Living *and* Landscaping *with* BATS in the San Juan Islands

KWIAHT

A **thumbnail guide** brought to you by

KWIAHT

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In memorium Parvin Baharloo, master chef and booster for island bats

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The purpose of this book

Over the past seven years, Kwiaht biologists have responded to requests for advice about bats from more than two hundred homeowners in the San Juan Islands. Some of them had found a bat indoors and wanted help freeing it. Many had bats roosting under eaves, inside an attic or a wall, and wanted to remove or exclude their uninvited guests either for health and safety, or in anticipation of building repairs and renovations. Others wanted to encourage more bats to visit their property as a way of controlling insect pests such as mosquitos. As we visited more homes and helped more islanders find ways to live safely with bats (through measures such as securing home interiors against accidental bat entry, and building exterior roost habitat including customized "bat houses" attached to walls, posts or trees), we realized that there was a vacuum of published information on the larger, longer term issue of securing good habitat for Pacific Northwest bat populations. The focus of our laboratory has been trophic ecology, which is to say "food webs," so we began by trying to learn more about the annual life cycle of island bats, their diet and how it changes with the seasons, and their foraging strategies and range. In practical terms, what resources do they require, and what habitats provide those resources?

We have explored those questions using a combination of acoustic monitoring—a network of automated "bat detectors" running nightly year-round on San Juan, Orcas and Lopez Islands—and identification of the traces of DNA left by insect prey in bats' feces (guano). These studies have enabled us to gain some understanding of bats' nightly choices of where to hunt, as well as the habitats and ecology of bats' prey. Three key findings have emerged: (1) island bats use large mosaic landscapes over the course of a year that include open water, wetlands, gardens, orchards and woodlands; (2) island bats disperse and reduce their activity levels in winter but continue to hunt sporadically for what insects are available—principally woodland moths; (3) moths comprise a consistent year-round prey resource for island bats, and in spring-summer they are probably most available in farms and gardens. This is a very different story from the "standard model" of bat ecology that assigns different bat species to different habitats eating different kinds of prey; and has bats hibernating or migrating in winter. Not in the islands!

Now that we know more about island bats, we feel it is important to re-think bat conservation in terms of the way we divide and use land, and the prey resources that we (inadvertently, for the most part) increase or decrease by the way we farm, garden, and landscape. Beginning the conversation is the purpose of this book.

Bats and the San Juan Islands

The islands are separated from mainland Washington State and British Columbia by salt water straits, and animals that can swim or fly were first to re-colonize the islands after the end of the last glaciation some ten thousand years ago. Animals accidentally riding drifting rafts of woody debris blown out of the Skagit and Fraser Rivers by spring floods were next, but relatively few species ever made it that way. As a result, the islands had relatively few species of rodents, for example, before humans introduced rats and rabbits. But our birds and insects are largely the same suite of species that can be found on the mainland. And we have most of the same bats, the only mammals capable of sustained long-distance flight. In fact, the islands have about as many species of bats as all of our other (terrestrial) native mammal species combined. And as far as total numbers of individuals, bats outnumber all other native mammals in the islands by an order of magnitude. On a calm August night, over five hundred bats can be heard chirping over Hummel Lake alone. Bat maternity roosts in the islands often number in the hundreds. A reasonable estimate of the number of bats in the San Juan Islands is 250,000, based upon our recordings of nightly flyovers. This necessarily has a significant impact on insect populations.

Bats and humans have a long history in the islands as well. Coast Salish peoples began erecting large communal cedar plank-houses in the islands several thousand years ago. Over a dozen big plank-house villages were thriving in the islands when European explorers arrived at the end of the 18th century. Bats would likely have enjoyed warm, dry roosts in the rafters and roofs, and it is not coincidental that bats appear in Coast Salish historical art and literature. High cedar "shed roofs" probably expanded bats' reproductive habitat considerably, and it is plausible that island bats were primed to roost in the ceilings and attics of the smaller wooden buildings erected by Euro-American settlers (and their remaining Coast Salish neighbors) after 1850. Today only two of the islands' nine bat species prefer roosting in trees; the rest prefer houses and barns by far.

Humans also unwittingly introduced dozens of species of European moths to the islands when they planted orchards and gardens in the latter 19th century. Moths are much greasier, calorie rich packages than mosquitos and other nocturnal members of the fly family (the Diptera), and we have found that moths are understandably a significant part of island bats diet, year-round. In this way, humans may have enriched bats' diet, helping support larger bat populations, while the bats helped protect orchards and gardens from Lepidopteran pests. Of course, when people began routinely applying toxic sprays such as lead-arsenate to orchards in the 20th century, bats almost certainly suffered from eating insects that had absorbed sub-lethal doses of pesticides. Likewise, reduced use of pesticides in the islands in recent years was probably a boon for bats—and has been successful in part because bat populations have grown and taken up the slack as insect regulators!

Introducing the Islands's bats

Nine species of bats have been documented in the San Juan Islands. All of them are widespread but some are much more abundant than others, and also more likely to be found resting inside, or on the exterior walls or eaves of homes and barns. All are insectivores, and larger bat species may target larger insect species including beetles and the largest moths. All use echolocation to navigate in the dark, chirping in species-specific ways that enable us to identify them once their ultrasonic voices have been slowed down to the range of human hearing. One species is known to stop chirping when it approaches prey, and lock onto the mate-attracting clicks and buzzes of the insects it hunts! That's Townsend's Big-Eared Bat, the rarest bat in Washington state but for reasons that remain unclear, relatively more abundant in the islands.

Island bats can be divided into two groups: the five small "mouse-eared" bats that all belong to the genus Myotis; and four larger, unrelated larger bats. Most of the bats you see in moonlight silhouettes or roosting in an attic or barn will be the more common Myotis species. Apart from Long-Eared Myotis, they are difficult to distinguish visually from each other or from Big Browns, without having them in your hand to examine their teeth, tail and legs. They are much easier to identify acoustically on the fly using a new-generation "bat detector" such as Wildlife Acoustics' EchoMeter Touch.

California Myotis, Myotis californicus (MYCA) pictured above: Most abundant bat in the islands, forming large spring-summer maternity colonies in homes and barns; mouse-sized like other Myotis species. MYCA often hunt flying just inches above water, including saltwater, but also pursue insects in fields, gardens and seasonal wetlands.

Yuma Myotis, Myotis yumanensis (MYYU): Nearly as abundant in the islands as MYCA, and also gregarious roosters that are adapted to hunting over lakes and seashores as well as woodlands, wetlands, and fields. Often roosts together with MYCA and Big Browns.

Little Brown Myotis, Myotis lucifugus (MYLU): Relatively uncommon in the islands, with only a few scattered (but relatively large) roosts.

Long-Legged Myotis, Myotis volans (MYVO): Distinguished by its proportionately longer legs but otherwise anatomically and ecological much like more abundant Myotis bats. Small roosts, and more peripatetic than other Myotis in the islands, changing its hunting areas frequently.

Long-Eared Myotis, Myotis evotis (MYEV) pictured right.: Easily identified by its longer, flattened leathery ears but otherwise similar is habits to other Myotis bats. Relatively uncommon, with scattered small roosts of no more than 25-50 bats.

Big Brown Bat, Eptesicus fuscus (EPFU): About 50 percent larger than Myotis bats but otherwise similar visually, and often found in small groups pf 15-25 roosting with MYCA or MYYU in homes and barns. More likely to hunt at treetop level.

Silver-Haired Bat, Lasionycteris noctivagans (LANO): One of the islands' two relatively solitary, highly mobile "tree bats" that avoid human structures (although they have a strange tendency to sleep in woodpiles in winter). These bats tend to nest individually in tree cavities, and when not raising pups they move frequently, mainly in forests. Their name means "night wanderer". They look like Big Browns but with a streak of silvery gray hair down the middle of their backs.

Hoary Bat, Lasiurus cinereus (LACI): Our largest bat, like juvenile rabbit in size, with thick gray hair, sometimes called the "teddy bear bat". A tree bat with behavior like LANO, relatively rare in the islands and most often encountered in or near dense woodlands. Elsewhere in the U.S., LACI migrate long distances in winter, as far as Central America, but they appear to remain in the islands year-round like other island bat species.

Townsend's Big-Eared Bat, Corynorhinus townsendii (COTO): Our rarest and most conspicuous bat with its long bunny ears that can roll up like an old-fashioned party noisemaker, COTO like to roost in quiet old barns and lofts in the islands. Two maternity roosts have been documented thus far in the islands with a total of more than two hundred female bats, perhaps as much as one-sixth of the statewide COTO population in the state's smallest county. COTO are difficult to track and study because they hunt silently, without chirping.

Our Northwest bats all belong to a group commonly described as "micro-bats" that are very small, largely insectivorous, and use echolocation. The "mega" bats are the so-called "fruit bats" that mainly dine on flowers and fruit, can weigh several pounds, and only live in Africa, south and southeast Asia and Australia. There are no fruit bats native to the Americas.

Bats and sustainable pest control

Insects were the first animals on land, hundreds of millions of years ago, and they continue to be far more diverse and abundant than vertebrate animals—reptiles, birds, mammals—many of which are insectivores. "Top-down" regulation of insect populations by vertebrate insectivores is a natural, sustainable process that benefits farmers and gardeners, as well as human health. Unfortunately, people have disrupted this top-down control of insects by degrading the habitat that birds and other insectivores need to reproduce—nesting habitat, mainly—and responding to declining insectivore populations, and increasing insect abundance, by poisoning the insects. Poisoning insects also poisons the remaining insectivores, a vicious cycle that is threatening the food supply for humans in many parts of the world.

Here in the Pacific Northwest, the insectivore guild has a "day crew" dominated by a number of small birds such as the swallows and martins, and a "night crew" dominated by bats. In the San Juan Islands, both of these insectivore teams rely heavily on homes and barns for their nests or, in the case of bats, "maternity colonies" where female bats congregate and share some of their pup-rearing responsibilities. An old barn or shed can house hundreds of swallows or bats during the critical few months each summer when these insectivores reproduce.

The alternative—annually buying and applying pesticides to farms and gardens—threatens the health and survival of non-target insects including bees and other pollinators, ladybird beetles and other aphid predators, and butterflies. Pesticides also kill soil organisms such as springtails, mites and centipedes that perform functions critical to recycling nutrients and maintaining soil fertility. Anything that poisons insects will also affect the birds, bats, and other animals that eat insects, of course.

Bats played an important role in the development of the San Juan Islands oldest, and still most sustainable modern agricultural project: fruit orchards, which enabled islanders to be net exporters of food from the 1880s to 1930s. Moths and other orchards pests were Imported to the islands on apple, pear, plum and cherry trees from the eastern states; but our native bats were quick to adapt to, and thrive on these new prey resources. Restoring and enhancing fruit-growing in the islands—especially "organic" fruit farming—may depend on bat conservation!

Bats' health and human health

White-Nose Syndrome (WNS) in bats has attracted a great deal of attention since it erupted in New York State bats in 2007. While it has killed millions of bats in the Eastern states, there have been only two confirmed cases in Washington, neither of them in the San Juan Islands. WNS is caused by a fungus found widely in the soft cold soil in caves.

European bats evolved immunity to a closely related fungal pathogen, but North American bats were unprotected. The pathogen grows on the faces of hibernating bats, waking them prematurely and causing death chiefly by dehydration. Only bats that hibernate in caves are at risk, which is why WNS remains relatively uncommon west of the Mississippi River, and extremely rare in Washington. Island bats do not hibernate, and the few that use small caves or rock shelters as roosts remain active all winter.

Our islands' bats are most likely to die from flying accidents, or encounters with domestic cats, just like small birds. Accidents frequently result in wing-bone breaks or wing tears, and are most common in juvenile bats that are inexperienced flyers. Reports of dead or injured bats peak at the end of August and early September each year, which is when young bats are fledged. Their wing bones are not yet completely rigid, which may help them survive their clumsy first weeks on their own. We have rarely seen evidence of mites, other parasites, or disease in island bats. On the whole they are healthy, probably healthier than bats on the mainland.

Bats and humans are mammals and can share some pathogens and diseases. The most familiar shared disease is rabies. Fortunately, the San Juan Islands have not yet had a confirmed case of rabies in a bat or other animal, or human. On mainland Washington, where perhaps as many as one in 10,000 bats carries the rabies rhabdovirus (0.01% and still a *very* small number) only two cases of human rabies have been reported in the last 25 years.

Most land animals on our planet are insects, and most viruses use insects as reproductive hosts. As insectivores, bats eat a lot of infected insects. Over millions of years, bats have evolved very strong immune systems to protect them from pathogens in their food. As a result, bats became "reservoirs" for many diseases that can affect people. However, humans rarely come into close contact with bats, and most viruses are distributed by contact with saliva and other body fluids.

In other words, a person would need to handle a bat, then put their hands in their mouth, nose or eyes, to be at risk from a bat. Or be bitten by a bat, which is also extremely unlikely. Bats are very unlikely to bite unless handled roughly. And their teeth are tiny: the canines of a MYCA or MYYU, our most common island bats, cannot go through thick rubber or leather garden gloves.

Histoplasmosis is a fungal respiratory disease that humans can acquire by breathing the spores released by the decaying feces of infected birds or mammals, including rodents and bats. Dogs can also acquire histoplasmosis and share it with their owners. This disease is principally found in the central United States. In our region, it is uncommon and restricted to the eastside of the state; no cases have been confirmed in western Washington. Of course, you should always use gloves and a dust mask when exposed to animal feces in enclosed spaces, such as an attic. But bat guano has not been a source of histoplasmosis in the San Juan Islands.

It remains an open question whether North American bats can acquire the SARS-Cov-2 virus) from contact with humans suffering from Covid-19, and then pass the virus back to humans. Of course, this cannot happen as long as people avoid direct physical contact with individual bats and most important of all, do not enter confined spaces where bats are roosting. Until more is known, it is prudent to assume that close proximity, a cough or sneeze, or the touch of unwashed hands could infect a bat as easily as another human, and accordingly exercise extra caution around bats.

A year in the life of an island bat

An island bat's year depends on its sex. Male bats spend their year moving from habitat to habitat, roost to roost, staying in one place for anywhere from a single night to several months, depending on how much insect prey is available. Roosts must always be close to fresh water, as every night begins with a drink of water taken while skimming just above the surface. Male bats roost by themselves under the eaves of a warm home, beneath a roof tile, inside a folded beach umbrella, a tree cavity or rock crevice in the woods. A few male bats may roost together temporarily, but rarely in direct contact with each other.

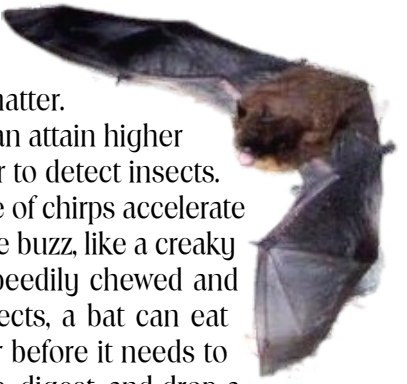
In October or November female bats leave their maternity roosts and disperse widely across the island landscape, mating with male bats they encounter after an aerial courtship dance. This is just a one-night stand; after mating bats continue on their separate winter journeys. Newly mated mothers-to-be do not begin developing embryos right away. They suspend development until spring, meanwhile roaming alone, roosting wherever prey can be found, and taking advantage of every calm, dry night to catch some snacks. Like male bats, female bats spend most of the winter in "torpor"—a deep sleep that slows physiological functions less than hibernation, and requires weekly drinking and eating.

If a female bat survives the winter, she will return to her maternity roost when the weather warms and insects begin to swarm in April to May. The maternity roost is a large, warm dry space that her clan—mother, grandmothers, aunts and female cousins have shared for many years, located close to fresh water and abundant summer insect resources. No boys allowed. When her clan has assembled, squeezed in together to help stay warm and groom each other, synchronized development of their embryos begins—usually just one pup per bat. The entire clan flies and feeds gluttonously every night if possible. After a gestation period of about two months (depending on the species), the clan's pups are born and mothers take turns nursing them and flying to find food. Bat pups grow in a warm, nurturing world of indulgent aunties with lots of milk, although they must cling tightly to fur at all times to avoid a fall, which would almost certainly be lethal.

Pups grow for another two months before they are strong enough to fly and learn to hunt with their mothers and aunties, who show them where to go and what to eat. In late summer, young bats begin feeding on their own, and by late September or October, the clan disperses from the maternity roost, together with all of the surviving young bats, to mate and begin another long, challenging winter of separation and limited food supplies.

What's on the menu?

Bats emerge at sunset thirsty and hungry. The first thing on their agenda is returning to a familiar nearby watering hole for a quick, swooping drink. Then off to breakfast, the first and largest meal of a bat's night.



What do our island bats eat? Just about everything with six or eight legs that flies at night, or rests exposed on leaves or the water's surface where a bat can scoop it off. Size and speed matter. Bigger bats have larger mouths, while some of the smaller bats can attain higher attack speeds. Bats use their echolocation like fish-finding sonar to detect insects. If you are eavesdropping with a bat detector you can hear the rate of chirps accelerate as the approaching bat targets its prey, followed by a satisfied little buzz, like a creaky screen door, when the target is sucked into the bat's mouth, speedily chewed and swallowed. On a good night, feeding on a dense swarm of insects, a bat can eat several insects per minute and fill its tiny belly in about an hour before it needs to find a safe spot in a tree or beneath the eaves of a house to nap, digest, and drop a little pellet of chewed up insect exoskeletons before flying off again for a smaller meal before sunrise. Bat mothers return home between meals to nurse their pups.

A small bat such as MYCA or MYYU weighs only about a much as a quarter—about six grams or two tenths of an ounce—but will eat a heaping teaspoonful of insects weighing as much as two grams or one-third of her body mass every night. One night's menu might include mosquitos, black flies, lacewings and incautious spiders from a lakeside; or flying ants and beetles from a wooded hillside; or bugs, thrips and moths from a garden or orchard. Moths are often the main course, especially in fall and winter.

Rather than simply returning to the same pond or garden every night to eat whatever flies up, our island bats explore miles of countryside to seek out fresh swarms. Different species of bats appear to excel at different hunting strategies. MYCA and MYYU often skim a lake, pond or beach for low-flying aquatic insects. Big Browns hunt in the tree canopy, and Townsend's acoustically target the mating calls of insects such as moths, beetles and bugs. It makes good ecological sense to focus on swarms during the warm months when insects emerge to mate: it takes energy to fly, so the number of tasty mouthfuls per minute of flight time influences net energy gain. Finding a dense swarm of greasy, calorie-rich mouthfuls such as moths is even better! But the locations of insect swarms change every few nights, so a bat must think strategically in order to eat well. At the same time, bats cannot always be choosy. A swarm of lacewings has fewer calories per bite than a swarm of micro-moths, but it may be the best opportunity to fill a bat's stomach on some nights.

The maternity roost

Bat conservation efforts typically begin with the identification and protection of maternity roosts: the places female bats congregate in the spring to birth and nurse their pups as a large extended bat family or clan. With the exception of Hoary bats and Silver-Haired bats, most maternity roosts in the islands are located in homes and barns that offer larger, safer, warmer and drier accommodations than natural tree cavities or rock shelters. Female bats are masters at discovering tiny openings into the interiors of buildings, such as torn vent screens, and loosely-fitted boards under eaves. The ceilings of barns were more frequently used by island bats in the past when livestock were routinely quartered inside and helped keep the interiors warm. Today barns are often used only for storage and less attention is paid to maintaining roofs; so bats prefer the attics and walls of residences.

Once established, a maternity roost may last decades and expand to hundreds of bats, including "great grandmothers" that have 10-20 years of experience that they can share with descendants. If a roost is raided by predators (chiefly owls, in the islands) or disturbed by humans, it is likely the grandmothers that decide where to seek a new home.

The loss of a bat roost can be a disaster. Songbirds lay one or two clutches of eggs a year, and we have seen a pair of swallows fledge a dozen chicks over a summer. A bat can only produce one pup per year (Hoary bats often birth twins), although she may live for 20 years or more. It takes bats a lifetime to recruit the same number of offspring that birds can produce in one or two summers.

In our surveys of bat roosts and nightly bat activity, we have found that the greatest threats to bats in the San Juan Islands are: (1) a loss of maternity roosts when people renovate their homes or remove bats that have found their way inside walls or attics; and (2) a loss of woody diversity. Bat clans are being disposed, and their winter food resources are diminishing.

Bats need complex landscapes

The basic unit of bat ecology is a bat clan—a group of related female bats that annually roost, pup and nurse together. (The boys fend for themselves, and may meet and mate females from several nearby clans.) While it is roosting together with pups, the members of a bat clan cannot travel far each night, but they need a great deal of food for pregnancy and milk production over a period of four to five months. They must find a roost that is not only warm, dry, safe and large enough for all of the mothers and pups (the clan will double in size when pups are born)

Maintaining a roost with sufficiently dense, concentrated food supply is a critical challenge for bat clans. If they lose a roosting space, they may not be able to find another with an adequate nearby food supply—at least not before they run out of time to raise a generation of pups that year. Embryos will be aborted or pups starve, and when the clan disperses in the fall they will be fewer and weaker, with the likelihood of greater winter mortality. While female bats can roam more widely in winter searching for insect prey, the risk of starvation or dehydration can be high. Grounded by stormy or freezing weather, bats can only remain in torpor for so long. And stormy winters also affect the survival, and delay the emergence of moths and other winter prey for bats.

We can think of island bats' summer habitat as secure roosts close to dense insect resources: a mix of homes and barns, with wetlands, lakes, ponds and seashores, and gardens that produce relatively predictable large seasonal swarms of flying insects—the more varied the vegetation, the better. Wet spots and fast-growing herbaceous vegetation (including gardens) are magnets for insects and bats. Island bats' winter habitat is more dispersed geographically, but generally woody: forests and orchards. Plant diversity is important here as well, though it may not be as obvious. A vast expanse of Douglas firs produces fewer species of winter-emerging moths and beetles—and fewer winter nights when insects are emerging—than a mix of conifers, willows, alders, crabapples and other shrubs and trees. Or an orchard or apples, pears and plums.

The ownership and land use pattern of the San Juan Islands helps maintain a summer mosaic of wetlands, ponds, lawns, pastures and gardens. Our woodlands have grown less and less diverse, however. Homeowners, farmers and foresters tend to regard native deciduous trees and shrubs as "trash" because they are messy and do not produce merchantable timber. But these species provide nests and fruits for songbirds, cavity nests for owls and bats (and native squirrels), and a great diversity of year-round insect prey for bats and insectivorous birds that over-winter here.

Bat-friendly landscaping

The San Juan Islands are mostly divided into relatively small parcels that form a mosaic pattern of homes and gardens, farm pastures, and woodlands with many seasonal wetlands, some large lakes, and scattered small ponds—more like the jigsaw-puzzle layout of the English countryside than the built-over landscape of the Seattle metropolis, or the rectangular grid of vast orchards and croplands of eastern Washington. This compact diversity of habitats is a good start for bat conservation, and undoubtedly one of the reasons that the islands have so many bats. To make the most of this broadly bat-friendly environment, it is important that we minimize the outdoor use of pesticides, and that we landscape and build in ways that continue to provide roosts, food and water for bats.

We can begin with some basic ground-rules:

Design, build and maintain homes so that they provide safe roosts for bats on the outside walls, while excluding bats from inside.

Maintain old barns if feasible, and when re-roofing with corrugated metal, leave at least some of the original wooden roofing beneath old rafters for bats to roost.

Include small open-water features in gardens and pastures. There are sound ecological reasons to avoid digging ponds, but shallow year-round pools provide bats with food as well as water.

Leave some parts of the garden and field scruffy to serve as bug farms; this is also very effective to attract and protect wild native pollinators.

Maintain rather than replace old orchards. Leave some trees standing that have beetle or moth larvae, or topple them and let them feed wildlife. Trees that have natural cavities or rectangular holes chiseled out by Pileated Woodpecker are critical roosting habitat for Hoary and Silver-Haired bats.

Avoid cutting down “trash trees” such as willows and native crabapple, and diversify Douglas fir woodlands by planting more native deciduous shrubs and trees. They are critical nesting habitat for birds and they help feed bats!

Building bat-friendly houses

Uninvited batty tenants are so commonplace in the San Juan Islands, it is baffling that architects and builders do not take this into account when erecting new homes. Hundreds of homes in the islands have easy entry-points for bats to roost inside walls, attics and roofs. The most frequent examples include unscreened attic vents; exterior ends of beams or rafters floating an inch or so below the underside of overhanging roofs, fascia separated from exterior walls by a half-inch to inch, large overlapping clapboards or roof tiles, center beams that are not quite tightly fit where they pierce walls, decorative woodwork beneath overhanging eaves. A male bat can comfortably squeeze into a space you can insert two fingers. Of course transient males are not a concern if they sleep scattered around the outside of a house. Problems arise when a dozen or more female bats find their way into a warm wall or other interstitial space and establish a maternity roost.

Our primary recommendation is to build for bats from the beginning—rather than deal with an unanticipated bat colony years later. Overhanging eaves are very common in our rainy islands, for example, and with an extra board or two, a few feet of under-the-eaves space on the sunny southern side of a home can become a warm, welcoming slot for bats to colonize. A slat or even a sheet of canvas beneath this "bat slot" can be used to collect guano for your garden. Naturally you should ensure that your home is otherwise "bat-tight" with no entries that a bat could use to enter the spaces within walls, in attics or crawl spaces.

Of course, another option is attaching a bat-house to the exterior wall of the house, following our guidelines for bat-box construction and location. When you start seeing a few fecal pellets below the box, you'll know that bats have moved in. One to three fresh pellets per night is one bat, so it is really obvious when you have a maternity colony of dozens of bats!

Common bat entry point to roof and walls

Exterior roosting and entry to interior

Old barns and sheds often host bat roosts in their ceilings, roofs, or haylofts. Bats are generally undisturbed by the use of a barn for livestock, hay storage, or shop-work. However, lighting the interior or exterior at night should be avoided. And if the roof is leaky or draughty, maintaining it will benefit the bats as much as people! Metal roofs are great for trapping the heat that bats love; but bats cannot roost on a metal surface. We have seen bats roosting in an old, decaying wooden barn roof that had a metal roof simply added on top. Or in wooden rafters below metal roofs. A "bat house" can also be mounted near the center beam at one end of a barn—inside as well as outside.

It is worthwhile bearing in mind that bats, swallows and owls rarely share a space. If you have a number of nesting swallows or an owl roosting in your barn, it's probably not a good idea to try to attract bats to the same building. Bats are also wary of domestic cats, and can be extirpated by rats if they can climb to the roost.

A limpet-type box mounted on a south facing exterior wall: space for 25-50 bats (Kwiaht design and construction)

Bat-friendly gardening

Avoiding outdoor use of pesticides--especially sprayed pesticides that can drift and affect non-target insects—is just the first step, but it is an important one. Pesticide aerosols can drift for a hundred feet or more before they settle on plants. Insects nibbling the leaves, or nectaring on flowers with a light smattering of pesticide may not die. Their behavior may change, however; for example, bees get confused and may not find their way back to their hive or nest. And if an insect with a sub-lethal dose of pesticides is eaten by a bat, the bat absorbs the pesticide. Bats eat about a third of their weight in insects *every night*, so they can accumulate pesticides from their diet very quickly.

Beyond the issue of pesticides, your garden is potentially a source of water and food for bats in your neighborhood. A water feature such as a bird bath, or (better yet) a shallow, well-watered rock-lined pool with aquatic plants, offers bats an opportunity to drink on the fly, and produces insects such as flies and midges that bats like to eat. Just a few square feet of open water could suffice. Consider something larger, like the shallow fish ponds of Japanese landscaping. Climate change will make garden water features even more important for the survival of island bats. As our summer droughts get longer, bats will find it harder to find water near their roosts, especially in mid- to late-summer when female bats are nursing pups.

When we say "shallow water" we mean that light can reach the bottom, so that aquatic plants can grow throughout the wetted area: no more than about three feet. Keeping water moving, even very slowly, helps maintain dissolved oxygen levels, which in turn supports more frogs and aquatic insects such as dragonflies and diving beetles. A solar-powered pond fountain or water paddle costs about $300 and can be very effective in shallow water. Just ensure that your water feature has a spot with a gentle gradient or a wire mesh ladder where bats can climb out if they accidentally take a tumble and fall in!

If you want bats to help control insect pests in your flower and vegetable beds, consider making your grounds even more attractive to bats by leaving some "messy" grassy or brushy patches as insect incubators at times of year when your garden is dormant. We admire neat, manicured gardens with nary a weed in sight, but beneficial insects such as native solitary bees and flower flies thrive in hedgerows, wood piles, dense shrubbery, unmown grass and wildflower thickets. Moths and beetles that bats love to eat also thrive in these undisturbed patches—and generally they are not the same species that lay eggs on your broccoli or munch your cucumber starts. In a word, a supremely tidy garden is often less attractive to pollinators and bats than a garden of scruffy edges.

Managing farm and forest

If you own or manage livestock pastures, hay fields or a patch of forest in the islands, you have additional opportunities to make the landscape bat-friendly.

Bats use irrigation ponds for water and hunting insects, so maintaining existing ponds (including protecting them from contaminated or nutrient-rich runoff) can contribute to bat conservation. Allowing shrubby vegetation to grow around the edges of ponds can help exclude geese, one of the main causes of eutrophication and algal "slime". Shrubs and trees can grow quite dense and high before significantly restricting bats' access to a pond; and they can boost insect production especially moths, beetles and bugs that do not threaten humans or gardens. Digging new ponds is not recommended, however. Because they trap warm, still water and as they evaporate, tend to concentrate nutrients, dug ponds usually "go slimy" sooner or later, and meanwhile they are inevitably weedy (notably with reed canary grass) and attract nuisances such as geese, bullfrogs and mosquitos. Shallow water features are easier to clean, modify, and maintain.

Planting some water-loving trees along one side of an existing pond provides shade for livestock and wildlife, and invites bats to roost between their evening meals. There are several species of native willows that will grow quickly and densely; also, quaking aspen, which has become rather rare in the islands and is more tree-like and less shrubby than the willows. Our native crabapple thrives in seasonally wet soil and produces small fall fruits that birds adore and historically were savored by Coast Salish peoples.

On the subject of shrubs and trees, one of the most important contributions that you can make to bat conservation is to help diversify our islands' woodlands where bats seek shelter and food in winter. Opening up the canopy by removed one or two Douglas firs can create a pool of light in an otherwise dark forest, where other woody species can get a foothold. Girdle target trees a few years before you plan to remove them so that the canopy opens gradually. Meanwhile, you can begin to transplant a few small deciduous shrubs or trees into the increasingly sunny patch. This will prevent weeds from taking over. Small "rooms" of deciduous diversity within the forest add significantly to the food supply for fruit- and insect-eating birds as well as bats, especially in fall and winter, increasing the likelihood that you will enjoy the company of wildlife year-round.

You have many species native to the San Juan Islands to choose from. We recommend that you try some of the following woody plants to build shrubby deciduous patches that feed birds, and produce a lot of moths, beetles and bugs that are tasty to bats:

- Serviceberry (*Amalanchier alnifolia*) a fast-growing tall shrub that tolerates a wide range of conditions and can produce thickets that are easier to manage than willows or ocean-spray. Early creamy flowers. Fruits are tasteless to people but delicious if you are a bird.
- Indian plum (*Oemleria cerasiformis*) is an early blooming tall woody shrub whose fruits attract Cedar Waxwings and other frugivorous birds. Unique to the Northwest, scattered and relatively uncommon at this time in the islands.
- Native crabapple (*Malus fusca*) tolerates seasonal flooding and can form dense galleries of gnarled trunks that endure for centuries, but are more manageable than willows. The small fruits, which ripen in September, are some of the latest in our native landscape.
- Bitter cherry (*Prunus emarginata*) produces straight tall trees with distintive cherry bark; the fruits are too tannic for human palates but birds are unfazed by the bitter taste. This species can form dense stands that support distinct beetle and moth populations.
- Salmonberry, thimbleberry, blackcaps (*Rubus* species) are fast growing in newly opened sunny patches, especially where is damp loamy soil.
- Red-flowering currant (*Ribes sanguineum*) is a rather spindly shrub that tolerates shade and forms sprays of early red flowers that attract hummingbirds and native bees. Fruits are small and uninteresting to humans but acceptable to birds. Early spring moth food.
- Red huckleberry (*Vaccinium parvifolium*) is currently quite rare in the islands, where it is often seen growing out of an old Douglas fir stump. Forms loose shrubby hedges. Juicy red berries are delicious to humans as well as birds.
- Red elderberry (*Sambucus racemosa*) is a much-overlooked native understory-building shrub with dense late summer sprays of tiny red sour berries that attract birds as well as small mammals, and were used to season salmon by Coast Salish islanders.

We also encourage the propagation of salal in coniferous woodlands, although it can be very difficult to start, and slow to spread. Birds are fond of the berries, which used to be prized by people as well for their tangy, blueberry-like flavor, and perhaps should become a part of our island diet once again! In addition, salal is fire-resistant and can help slow the spreads of a fire through dry conifer forests. Many small species of moths use salal as larval food, so a hedge of salal is an excellent year-round food resource for bats.

Most of these woody species can be sourced locally from the remaining deciduous woodlands in the islands. Sourcing on your own island is always best because it helps preserve the species' local gene pool. Nurseries and plant sales generally source their stock on the mainland, from genetically distinct populations that have been separated from their island cousins for several thousand years. Their flowers, fruits or leaves may be different, and they may be less adapted to island conditions. Serviceberry is a good example. The islands have a distinct population or subspecies with differently shaped leaves, and imported plants are displacing the native type.

As noted earlier, existing orchards—especially older orchards with trees that have some round cavities and old hollow trunks—are some of the islands most ecologically beneficial deciduous patches, producing both native and introduced moths for bats, as well as fruit for humans and birds (and for some other fruit-loving animals). Maintaining an old orchard, pruning it properly and adding (and grafting to) younger fruit trees rather than removing old ones, is a significant contribution to bat conservation, to human nutrition, and potentially to the islands' economy.

Don't waste money on a bat house

The key to bat reproduction and survival is the availability of safe, warm and secure maternity roosts. For most species of bats in the San Juan Islands, home is with humans. Like a great many insects, birds and rodents island bats are "synanthropic." They prefer roosting in suitably large spaces that are kept warm by their human landlords.

Nearly all of the bat boxes advertised online—whether as blueprints, kits, or finished boxes for sale—are too small and too cold for use by our island bats. At best they may be used briefly by transient male bats, but the contribution of this to overall bat population survival is negligible. Most of the boxes we have see around the islands are not used at all, except perhaps by wasps and spiders.

There exist situations where a specially designed "bat house" is needed: a maternity colony has already become well established inside a roof, wall or attic but must be relocated; for example, for structural repairs or renovations, where it is impossible for contractors to work around the space occupied by bats, or to work during the winter months when bats live dispersed. In such cases, a bat house may be the best option. If properly designed and situated, however, it has at best about a 50 percent likelihood of being occupied by the displaced colony, or (eventually) by another one.

We have designed, built and installed several dozen beer-fridge-sized "colony houses" since our first experiments with bat boxes in 2012, and here is what we have learned:

- The box must be large enough to comfortably house the particular bat colony or clan. A useful rule of thumb is a cubic foot for every dozen bats, with a minimum internal space of two to three cubic feet.
- The interior can be subdivided into vertical compartments as narrow as one inch, but if a maternity colony, bats will prefer space beneath the roof where the entire colony can congregate as one—a kind of penthouse area, at least four to six inches in height.
- The box must have thick walls to trap heat. We use one-inch cedar, and in some locations, we have added a layer of Thinsulate and/or a garden heating pad. Bats will cluster at the warm top end of the box, nearest the roof, where they will want to attain 90°F or more!
- Insolation is improved by using sheet metal for the roof and painting the entire box dark colors. Special solar paints are available that serve this function well.

- The landing strip and interior surfaces must be raw unfinished wood so that bats can get secure handholds for climbing and sleeping. Finished wood may be attractive to human eyes but can be a death trap for bats.
- The box should be situated as close as possible to the entry point that bats have already been using to access attics, walls, or other roosting space from which they are about to be excluded. Ideally this means attaching the box to the exterior wall of the house, just below the eaves. We call this a "limpet".
- If there is no choice but to mount the box on a nearby tree or post, be sure that the box is at least eight to ten feet off the ground, faces the sun (south-to-southwest), and there are no overhanging ledges or branches for owls to sit and wait for emerging sleepy bats. Avoid setting a post out in the middle of an open lawn or field. Bats prefer to have their back to a wooded area where they can escape quickly if an owl is hunting in the vicinity.

The most important rule is simply this: use a bat house only as a last resort. Leave maternity colonies undisturbed if at all feasible. And while it may be tempting to mount a bat box as a way of "attracting" bats to a home where they do not already have a roost, you will be very lucky if one or two of the boys moves into it. Better to assume that grandmother bats have already found the best roosts in the neighborhood—and let them stay there.

Kwiaht design: displaced-colony roosts built by Cascadia Homesteads, Orcas

Climate change and island bats

Climate change is making life harder for the islands' bats. Our forecast is for warmer, stormier winters and drier summers. Both of these changes affect food availability for bats.

Superficially it may seem that warmer winters would be a blessing for bats. Salish Sea bats are already benefiting from the warm California current that moderates our winter temperatures, making it unnecessary for bats to hibernate or migrate to warmer climes for part of each year. Shouldn't warmer be better? Unfortunately, the same planetary processes that are heating up the Northeast Pacific Ocean are generating more energetic storms with higher winds and much heavier rainfall (inches of rain per minute, not total annual precipitation). Bats are even lighter than birds and cannot control their flight in high winds or downpours. Hence stormier winters will have the same adverse impact on bats as colder winters: they will have to remain indoors, in torpor, for more nights and go for longer periods of time without drinking or eating. Fewer will survive to return to their maternity roosts and pup in spring.

While there is little we can do to avert these deteriorating winter weather conditions for bats, what we can do is to improve winter prey availability so that when bats can fly, they are more likely to eat well. Diversifying winter prey species depends, in turn, on re-diversifying forests in the islands: breaking up acres of homogeneous young Douglas fir regrowth to include patches of other conifers such as spruce, grand fir and red cedar, and even more importantly groves of deciduous species that once comprised a much larger proportion of island forests. As detailed above, some of the most beneficial species produce fruit for birds as well as bugs for bats, such as our native crabapple, bitter cherry, Indian plum, and serviceberry. Reviving, enhancing and expanding the islands' historical orchards will also contribute to woody diversification; but of course, this also requires that we avoid pesticides. Orchards in the islands have shrunk even faster than deciduous woodlands—by more than half just since the 1970s, we estimate—chiefly replaced by lawns and hayfields, which do not help feed bats in winter.

Climate change also appears to be interfering with island bat clans' ability to congregate and pup early enough in the spring to fledge their pups before the end of summer. Spring weather is also growing stormier, with more temperature fluctuation. Female bats wait for calmer and warmer weather because, once they give birth, they must keep their roost very warm and get enough food each night to produce milk. A premature start can be deadly for the year's pups. But waiting until (say) June can result in pups still needing milk when fall weather begins. We believe this happened in 2019; there was a late start and high pup mortality in September.

Resources for bat conservation

KWIAHT is your primary resource for assessments and responsible management of existing bat roosts in the San Juan Islands, including unavoidable bat exclusions from indoor space, and customizing alternative housing for bats displaced by home renovations and repairs. If you share your home or barn with bats, we want to know about it, identify the species, and help you enjoy and live safely with them. Contact us at:

info@kwiaht.org

If you find a bat flying inside your home, open the nearest window or door, turn off all the lights, and if possible leave the room and close the door behind you. Healthy bats usually find their way out in 10-20 minutes. If you find a sick, injured or unresponsive bat, avoid handling it. Our local wildlife rescue experts should be called first:

Wolf Hollow Wildlife Rehabilitation Center, 460 378-5000

If someone in your household is bitten by a bat, contact your physician immediately and follow their instructions. County and state authorities will want the bat caught and tested if possible. San Juan County Public Health is at 360 378-4474.

Interested in learning more about North American bat biology and ecology? We strongly recommend the following books:

Michael J. Harvey, J. Scott Altenbach and Troy L. Best. **Bats of the United States and Canada**, Johns Hopkins University Press, 2011.

Rick A. Adams and Scott C. Pedersen. **Bat Evolution, Ecology, and Conservation**. Springer Science & Business Media, 2013.

Thomas H. Kunz and M. Brock Fenton (eds.) **Bat Ecology**. University of Chicago Press, 2003.

Silver-Haired rescue bat at Wolf Hollow Wildlife Rehabilitation Center