant and the Naval Reactor Facility. Survey dates and results are summarized in Table 3. No banded bats have been encountered at facilities so we do not yet know the connection between bat populations at facilities and populations at caves.

Mist net sampling was supplemented by surveys of ultrasonic activity. These data were used to assess activity levels of mixed populations of foraging bats. Activity levels were highest at the ICPP sewage ponds although few bats were netted at this site. Activity at NRF was limited to approximately three bats which quickly passed through the area and were not subsequently detected. Moderate to low activity was recorded at ANL-W with slightly

Table 3. Summary of summer surveys at facilities. Net meter hours is a measure of mist-net sampling effort and is calculated as the total length of the mist nets multiplied by the number of hours sampled. Activity level is a subjective measure of the intensity of overall bat activity at a given sampling area. The activity level was ranked on a scale of zero to ten.

LOCATION	DATE	NET METER HOURS	ACTIVITY LEVEL	SPECIES CAPTURED OR DETECTED (*)					
				<i>Eptesicus fuscus</i>	<i>Myotis leibii</i>	<i>Myotis lucifugus</i>	<i>Plecotus townsendii</i>	<i>Lasionycteris noctivagans</i>	<i>Myotis spp.</i>
ARGONNE -SEWAGE POND -INDUSTRIAL WASTE POND	12AUG92	517	3		2				
	12AUG92	0	4						
	29JUN93	0	3	*					*
ICPP -SEWAGE PONDS	13AUG92	345	6			1			
	30AUG92	517	4						
	12JUN93	0	5	*					*
NRF -SEWAGE POND	18AUG92	689	1						
CFA	26AUG92	0	0						

greater activity over the industrial waste pond than over the sewage ponds. Roosting locations for these bats are as yet unknown.

Sonograms generated from recorded calls of bats can be used to identify the species of bat producing the echolocation calls, because each species produces unique call characteristics. The identification of species and the certainty of this identification are contingent upon matching diagnostic frequencies of the sonogram with data generated from calls of known origin. Such data are scarce in the open literature. Published sonographic data are of limited use because considerable variation in call characteristics exist across the geographic range of a species. No such data are available for the INEL but will ultimately be produced as a result of our work.

A potential bias in determining species present in a given area exists. Not all calls are of useful quality; recording multiple bats in the same sequence, harmonics within the calls and background noise render approximately one-half of the sonographic sequences unidentifiable. Bats with high intensity calls seem to produce the most usable calls. Of the known INEL species, *P. townsendii* produces the least intense calls. It may often be undetected or overwhelmed by other bat calls when a mixture of species is active. Although species within the genus *Myotis* generally produce good quality sonograms, these species are difficult at best to differentiate using sonographic analysis. Although a considerable number of calls from INEL bats have been compiled by us, sorting frequencies into reasonable groupings and establishing connections to knowns is a slow process requiring a rather large number of good quality recordings. Data are still insufficient to make reliable identification to species possible in most cases. However, *Myotis* spp. and *E. fuscus* have been identified on recordings from the ANL-West industrial waste pond and at the CPP sewage ponds.

Research Task 3. IF the Big Lost River is flowing on the INEL and/or if the Big Lost River sinks contain water, determine species present, numbers and season of use.

During the 1992 summer activity period, no water was flowing in the Big Lost River or its drainages on the site. This area was surveyed in September of 1992 for standing water, insect activity and potential bat roosting habitat. The area was extremely dry and there were no indications that it could support bat populations. The Birch Creek Drainage from TAN to the northern boundary of the INEL was surveyed similarly during the summer of 1992. Conditions here were equally dry. A sonic survey yielded no evidence of bat activity.

The Big Lost River flowed on the INEL on 9 June 1993 for the first time in seven years. During our initial surveys shortly after this, no bats were detected at the Big Lost River Sinks, along the river between the sinks and Lincoln Blvd or between Highway 20 and the west boundary of the site. A second survey at

the sinks on the 22 of June revealed moderate activity by at least three species of bats (two *Myotis* spp. and *E. fuscus*) with the river being used as a flight corridor. On 30 June 1993 a sonic survey of the entire river from the sinks to the west boundary of the INEL was conducted. Moderate bat activity was detected at every survey location. The initial flow rate of about 300 cfs (Tim Reynolds, personal communication) was reduced to small puddles of standing water by 6 July 1993. At this time, small numbers of bats were detected still using the dry river bed as a flyway at the sinks and one *M. leibii* was captured. We conclude that lack of water in the Big Lost River may be negatively impacting bat populations on the INEL and recommend that a minimum flow be permanently established to enhance wildlife populations on the INEL.

Research Task 4. Determine the habitat requirements of Townsend's big-eared bats, including the microclimate of caves containing Townsend's big-eared bats as compared to other caves that do not contain bats.

To evaluate the habitat requirements of bats within natural roosts we have collected data on environmental variables at two levels. First, three caves were equipped with thermocouples for continuous monitoring of changes in the thermal environment. These include two caves (West Rattlesnake Cave and Middle Butte North Cave) supporting significant winter populations of bats and one (East Rattlesnake Cave) containing a limited number of hibernating bats. Automated sensors were positioned to assess general horizontal and vertical trends throughout the cave space. Second, automated monitoring was supplemented with periodic manual data collection. Periodic data collection was undertaken near torpid bats, in unoccupied areas and in vacant caves, allowing for greatly increased resolution. Because hibernating Townsend's big-eared bats move frequently during the hibernation period, manual measurement of selected roost sites is the only way to gain a precise measure of actual roost site conditions. The integration of these two methods has allowed us to describe roost site characteristics and the significance of temporal and spacial variability.

Both the environment of roosts and the physiology of hibernating bats undergo seasonal patterns of change. Results, are summarized as follows: 1) Summer and early fall present an extremely uniform thermal environment with relative humidities in the 75 to 80 percent range. In West Rattlesnake Cave, temperature varied less than 2 C from mid-September through mid-October (4.8 to 6.0 C). 2) Bats entered hibernation while caves were still exhibiting summer temperature profiles. Without a significant thermal gradient established, bats roosted throughout the cave space during this early period. Thermal selection became more evident during winter. 3) Conditions during mid-hibernation appear to be quite different, with stable thermal gradients forming in successful hibernacula. During this period, INEL caves provide a broad range of habitats available to bats. The warmest cave

available for hibernation was found to be Lost Cave which had a winter temperature range of 8.5 to 9.5 C on 13 February. This cave contained no hibernating bats and did not serve as a maternity roost in the spring. The coldest cave examined was Barricade Cave which had a temperature range of -7.3 to -6.1 C on 3 March 1993. No bats were found here. 4) Though a broad range of temperatures are available both within and among caves, actual temperature selection by bats is quite narrow. During mid-hibernation, no bats have been found in locations above 3.0 C or below -1.8 C. Hibernating bats seem to distribute themselves within this range across a cave's thermal gradient. The actual distance bounded by these temperatures varied greatly among caves from approximately 400 m in Middle Butte North Cave to 160 m in West Rattlesnake Cave to less than 10 m in West Aviator Cave. 5) Air flow within caves seems restricted to air mass movement into or out of cave mouths. This movement is driven by barometric pressure differences between the cave space and the outside. Though air flow is frequently detectable at restricted cave openings, on only one occasion has air flow been detectable in the vicinity of a bat. 6) Winter relative humidity tends to be low (40 to 50 %) but quite variable. 7) Temporal temperature variation is inversely proportional to distance into caves. The deepest regions of deep caves seem to show little annual variation.

Several hibernacula were completely closed by snow in 1993. It is unclear how normal thermal patterns or bat movements change when the cave space is disconnected from the outside environment.

Research Task 5. Determine daily/seasonal home range on or adjacent to the INEL for a limited number of individual Townsend's big-eared bats.

Three techniques are available to determine space use by *P. townsendii*, a small vespertilionid bat, in Idaho. Mark-recapture studies are the best technique to gain some estimation of long term space use by individuals, but this technique proved inadequate to provide data for the short-term assessment of movement necessary for home range determination. A second strategy is to attach luminescent material to the bat prior to release thereby allowing the behavior of free-ranging nocturnal individuals to be directly observed. For bats, the most effective light source is a gelatin capsule containing a chemiluminescent liquid such as Cyalume. This material is activated by mixing two components; the intensity of the light can be increased at the expense of light duration by altering the proportions of the two components (Buchler, 1976). Conditions required for successful light tagging include good levels of activity, relatively high evening temperatures so as to promote extended activity bouts, and low ambient light levels to enhance the visibility of the small tags. Radiotelemetry is a technique similar to light tagging except that the attachment emits a radio signal rather than light. These last two techniques can be used on an individual for short periods of time, until the device expires, the attachment is removed or the bat cannot be relocated. When applying these techniques to bats, the life of the device, the

strength of the attachment, and the range of the signal are all severely constrained by wing-loading capacities of small species. In general, a "five percent rule" is implemented when determining the maximum weight that a bat can carry; any weight added to a bat should not exceed five percent of its body weight (Bradbury, et al., 1979). Although more weight can be carried, maneuverability, flight speed and behavior are all potentially affected. For the heaviest individual *P. townsendii* the weight of attachments and adhesives should be limited to 500 milligrams. Our results, achieved under the constraints of these three systems follows.

All handled bats which were not kept as vouchers received individually numbered split-ring bands. Banding returns give information on long-range movements. Because bats are obtainable in far greater numbers during hibernation, a high number of previously banded bats was observed. A high degree of hibernaculum fidelity has been consistently noted in this study and previous INEL bat-banding studies. To a lesser degree, cave exchange occurs. The incidence of this exists on an intra-season level as described earlier (Task 1) and on an inter-season scale with bats banded in one cave being observed in another cave during a subsequent winter. These inter-season exchanges give us direct evidence for some long-distance movements in *P. townsendii* on the INEL. Bats have moved from West Aviator to West Rattlesnake Cave (8 km), from West Rattlesnake to Middle Butte North Cave (9 km), and from West Rattlesnake to Moonshiner's Cave (8 km). Thus on a seasonal level, we have documented movements up to 9 kilometers. All of these movements in some way involved West Rattlesnake Cave suggesting an important role for this cave as a hub for population exchanges in the southeastern portion of the site. Movements reveal a surface area of use by these bats which encompasses ANL-West.

Light tagging was attempted on two occasions. First the technique was tested at the Aviator Cave Complex during the fall of 1992. This attempt allowed us to determine the feasibility of field implementation and to evaluate logistical complications. The technique was used at the Middle Butte Cave complex in September of 1993. Though functional for at most one evening, these tags have begun to give us initial information regarding summer activity patterns and habitat use for *P. townsendii*. Light tagging efforts have been unsuccessful in determining home range for *P. townsendii* but have been useful for elucidating some behavioral characteristics of foraging individuals. This species forages low over the sagebrush, occasionally dropping down into the vegetation in pursuit of insects, limiting the distance over which the bats are visible, more so than the intensity of the light tag. Bats leave the cave crater on foraging runs lasting from less than a minute to as many as 35 minutes before returning to the crater. Movements were in two directions from the crater. From the crater bats moved either towards Middle Butte or south. Because of their low flight, bats were often lost from view for extended periods but the maximal distance observed from the cave being 400 meters. During longer absences, bats could be covering nearly 9 km assuming an average flight speed of 4.2 m/s (Hayward and Davis, 1964). The

actual surface area covered during these excursions remains unknown.

Radiotelemetry has been the least successful method. The lightest transmitter currently available is the Holohil BD-2B weighing 650 milligrams (not including adhesive weight). This is still heavier than the recommended transmitter weight for a 10 gram bat. The small battery size needed to achieve this weight limits operational life and signal strength. Under optimal conditions, this transmitter cannot be received at greater than one kilometer. This transmitter cannot be detected when bats are below ground, limiting tracking to hours during which bats are active. As this species frequently forages among the sagebrush, range is reduced during activity periods as well. Flight speeds exceeding 4.2 m/s (Hayward and Davis, 1964) prohibits following bats on foot once their signal is acquired.

Cross (personal communication) has not produced home range estimates for *P. townsendii* in Oregon but has had limited success discovering new roost sites. For this reason, it was decided that radio tagging a bat just prior to the end of hibernation would yield the best combination of data sets; in the event that home range estimates could not be produced, possibly roost locations utilized during the post hibernation period could be discovered. In the spring, females of this species move from hibernacula to maternity roosts forming large clustered colonies. At these colonies, they are most susceptible to disturbance (Humphrey and Kunz, 1976). Since a maternity colony has yet to found on the INEL, we attempted to radio track a female leaving hibernation from West Rattlesnake Cave. The protracted dispersal period and short transmitter life required our waiting until late in the hibernation season and selecting a female of the right weight and high probability of shortly leaving hibernation. A transmitter was attached to a female *P. townsendii* in the last days of hibernation. Unfortunately the tagged bat emerged between monitoring periods. Despite a concentrated effort to locate the bat at West Rattlesnake Cave and numerous searches at likely places over the entire INEL over the next three weeks, the bat was not relocated. The only conclusion from this trial effort is that this bat did not utilize the Rattlesnake Cave Complex following abandonment of this hibernaculum. We believe that radiotelemetry efforts will not be useful for developing home range data on this species as a result of the low mass of most individuals occupying the site, the extensive financial commitment required to purchase a large number of transmitters, and field test that clearly demonstrated the need to commit massive time to such a study. If undertaken, the study should be the sole commitment for a master thesis topic.

Research Task 6. Determine and describe an economical and efficient bat census technique to be used periodically by the INEL scientists to determine the status of bats on the INEL.

Because of their cryptic and secretive nature, bats require labor-intensive census techniques. They often are difficult to find, exhibit highly variable activity patterns, and do not respond

well to disturbance. An effective survey plan must consider all of these factors. Our research on INEL bats over the past two years has produced several recommendations.

During winter months bats are amassed in hibernation colonies and are most easily encountered. This is also the time of year that they are most easily disturbed. Survey schedules must be arranged so as to maximize useful data collection and minimize harmful disturbance. Copulation in temperate vespertilionid bats occurs during the early hibernation period. Also, population levels are unstable and plateau later. Consistent counts during the first week of December should produce reliable results and be comparable between years. A second count may be performed during the final week of January prior to the onset of the spring decline. This will validate the first count. These counts should be performed annually in West Rattlesnake Cave and Middle Butte North Cave. West Aviator Cave should be censused every three years.

Surveys of summer bat populations can be accomplished by mist netting or by monitoring ultrasonic calls. Each of these has its strengths and weaknesses (Table 4). For the purpose of assessing the population status of INEL bat populations, we recommend emphasis on sonic surveys. Tentatively, we advise that these surveys be initiated on the first week of August at Middle Butte Cave, Rattlesnake Cave, and the ICPP sewage ponds. Because of variability in activity levels, another survey should be completed two weeks after the first. It should be noted that our work on the INEL has encompassed only one complete summer season (1993) which was atypically wet and cold. Ideally, more work should be completed over a number of field seasons to establish normal activity levels before final a permanent sampling plan is developed.

The following simplified key may be used by INEL personnel to identify bats known to occur on the INEL.

Key to the bats of the Idaho National Engineering Laboratory, modified from Keller, 1985. VERY IMPORTANT CHARACTERISTICS ARE IN BOLD. **= known to occur on the INEL, but no validated specimens collected during 1992-3. Common names after Jones. et al., 1992. Approximate standard scientific measurements are directly under the common name. Extremes of total length, forearm measurements, and the greater length to the skull are from Hall, 1981. Other general useful information, summarized from a variety of literature, as available, is also provided. Numbers on the left represent half of the upper and lower dental formula, as an ICPM sequence, the total teeth appear after the equal sign.

Table 4. Comparison of mist netting and sonic surveys as sampling techniques.

	Strengths		Weaknesses
Mist Netting	<p>Absolute identification of species</p> <p>Allows banding of individuals, collection of recapture data, sexing, weighing, etc.</p>		<p>Bias sampling</p> <p>Requires field training</p> <p>Potentially injurious to bats</p> <p>Results may not reflect activity levels</p> <p>Results may not be obtained despite bat activity</p> <p>Results affected by ambient conditions including weather and light levels</p>
Sonic surveys	<p>Can be automated</p> <p>Yields good estimates of activity</p> <p>Not affected by weather</p> <p>Does not cause disturbance to populations</p> <p>Low activity levels yield good results</p>		<p>Some uncertainty in identification</p> <p>Bias sampling</p> <p>Technical problems common (i.e. harmonics, tape speed, power levels, etc.)</p> <p>Difficult to make good recordings during periods of high activity</p>

1a. UPPER SURFACE of INTERFEMORAL MEMBRANE AT LEAST WELL-FURRED OVER HALF OF SURFACE to tip of tail.

. . . Go to 2

1b. Upper surface of interfemoral membrane not well-furred over half of surface.

. . . Go to 3

2a. Upper interfemoral membrane furred to tip of tail; Body YELLOWISH to brownish with white-tipped hairs producing a FROSTED appearance; TAN THROAT PATCH; EARS with BLACK RIMS.

1 1 2 3 =32
3 1 2 3

Lasiurus cinereus **

Hoary Bat

134-54-12-16

total length, 134-140

length of tragus, 9

forearm, 46-55

g.lgth.sk1., 17.0-18.5

wt., 21-42g

2b. Upper interfemoral membrane heavily furred outward from body for slightly more than 1/2 of its length; BODY VERY DARK BROWN OR BLACKISH WITH SILVERY-WHITE TIPS TO THE HAIRS GIVING A FROSTED APPEARANCE.

2 1 2 3 = 36
3 1 3 3

Lasionycteris noctivagans

Silver-haired Bat

93-39-8-6

total length, 92-115

length of tragus, 8

forearm, n/a

g.lgth.sk1., n/a

wt., 8-11g

3a. GLANDULAR LUMPS on FACE BETWEEN NOSTRILS and EYES; upper fur brownish to grayish-brown, underparts sooty; EARS, LONG (to 35mm), BROWN and MAY be FOLDED or COILED AGAINST BODY.

2 1 2 3 = 36
2 1 3 3

Plecotus townsendii

Townsend's Big-eared Bat

95-46-9-35

total length, 90-112

length of tragus, 15

forearm, 39.2-47.6

g.lgth.sk1., 15.2-17.2

wt., 9-14

3b. No glandular lumps on face between nostrils and eyes

. . . Go to 4

4a. TIP of TAIL EXTENDS UP TO 4mm BEYOND INTERFEMORAL MEMBRANE; upper fur chocolate brown or reddish-brown, underparts paler; size relatively large, forearm usually more than 45mm; wing span may exceed 32cm.

2 1 1 3 = 32
3 1 2 3

Eptesicus fuscus
Big Brown Bat
115-46-12-14
total length, 87-138
length of tragus, 9
forearm, 39-53.6
g.lgth.skl., 15.1-23.0
wt., 14-21g

4b. Tip of tail does not extend much beyond interfemoral membrane; color variable; forearm less than 45mm.

. . . Go to 5

5a. DISTINCT BLACK MASK ACROSS MUZZLE AND FACE to ears; ears blackish; upper fur color variable brown to yellowish; calcar keeled.

2 1 3 3 =38
3 1 3 3

Myotis leibii
Eastern small-footed Myotis
79-36-7-13
head-body, 34.4-48.0
length of tragus, n/a
forearm, 29.6-36.0
g.lgth.skl., 13.1-14.7
wt., n/a

5b. No distinct mask across muzzle and face to ears; ears blackish or brownish; upper fur color variable brown.

. . . Go to 6

6a. TIPS of HAIRS IMPARTING INCONSPICUOUS BRONZE TONE, especially when fur ruffled; yellowish to olive-brown fur on back appears long and glossy; calcar not keeled.

2 1 3 3 =38
3 1 3 3

Myotis lucifugus
Little Brown Myotis
85-36-11-13
head-body, 41-54
length of tragus, 8
forearm, 33.0-41.0
g.lgth.skl., 14.0-16.0
wt., 7-9g

6b. Tips of hairs not imparting inconspicuous bronze tone; color variable, but dull.

. . . Go to 7

7. Upper fur brownish, dark at base, underparts buffy; BLACK EARS, LONG, CAN BE EXTENDED BEYOND TIP OF NOSE, AND WIDE, 9-10mm ACROSS at BASE; TRAGUS MORE THAN 1/2 LENGTH of EAR.

2 1 3 3 = 38
3 1 3 3

Myotis evotis
Long-eared Myotis
88-41-8-20
head-body, 41.6-56.0
length of tragus, 9
forearm, 35.5-41.0
g.lgth.sk1., 15.0-16.4
wt., 5g

Research Task 7. Provide a suggested management and protective plan for bat species on the INEL that might, in the future, be added to the endangered and sensitive list.

We suggest a management plan that includes three components:

I. Long-term monitoring of populations.

See Task 6 for details.

II. Protection of roosts.

Roosting locations are where bats populations are most vulnerable to disturbance. Although intentional vandalization of caves is one of the most important threats, inadvertent disruption of roosting colonies can be equally damaging to bat populations. For this reason, protection of known roosts is one of the most important aspects of any protective plan. The following strategies should be included as minimum requirements to this plan:

1. Control knowledge of cave locations.

Limiting the number of people who know the location of INEL caves is one of the most effective ways to control the number of people visiting caves. Avoiding publication of these locations and holding persons accountable for disclosure of locations are two means to achieve this.

2. Control access to areas containing caves.

Intrusion by unauthorized personnel to areas of the INEL containing caves is possible despite security patrols. Furthermore, most of the 10,000+ employees of the INEL have authorized access to these areas. Most INEL caves are supplied with roads leading directly to them. Gating or otherwise controlling access to these roads is an acceptable way to discourage intrusion. However, these deterrents should be positioned so that admittance into these areas is discouraged rather than encouraged. One gate has already been installed near Middle Butte Cave. This gate has been erected essentially at the cave location. This effectively draws attention to the area and is in no way impeding access to the cave.

3. Control access into caves.

Cave gating has been effectively implemented at many locations. The gates should not duplicate published designs as the minimal opening size was developed to eliminate entrance by children, a size that may negatively affect bat flight patterns into openings, and a unnecessary design because children are excluded from the SITE. We suggest that a contract be let to test several special designs for specific caves we have studied.

4. Control or restrict disruptive activities near or within caves.

Any actions near or within roosts that could increase mortality or disrupt reproduction should be avoided. These actions include, but are not limited to: pesticide use, insecticide use, introduction of other harmful materials, any significant alteration of physical structures or restriction of accessibility to the cave by bats, actions that produce vibrations or noise within the roost or actions that would increase human presence in roosts.

5. Sign specific caves and develop arrest/prosecution rules to empower security personnel.

III. Develop management strategies.

Develop habitat enhancement strategies and conduct research on the effectiveness of each strategy on population processes.

Suggested strategies include:

1. Increase water availability (especially historic sources) and make pond in CFA for tree species.
2. Limit exposure to contaminated water.
3. Increase habitat diversity (more wetland areas and maintenance of vegetation near existing waters).
4. Establish bat roosts, especially in North end of INEL.
5. Develop a specific INEL bat education program. Inform employees that sensitive bat species utilize caves on the INEL and that cave entry will damage populations. Prepare annual update article for INEL paper.

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