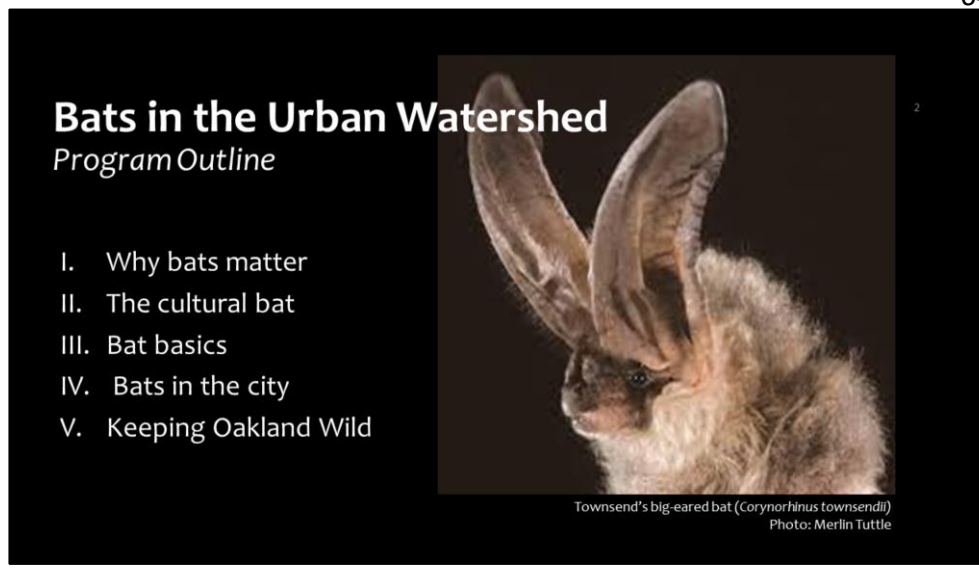
APPENDIX 1: SLIDE SHOW PRESENTATION WITH NOTES

Presentation Title Slide



Presentation Outline

Theme: The lives of people and bats are interrelated.
Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

You may be wondering, why should I care about bats? What have they done for me lately? It turns out a lot! Our lives are closely linked to the lives of bats who provide many important services for us.

- About 50 bat species feed exclusively on nectar, while many others are omnivores, feeding on fruit and insects as well as nectar (Altringham 2011).
- When bats visit flowers for food they spread pollen, making them primary nighttime pollinators along with moths (USFS n.d.).
- Bats pollinate over 300 species of fruit, including commercially important ones such as banana, mango, guava and tequila agave (USFS n.d; Jemison 2015).
- Only one bat found in CA is primarily nectivorous: the lesser long-nosed bat (*Leptonycteris curasoae),* who feeds on agave nectar (USFS n.d).

- It is energetically expensive for flowers to produce enough nectar to attract bats, the pay-off is worth it: compared to insect pollinators, bats carry more pollen over longer distances. This is an especially important factor in areas where plants are spread out from each other, as in the desert or fragmented rainforest landscapes (Fleming, Geiselman and Kress 2009).

*For more detail on coevolution of plants and bats, including flower structure and odor favored by bats, see Altringham 2011, 230-231; USFS n.d; Fleming, Geiselman and Kress 2009; Jemison 2015.

Theme: The lives of people and bats are interrelated.

Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- Some bats are primarily frugivores.
- Frugivorous bats are important in dispersing seeds and are capable of carrying seeds long distances without damaging them (Altringham 2011).
- In the case of larger bats who are able to carry seeds a long distance from the tree, the longer time in the gut serves to break down seed cases, thereby enhancing germination success (Altringham 2011).
- Bats are critical to revegetating cleared tracts of rainforest (Muscarella and Fleming 2007).

Theme: The lives of people and bats are interrelated.
Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- Over 2/3rds of all bat species are primarily insectivores (Kunz et al. 2011).
- A pregnant or nursing female can consume as much as two-thirds of her body weight in insects per night. That's like a 150-pound man eating 100 pounds of food per day (UC Ag 2015).
- Bats eat pests of important commercial crop including corn, cotton, tomatoes, beans and orchard fruit (Kunz et al. 2011; Long et al. 1998).
- In Texas, it is estimated that 100 million Mexican free-tailed bats (*Tadarida brasiliensis*), many of them hungry mamas, feed every night during the summer months, consuming roughly 800 million tons of insects in a single night (Kunz et al. 2011; Cleveland et al. 2006).

- Environmental economists have begun to put monetary figures on the value provided by bats who eat agricultural pests. The value of bats' global pest control ranges between $54 billion and $1 trillion, an estimate that includes reductions in both crop losses due to pests and direct/indirect costs of pesticide use (Kunz et al. 2011).
- In California, we also have large colonies of Mexican Free-tails; one of the largest is under the Yolo Bypass Causeway in Davis with 250,000 bats. This species is important in pest management for Central Valley crops including walnut orchards, where researchers from UC Davis estimate that each bat has an economic value of $10 per year in increased walnut yields due to their predation of codling moths (UC Ag 2015; Long et al. 1998).

Theme: The lives of people and bats are interrelated.
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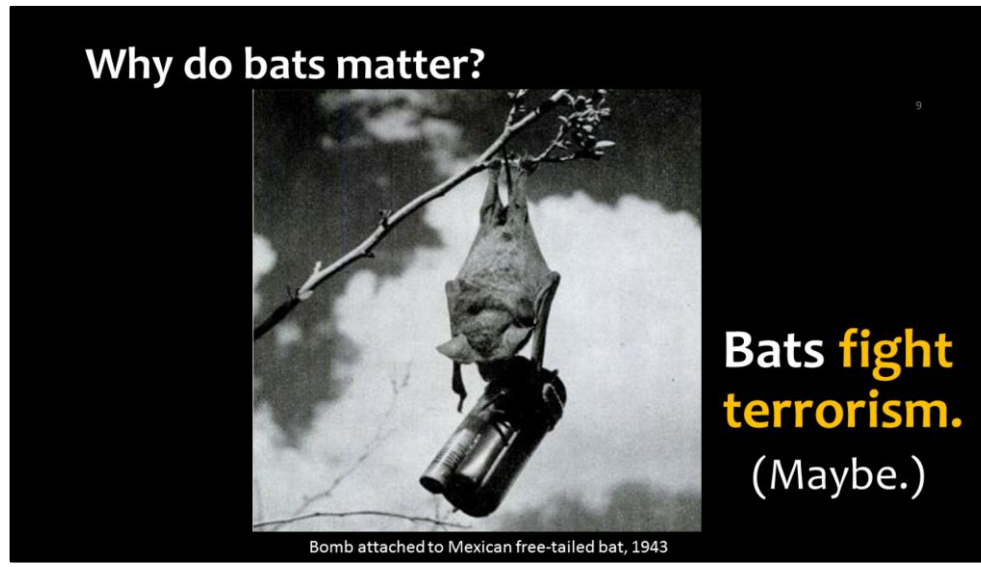
Presentation Points

- Researchers have been developing an anti-coagulant drug derived from a glycoprotein found in the saliva of vampire bats (Ohio State 2011).
- The name of this glycoprotein? Draculin!
- Draculin has already been found to be safe and effective in extending the short time period after a stroke when the blood will start to clot and cause death or brain damage (Ohio State 2011).



Theme: The lives of people and bats are interrelated.
Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- In 1942, a Pennsylvania dentist named Lytle S. Adams cooked up a scheme to win the war against Japan using bats (Madrigal 2011).
- He was inspired by his trip to Carlsbad Cavern which has a colony of about a million Mexican Free-tailed bats. He thought that we could strap tiny incendiary bombs to thousands of bats and let them loose over Japan (Madrigal 2011).
- Lytle had some Washington connections and actually got someone from the military to take a look. The Marine Corps took up the project, called Project X-Ray, which it funded with $2 million (Madrigal 2011).
- Project X-Ray was abandoned in late 1943, probably because of resources now being devoted to a bigger bomb: the Manhattan Project (Madrigal 2011).

Theme: Bats make great neighbors
(*Conceptual Node*: *Cultivating meaningful connections between humans and wildlife*)

Presentation Points

- As you can see, bats are very important to us – our lives would be greatly impoverished without them. However, in this presentation, I do not want to emphasize bats' economic or ecological value or even their importance in winning wars against military foes or mitigating the effect of strokes. I want to talk about how they make our lives more interesting. And, you don't have to go anywhere to enjoy their company – bats live right here in Oakland where you may be surprised to learn there is some really excellent habitat. I think you will agree that bats make great neighbors!

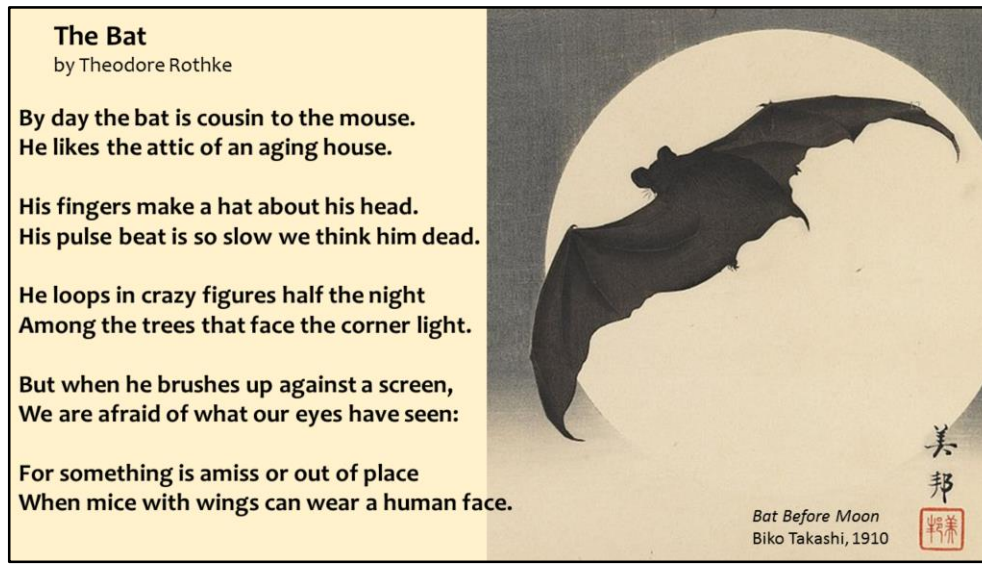
Photo: Mexican free-tailed bats in Austin, TX

Theme: Bats make great neighbors; they are mysterious and cool because they defy easy categorization.

(*Conceptual Node*: *Cultivating meaningful connections between humans and wildlife*)

Presentation Points

- At the very least, bats will be the most *interesting* neighbors you will ever have. They are mysterious and cool because they defy easy categorization.
- The human relationship with bats is . . . complicated. For much of history, we have simply not understood them. Who can blame us? Here we are, stuck on the ground with legs, only able to see in the day and hear sound within a limited frequency range. Until very recent advances in technology, bats have seemed to be totally alien, otherworldly creatures.



Theme: Bats make great neighbors; they are mysterious and cool because they defy easy categorization.

(*Conceptual Node*: *Cultivating meaningful connections between humans and wildlife*)

Presentation Points

- The name for bat in different languages reveals this confusion over what they are and how they fit into the natural world (McCracken 1993b).
- Many peoples have assumed that bats were some kind of flying mouse. In Spanish the word for bat, *murcielagos*, means "blind mouse" and the German word for bat is *fledermause*, "flying mouse" (Adams 2003).
- That bats are often compared to other, more familiar creatures is not surprising. We like order in our world and bats do not easily fit into a category. So, we call them mice or maybe birds or even magical spirits. Then, when we do come into close contact with a bat, it can be a jarring experience as illustrated in Theodore Rothke's 1938 poem "The Bat" (Rothke 1938).
- Despite our attempts to understand bats, their mysterious ways and appearance have historically confounded us.

Theme: Bats make great neighbors; they are mysterious and cool because they defy easy categorization.
(*Conceptual Node*: *Cultivating meaningful connections between humans and wildlife*)

Presentation Points

- Bats' ambiguous nature, especially their ability to fly and see in the dark, has made them sacred, if fearsome, in some cultures.
- In Uganda and Zimbabwe they are seen as ancestors visiting the living (Sax 2001).
- In ancient Maya culture, bats are associated with the underworld and sacrificial death (Read and Gonzales 2002).
- In Pomo mythology, bats are able to swallow pieces of obsidian that they vomit back up in the form of perfect arrowheads (McCracken 1993b).
- In China, they are symbols of long life and good fortune. "The bat is a symbol of happiness and joy. The Chinese for bat (fu 蝠) sounds identical to the word for good fortune (fu 福). Five bats together represent the 'Five Blessings' (wufu 五福): long life, wealth, health, love of virtue and a peaceful death" (British Museum 2008; McCracken 1993c).

Theme: Bats make great neighbors; they are mysterious and cool because they defy easy categorization.

(*Conceptual Node*: *Cultivating meaningful connections between humans and wildlife*)

Presentation Points

- In Western cultures, however, bat behavior and association with night have made them maligned symbols of evil for centuries.
- Bram Stoker is credited with being the first to connect European vampire legends with bats in his 1897 novel, *Dracula* (Wikipedia 2016a).
- The association was furthered by the popular 1931 Bela Lugosi vampire movie, *Dracula* (Wikipedia 2016a)
- The mythology of bats as evil or associated with the devil has been nurtured by the movie industry in contemporary culture as seen in the film poster for the 1979 masterpiece of cinema, *Nightwing* (Wikipedia 2016b).

Theme: Bats make great neighbors; they are mysterious and cool because they defy easy categorization.

(*Conceptual Node*: *Cultivating meaningful connections between humans and wildlife*)

Presentation Points

- Demonization – literally – of bats is perpetuated by contemporary media as shown in this article appearing on a news site. A spike in downed bats found with rabies in Los Angeles and Ventura counties was easy fodder for attention-grabbing headlines and copy (Mail Online 2011).
- A nationally-televised ABC news story from 2011 used similarly alarmist language to describe vampire bats, the species implicated in a rabies-related death of a man in Louisiana. News anchor Diane Sawyer states, ". . . the fear is that the warming climate will drive a new swarm of the bats north into this country." Reporter David Wright continues, "They are creatures straight out of a horror movie – nocturnal bloodsuckers with razor-sharp fangs" (Vampire Bat 2011).

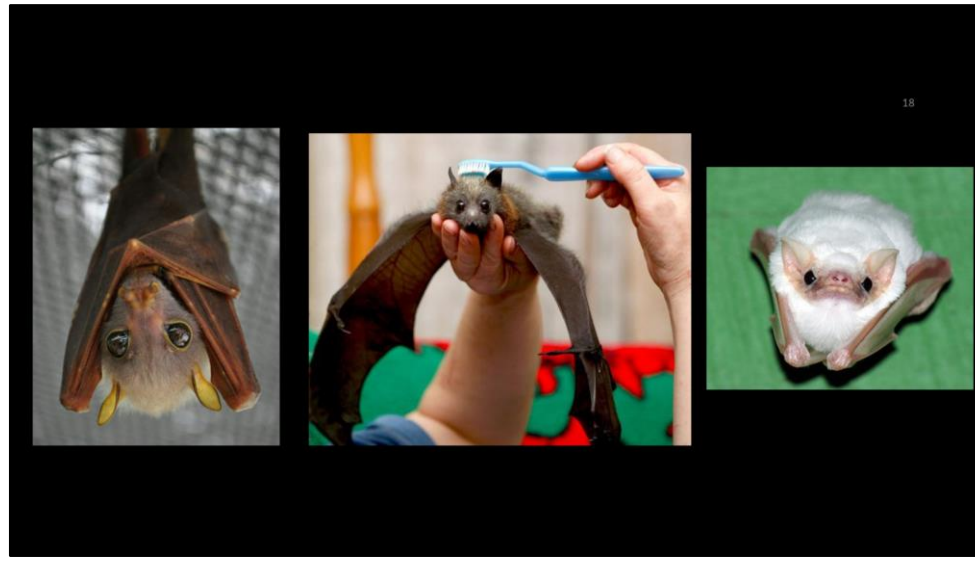
- It is true that bats are carriers of rabies and this is a legitimate public health concern, but research has shown that persecution of bats as a strategy for controlling rabies transmission is not effective (Streikler et al. 2012). What *is* effective is education about bats and rabies – more on this later in the presentation (Chomel, Belotto and Meslin 2007; Friend 2009).

Theme: Bats make great neighbors; they are mysterious and cool because they defy easy categorization.

(*Conceptual Node*: *Cultivating meaningful connections between humans and wildlife*)

Presentation Points

- Bats are perceived as dangerous, but dangerous is also kinda sexy, as shown in these two images. I don't know much about the one on the right (except that it is a fabulously spooky-saucy pin-up).
- The image on the left is of the DC Comic character Batwoman. Batwoman was first developed in the 1950s as a love interest for Batman who some people had charged as being gay. In 2006, though, the character was reborn as a sexy Jewish lesbian superhero (Wikipedia 2016). In my opinion, this reflects not only contemporary liberal attitudes towards ethnicity and sexuality, but simultaneously the universal, ancient recognition of bats as ambiguous animals that defy simple categorization. Like this modern Batwoman, bats embody diverse - and sometimes subversive - qualities in a single exciting identity. Bats are cool!



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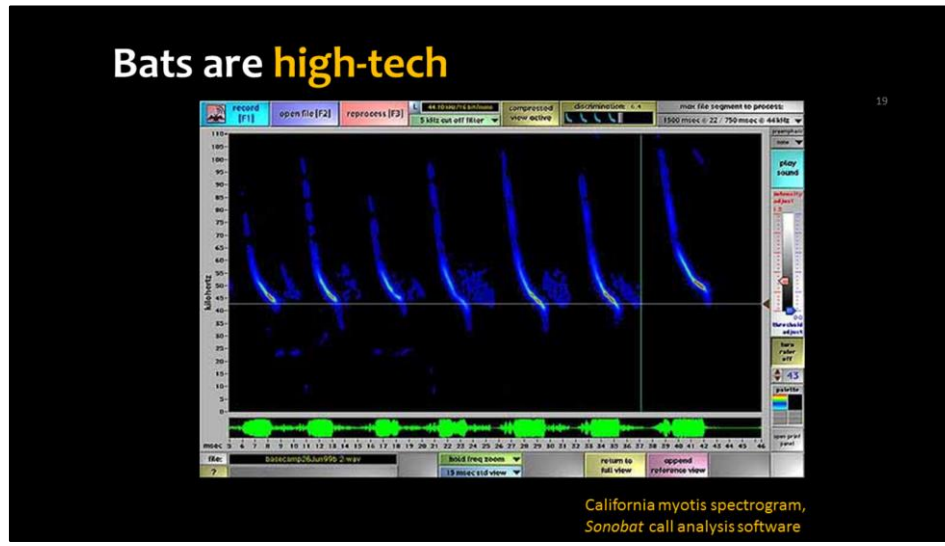
Presentation Points

- The internet has enabled circulation of charismatic bat photos. Bat rescue organizations in Australia are a source of endearing photos such as this one of an orphan flying fox being groomed with a toothbrush (middle photo). Because of websites like "Cuteoverload" and "Awesomly Cute" (source for outside photos), bat adorability is just a click away.

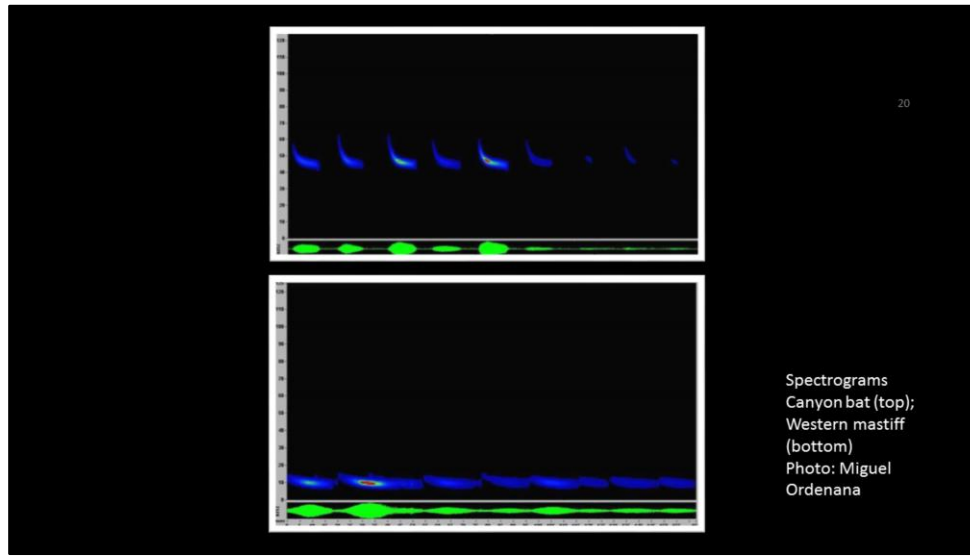


Theme: Bats make great neighbors; they are so "high-tech" that human technology is just catching up to them.

Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- Bats are your most interesting neighbors because they are so high-tech.
- In the late 1700s, an Italian scientist named Spallanzani conducted experiments to figure out how bats could "see" in the dark. After covering their eyes and then ears, he hypothesized that bats navigated using their auditory system, but it wasn't until 1938 when a Harvard undergrad determined bats used echoes made by high frequency calls, a process he termed "echolocation" (Griffin and Galambos 1941; Jones 2005).
- Donald Griffin borrowed a device built by a Harvard physics professor that could convert ultrasonic sound into audible sound and conducted his own studies in which bats were blindfolded and their ears and mouths covered (Griffin and Galambos 1941; Jones 2005).
- Griffin's findings were not readily accepted, even by fellow scientists (Jones 2005). Echolocation, the basis for sonar, was then a top-secret U.S. military technology. Who did these bats (and biologist) think they were?



Theme: Bats make great neighbors; they are so "high-tech" that human technology is just catching up to them.

Conceptual Node: Cultivating meaningful connections between humans and wildlife

Presentation Points

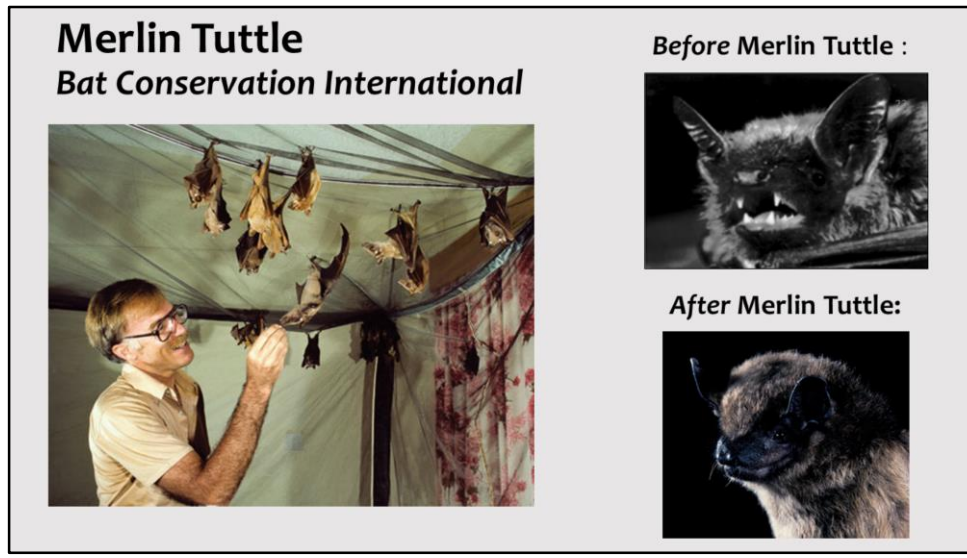
- Since Griffin's discovery, we have come a long way in understanding echolocation in bats and other animals such as whales who cannot reliably use vision to perceive their environment.
- Today, we have a range of equipment that can detect ultrasonic bat calls and convert them into audible sound or images as in the spectrogram of sound pulses emitted by a California myotis (*Myotis Californicus*) on the previous page (Sonobat n.d).
- Sound analysis software that produces these spectrograms has been key in identifying bats which are otherwise extremely difficult to identify without actually catching them (Sonobat n.d).
- This slide shows the different sonic signatures of bat calls from two species.

Theme: Bats make great neighbors; they are so "high-tech" that human technology is just catching up to them.

Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- Advances in photography have allowed us to take high-resolution photos of bats engaging in natural behaviors like eating nectar. (Notice that this photo was taken by Merlin Tuttle.)



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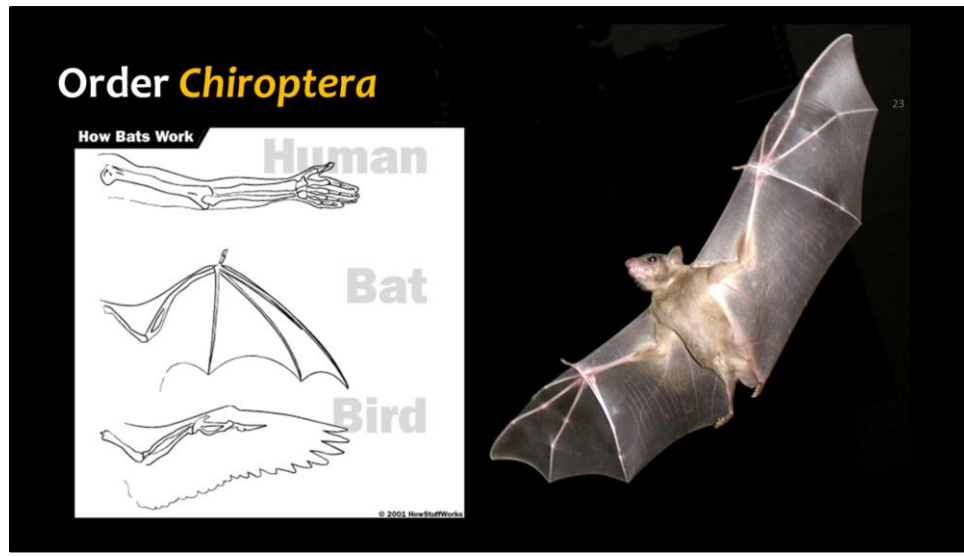
Presentation Points

- Arguably, one of the most influential contributors to the knowledge of bats has been biologist Merlin Tuttle. Tuttle was inspired to take up photography of bats because he was "appalled at the vicious-looking pictures of bats" and aspired to "show bats as they really are" (Ackerman 1991, 45).
- Not only has Tuttle perfected the art of bat portraiture, but he has developed humane methods for capturing images of relaxed bat subjects engaged in natural behaviors. As seen in this photo, he creates temporary enclosures in the field and hangs out with bats long enough for them to relax. He then photographs them foraging for food, as he did with the bat in the previous slide. Furthermore, Tuttle's mission to show the wonder and beauty of bats has reached a global audience of lay people like you and me through his organization, Bat Conservation International, the world's preeminent bat research, conservation and education body (Ackerman 1991; BCI 2016a).



Theme: Bats make great neighbors; they are interesting because they are so different from us.

Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- Now that human technology has reached the sophisticated level of bat technology, we can appreciate, better than ever before, the incredible diversity and complexity of physical and behavioral adaptations in bat species. Bats make an outstanding subject for learning the basics of biology. It is my opinion that bats make us smarter: learning about them helps us understand some core principles of biology and ecology.
- Bats are in their own order, chiroptera: "hand wing" – they are the only mammals capable of true flight. And they are excellent flyers.
- Some are really fast (up to 60mph) and can fly really high (up to 10K ft) (Altringham 2011). Some species fly with their babies weighing up to 30% of their own weight at birth (Altringham 2011). Many are very agile when hunting insects and some hover like hummingbirds (Altringham 2011).

- The similarities between the over 1,300 species (and counting) of bats just about ends there – with the wing (BCI 2016b).
- These wings are one of the primary reasons this order is so diverse and widespread - with wings, they can move over large distances. For example, bats are the only native terrestrial mammal to the Hawaiian Islands, Galapagos and New Zealand (Altringham 1996).
- Bats live in every habitat besides the extreme upper latitudes and some *very* remote islands (Altringham 1996, BCI 2016b).

Theme: Bats make great neighbors; they are interesting because they are so different from us.

Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- About a quarter of all mammal species are bats (Altringham 1996). Among mammals, only humans are more widespread than bats (Altringham 1996). In both of our cases, it is due to the development of "high tech" adaptations – both physical and behavioral – that allow bats and humans to make the most of varied environments.
- To give you a small taste of the incredible diversity of bat adaptations, let's look at some bat faces.
- There are two sub-orders: Megachiroptera and Microchiroptera. There are a couple really fundamental differences, one of them being geography. Megabats are only found in the Old world tropics (Altringham 1996).
- Here's an easy way to tell the difference between the two groups: megabats look like foxes and microbats look like . . .

Theme: Bats make great neighbors; they are interesting because they are so different from us.

Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- . . . this . . .

Theme: Bats make great neighbors; they are interesting because they are so different from us.

Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- and this . . .

Theme: Bats make great neighbors; they are interesting because they are so different from us.

Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- and like this . . .

Theme: Bats make great neighbors; they are interesting because they are so different from us.

Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- and this . . .
- Does anyone want to guess why there is such a big difference in facial structure between megabats and all of these microbats at whom we've been looking?
- Megabats don't use echolocation, but microbats do (Altringham 1996).

Theme: Bats make great neighbors; they are interesting because they are so different from us.

Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

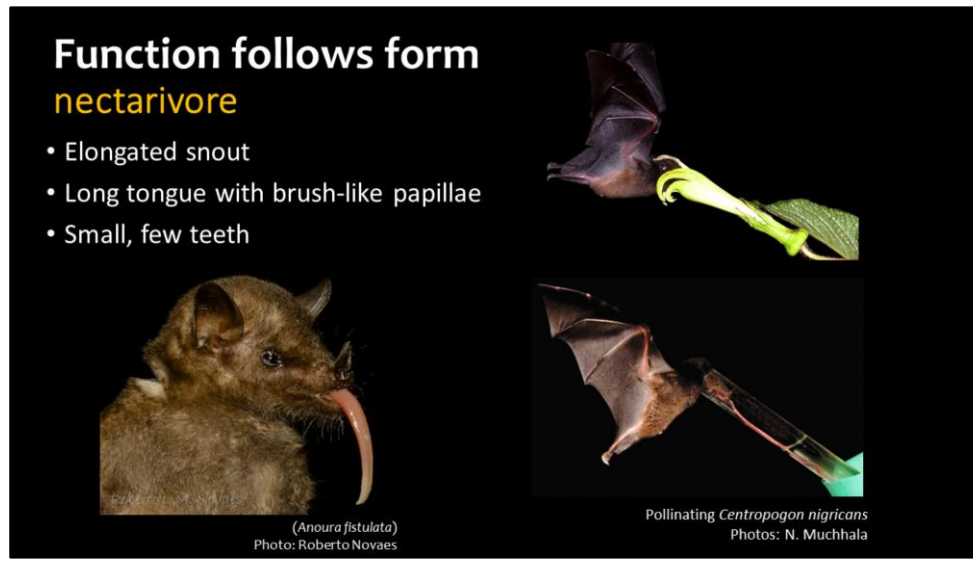
- The form of an animal's body structure– in this case, the face – allows it to function in very specific ways. Therefore, form is a clue to function. Although their faces may look odd or even freakish, they are totally utilitarian – in ways that will blow you away in their evolutionary "genius."
- Megabats don't echolocate because they eat primarily fruit, not insects; insects stay put, therefore requiring less sophisticated tracking capabilities. Therefore megabats have small ears (no need for super-acute hearing) and big eyes because they rely on their sight and smell rather than hearing to navigate. They also have large skulls and jaws to support strong facial muscles that they use for chewing and crushing fruit (Altringham 1996).
- Side note about tube-nosed bat's tubes: function is unknown!

Theme: Bats make great neighbors; they are interesting because they are so different from us.

Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- The facial ridges of the wrinkle-faced bat are not a common adaptation, but they are super cool. It is hypothesized that the wrinkles may help to direct fruit juice to the mouth (Miller et al. 2008).

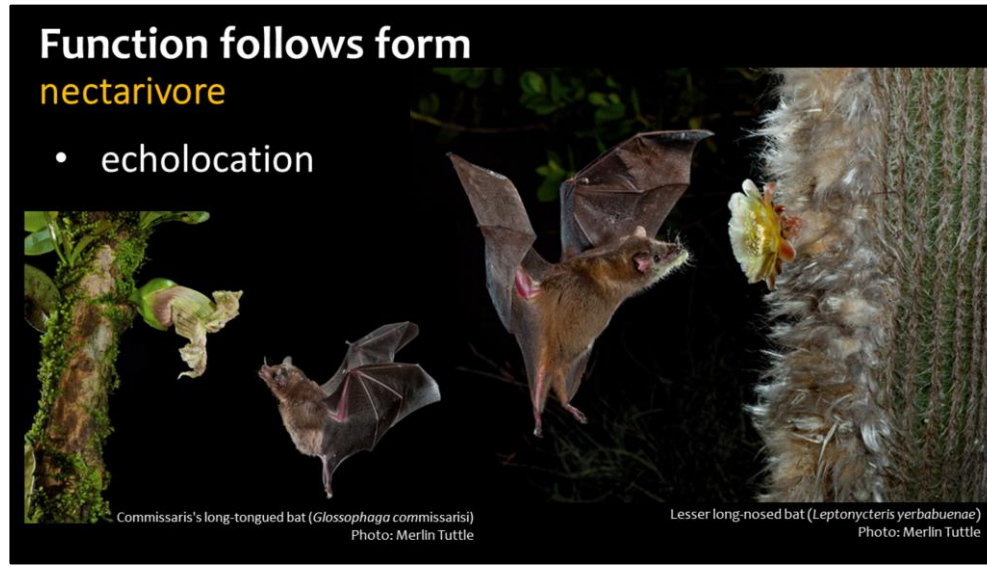


Theme: Bats make great neighbors; they are interesting because they are so different from us.

Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- Nectivorous bats feed primarily on nectar and pollen (Altringham 1996; Fleming, Geiselman and Kress 2009).
- Facial adaptations include an elongated snout, reduced number of teeth and long tongues with little papillae that help bats gather nectar quickly (Fleming, Geiselman and Kress 2009).
- Pictured in this slide is the Tube-lipped nectar bat (*Anoura fistulata*) of the Ecuadorian Andes who was just discovered in 2005. It has the second longest tongue compared to its body length – 150% - of any vertebrate (chameleon is #1). This little bat is an obligate pollinator for the *Centropogon nigricans*, which means that this plant and bat have coevolved – there is no other bat (or other pollinator) with a tongue length adapted to access nectar in this tube-shaped flower. *C. nigricans* is the only known flower pollinated exclusively by a bat (Muchhala 2006).



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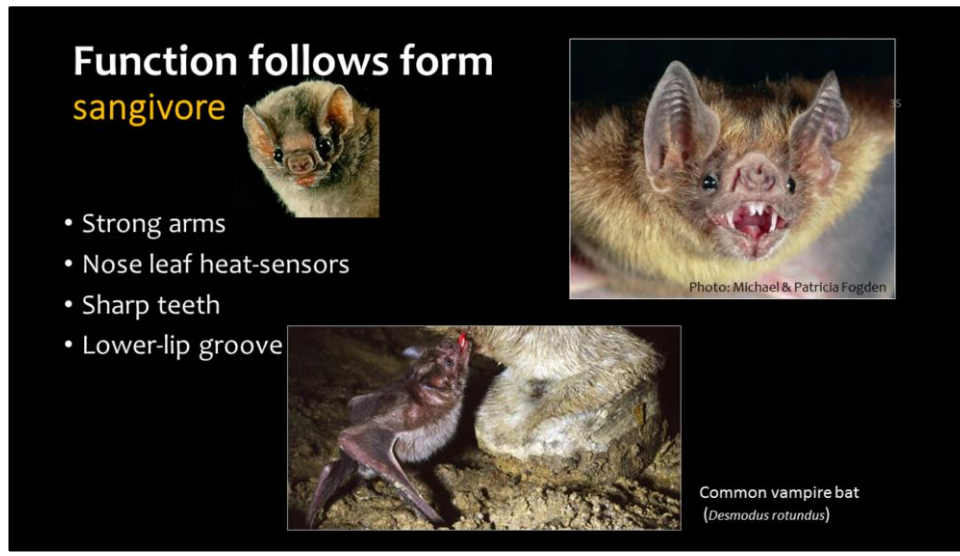
Presentation Points

- Microbats use echolocation to find flowers of nectar-containing plants. Certain plant species create distinct echoes that the bat recognizes. These plants display *chiropterophily* – "bat love" literally translated – because their flowers all have specific sonic signatures evolved to communicate their location to echolocating bats (McGrath 2014).
- One of the most spectacular examples is in the plant *Mucuna holtonii* whose virgin flowers (flowers not yet visited by a pollinator and thus having the max amount of nectar) have a specific "sonic signature" (Fleming, Geiselman and Kress 2009; McGrath 2014). See photo on left.
- The lesser long-nosed bat (on right in slide) is considered the "hummingbird" of bats because it hovers when it feeds. Notice the sound-deadening backdrop that heightens the flower's echoes (Twombly and Schumacher 2014).

- A note about this particular bat species: the lesser long-nosed bat. Its tongue is only the length of its body, not 1.5 like the Tube-lipped nectar bat. It is one of the bats that pollinates agave plants, used to make tequila. It also pollinates saguaro cactus. It is a migratory bat with an extensive range from Mexico to Arizona and even there is a record of its appearance in California (Arroyo-Cabrales et al. 2008).



Theme: Bats make great neighbors; they are interesting because they are so different from us.

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Presentation Points

- There are only three species of blood-eating bats, all of them occurring in Central and South America (Altringham 1996). These bats feed exclusively on blood, some species preferring birds and others preferring large mammals. With the introduction of domestic livestock, the population of vampire bats has increased significantly over the past few hundred years, causing conflicts between humans and bats as these bats do carry rabies (Altringham 1996; Streikler et al. 2010).
- Current attempts to control rabies though culling bat populations has not proven successful (Streikler et al. 2010). More research needs to be done into management of livestock practices and habitat encroachment and access to health care needs to be improved.

- Vampire bats have very strong arms because they often walk and hop on the ground rather than fly when approaching their prey (Altringham 1996).
- Their nose leaves (fleshy structures projecting from the nose) have heat sensors to help them locate prey (Altringham 1996).
- They have very sharp teeth to make tiny cuts and their saliva contains draculin, a substance that inhibits blood clotting (Altringham 1996; Ohio State 2011).
- They have a deep groove in their lower lip through which their tongues pass because they lap up blood instead of sucking it (Altringham 1996).

Theme: Bats make great neighbors; they are interesting because they are so different from us.

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Presentation Points

- Now we have come to our hometown bats – the insectivores! There are 23 bat species in California and all but one, the Mexican long-tongued bat are insectivores. All Bay Area bats are insectivores (CDFW n.d.; BCI 2016d).
- Around 70% of all bat species are insectivores, which all belong to the suborder microchiroptera (Altringham 1996).
- Facial structures of insectivorous bats vary, e.g. bats that mostly eat beetles have strong jawbones and fewer, bigger teeth (Altringham 1996).
- Many insectivorous bats have large ears to aid in echolocation, but some species also use hearing, not echoes, to detect prey like the pallid bat.
- A bat found in the Bay Area and around California and the entire Western U.S. is the pallid who can hear the footsteps of insects from up to 16 feet away (BCI 2016c). Pallids eat crickets, grasshoppers, centipedes and even scorpions – it is immune to the scorpion's sting (BCI 2016c).

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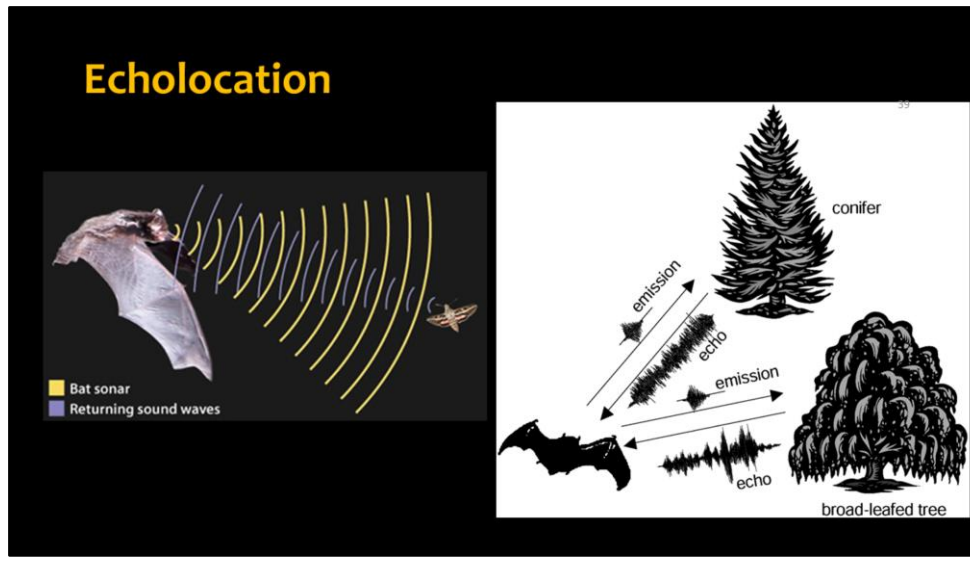
Presentation Points

- Most insectivorous bats do not have large eyes. They can still see – they are NOT blind as bats – but it is more important that their other sense organs involved in echolocation are more developed. These sense organs include the ears and nose and account for some of the wild facial forms of bats.
- Some echolocating insectivorous bats have fleshy structures like the nose leaf found on the yellow-winged bat pictured here that are used to emit ultrasonic calls (Altringham 1996). Bats with noseleaves emit calls through their noses (as opposed to those who emit sound out of their mouths); it is believed that the noseleaf "acts as an acoustic lens, focusing the sound into a narrow beam in front of the bat" (Altringham 1996, pg. 81).
- Large and specially shaped pinnae and tragus help bats to perceive sound and detect its direction (Altringham 1996).



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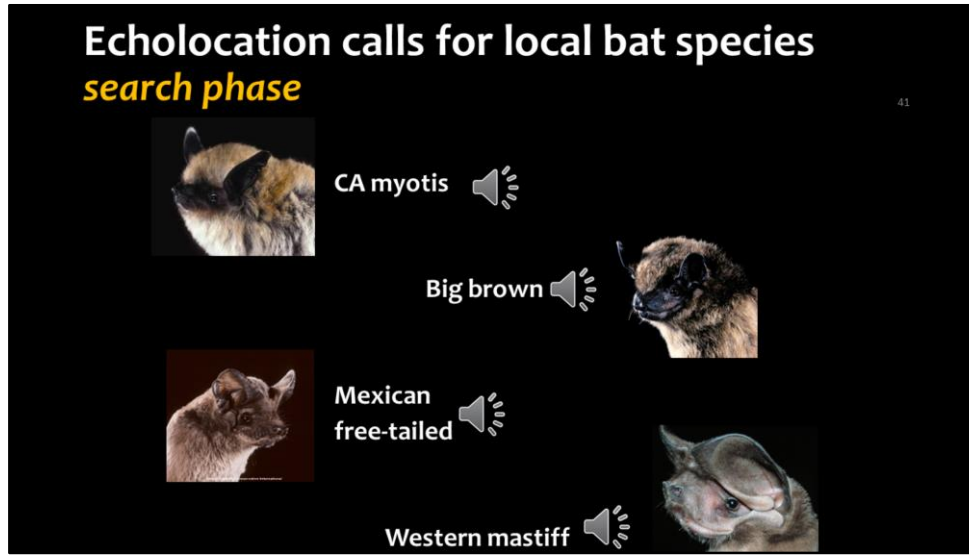
Presentation Points

- Echolocation is the ability to observe an environment using sound. Bats emit powerful, high frequency sounds that bounce off nearby objects, returning an echo the bat uses to determine information such as the size and shape of the object, its direction in relation to the bat, if it is moving towards or away from the bat and how fast it is moving. The pulse-echo delay is how bats tell how close the object is (Altringham 1996).
- High frequency sound waves are used because they have shorter wavelengths and are thus better at detecting smaller prey like insects. There may be other advantages to high frequency calls such as less interference from other sounds, including the calls of other bats and less chance that the calls will alert predators (Altringham 1996).

- Human hearing range is between 40 Hz – 20 kHz, while bat echolocation calls fall between 20 kHz – 120 kHz. We can hear some echolocation calls like those from the Western mastiff bat, a large bat that does occur in the Bay Area and we can also hear social calls or sounds that are not the kind used for echolocating (Altringham 1996).
- High frequency sound waves do not travel very far, so they are emitted frequently and primarily for foraging, not navigation over distance. It has been found that bats use the earth's magnetic field to navigate back to their night roosts after foraging (Holland et al. 2016).



Theme: Bats make great neighbors; they are interesting because they are so different from us.

Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- Specialized equipment converts high frequency bat calls into frequencies that humans can hear. Bats have distinctive calls, so being able to hear them allows us to identify them. Here is a sampling of "search phase" bat calls from some species who live in the Bay Area.
- The character of bat calls changes as a bat hunts. When they are trying to locate prey, they send out *search* calls. When they find an insect, they start sending out more frequent pulses during the *approach* phase and even more frequent ones during the *terminal* phase right before capture (Altringham 1996).

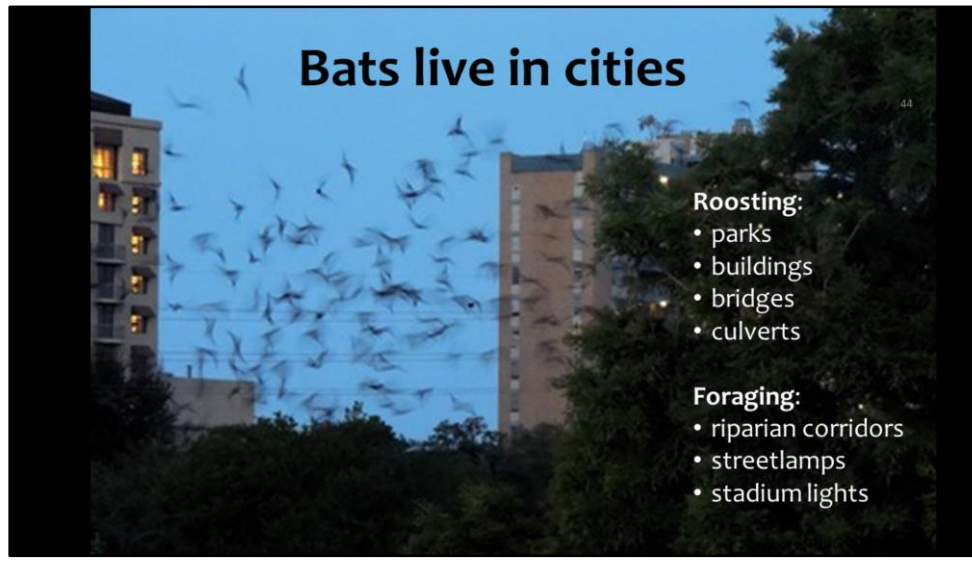
Theme: Bats have a lot to teach us.

Conceptual Node: Cultivating meaningful connections between humans and wildlife

Presentation Points

- As you can see, studying bats can teach us a lot about ecology and evolution, including that we should never be too confident we have figured out the workings of nature and animal behavior. Does anyone see anything odd or unexpected in this photo of a pollen-covered pallid bat?
- Even if you don't know anything about the feeding ecology of pallids, you can look at its facial features to see that it probably isn't a nectar specialist. (No long snout and lots of little sharp teeth for eating insects).
- In 2013, a UCSC research team discovered that, contrary to their (very sound) hypothesis, pallid bats delivered 8 times as much pollen upon each cactus flower visit as a nectar specialist (Frick et al. 2013).

- The pallid bat can't hover like the lesser long-nosed bat and has to hold on while it feeds (left photo). Pallids specialize in feeding on ground-dwelling insects like scorpions and millipedes not hovering in the air to gather nectar from columnar cacti (BCI 2016c).
- What does this tell us? For one, we learn that our assumptions, even when based on sound research and reasoning, are not always true; just because natural selection favors adaptations that allow pollinator and flower species to specialize, doesn't mean that this kind of "picture-perfect" mutualism is the most effective or only system in play. Nature is complex!



Theme: Bats, like humans, adapt to and shape urban environments.
Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

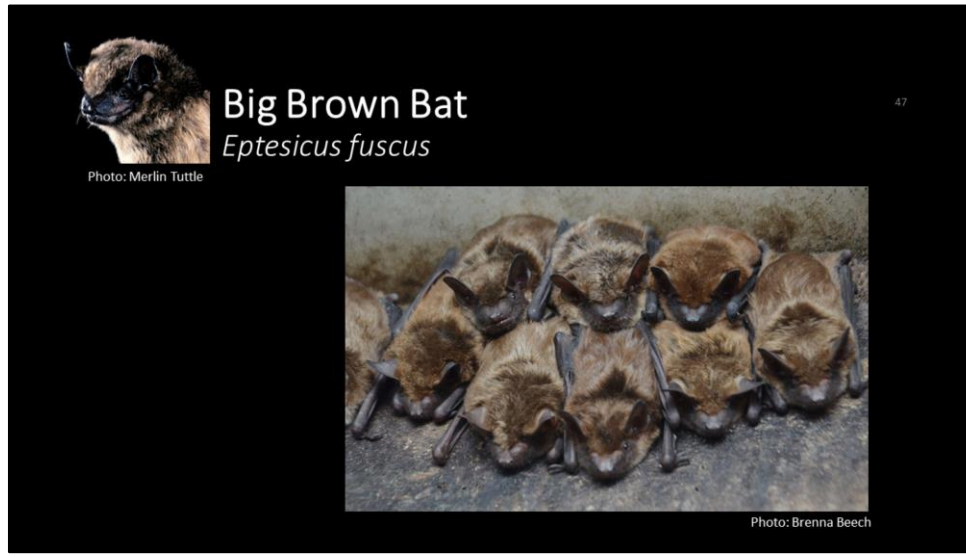
- This example of the pollinating pallid bat also teaches us the wisdom of opportunists: make the most of your environment, no matter what it is.
- There are adaptations passed genetically through natural selection (e.g. ear size), but there is also adapting within your lifetime – behavioral plasticity. This is the key to thriving in our constantly changing and increasingly urbanized world and means that bats, like humans, can adapt to the city life.
- Consistent with studies of urbanization effects on wildlife, many bat species are negatively affected by natural habitat loss (Ghert and Chelsvig 2003; McKinney 2006). Members of some bat species, however, tolerate human-shaped environments by adapting to the opportunities found there.
- Studies show that bat populations in suburban areas are higher than in the urban core and surrounding rural areas (Gaisler et al. 1998; Avila-Flores and Fenton 1998). Suburban areas have lower population density and high vegetation, providing bats with roosting and foraging opportunities.

Theme: Bats, like humans, adapt to and shape urban environments.
Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

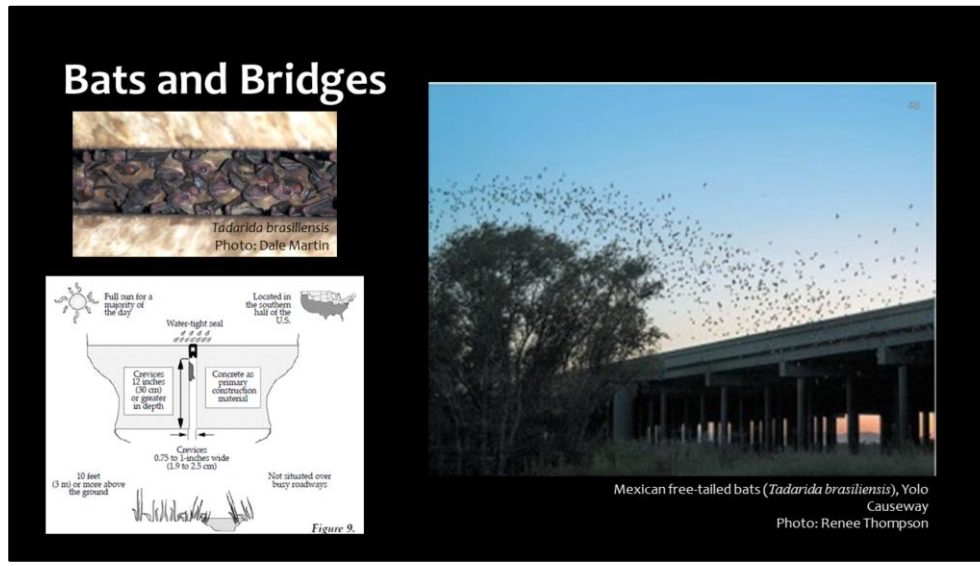
Presentation Points

- Urban areas have an abundance of natural and artificial roosts. Bats need day and night roosts for digesting, socializing, mating and rearing young. Bats spend most of their lives in roosts, so finding good ones that offer protection from predators and buffer wide temperature fluctuations is critical to their survival (Altringham 1996).
- On the right is a photo of a maternity colony of little brown bats (*Myotis lucifugus*) who was evicted from their residence in a historic Washington State building because the roof needed to be replaced (Relyea 2015).
- A study of big brown bat (*Eptesicus fuscus*) maternity colonies located in buildings revealed that these roosts provided thermoregulation benefits and increased protection from predation compared to natural roosts such as those in rock crevices (Lausen and Barclay 2006).

- On the left is a photo of a giant bat house designed by Charles Campbell, a physician from San Antonio, TX. Campbell conceived of the idea of building artificial roosts to attract more bats for the purpose of malaria control. The idea was eventually embraced by the Texas State Board of Health and a law was passed in 1917 making it a crime to kill a bat in TX. Malaria was eradicated in the area, but it is not certain that this was due to the bats. Campbell was nominated for a Nobel Prize in 1919 for his work.



- Some species such as the big brown bat (pictured here) and the little brown bat have become so well-adapted to artificial roosts that they rarely use natural ones (Altringham 1996).

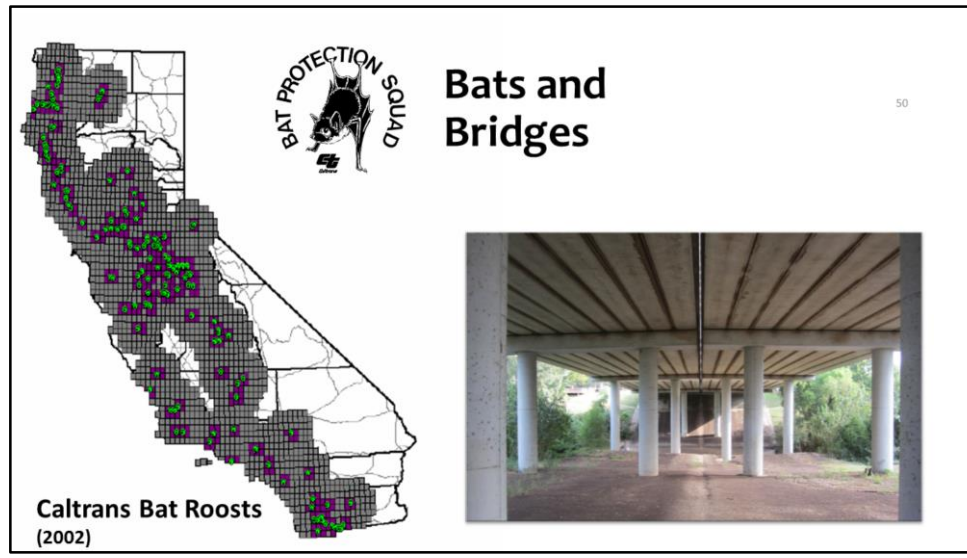


Theme: Bats, like humans, adapt to and shape urban environments.
Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- Loss of natural roosts has driven bats to artificial roosts including bridges (Keeley and Tuttle 1999; Erickson 2002).
- For day roosts, bats use crevices such as those in bridges' expansion joints which are most protected from predators and temperature fluctuations (Keeley and Tuttle 1999; Erickson 2002).
- As shown in the diagram of an ideal bridge roost, the other characteristics of preferable bridge roost include an optimal height from the ground, that the bridge isn't over a busy roadway, etc. (Keeley and Tuttle 1999).
- Of great importance is that the bridge is located over a water way as this provides good foraging and low disturbance from humans (Erickson 2002).
- Although bridges are subject to traffic noise, bats appear to be tolerant of this. Noise or disturbance from below, however, is not tolerated (Erickson 2002).

- The most frequent user of bridges is the Mexican free-tailed bat (Keeley and Tuttle 1999).
- The most spectacular urban bat watching and conservation initiative is located in the city center of Austin Texas at the Congress Avenue Bridge where 1.5 million Mexican free-tailed bats (*Tadarida brasiliensis*) form the world's largest urban bat colony every year (BCI 2007). This bridge colony is good for humans as well as bats: the site is estimated to bring in 140,000 visitors and an $8 million annual economic boost to the city of Austin (Pennisi, Holland and Stein 2004).



Theme: Bats, like humans, adapt to and shape urban environments.
Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

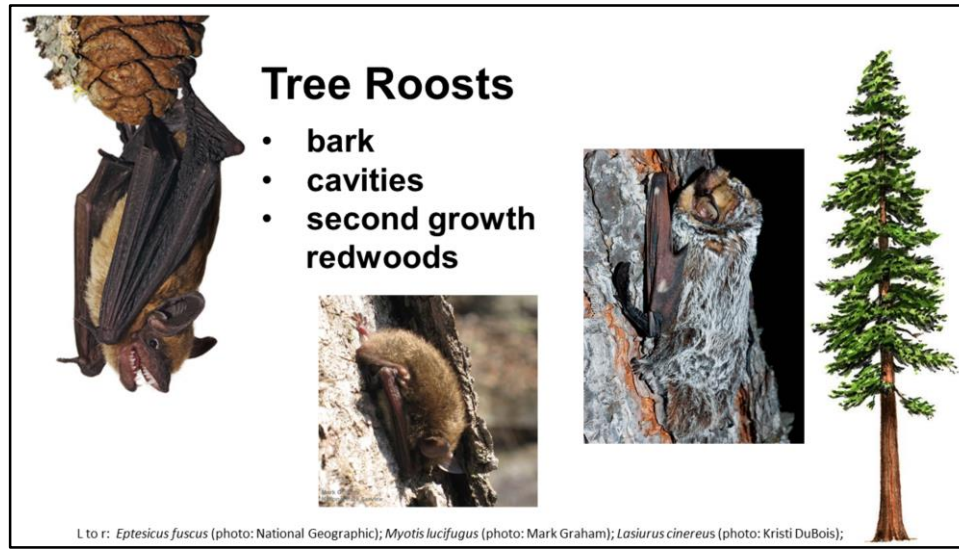
Presentation Points

- As one of the largest property managers in California, CalTrans has a huge impact on bats in our state (Erickson 2002).
- 18 of the state's 23 species use bridges for roosting; 93% of rare species either use or would likely use bridges (Erickson 2002).
- Retrofitting bridges to make them suitable habitat is relatively low-cost and may make a huge difference in bat survival (Keeley and Tuttle 1999).
- "Bridge structures have historically been considered an intrusion into biologically valuable riparian areas. They are not generally considered an asset to the local ecosystem. . . It is quite remarkable that these adaptive little animals have learned to use a prominent symbol of our intrusion into their world as a base from which to attack the insect pests that affect our food supply, and in effect, have forged a symbiotic relationship with us" – Gregg Erickson, CalTrans bat biologist (Erickson 2002).

Theme: Bats, like humans, adapt to and shape urban environments.
Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- Although the largest Mexican free-tailed bat colonies are in Texas, we have big ones in California, including a summer maternity colony of about 250,000 bats at the Yolo Bypass Causeway outside Davis (pictured in this slide) (Costabile 2012).
- They are a migratory species, but it is not quite clear whether those found in the Bay Area are year-round residents or are Central Valley residents that overwinter here (Johnston 2007; Krauel 2009).
- This species flies high (up to 10,000 ft) and fast (an average of 40 mph) and is a champion eater of agricultural pest bugs (Harris 2005; Fleming 2011; Cleveland et al. 2006).
- My guess is that bats around the Oakland Coliseum lights are Mexican free-tails because they are adapted to foraging in open habitats, not forested ones.



Theme: Bats, like humans, adapt to and shape urban environments.
Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

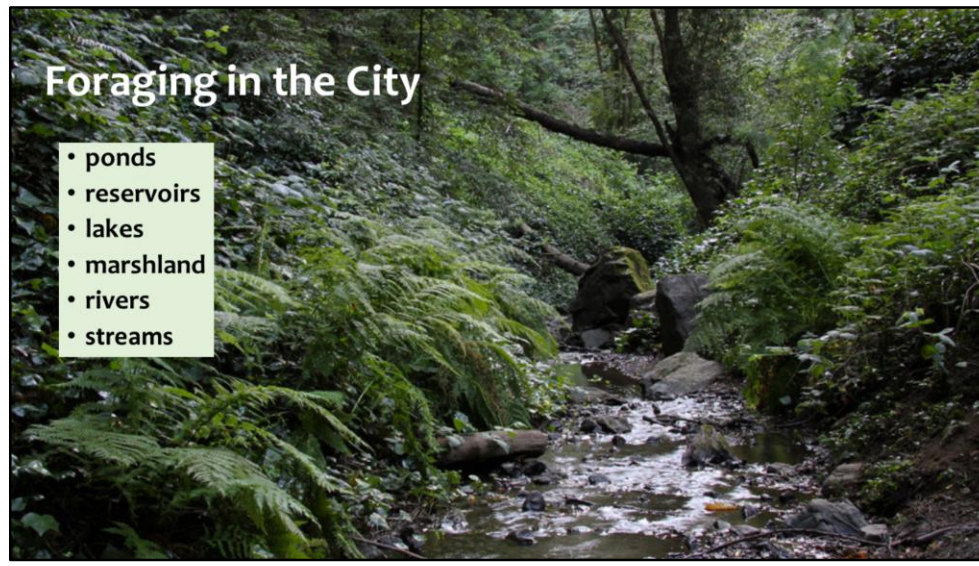
- Several studies have found a consistent, positive correlation between woodlands and bat activity in urban areas (Ghert and Chelsvig 2003; Gaisler et al. 1998; Avila-Flores and Fenton 1998).
- Trees provide roosts in the form of spaces created by exfoliated bark or bark crevices and cavities within the trees. On the photo on the right, you can see a little brown bat making use of a space under a piece of bark. Bats roost singly in and on trees and also in small colonies (Altringham 1996).
- The hoary bat (right photo slide), a local Oakland species, has specialized fur coloring that helps camouflage it while it roosts on bark (Tuttle 1995).
- Hoaries are not usually associated with urban habitats, but they have been detected in Tilden and Redwood Regional Parks. According to bat biologist Gabe Reyes (personal communication, 28 May 2016), the Oakland and Berkeley hills are probably important in the life cycle of this migratory species who overwinters in our area.

- Redwood trees provide excellent roosts for bats. Pictured here (on left) is a big brown bat (not actually very big!) hanging from a sequoia cone, but our local *coast* redwood forests are likely a large reason we have bats in Oakland. Although our second and third growth trees are not nearly the size of old-growth ones, a study conducted in the South Bay found that second growth trees were preferred for roosting by a common local species, the Yuma myotis (Evelyn, Stiles and Young 2004).

Theme: Bats, like humans, adapt to and shape urban environments.
Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

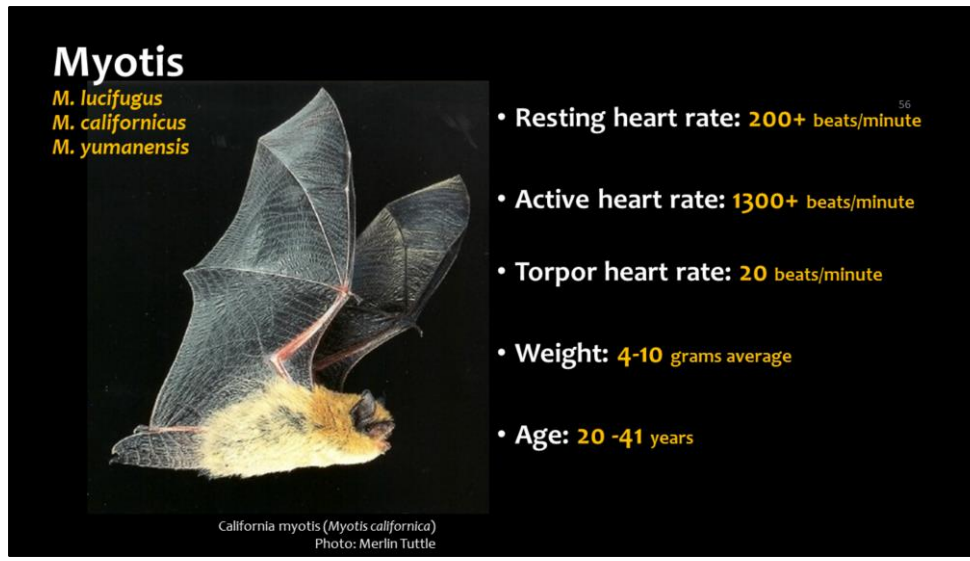
- This is a video of a hoary bat filmed by a local resident in Oakland's Montclair district. Given that Montclair is located in the hills, close to forested land, it is not surprising that this is where the bat was seen.
- Note that the person did NOT touch the bat, but used a tool to move it from the middle of the sidewalk.
- Do not ever touch a bat, even if it doesn't appear aggressive or sick.



Theme: Bats, like humans, adapt to and shape urban environments.
Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- In addition to woodlands, water bodies have been found to be the most significant factor supporting the presence of bats in urban areas (Ghert and Chelsvig 2003; Gaisler et al. 1998;Walsh and Harris 1996; Everette et al. 2001) .
- Bats need water for drinking, but it also provides good foraging as water is associated with insects (Ghert and Chelsvig 2003, Gaisler et al. 1998; Walsh and Harris 1996; Everette et al. 2001).
- For this reason, fresh water as well as brackish water like that found in marshland attracts bats (Johnston 2007).
- In Oakland, watersheds with open, flowing waters and riparian corridors such as Sausal Creek watershed are important bat habitat.

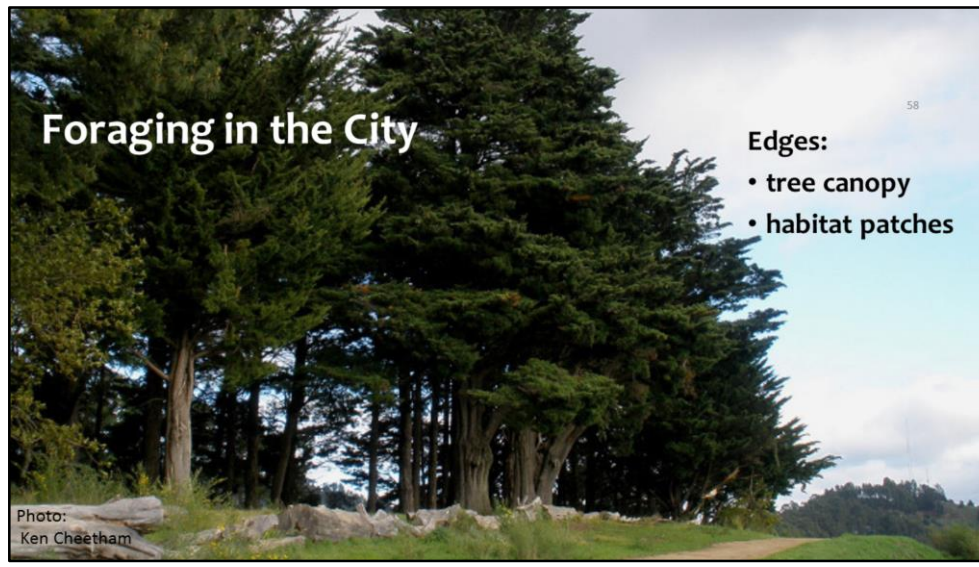


Theme: Bats, like humans, adapt to and shape urban environments.
Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- The upper Sausal Creek watershed provides just what myotis species need. They are associated with woodlands habitat and a large part of the diet of our local myotis species are aquatic insects (BCI 2016e; Harris 2005b). Oakland has three species of myotis (see slide list). Yuma mytois is strongly associated with foraging primarily over water bodies including streams (Harris 1990a). When local bat biologist Gabe Reyes used call analysis software to identify the bats we observed on the Bridgeview Trail in July 2015 they were California myotis and perhaps some Yuma myotis (similar calls).
- Little brown bats (*Myotis lucifugus*) are widespread and common urban dwelling bats that will form big maternity colonies in buildings (BCI 2016e).

- Myotis are small: Our local species range in weight from 4-13 grams (Smithsonian n.d.). For reference: a quarter weighs 6 grams. Myotis are dynamic little bats that can go really slow or super-duper fast - see heart rate stats on slide (Tuttle 2006). Also, they are extremely long-lived for their size: Several myotis species live 20+ years in the wild! (Podlutsky et al. 2005, Seim et al. 2013).
- Myotis are efficient foragers of small insects, including mosquitos (BCI 2016e). A Yuma myotis was recorded resting with a full stomach only 15 minutes after dusk (Harris 1990). An individual little brown bat can eat up to 1200 insects in an hour (BCI 2016e).



Theme: Bats, like humans, adapt to and shape urban environments.
Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

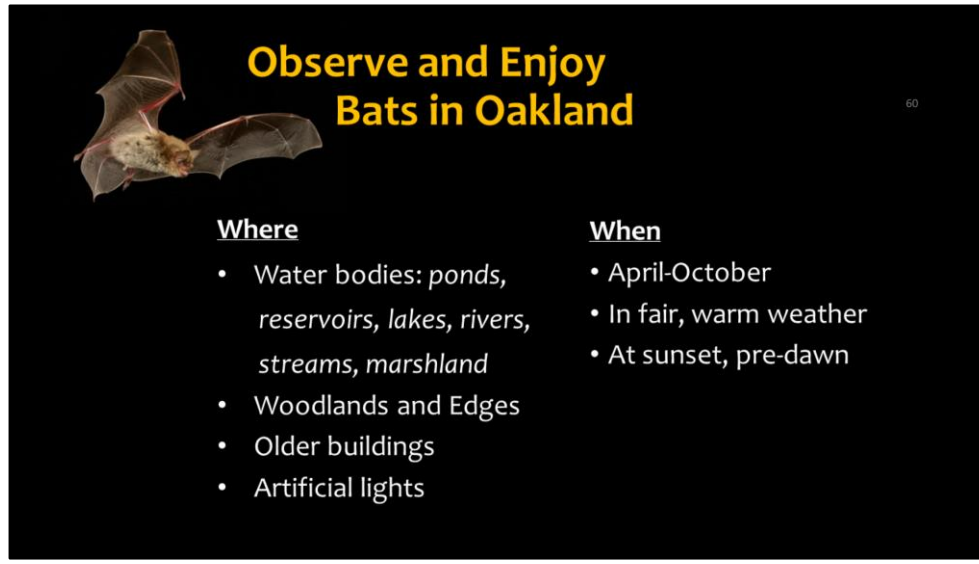
Presentation Points

- An edge is the boundary between two different habitats and have greater biodiversty than non-edge areas.
- Edge habitat has been found to have a positive correlation to bat populations as these areas are sites of increased insect abundance and are easier for flight navigation (Ghert and Chelsvig 2003; Walsh and Harris 1996; Everette et al. 2001; Krauel 2009).
- Landscapes that are a mosaic of differing habitat patches contain more edge. Cities, especially suburban zones, tend to be patchy.
- A tree itself creates a microhabitat with edge. I personally have observed greater numbers of bats in the Sausal Creek watershed foraging on the edge of trees than in open areas with no canopy edge.

Theme: Bats, like humans, adapt to and shape urban environments.
Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- Streetlights are favored by some bat species. Fast-flying bats who forage on aerial insects use streetlight microhabitats, while slower flying bats do not, maybe because of higher predation risk (Rowse, Harris and Jones 2016).
- Streetlights do create foraging opportunities, but not for all species, so it is important that artificial light does not dominate a landscape and variety is preserved (Rowse, Harris and Jones 2016; Jung and Kalko 2010).
- White light attracts smaller, but more insects and orange light attracts larger insects, but fewer (Gaisler et al. 1998). Activity is highest at bluish-white lights (Jung and Kalko 2010). LED lights appear to have similar effects as low-pressure sodium lights that are orange (Rowse, Harris and Jones 2016). Stadium lights that attract bugs and bats are usually metal halide which is a white light. Next time you go to an A's night game, look up!



Theme: Bats, like humans, adapt to and shape urban environments.
Conceptual Node: *Cultivating meaningful connections between humans and wildlife*

Presentation Points

- The upper Sausal Creek watershed has some prime real estate for the urban bat. As you can see from the guidelines presented on this slide, we've got:
- Clean flowing water; aquatic insects; woodlands (in particular redwoods forests that we know Yuma myotis like); edges: the landscape is pretty patchy in the upper Sausal Creek watershed. We have patches of woods next to patches of houses next to patches of water and patches of open grasslands; buildings that aren't so new and plumb that bats can't find little nooks for roosting; streetlights
- So, do we have bats? Yes! Last July a bat biologist, Gabe Reyes, and I did an acoustical survey of the bats on the Bridgeview Trail located in the Oakmore neighborhood. We found Yuma myotis and California myotis. Now that you know where to see bats, when should you see them without having to use any special equipment?

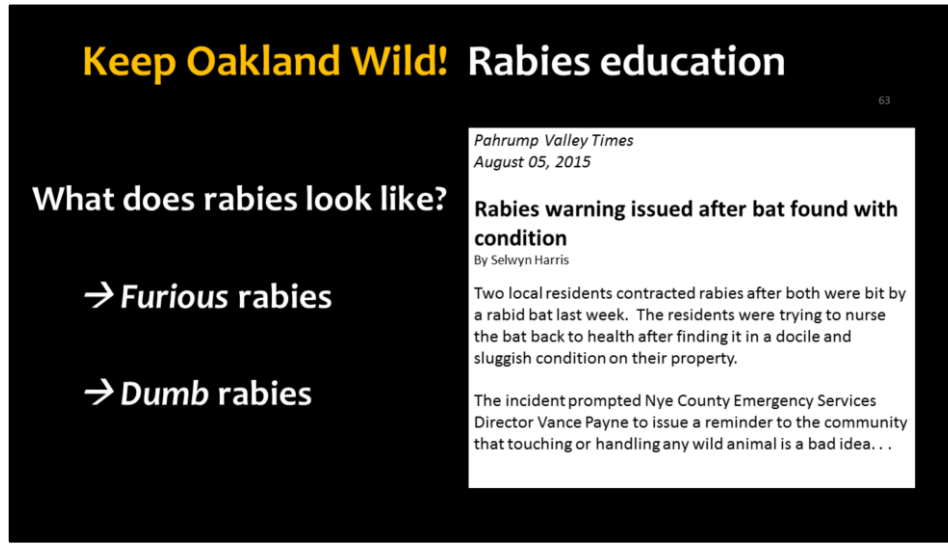
- In fair, warm weather: some bats stay in the area for the winter, but in inclement weather, they will not bother to forage. Instead they will save energy by going into torpor until the weather is better (Altringham 1996).
- April-October: This is the season when the weather is warmest in Oakland and you are most likely to see bats out and about.
- At sunset, pre-dawn: different species have different emergence and peak foraging times, but this is the time when it is dark enough for the bats to become active, but light enough that you can still see.

Theme: Bats make great – *wild* - neighbors; we should take care of them

Conceptual Node: *Ethic of care and wildlife politics*

Presentation Points

- With all the rapid changes going on in Oakland these days, we want to make sure that bats don't get displaced as has been happening to folks without a voice.
- Bats don't really have a place at the table – they don't make political contributions or hold rallies or pay taxes – so we can act on their behalf.
- What can you do to make sure that Oakland stays wild?



Theme: Bats make great – *wild* - neighbors; we should take care of them

Conceptual Node: *Ethic of care and wildlife politics*

Presentation Points

- One of the most important ways we can take care of Oakland's bats is by becoming educated about rabies. Bats are carriers of rabies, but this fact does not mean that we need to fear them or remove them from our neighborhood. If we educate ourselves about rabies in bats then we are not in danger. Here's what you need to know:
- Rabies is a viral disease of the central nervous system transmitted through saliva and broken skin. It is fatal if not treated immediately (CDC 2016, CDPH 2016).
- Rabies mostly affects wild animals and dogs or cats bitten by an infected wild animal (CDC 2016, CDPH 2016).
- For this reason, you should vaccinate your pets and keep your cats inside! You do not want your cat bringing home a sick bat (or killing healthy critters in the watershed, for that matter).

- Rabies does occur in the Bay Area. From 2005-2015, there were 49 cases of rabies found in wild animals (CDPH 2016). Of these animals, all but one were bats. The other one was a skunk. So yes, bats are primary carries of this extremely serious disease, but there is a simple way to avoid catching rabies: NEVER TOUCH A BAT. EVER, EVER.
- The disease's appearance in bats does not meet the conventional perception of rabies. Rabies expression in bats is paralytic, not furious, so a rabid bat will often lie quietly on the ground, appearing non-threatening – see article excerpt on slide (Mickleburgh, Hutson and Racey 2002).

Theme: Bats make great – *wild* - neighbors; we should take care of them
Conceptual Node: *Ethic of care and wildlife politics*

Presentation Points

- Pictured in this slide is a bat house that Upper Rockridge resident and FOSC member Joe Maffei installed on his chimney.
- Full disclosure: no bats have taken up residence in this little house, YET!
- Bats are notoriously picky when it comes to where they roost, so it is really important that you place the house in the best possible location. Even if you do this, as Joe has done, there is no telling when they will take up residence.
- The best resource I know of for information on building and installing bat houses is on the Bat Conservation International website: www.batcon.org.

Theme: Bats make great – *wild* - neighbors; we should take care of them

Conceptual Node: *Ethic of care and wildlife politics*

Presentation Points

- Work to enhance woodland and water habitat.
- The best way to do this is by joining a group like Friends of Sausal Creek that is dedicated to protecting the natural resources in our watershed. You will be a part of an organization of like-minded neighbors that makes restoration projects such as the current one at Dimond Park possible.
- This major restoration project has brought a formerly buried section of the creek back onto the surface. This means more water and more BUGS for bats!

Theme: Bats make great – *wild* - neighbors; we should take care of them
Conceptual Node: *Ethic of care and wildlife politics*

Presentation Points

- Most importantly, it is vital for the health and happiness of our bats, our cities, our planet and ourselves that we get out there and enjoy being in the company of our bat neighbors.
- City living with so many different people and creatures livening in close quarters isn't easy, but it is exciting. As British geographers Steve Hinchliffe and Sarah Whatmore note, our encounters with local wildlife are "entanglements that make life more interesting" (2006, 129).
- Thank you!