October 2000

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The Ninth Wildlife Damage Management Conference Proceedings. Edited by Margaret C. Brittingham, Jonathan Kays and Rebecka McPeake. Oct 5-8, 2000 State College, PA USA

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Abstract: This paper reviews the basic concepts behind a comprehensive management approach to managing commensal species, and then considers how this approach is applied to bats that live within and about the built environment. Management activities should take into consideration the whole environment in which the target species is active, including the periodic changes that occur within that environment. Comprehensive management includes a clear understanding of: the biology, behavior and ecology of the species to be managed; the environment in which that species is active (especially harborage location); and the appropriate intervention methods used to manage such species. Interventions fall under eight general categories: educational, legal/regulatory, physical, cultural, biological, mechanical, chemical, and electric/electronic. It should be underscored that in the comprehensive approach, education is the single most important intervention and toxicants are the least emphasized action. Toxicants and other lethal measures are always contraindicated in the management of bats. The reasons for such limitations of interventions, and the overall components of the comprehensive strategy will be clarified. As applied to managing commensal bats, the discussion will review: values and dilemmas regarding bats; possible reasons why bats readily seek harborage in the built environment; intervention methods used, abused, and those to be avoided; and other considerations in the decision-making process for mediation of specific bat incidents.

Key words: bats, commensal, comprehensive management, conservation, control, IPM

It appears that over the last several decades, the dominant approach to abatement of nuisance, pest, and/or vector problems has focused on attempts to eradicate the problematic species with techniques that do not adequately consider the rest of the environment. However, it is clear that we must think of management in terms of the whole environment in which the problematic species is active, including the periodic changes that occur in that environment. While many people would like to press a button to quickly mitigate the problems, such a simple, easy, rapid solution does not (and has never) existed. The overriding goal of any comprehensive management program is to enhance human health and quality of life through sustainable, risk-reducing interventions that are based on knowledge of the target species' behavioral ecology. Toward this end, the objectives of this presentation are to review the basic concepts of the comprehensive management approach and how it differs from typical pest control, and describe how the comprehensive management approach is applied to bats that live within and about the built environment.

Bat species of primary interest

Forty species of bats inhabit North America, but 3 species are most commonly involved with nuisance, pest, and vector related issues. These bats are the big brown *{Eptesicus fuscus),* the little brown *{Myotis lucifugus),* and the Mexican free-tailed *(Tadarida brasiliensis).* These 3 species are commensal because in some way they depend on humans for survival, primarily regarding summer roost sites in buildings. The majority of the bats that people encounter, and therefore the bulk of the problem complaints, will probably include one of these common, abundant, and adaptable species. Each species has particular preferences regarding the structures that they inhabit, but the comprehensive approach discussed in this paper is suitable for understanding and managing all 3 species. Where their distributions overlap, it is not uncommon to find more than one of these species roosting in the same structure, but utilizing different roosting niches. In general, these bats follow a similar seasonal pattern that fulfills certain ecological requirements for their survival and propagation. In the spring, adults relocate from winter hibernacula (M *lucifugus and E. fuscus)* or their wintering grounds *(T. brasiliensis)* to roost sites more suitable for rearing young. All 3 species spend the summer and early fall building up fat reserves that become important during periods of energy stress such as hibernation and migration. *E. fuscus* and *M. lucifugus* typically spend the winter hibernating in caves and mines. *T. brasiliensis* will either migrate (most populations) to winter feeding grounds,or remain locally feeding on available insects with occasional periods of torpor during cold or inclement weather.

The following information regarding these three commensal species was taken from a number of sources including: for *E. fuscus* (Christian 1956, Barbour and Davis 1969, Greenhall 1982, Frantz 1986a, Turtle 1988, Kurta and Baker 1990, Whitaker and Gummer 1992, and Greenhall and Frantz 1994), for *M. lucifigus* (Barbour and Davis 1969, Fenton and Barclay 1980, Greenhall 1982, Frantz 1986a, Tuttle 1988, and Greenhall and Frantz 1994), and for *T. brasiliensis* (Jennings 1958, Barbour and Davis 1969, Greenhall 1982, Hill and Smith 1984, Hermanson and Wilkins 1986, Tuttle 1988, Wilkins 1989, and Greenhall and Frantz 1994).

Big brown bat *(Eptesicus fuscus)*

E. fuscus is the most commonly observed and widespread bat in North America. Its distribution ranges from southern Canada to northwestern South America as well as populations residing on some of the Caribbean Islands. This bat utilizes many different habitats for both feeding and roosting, and can be found living in both urban and rural areas. *E. fuscus* typically weigh between 11 and 23 grams, have wingspans of less than 35.0cm, have litter sizes of 1-2 (depending upon geographic distribution), and roost in colonies ranging from a few individuals to as many as 700 or more. Most colonies number less than 75, consisting primarily of females; males usually roost elsewhere as individuals or small clusters. Maternity colonies occur where roost temperatures typically do not exceed 35°C, and are found roosting in barns or other outbuildings, behind chimneys, and in boxed soffits. *E.fuscus* typically reach their summer roost sites during April through mid May (geographic and weather dependent) where they begin to re-familiarize themselves with the site and females begin to feed heavily to support growing embryos. In mid May through mid July (specific timing is geographic and weather dependent), they have young that will remain non-volant for 4-6 weeks. By late June B late July, most juveniles are volant and begin flying with their mothers and capturing their own food. August through October is spent feeding heavily to build up fat reserves for hibernation. In October B December, they enter into hibernation in regional caves and mines, and occasionally in buildings, where they remain for 4-6 months.

Little brown bat *(Myotis lucifugus)*

M. lucifugus is probably the second most commonly observed and widespread bat in North America. Its distribution ranges from Alaska to northwestern South-central Mexico. This bat feeds on small, flying aquatic insects primarily over or near sources of water. They can be found living in both urban and rural habitats, but favor the latter. *M. lucifugus* typically have wingspans of less than 26.9cm, have a litter size of 1 (twins occasionally occur except in the Northeast), and roost in colonies ranging from several individuals to as many as 1000 or more. Most colonies number less than 200, consisting primarily of adult females; males and non-parous females may be found in cooler areas within the roost. Maternity roosts are typically found in the peaks of barns, under tin and asphalt roofs, or in attics and crawl spaces where temperatures exceed 38°C. *M. lucifugus* relocate to their summer roosts in April B mid May (specific timing is geographic and weather dependent). From mid May into late July (geographic and weather dependent), females have young that will remain non-volant for 3-5 weeks. From mid June to late July most juveniles become volant and begin feeding on their own. August through October is spent building up fat reserves for hibernation. In late August - November (geographic and weather dependent) they enter into hibernation in regional caves and mines for 4-6 months.

Mexican free-tailed bat *(Tadarida brasiliensis)*

T. brasiliensis is one of the most frequently seen and abundant species in the southwest and are locally abundant in southeastern and south central states, and the west coast. Its distribution ranges from Oregon to North Carolina south into South America. This bat roosts in buildings and under bridges throughout its range, though primarily roosts in caves in Arizona, New Mexico, Oklahoma, and Texas, and can be found in both urban and rural environments. *T. brasiliensis* typically weigh less than 15 grams, have wingspans of less than 32.5cm, with a litter size of 1, and roost in colonies ranging from several individuals to millions. This species forms the largest colonies of any warm-blooded animal. Most large colonies consist primarily of females, but it is not uncommon to find males roosting in these large colonies, though they tend to roost in separate areas from the females and young. Migrating *T. brasiliensis* typically reach their summer roost sites in March - April (geographic and weather dependent). From June through early July they have young that will remain non-volant for 4-5 weeks. By late July most juveniles are capable of flight and begin feeding on their own. August B September is spent feeding to build up fat reserves for migration. In September and October, they fly hundreds of kilometers to warmer climes (largely Mexico and southern California) where they remain for 4-6 months.

Some bats may overwinter in buildings in the Southeast (as far north as South Carolina) and in the Northwest (as far north as Oregon).

Comprehensive management

Definition

Integrated pest management, commonly referred to as "IPM", is a decision-making process in which all necessary treatments are brought to bear on a pest problem with the goal of providing a remedy that is the most effective, safe, economical, and sustained (Frantz and Davis 1991). Simply stated, IPM is a process for determining if, where, when, and what suppression or prevention treatments are needed or justified. Through this process, one is able to define the particular problem to be resolved. It should be kept in mind that, in the mitigation of nuisance, pest and vector problems, whatever efforts are utilized should be designed within the philosophy of IPM as provided above. IPM is not a singular type or mode of intervention, IPM is the "umbrella" strategy under which all problematic species management efforts logically reside.

IPM is a comprehensive approach. The term "comprehensive" is used here, and is generally preferred, largely because within the pest control industry (primarily the industrial, institutional and structural sector), the term IPM has frequently been misinterpreted and/or misrepresented in practice. It is not uncommon for pest control representatives to sell clients a monthly contract to allow them to return monthly to only spray, bait, or trap. With such an approach, no significant measures are being taken to actually correct the causative conditions (available food, water, harborage, and access routes) that support the problematic species. This approach is sometimes referred to as "calendar pestcontrol" or "pest farming". That is, regardless of what else is happening at the problem site, pest control personnel return at fixed intervals to "harvest a crop of pests", and, of course, to collect payment. True resolution of the problem is not a significant part of this scenario.

Components of the comprehensive management strategy

The components of the comprehensive management strategy remain basically the same regardless of problematic species (Frantz and Davis 1991), including bats. However, bat work is unique in that while we manage them we simultaneously want to conserve them in order that their ecological benefits are preserved. The four basic components are detailed below:

Inspection/monitoring system. A systematic survey(s) at regular intervals to keep one apprised of all aspects of the problem situation and which establishes baseline data for later evaluation efforts. This component begins with a comprehensive survey (detailed inspection) to accomplish a number of necessary objectives:

1. To locate, determine, and identify problematic species. With bat work, we must often make certain that bats are actually involved because bats are sometimes confused with the presence of other animals (e.g., birds, squirrels, mice) that nest or travel in the various cavities of buildings.

2. To regularly sample the target species population through direct observation, signs of infestation, and/or trapping. With bats, one maybe able to observe animals directly roosting or flying; or indirectly via

signs of infestation, including guano, urine, stains, odor, and noise. We do not encourage trapping bats for monitoring purposes because: it is unnecessary for management purposes; handling may result in injury to bats; and such activities increase the probability of human exposure.

3. To investigate causative conditions that might be altered to help solve the perceived problem. With bats, attention is given to entry points, roosting areas, and light attractants (e.g., ultraviolet light attracts insects, which then attract bats).

4. To identify natural enemies and potential problem species, which may become important once the initial or primary problem species is managed. With commensal bats, we must remain keenly aware of the valuable ecological role played by their insectivorous habits. If bat populations were significantly diminished, crepuscular and nocturnal flying insects would become more numerous, including zoonotic vectors and crop pests.

5. To keep aware of other management decisions and practices that could affect a target species population. With bats, our concerns would include the demolition of a nearby building containing a bat roost that could affect bat populations of other buildings. Also, note that naturally occurring structural damage (e.g., ice damage to a roof edge) can result in an otherwise inaccessible building becoming accessible to bats. Lastly, the spraying of roosting bats with an insecticide or other toxic substance (never a justifiable action), could result in sick and dying bats becoming grounded where they are more likely than healthy bats to come into contact with people, pets and livestock. Hence, such lethal actions can exacerbate the risks of bat contact and possible exposure to rabies.

6. To note significant weather or seasonal changes that might affect target species populations. With bats, an early or late onset of cold weather in the autumn could result in bats' early or late departure for hibernacula. During the winter months, a sudden reduction in temperatures might result in *E. fuscus*, hibernating within an attic or associated structural recesses, moving deeper into the warmer spaces of a building, including their entering human living quarters where they could encounter people.

Tolerance Limit (Action Threshold, Injury Level) This refers to the size of a problematic species population that can be correlated with annoyance or injury sufficient to warrant intervention. When the tolerance limit is exceeded, some problem reaches human perception and becomes recognized as some intolerable depredating effect or insult (Frantz 1988). Obviously, there are various levels of insult that might exceed one's tolerance and each situation must be considered on its own merits. The degree of insult clarifies the role of the problematic species as nuisance, pest, or zoonotic vector.

1. What might be considered at the lowest level of insult are esthetic and nuisance issues. With bats, this could include urine streaks on windows, guano accumulations on a porch, and odor associated with accumulations of urine and guano.

2. At a higher level of insult are the contamination of food and food preparation areas, and damage to foodstuffs. With bats, contamination issues would be relevant where roosting or flight areas occur within food factories and storerooms, or even within picnic

pavilions. Food damage *per se*, as in food consumption, is not relevant regarding commensal bats because they are insectivorous.

3. Damage to goods occurs with many problem species, including bats. For the latter, this is especially true for items in the path of falling urine and guano. Thus, items under flight paths or beneath roosts become soiled with urine and guano, metal corrodes, paint becomes discolored, etc. A mild form of damage to structural materials also occurs when bat urine that has soaked into wooden beams rapidly crystallizes. This results in wood fibers separating and then being torn loose by the claws of bats as they crawl over the beam surface. The cutting and tearing by bats' claws of aged roofing felt under metal ridge caps also has been observed.

4. At the highest level of human insult by problematic species are public health issues. A brief review of such issues regarding vertebrates, including bats, is provided in Frantz (1988). With bats, there are two primary categories of such issues: psychological and zoonotic. Human overreaction to bats' presence is not uncommon among individuals who are not well informed about bat biology and behavior. This is especially true in cultures such as ours, which vilify that which they do not know or understand, and where tales of vampires and other fantastic beasts have been told and retold for many generations. This does not mean that fear issues are to be treated with indifference or insensitivity; and, the remedy is often found in carefully crafted educational efforts.

At least two zoonoses, histoplasmosis and rabies, offer greater degrees of human risk. Histoplasmosis is a common lung disease of worldwide distribution caused by a microscopic fungus, *Histoplasma capsulatum.* Long-term bat roosts are mentioned in the literature as being favorable for fungal growth. It is the inhalation of the fungal spores that can result in human disease. Thus, prevention focuses on not disturbing guano accumulations, wearing appropriate protective clothing when disturbing such guano, or by avoiding guano accumulations altogether. Most human cases of histoplasmosis produce generalized symptoms similar to influenza and resolution occurs relatively uneventfully. A small number of cases, particularly in young children and in immunocompromised adults, result in severe infections that may be fatal.

Rabies is a preventable viral infection of mammals most often transmitted through the bite of a rabid animal. Once symptoms occur, rabies does not respond to antibiotic therapy and is nearly always fatal. Because of its relatively long incubation period of from two weeks to many months, prompt local treatment of wounds and vaccination following exposure (post-exposure prophylaxis [PEP]) can prevent human rabies. However, PEP should not be considered a viable primary prevention strategy because such an approach would result in many people being treated unnecessarily, does nothing to prevent future exposure incidents at a particular building, does not provide "peace of mind" for a building's occupants, and can lead to an unnecessarily large numbers of bats being submitted for rabies diagnosis (Frantz 1999).

Prevention of bat-borne rabies focuses on education against careless handling of bats, general prevention of bat contact with humans (hence, excluding bats from human living quarters is essential), and vaccination of pets. When bats have entered living quarters and may have contacted humans or pets, it is important to capture such bats until properly trained experienced public health professionals can evaluate the situation. Fortunately, human rabies of bat origin is difficult to acquire and is quite rare in North America. Indigenous rabid bats are reported to have caused 37 human deaths in the United States over the last 4 decades (CDC 1999,2000). Unfortunately, the ACEP (Advisory Committee on Immunization Practices) guidelines for human rabies prevention (CDC 1999) are vague and subject to misinterpretation regarding bat encounters and other potential rabies exposures. The resultant costs of overreaction (to the 'possibility" of rabies exposure) are great regarding public anxiety, health administration and treatment budgets, rabies diagnostic work, and the terminal costs to bats submitted for rabies testing (Cieslaketal. 1998,Frantz 1999, Mlot 2000, Moran et al. 2000). There is a significant need for the ACIP guidelines to be reviewed and revised regarding basic biological and epidemiological accuracy and utility. Further, well-designed educational and training programs are needed for public health and medical officials who must utilize the aforementioned guidelines.

At this point, it is important to underscore the favorable ecological, esthetic, and associated positive issues regarding bats. Not only do bats= insectivorous habits benefit people, but some bat populations also have significant entertainment, tourism, and economic values for human communities (McCabe and Acker 2000). This is clearly the case in parts of Texas. Hundreds of tourists and other onlookers are regularly entertained and fascinated by 1.5 million *T. brasiliensis* as they depart each evening from their roost under the Congress Avenue Bridge in downtown Austin (Figures la and lb).

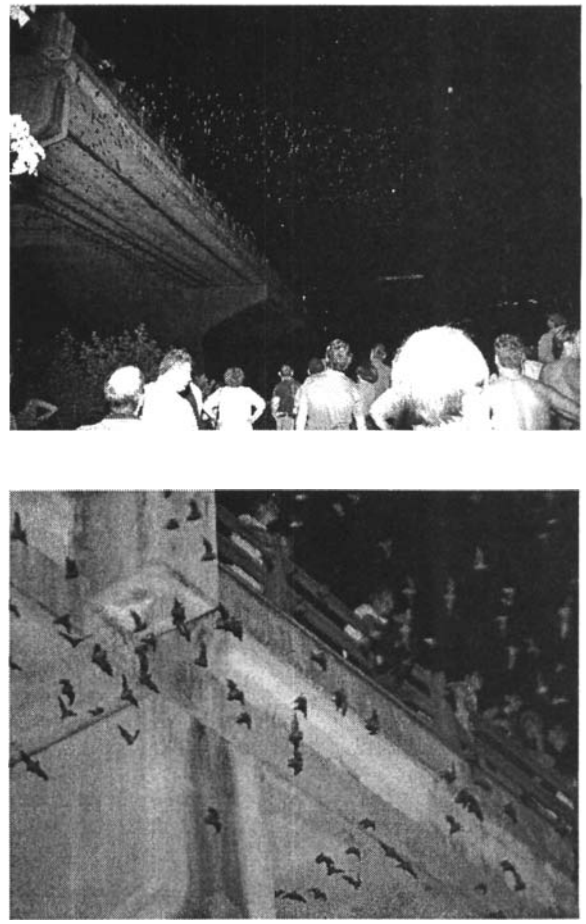

Figure 1. Spectators enjoying the nightly egress of *T. brasiliensis* from under the Congress Avenue Bridge in downtown Austin, Texas: (a) wide view with people, bats, and bridge; (b) close-up view of bats and people (Photo by B. R. Laniewicz).

This is reported to be the largest urban bat colony in the world and one of the most impressive urban wildlife spectacles in America (Tuttle 1988), and it generates nearly 8 million dollars in tourism revenue annually for the city of Austin (Ryser and Popovici 2000). Further, at nearby Bracken Cave, a colony of more than 20 million *T. brasiliensis* begin their evening flight as much as two hours before sundown (Figure 2). To the delight of visitors, great undulating columns of emerging bats are visible for up to two miles. These cave bats are estimated to consume 250 thousand pounds of insects nightly.

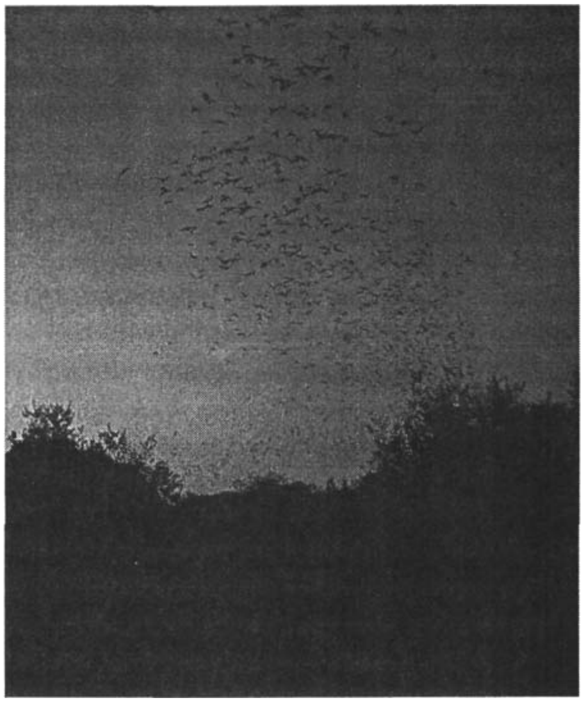

Figure 2. More than 20 million *T. brasiliensis* emerge from Bracken Cave each evening to forage on more than 100,000kg of insects (Photo by B. R. Laniewicz).

Interventions (Treatments, Actions) Interventions are practices one does to mitigate the size of the offending problem species population and/or its concomitant damage (Frantz and Davis 1991). Several categories of interventions will be given here, but keep in mind that the classifications are somewhat flexible. That is, different individuals might consider the same body of actions within a different group of categories. Regardless of the categorization of treatments, in practice it is best to select a blend of treatments for the overall management strategy. The blend will often provide synergistic effects not achievable when using the same treatments individually.

1. Educational Interventions. Human behavioral change is the single most important action, and is that upon which depends the sustainability of most other interventions. "Management" is not synonymous with "killing", a point that is often not clearly understood by those with whom rests the responsibility for target species management. Many of the decision makers regarding such management (including government agencies, institutional staff, and homeowners) have had little or no training to prepare them to handle a system that must respond in a comprehensive simultaneous fashion to a particular target species, people, physical structures, climate, etc. "Simply put, an ecologically literate perspective is often wanting" (Frantz and Davis 1991). The human aspects sometimes assume such importance that progress seems more likely to be made by an expert in human relations than one in nuisance, pest, or vector management.

Seemingly unrelated events concerned with non-target species problems, performed by various people or staff unrelated to target species management, may have a direct bearing upon the successful management of a nuisance, pest, or vector problem at a particular time. While we have not the space here to address particular educational programs regarding bat ecology, behavior and management, it should be noted that target audiences include: the general public; medical and public health staff; and pest/wildlife managers (including meaningful certification programs, and improved regulation of the industry's practices).

2. Legal interventions consist of laws, ordinances, and regulations, and can be considered as "extensions" of educational interventions. That is, such measures often result in financial penalties for non-compliance; and, unfortunately, it appears that only through this penalty process do some individuals become educated. In bat work, legal measures include: the Endangered Species Act; the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); and vaccination of pets against rabies infection.

3. Physical Interventions (Habitat Modification) focus on changes associated with structural integrity, sanitation, housekeeping, storage practices, and landscape design that will deny problematic species access to food, water, harborage, and/or travel routes. In bat work, the relevant primary physical intervention is "stoppage" which consists of changing the structural details of a building to prevent bat ingress (Frantz 1999). Stoppage can occur as "exclusion", denying bats (already utilizing an existing structure) re-entry, and as "proofing" regarding the design and construction of buildings to prevent bat ingress.

Since most construction materials are impervious to bats, stoppage focuses on openings relative to human behavior, construction errors, remodeling efforts, weather damage, and deterioration (Figure 3). Opening sizes of 0.6 X 3.8 cm and 1.6 X 2.2 cm are targeted for closure (Frantz 1986a). Appropriate stoppage targets are most commonly associated with the upper levels of a building (e.g., roof, roof edge, ridge cap, chimney, vents, and windows).

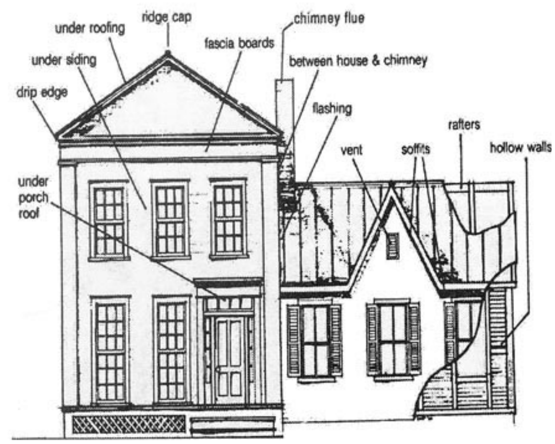

Figure 3. Common points utilized for entry and for roosting sites by commensal bats in and on buildings (from: Frantz 1986a).

It is important to not conduct stoppage work while pre-volant young bats are present because they would likely become trapped inside the building (Frantz and Trimarchi 1984, Greenhall and Frantz 1994). Thus, in the northeast, stoppage procedures are best accomplished before the end of May or after mid-August; timing will vary with geographic regions and weather conditions. Building-specific stoppage needs can be assessed via the detailed inspection and through conducting a bat watch at dusk. Remember however, that when the preferred entry points are no longer available, bats will utilize less preferred openings (hence, all potential points of egress must be addressed).

The traditional procedure for excluding bats required an initial bat watch, closing openings after bats departed the building (after dark and often on a ladder), and was followed by an interior inspection for bats the next day (e.g., in attics, listening at roof edges, etc.). If bats were still present one was required (again, after dark and often on a ladder) to re-open excluded holes that evening to allow bats to escape, and then to re-close the openings, followed t he next day by an interio r inspection, etc. until all bats were effectively excluded.

TheFrantz checkvalve simplifies the aforementioned exclusion process, makes the operation less risky for people and bats, and is highly efficacious when properly applied (Frantz 1986a, *b,* Greenhall and Frantz 1994). Basically, the checkvalve is an open-bottomed box (or sleeve) fabricated of polypropylene bird netting which is affixed to virtually any architectural configuration over major points of bat egress (Figure 4).

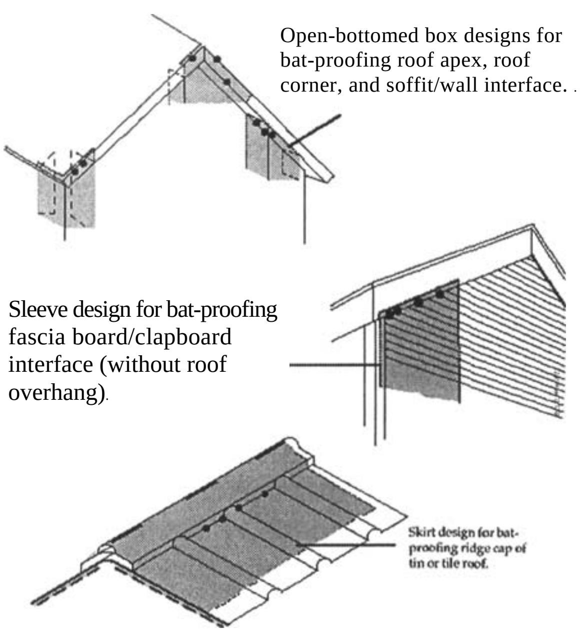

Figure 4. Examples of applied configurations of Frantz' checkvalve for excluding bats from buildings (Key: shaded area = birdnetting; — = netting's attachment to building; • = entry and exit holes for bats) (from: Frantz 1986a).

Bats are able to easily exit the building through the checkvalve interior, but upon returning to a treated opening they cannot enter the exterior netting barrier. Within a period of three to five days, the bats are effectively excluded. Detailed guidelines for batproof design and construction *per se* have not been written though the subject is briefly discussed in Frantz (1986, 1988), Frantz and Trimarchi (1984), Greenhall (1982), and Greenhall and Frantz (1994).

4. Cultural Interventions: this category originally came from "horticultural" in agricultural IPM, and includes landscaping activities, pest-resistant plants, removal of plants near buildings, etc. In bat work, cultural interventions take a conceptual shift in management principles to become environmental enhancements that promote bat conservation while reducing bat encounters with humans. This form of intervention is accomplished via the introduction of alternative roosts or bat boxes (Figure 5). This work is accompanied by "convincing" a specific bat colony to move into an alternative roost from their primary roost, and then relocating the newly colonized alternative roost to areas of low human traffic (Frantz 1986*b*).

5. Biological Interventions are management activities which are a part of the natural control of animal populations (or the human enhancement of natural control), including the actions of predators, pathogens or parasites on a host or prey population producing a lower population size than would prevail in the absence of those agents. Currently, we are not aware of biological interventions appropriate for bat management work.

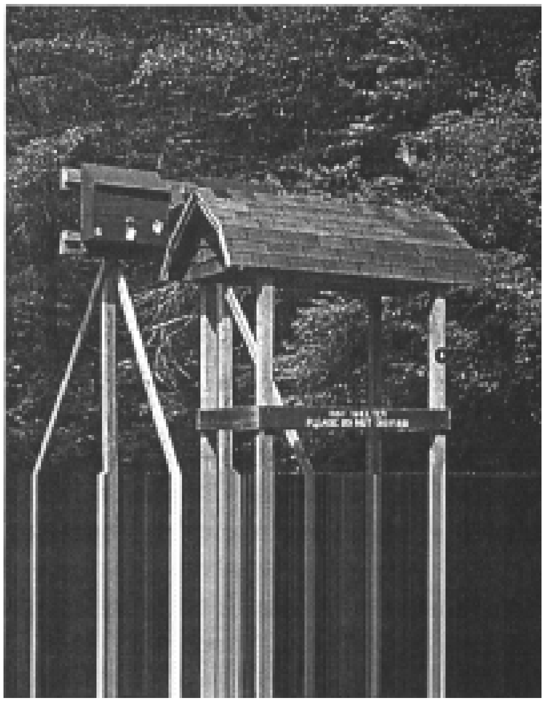

Figure 5. Examples of two bat house designs successfully used in the relocation of *M. lucifugus.* The foreground shows one modified Missouri style bathouse; the background shows two modified Pennsylvania Game Commission style bathouses. The fence is positioned about the perimeter of the bathouses to discourage human interference and to reduce the probability of bat contact with humans. (Photo by S. C. Frantz).

6. Mechanical (Trapping) interventions involve various devices that a target animal would enter, and perhaps release a trigger mechanism, that results in the animal being captured. While trapping devices for bat management have been used by some individuals (e.g., nuisance wildlife control staff), we do not (as mentioned previously) recommend trapping. Trapping is discouraged for at least three reasons: the health of the captive bats is likely to be jeopardized; the probability of bat contact with humans is increased resulting in zoonosis issues to be resolved; the efficacy of trapping alone is nil and there are better ways to remove bats (see "checkvalves" above) from a roost before physical interventions are initiated.

7. Chemical (Toxicants & Repellents) For such interventions in general, it is very important to read and understand product labels and all use restrictions. Toxicants are clearly contraindicated in the management of bats because such treatments can be deleterious to bats; can exacerbate rabies risks via intoxicated, grounded bats; and contaminate the environment (Frantz and Trimarchi 1984). Further, there are no toxicants federally registered for controlling bats (Greenhall and Frantz 1994). In terms of chemical repellents, there are none available at present (including naphthalene and other aromatics) that are both efficacious and safe for bats and humans. On the positive side, we have been experimenting with non-toxic repellent formulations that are showing promise.

8. Electric/Electronic Repellents includes electric lighting and ultrasonic devices for repelling bats from buildings. Floodlight illumination has been reported to be useful in repelling bats; however, in attics and related roof spaces, shadow areas are likely to greatly limit efficacy and the addition of such lighting may introduce electrical hazards. Electronic ultrasonic devices are not efficacious (Greenhall and Frantz 1994, Hurley and Fenton 1980) and have no legitimate role in bat management. Further, the New York State Consumer Protection Board has cautioned against the utilization of such devices (NYSCPB 1988). Note that several types of

interventions properly coordinated often can produce a synergistic effect that is greater than that of using each of the interventions alone at different points in time. The corollary to this is that when any necessary component intervention is incomplete or missing, one should expect reduced management efficacy, if not outright failure of the effort. One should always attempt to correlate interventions with other relevant variables, such as bat population size, complaints by building occupants, clean-up activities, weather changes, etc. Lastly, one must be cautious in selecting vector/pest management products since advertising prowess is not necessarily related to the management utility of that product.

Evaluation is a final step in determining the outcome of any intervention(s) and establishes what actions will occur next in the comprehensive program in order to meet the needs of a specific problem. The next activity could be a change of treatments, termination of treatments, or only monitoring. Evaluation parameters generally include determination of the continued presence of the perceived problem species, level of participation and cooperation of a problem site's human occupants, proper maintenance of interventions, and actions needed to prevent a resurgence of the problematic species at a specific site.

A concluding measure in evaluation should be cost effectiveness. However, cost/benefit analyses of comprehensive management efforts involving complex natural systems are difficult and should probably be kept modest (Frantz and Davis 1991). The problem is that economic valuation relies critically on understanding and measuring (quantitatively, if at all possible) the physical, chemical, and biological effects of our interventions (Hufschmidt et al. 1990). Available methods for placing monetary value on nonmarket goods and services are not well developed. For example, it is difficult to place a value on human or nonhuman life and insult to same. When most future costs and benefits are discounted, and especially those of nonhumans are disregarded, cost/benefit analysis becomes a specious exercise (Attfield 1991).

Thus, for the comprehensive bat management approach described herein, we suggest that it may be more expensive monetarily in the short term than typical pest control efforts. However, considerable economic cost can be eliminated directly through homeowner, or institutional in-house staff, participation in completion of interventions. Over time, the permanence of this approach should save effort and money that might otherwise be devoted to management efforts, and its environmentally sensitivity should reduce human and nonhuman stresses that might otherwise result from typical control efforts.

Overview of comprehensive management

Bat management requires a comprehensive approach that considers all relevant measures and uses whatever necessary when and where it will be most effective in a sustained fashion against the target species, while maintaining high safety standards for bats, for non-target species, and for the environment. While this is a somewhat complicated and detail-dependent approach, it is "bio-logical". Comprehensive management functions from an ecologically literate perspective that emphasizes non-lethal actions, including education of the general public, health officials, and pest/wildlife managers; exclusion of bats from human-occupied buildings with temporal considerations so as to not endanger pre-volant young; the introduction and relocation of alternative bat roosting shelters; and a hope for the future development of non-toxic repellents. This approach avoids all lethal measures for bat management purposes. Lastly, while comprehensive management can be more expensive in the short term (compared to typical pest control efforts), the long-term results should provide the most satisfactory sustained outcome for people, bats, and the environment.

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