BAT HOUSES FOR INTEGRATED PEST MANAGEMENT BENEFITS FOR BATS AND ORGANIC FARMERS: PHASE I

FINAL REPORT

MARK AND SELENA KISER

BAT CONSERVATION INTERNATIONAL
AUSTIN, TX

SUBMITTED TO:

ORGANIC FARMING RESEARCH FOUNDATION
SANTA CRUZ, CA

11 JANUARY 2002

BAT HOUSES FOR INTEGRATED PEST MANAGEMENT BENEFITS FOR BATS AND ORGANIC FARMERS: PHASE I
FINAL REPORT

Project Summary

Bats are helpful to farmers, as they consume large quantities of insect pests, but many bat species are declining due to loss of roost sites. Farmers can help bats by providing new roosts in the form of bat houses while at the same benefitting from bats' pest reduction services. However, as much of the evidence for bats' roles in insect biocontrol is anecdotal, further studies are needed to better document bats' contributions to agriculture. For this study, ten organic farms in central California were selected in 2001 as installation sites for bat houses to initiate the first phase of an integrated pest management project. A total of 45 bat houses (25 on buildings, 20 on poles) were erected in June and August 2001 in a manner such that bat preferences could be tested to determine optimal design and mounting strategies for this region.

Bat houses at five of the 10 farms (50%) were used by bats within one to five months of installation, an encouraging find given that houses were installed late in the year (after maternity colonies of bats had formed). Eleven of the 45 houses (24%) were known to be occupied, though possibly more were used. Bat houses on barns performed better than those on poles (36% vs. 10% occupancy), although additional monitoring for two summer seasons will be required to accurately identify any preferences. This study was designed to be the first part of a long-term research project. Once a large number of these houses successfully attract colonies, we anticipate that the next step (Phase II) will help quantify the impacts bats have on crop pest reduction.

Introduction to Topic

More than half of the 45 species of bats living in the United States and Canada are either endangered or candidates for such status, and many of those still considered abundant are also in alarming decline. As was formerly the case with purple martins and bluebirds, roost loss is an important factor in decline. Millions of bats have been forced from caves and old growth forests by human activities. Many that have relocated to abandoned mines have been buried during mine safety closures. Others have occupied buildings from which they are increasingly being excluded. Bats are not well equipped to handle these threats because they are the world's slowest reproducing mammals for their size, and they form the largest and most vulnerable aggregations of any vertebrate.

Loss of bat habitat poses a particular problem to agriculture because bats are primary predators of vast numbers of pests that cost American farmers and foresters billions of dollars annually. For example, Brazilian (Mexican) free-tailed bats (*Tadarida brasiliensis mexicana*) from central Texas alone consume approximately two million

pounds (900,000 kg) of insects nightly, a large proportion of which are corn earworm moths (also known as cotton bollworm moths), the most damaging agricultural pest in America (McCracken, 1996; Whitaker et al., 1996). In Indiana, a colony of just 150 big brown bats (*Eptesicus fuscus*) consumes sufficient cucumber beetles each summer to prevent egg laying that would produce 33 million of their rootworm larva, another costly pest (Whitaker, 1995). Even one little brown bat (*Myotis lucifugus*) can catch up to 1,000 insects in an hour, including many mosquitos (Tuttle, in prep.; Fascione et al., 1991). Without adequate habitat, however, bats are unable to fulfill their vital roles in keeping insect populations in check, threatening environmental and agricultural health.

This study of bat houses and their effect on agriculture is the newest component of BCI's North American Bat House Research Project. The Bat House Project seeks to provide alternative habitat for thousands of American bats that have lost their roosts in caves and old-growth forests. The project enlists the aid of wildlife professionals and amateur enthusiasts in the process of researching bat roosting preferences in artificial habitat. In this way, the project is also an innovative conservation education program.

Just as programs for bluebirds, wood ducks, and purple martins have provided clear evidence that artificial roosts reverse population declines, so has the Bat House Research Project convincingly demonstrated that artificial roosts also work for bats. At least ten species of bats in North America use bat houses. Currently, 75% of all of nursery-style bat houses reported that meet minimum Project requirements of location, color, and sun exposure are occupied, providing homes for approximately 25,000 bats throughout the U.S. and Canada. Custom-built, extra-large bat houses shelter more than 100,000 others.

Recent studies show that the most common bat house occupants, big brown, little brown, and free-tailed bats, can be extremely beneficial to agriculture. An organic farmer in Oregon who attracted 600 little brown bats to bat houses reported elimination of a previously serious corn earworm problem. Not only do they consume pests, including corn earworm, armyworm, and tobacco budworm moths, but their mere presence can have an effect on insects. It has been documented that moths listen for bat echolocation sounds and avoid areas within 150 feet (46 m) of where they hear even one bat.

Though the Bat House Project has already developed many successful bat house designs, these models do not necessarily meet the needs of farmers. Most house only small numbers of bats and large designs are often too costly for most farmers to build or purchase for large colonies. In this study, BCI proposed testing a newly-developed larger design, both inexpensive and lightweight, at five selected sites alongside conventional designs. These new houses are based on the latest research and are built by Marvin Maberry (Maberry Centre Bat Homes), one of the leading bat house manufacturers and researchers in the U.S. They can accommodate 500 to 800 bats (depending on species) in a space of approximately 2 feet x 2 feet x 1 foot (61 x 61 x

30.5 cm).

Objectives Statement

The first objective of this study (Phase I) was to establish four bat houses (two pairs each of a proven nursery design) at 10 organic farms in California and Utah. Larger, experimental designs were to be installed at five of these sites for testing purposes. Data from the North American Bat House Research Project shows that pairs or groups of houses are more successful than single houses. Rachael Long, co-investigator and Farm Advisor with the University of California Cooperative Extension, was to select organic farm cooperators in Yolo, Solano, Sacramento, Colusa, Sonoma, and San Joaquin Counties in California's Central Valley. She had previously experimented with bat houses in the area, and had already worked with a number of farmers in these counties. Originally, one farm in Utah had been targeted based upon previous interest. Once a large number of the bat houses become occupied (some take two years or more), the second objective (Phase II) will be to determine the degree of impact that bat house-roosting bats have in reducing crop pests.

All objectives for Phase I were met, and all 45 houses installed, however, the locations of some of the farms were altered. To ensure that all sites met our criteria and that bat houses were properly installed, the investigators personally traveled to each farm and were involved in the installation of all 45 houses. For logistical reasons, the site in Utah was not selected. All 10 farms were located in the Central Valley of California in the following seven counties: Colusa (1 site), Yolo (3 sites), Sutter (1 site), Solano (1 site), San Joaquin (1 site), Merced (2 sites), and Fresno (1 site). Houses were not installed as early as had been planned (by Spring 2001) due to scheduling problems, manufacturing delays, and greater-than-anticipated time required to locate cooperators with suitable test sites.

Materials and Methods

Ten farmer cooperators were selected based on phone interviews and site inspections by Rachael Long and BCI. Locations are provided in Table 1 and Figure 1. Sites were chosen to represent a variety of organic crop types. Other site requirements included: 1) a building suitable for attaching two or three bat houses side by side on either the north or east sides, at least 12 feet (3.7 m) off the ground; and 2) an open area with at least one large deciduous tree for partial shade. Installation for the first nine sites was completed in June 2001. A new location for the tenth site was selected and installation completed in mid-August 2001.

Four wooden bat houses were installed at each site, and five of the sites also received a plastic insulated bat house. The wooden houses had four chambers and were 2001 models built by Swetman Enterprises of Madison, Virginia (540-948-4146; houses sold through Bat Conservation International's catalog, Austin, Texas, 512-327-9721). External dimensions were 32" H x 18" W x 5" D (81.3 x 45.7 x 12.7 cm). Wooden

houses were patterned after the nursery house from *The Bat House Builder's Handbook* (2001 revision) published by BCI. The experimental plastic insulated models were eight-chamber "Condo" houses (2001 models) with a commercial-grade stucco coating inside and out, built by Maberry Centre Bat Homes (Daingerfield, Texas; 903-645-7780, www.maberrybat.com). External dimensions were 23" H x 19" W x 11 ½" D (58.4 x 48.3 x 29.2 cm).

Two wooden houses at each farm were painted a light color (off-white) and two were painted a medium color (medium brown) prior to installation. One coat of water-based primer was used, followed by two coats of exterior grade latex paint. Plastic insulated bat houses were pre-painted either medium green or light gray. Colors and mounting sites were selected based upon Rachael Long's experience with bat houses in the area. The goal was to install two wooden houses (one lighter, one darker) on a pole, side by side, and the other two wooden houses side by side (one lighter, one darker) on a building. Plastic insulated houses were attached adjacent to wooden houses on the same building at five sites. Overall, 25 houses were mounted on buildings and 20 houses were mounted on poles (see Figures 2 and 3 for mounting diagrams). Identification numbers were affixed to all houses to enable tracking over time.

Through this experimental design, we wished to test pole-mounted houses versus building-mounted houses, as well as plastic versus wooden houses, and light-colored versus medium-colored houses. Bats use houses that best meet their temperature needs, and will move between different ones as ambient temperatures change (for example, on hot days, bats may choose light-colored houses, and on cool days, medium-colored houses). Therefore, the above tests will help us determine which models, colors, and which mounting and placement strategies work best in California's Central Valley.

Based upon earlier bat house testing in the area, mounting sites were selected to avoid afternoon sun exposure to prevent overheating. For this reason, most houses attached to barns were affixed to the north and east sides. Similarly, most pole-mounted houses faced either north or east and were located north or east of large deciduous trees to block harsh afternoon sun from the west in summer. Finished installation heights for houses mounted on buildings ranged from 13 to 20 feet (4 to 6.1 m), as sizes and types of available barns varied considerably. For pole-mounted houses, 21-foot-long (6.4 m), 2-inch (5.1 cm) inside diameter steel (Schedule 40) poles were used. Custom steel mounting brackets were fabricated by Maberry Centre Bat Homes (Daingerfield, Texas; 903-645-7780) to slide over the end of the poles. These mounting brackets greatly reduced time of installation. Poles were set in holes 3 to 4 feet (0.9 to 1.2 m) deep and anchored with concrete mix; finished installation heights (measured from the ground to the bottom of the bat house) ranged from 15 to 16 feet (4.6 to 4.9 m). Bat houses were secured to barns and pole mounting brackets with galvanized screws. Forklifts, trucks, tractors, extension ladders, and volunteer labor were used to erect poles and install bat

houses.

Following installation, bat houses were monitored by farmers and by Rachael Long to check for occupancy. Numbers of bats and species (if known) for each occupied house were forwarded to BCI. Other bat house data (habitat, farm type, distance to nearest water, etc.) were recorded by BCI and Rachael Long at the time of installation and entered on BCI's standardized Bat House Research Project data forms (see attached form as an example) for inclusion with BCI's 2001 North American bat house survey.

Table 1. Farm locations and bat house installations.

Site 1. Maxwell, CA; Colusa County; crops: rice, herbs for seed

Two wooden houses under metal pole barn facing South, 19 feet (5.8 m) high (limited sun exposure of 1 to 2 hours)
Two wooden houses on pole facing North, 16 feet (4.9 m) high

Site 2. Dunnigan, CA; Yolo County; crops: mixed vegetables, orchards

Two wooden houses on white wooden barn facing East, 20 feet (6.1 m) high
One medium green plastic insulated house on white wooden barn facing East, 20 feet (6.1 m) high
Two wooden houses on pole facing North, 15 feet (4.6 m) high

Site 3. Esparto, CA; Yolo County; crops: field crops (including alfalfa)

Two wooden houses on medium brown barn facing North, 13 feet (4 m) high
One medium green plastic insulated house on medium brown barn facing North, 13 feet (4 m) high
Two wooden houses on pole facing North, 16 feet (4.9 m) high

Site 4. Woodland, CA; Yolo County; crops: walnuts

Two wooden houses on red/medium brown wooden barn facing East, 20 feet (6.1 m) high
Two wooden houses on pole facing East, 15 feet (4.6 m) high

Site 5. Pleasant Grove, CA; Sutter County; crops: rice, orchards, beans, popcorn

Two wooden houses on dark brown wooden barn facing East, 16 feet (4.9 m) high
Two wooden houses on pole facing North, 16 feet (4.9 m) high

Site 6. Winters, CA; Solano County; crops: walnuts

Two wooden houses on medium brown wooden barn facing East, 13 feet (4 m) high

One light gray plastic insulated house on medium brown barn facing East, 13 feet (4 m) high
Two wooden houses on pole facing East, 16 feet (4.9 m) high

Site 7. Linden, CA; San Joaquin County; crops: nut and fruit orchards, vegetables

Two wooden houses on metal pole barn facing South, 14 feet (4.3 m) high
One medium green plastic insulated house under pole barn roof facing East, 16 feet (4.9 m) high (no direct sun for this bat house)
Two wooden houses on pole facing Northeast, 15 feet (4.6 m) high

Site 8. Hilmar, CA; Merced County; crops: almonds

Two wooden houses on dark brown wooden barn facing North, 13 feet (4 m) high
Two wooden houses on pole facing East, 16 feet (4.9 m) high

Site 9. Livingston, CA; Merced County; crops: almonds and walnuts, mixed row crops (blueberries, lavender)

Two wooden houses on dark brown wooden barn facing North, 17 feet (5.2 m) high
One light gray plastic insulated house on dark brown wooden barn facing North, 17 feet (5.2 m) high
Two wooden houses on pole facing East, 16 feet (4.9 m) high

Site 10. Kingsburg CA; Fresno County; crops: plums, peaches, and nectarines

Two wooden houses on white masonry/wooden building facing East, 17 ft. (5.2 m) high
Two wooden houses on pole facing Northeast, 15 feet (4.6 m) high

Project Results

At five of the 10 farms (50%), at least one bat moved into at least one bat house by November 2001 (Table 2). For this first (partial) season, time until first occupancy ranged from one month to five months. A total of 11 of 45 houses were occupied (24%), though several others may also have been used. Bat houses mounted on barns (9 of 25, 36%) were used more often than those on poles (2 of 20, 10%), though observations were limited to less than one full season. Two of the five plastic houses (40%) had confirmed use, indicating the design is acceptable to bats.

Based upon observations of bats inside houses and bat guano underneath houses, at least two species were present. Most were Mexican free-tailed bats (*T. brasiliensis*), while some were thought to be big brown bats (*E. fuscus*). Yuma myotis (*Myotis yumanensis*) and/or little brown bats (*M. lucifugus*) and pallid bats (*Antrozous pallidus*) were observed in other previously-installed bat houses in the area in June 2001, and could potentially use bat houses installed for this study. Multiple species often inhabit the same bat house, and as each species has different dietary preferences, attracting more than one species to a farm can increase the number of pest types consumed. For

example, Mexican free-tailed bats feed primarily on moths, while big brown bats mainly eat beetles.

Table 2. Occupied Bat Houses.

Site 1. Maxwell, Colusa County: three of the four houses were occupied. Both houses on the pole barn were inhabited in July, and approximately 20 to 30 bats were observed using these houses in October. Six bats were observed in the brown, pole-mounted house on the same day in October.

Site 3. Esparto, Yolo County: a few guano pellets were observed under the plastic house on the barn in October.

Site 4. Woodland, Yolo County: installation at this site was completed in August, and both houses on the barn were used by September. The off-white house was occupied first and contained more bats than the brown house.

Site 6. Winters, Solano County: four of the five bat houses were occupied, including all three houses on the barn (both wooden and the plastic house, mounted side by side). A row of approximately 300 guano pellets (indicating probably several dozen bats) was observed under all three houses in September. Several guano pellets were later observed under bat houses on the pole in September, however it was not determined whether bats were using one or both houses.

Site 9. Livingston, Merced County: one of the three bat houses on the barn was occupied. One bat was observed in the top, west corner of the white wooden bat house in November.

Conclusions and Discussion

This was the first phase of a long-term study. We are encouraged that many of the bat houses were inhabited this early in the project, especially considering that they were installed in June and August. Occupancy may have been higher in 2001 if houses had been installed before March, before maternity colonies had formed. We are also pleased that two of the plastic insulated houses were used. At three other sites in 2001, two in Texas, and one in Wyoming, bats also used this Maberry design. Additional monitoring will be needed in 2002 and 2003 to determine bat preferences for each model, color, and placement, and to determine overall how successful Phase I of the project will be, as it often takes several years for bats to be attracted and for colonies to become established. We expect the occupancy rate and overall numbers of bats to improve considerably over the next several years. At this point, further investigations into bats' roles in crop pest reduction can begin (Phase II). Continued monitoring will enable us to determine if any adjustments are needed, such as moving or repainting houses to improve our results. As we could not hope to complete Phase I in just one year, BCI will continue to update the Organic Farming Research Foundation on the bat house project's progress.

Although results are preliminary, bat houses mounted on buildings performed better than those on poles. These findings are in agreement with Rachael Long's previous experience with bat houses in the Central Valley. Buildings, with their large thermal mass, act as heat sinks and help to buffer daily temperature fluctuations. Therefore, temperatures inside bat houses mounted on buildings fluctuate less than those mounted on poles, which may explain why bat houses on barns had a higher occupancy rate. Elsewhere, pole-mounted houses do almost as well as those on buildings. In a survey of 636 bat houses in the U.S., Canada, and the Cayman Islands, 69% (117 of 169) of bat houses mounted on buildings were used compared to 61% (241 of 395) for pole-mounted houses (Kiser and Kiser, 2001). Perhaps in the hot, dry summer climate of California's Central Valley, where temperatures at night can fall 30° to 35° F (17° to 19° C) (or more) below those during the day, bats prefer the greater stability of temperatures found in roosts in/on buildings.

The next step (Phase II, as stated above), investigation of reduction of crop pest damage, will be the most useful to farmers and researchers. While results from Phase I demonstrate that bats can be attracted to organic farms in the Central Valley of California, we anticipate that results from Phase II will better demonstrate the value bats have to agriculture, therefore encouraging other farmers across North America and beyond to incorporate bats into their integrated pest management schemes. Several farmers across the U.S. maintain that they experienced less crop damage after attracting bats to bat houses (Murphy, 1993; Kiser, 1997; Acker, 1999; Kiser, 2000). While such anecdotal evidence is encouraging, further scientific studies are needed to convince the public, farmers, and researchers.

In Phase II, sites where bats are attracted will be slated for crop pest comparison research by graduate students or other researchers. To avoid bias from differing weather patterns among years, the study will identify the varieties and numbers of pests being eaten by bats, followed by comparison of pest numbers and/or damage at varying distances from bat houses. The amount of bat foraging activity over agricultural fields and bat-insect interactions will also be documented. Presence of foraging bats and changes in bat density will be documented using ultrasonic bat detectors and night vision verification, and pest abundance and damage will be compared to bat densities and distances from bat houses. Additional evidence will come from comparison of pest hatch times with the bats' activity patterns. Insect identification will be based on guano analysis as well as on culled insect remains collected beneath roosts.

If this study were conducted again, bat houses would be installed earlier in the year, preferably by February or at the latest March. Bat houses would have been painted and shipped to individual farms in advance. The logistics of transporting 45 bat houses,

mounting brackets, tools, hardware, paint, poles, and cement mix to 10 farms over a seven county area were quite challenging.

Outreach

As of January 3, 2002, Rachael Long, co-investigator and Farm Advisor for the

University of California Cooperative Extension, has distributed 38 of the 50 *Building Homes for Bats* video tapes donated by BCI. She is now loaning out the remainder of the tapes, so that additional farmers will be reached. In November 2001, she also presented information and slides about this project to 40 growers and pest control advisors in Ukiah, CA. Bat Conservation International posted a press release about this project on our web site at www.batcon.org (under "What's New"; see attached) in October. In the Spring 2001 issue of *The Bat House Researcher* newsletter, a brief article mentioned the grant and project (see attached). After more of the houses are occupied with larger numbers of bats, a complete article with project results will be included in *The Bat House Researcher*, and a scientific article will be submitted for publication to *California Agriculture* or *The IPM Practitioner*. Once published, copies of these articles will be given to the University of California Cooperative Extension for free distribution.

References

Acker, E. 1999. Backyard bats. Bats, 17(4):3-9.

Bat Conservation International. 2001. News and notes. The Bat House Researcher, 9(1):7.

Fascione, N., T. Marceron, and M.B. Fenton. 1991. Evidence for mosquito consumption in *Myotis lucifugus*. Bat Research News, 32(1):2-3.

Kiser, M. 1997. Bat houses help Texas farmer. The Bat House Researcher, 5(2):7.

Kiser, M. 2000. Bats and pecans: a growing partnership. The Bat House Researcher, 8(2):1-2.

Kiser, M. and S. Kiser. 2001. Survey results from 2000. The Bat House Researcher, 9(1):2-4.

Long, R. F. 1996. Bats for insect biocontrol in agriculture. The IPM Practitioner, 18(9):1-6.

Long, R. F., T. Simpson, T. Ding, S. Heydon, and W. Reil. 1998. Bats feed on crop pests in Sacramento Valley. California Agriculture, 52(1): 8-10.

McCracken, G. 1996. Bats aloft: a study of high-altitude feeding. Bats, 14(3):7-10.

Murphy, M. 1993. Bats: a farmer's best friend. Bats, 11(1):21.

Tuttle, M.D. Bats of North America. In preparation.

Tuttle, M.D. and D. Hensley. 1993. The bat house builder's handbook. 2001 revision. Bat Conservation International, Austin, TX, 34 pp.

Whitaker, J., C. Neefus, and T. Kunz. 1996. Dietary variation in the Mexican free-tailed bat, *Tadarida brasiliensis mexicana*. Journal of Mammalogy, 77(3):716-724.

Whitaker, J. 1995. Food of the big brown bat, *Eptesicus fuscus*, from maternity colonies in Indiana and Illinois. American Midland Naturalist, 134:346-360.

Addenda

1. Figure 1. Locations of the 10 study sites
2. Figure 2. Diagram of Bat House Mounting Procedure (pole-mounted houses)
3. Figure 3. Diagram of Bat House Mounting Procedure (barn-mounted houses)
4. Slides and captions (and reproduction rights)
5. BCI press release
6. Sample data form
7. *The Bat House Researcher* newsletter, Spring 2001 issue

Slide Captions

All photos were taken June 2001; ©Mark and Selena Kiser, Bat Conservation International.

CA002: Site 6.
Three bat houses were installed on a barn at Sierra Orchards, an organic walnut orchard, near Winters, CA, to attract bats for an OFRF-funded integrated pest management study. The house on the left (grey) is a plastic insulated model, while the other two are wooden nursery models. All three of the houses were occupied within three months of installation. They face east and receive approximately six hours of direct daily sun during summer.

CA005: Site 5.
Mark Kiser, project coordinator for BCI's North American Bat House Research Project, installs two wooden nursery bat houses on a barn facing east. These houses are located on an organic farm near Pleasant Grove, CA, installed as part of an OFRF-funded integrated pest management study.

CA007: Site 7.
Rachael Long, farm advisor with the University of California (Yolo County) Cooperative Extension, installs two wooden bat houses on a pole barn at Ferrari Farms, near Linden, CA. These houses were installed as part of an OFRF-funded integrated pest management study.

CA008: Site 7.
Rachael Long, farm advisor with the University of California (Yolo County) Cooperative Extension, installs two wooden bat houses on a pole barn at Ferrari Farms, near Linden, CA. These houses were installed as part of an OFRF-funded integrated pest management study.

CA010: Site 9.
Mark Kiser, coordinator of BCI's North American Bat House Research Project, installs three bat houses on a barn at an organic farm near Livingston, CA. The white wooden house (far right) was occupied first, within five months of installation.

CA011: Site 8.
The owner of Anderson Almonds takes notes on his newly installed bat houses near Hilmar, CA. These houses were installed as part of an OFRF-funded integrated pest management study.

CA029: Site 9.
Together with the owners of Living Farm Systems, Selena Kiser (left), project assistant for BCI's North American Bat House Research Project, installs wooden bat houses side by side on a pole on an organic farm near Livingston, CA. These houses were installed as part of an OFRF-funded integrated pest management study.