Bats of Montana: Identification and natural history

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Prepared for:

Montana Department of Environmental Quality
Air, Energy, & Mining Division, Coal Section

Prepared by:

Dan Bachen, Alexis McEwan, Braden Burkholder, Shannon Hilty, Scott Blum, and Bryce Maxell
Montana Natural Heritage Program
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MONTANA Natural Heritage Program

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Introduction

With the impending arrival of White-Nose Syndrome and increasing impacts from wind energy development, Montana's bat species are increasingly at risk of catastrophic declines and extirpation. To assess the current status of species, document potential changes in status, and inform management of these species, baseline information is needed on the species themselves as well as the landscapes they use. In response to this information need, the Montana Natural Heritage Program has collaborated with state, federal, and tribal agencies as well as universities and private organizations to collect data on the state's bats at a landscape level scale. The primary methods used to collect these data have been the deployment of short- and long-term acoustic monitoring stations and surveys of known and potential active season roosts and hibernaculum. These efforts have allowed us to expand the known range of several species, increase the number of known roosts, expand the distribution of these roosts, identify when animals are active on the landscape, and infer which species migrate and which are year-round residents. Although the presentation of these data in their entirety is beyond the scope of this document, the following summaries should give the reader an overview of what is known about the 15 bat species that are known to occur in the state. We have by no means collected all the data that is needed or answered every question relevant to management of these species, but these efforts have provided a sound basis for directing future work to address these additional information needs.

Acknowledgements

We would like to acknowledge and thank the following organizations for their assistance and support, without which the collection and presentation of these data would not be possible. The US Forest service, The Bureau of Land Management, the US Fish and Wildlife Service, The National Park Service, The Army Corps of Engineers, Montana Department of Environmental Quality, Montana Fish Wildlife and Parks, The Confederated Salish and Kootenai Tribes, American Prairie Reserve, Weyerhaeuser, Northwestern Energy, MPG Ranch, the Northern Rocky Mountain Grotto, Sonobat, Wildlife Acoustics.

A Check List of Montana Bat Species

Chiroptera (Class)

Vespertilionidae (Family)

- Pallid Bat (*Antrozous pallidus*) LeConte 1856
- Townsend's Big-eared Bat (*Corynorhinus townsendii*) W. Cooper 1837
- Big Brown Bat (*Eptesicus fuscus*) Beauvois, 1796
- Spotted Bat (*Euderma maculatum*) J.A. Allen, 1891
- Eastern Red Bat (*Lasiurus borealis*) Müller, 1776
- Hoary Bat (*Lasiurus cinereus*) Palisot de Beauvois, 1796
- California Myotis (*Myotis californicus*) Audubon & Bachman, 1842
- Western Small-footed Myotis (*Myotis ciliolabrum*) Merriam, 1886
- Long-eared Myotis (*Myotis evotis*) H. Allen, 1864
- Little Brown Myotis (*Myotis lucifugus*) Le Conte, 1831
- Silver-haired Bat (*Lasionycteris noctivagans*) La Conte, 1831
- Northern Myotis (*Myotis septentrionalis*) Trouessart, 1897
- Fringed Myotis (Myotis *thysanodes*) Miller, 1897
- Long-legged Myotis (*Myotis volans*) H. Allen, 1866
- Yuma Myotis (*Myotis yumanensis*) H. Allen, 1864

Conservation Status and Threats

Table 1. Species of bats found in Montana and the conservation status and threats of each.

Species	Conservation Status	Species known to be affected by White-Nose Syndrome / *P. destructans*	Species known to be subject to mortality at wind turbines*
Pallid Bat (*Antrozous pallidus*) = ANPA	G4 S3, MT SOC, BLM Sensitive, USFS Sensitive	No connection known at this time.	No mortalities documented in literature.
Townsend's Big-eared Bat (*Corynorhinus townsendii*) = COTO	G4 S3, MT SOC, BLM Sensitive, USFS Sensitive	Detected, but no diagnostic sign of WNS (USFWS 2014). Potential winter roost vector.	No mortalities documented in literature.
Big Brown Bat (*Eptesicus fuscus*) = EPFU	G5 S4	Blehert et al. 2008, Langwig et al. 2012, 2014, Frank et al. 2014.	Johnson et al. 2004; Kunz et al. 2007; Arnett et al. 2008, 2011.
Spotted Bat (*Euderma maculatum*) = EUMA	G4 S3, MT SOC, BLM Sensitive, USFS Sensitive	No connection known at this time.	No mortalities documented in literature.
Silver-haired Bat (*Lasionycteris noctivagans*) = LANO	G3G4, Potential MT SOC	Detected, but no diagnostic sign of WNS (Bernard et al. 2015, USFWS 2014). Potential regional migratory vector.	Johnson et al. 2004; Kunz et al. 2007; Arnett et al. 2008, 2011; Baerwald et al. 2009; Poulton and Erickson 2010.
Eastern Red Bat (*Lasiurus borealis*) = LABO	G3G4 S3, MT SOC	Detected, but no diagnostic sign of WNS (Bernard et al. 2015, USFWS 2014). Potential regional migratory vector.	Kunz et al. 2007; Arnett et al. 2008, 2011.
Hoary Bat (*Lasiurus cinereus*) = LACI	G3G4 S3, MT SOC	No connection known at this time.	Johnson et al. 2004; Kunz et al. 2007; Arnett et al. 2008, 2011; Baerwald et al. 2009; Poulton and Erickson 2010.
California Myotis (*Myotis californicus*) = MYCA	G5 S4	Close relatedness to *M. leibii* indicates possible susceptibility (Agnarsson et al. 2011, Langwig et al. 2012)	No mortalities documented in literature.
Western Small-footed Myotis (*Myotis ciliolabrum*) = MYCI	G5 S4	Susceptible (USFWS 2018)	No mortalities documented in literature.
Long-eared Myotis (*Myotis evotis*) = MYEV	G5 S4	Close relatedness to *M. sodalis* indicates possible susceptibility (Agnarsson et al. 2011, Langwig et al. 2012)	Kunz et al. 2007
Little Brown Myotis (*Myotis lucifugus*) = MYLU	G3 S3, MT SOC	Blehert et al. 2008, Frick et al. 2010, Lorch et al. 2011, Warnecke et al. 2012, Johnson et al. 2014, Langwig et al. 2012, 2014.	Johnson et al. 2004; Kunz et al. 2007; Arnett et al. 2008, 2011.
Northern Myotis (*Myotis septentrionalis*) = MYSE	G1G2 S2, BLM Special Status, USFS Threatened, USFWS Listed Threatened	Blehert et al. 2008, Langwig et al. 2012, 2014, USFWS 2015.	Kunz et al. 2007; Arnett et al. 2008
Fringed Myotis (*Myotis thysanodes*) = MYTH	G4 S3, MT SOC, BLM Sensitive	Relatively close relatedness to *M. lucifugus* indicates possible susceptibility (Frick et al. 2010, Agnarsson et al. 2011)	No mortalities documented in literature.
Long-legged Myotis (*Myotis volans*) = MYVO	G4G5 S4	Close relatedness to *M. sodalis* indicates possible susceptibility (Agnarsson et al. 2011, Langwig et al. 2012)	No mortalities documented in literature.
Yuma Myotis (*Myotis yumanensis*) = MYYU	G5 S3, MT SOC	Susceptible (USFWS 2017)	No mortalities documented in literature.

Seasonal Presence of Confirmed Species.

Table 2. Documented presence of Montana bat species by month, and method of detection for each. Presence is based on 11411 observations of bats in the Montana Natural Heritage Program's Point Observation Database.

Species	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Townsend's Big-eared Bat (*Corynorhinus townsendii*) [1]	O	O	O	O	A, O	A, O	A, O	A, O	A, O	A, O	O	O
Pallid Bat (*Antrozous pallidus*)				A		A, O	A, O	A,O				
Big Brown Bat (*Eptesicus fuscus*)	A, O	A, O	A, O	A	A	A, O	A, O	A, O	A, O	A, O	A, O	A
Spotted Bat (*Euderma maculatum*)			A	A	A	A, O	A, O	A, O	A	A	A	
Hoary Bat (*Lasiurus cinereus*)			A	A	A	A, O	A, O	A, O	A	A	A	
Eastern Red Bat (*Lasiurus borealis*)						A	A	A, O	A	A		
Silver-haired Bat (*Lasionycteris noctivagans*)	A	A	A	A	A, O	A, O	A, O	A, O	A, O	A	A	A
Western Small-footed Myotis (*Myotis ciliolabrum*)	A, O	A, O	A, O	A, O	A, O	A, O	A, O	A, O	A, O	A	A	A, O
Long-eared Myotis (*Myotis evotis*)	O		A, O	A,O	A, O	A, O	A, O	A, O	A, O	A	A	O
Little Brown Myotis (*Myotis lucifugus*)	O	O	A, O	A, O	A, O	A, O	A, O	A, O	A, O	A, O	A, O	O
Fringed Myotis (*Myotis thysanodes*)			A, O	A	A	A, O	A, O	A, O	A, O	A		
Long-legged Myotis (*Myotis volans*) [2]		O	O	O	A, O	A, O	A, O	A, O	A, O	A, O		O
Northern Myotis (*Myotis septentrionalis*)	O						O	O				
Yuma Myotis (Myotis yumanensis)				A	A	A, O	A	A	A	A		
California Myotis (Myotis californicus)			A	A	A, O	A, O	A, O	A, O	A	A	A	

O denotes in-hand confirmation of a captured individual during a hibernacula or roost survey, or mist netting. A denotes an acoustic detection. Monthly presence inferred from these data are denoted by blue (year-round), green (migrant), or orange (unknown).

General Patterns of Bat Activity

Seasonal

Bat activity across the landscape varies with season, with animals of all species most active during the spring, summer and fall and limited activity during the winter. The Active Season typically begins in April or May when animals emerge from hibernation or migrate into the state and begin foraging. Bat activity on the landscape increases through the spring, peaking in mid-summer, and decreasing through the fall (Figure 1). By late October some animals have begun to make local migrations to hibernaculum while others have migrated to more favorable climates. During the winter animals are active during periods of favorable weather but activity recorded across detectors is generally very low and inconsistent. Currently it is unknown why some animals are active on the landscape during the hibernation period.

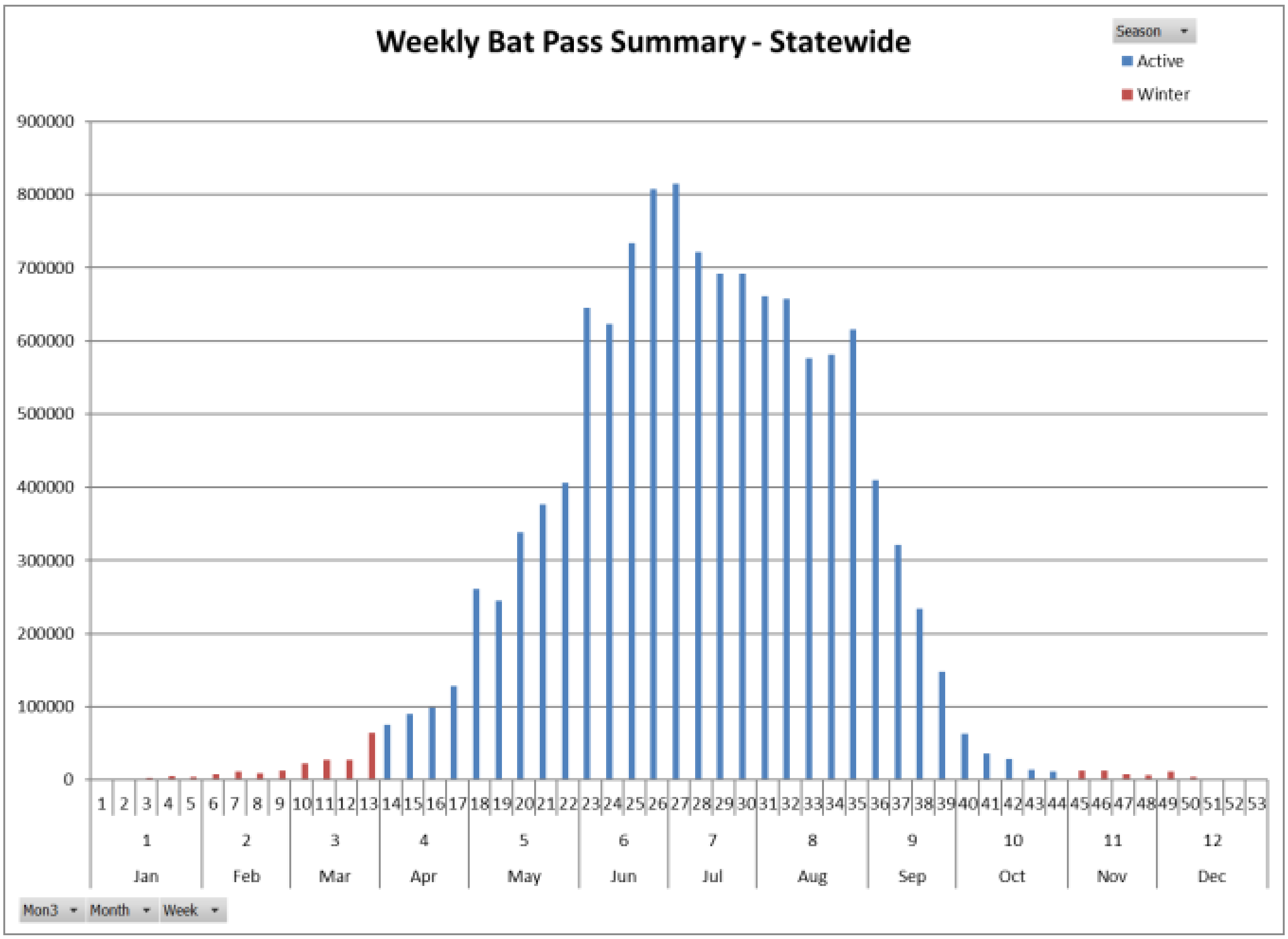

Figure 1 Total activity of all species recorded across the state at 79 long-term acoustic detector/recorder stations. The number of call sequences are summed by week across the year. 112 detectors at 79 sites, 62,440 nights recorded with an average of 578.1 nights per detector.

The general activity pattern is consistent across the state, however animals overwintering in some regions appear to arouse earlier than other regions. Bats in the southeastern region had higher average activity levels in March than the rest of the state, with the exception of detectors in, and west of, the

Flathead Valley placed a low elevation sites (Figure 2). These areas also have higher activity levels later into the year. Although the ultimate reason for the relatively long active season within these regions of the state is unknown, local climate and prey availability may play an important role.

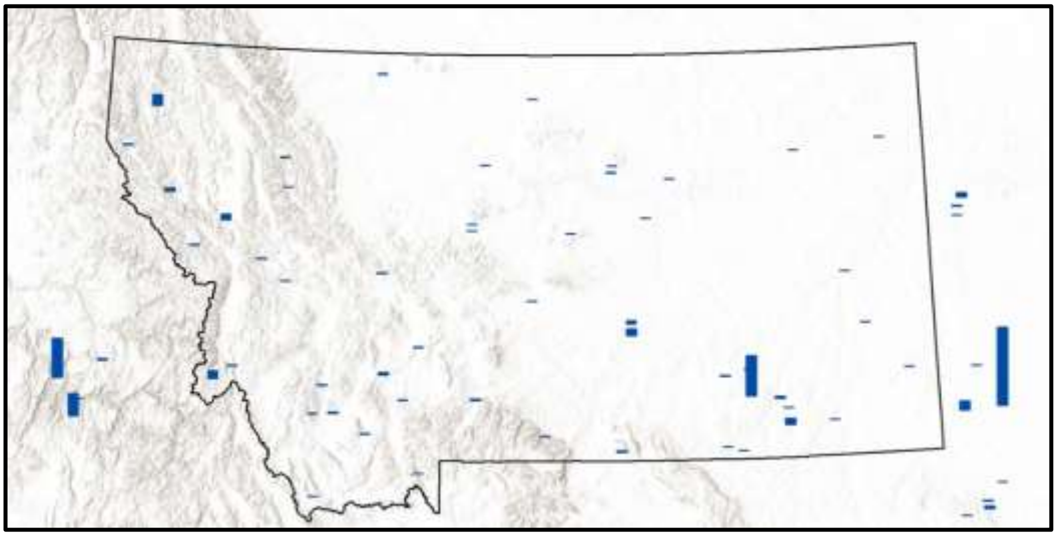

Figure 2 Average bat activity in March displayed by 79 long-term detector site across Montana and surrounding states.

Nightly

During the active season (April through October) some level of bat activity was evident throughout the night. In the spring activity is generally highest early in the evening, then decreases through dawn (Figure 3). As the season progresses, activity assumes a bimodal distribution and peaks within a few hours after sunset and again within a few hours of sunrise, which is likely the result of multiple bouts of foraging by some species. In the late summer and early fall, activity returned to pattern similar to the spring. During the early winter activity is generally highest around dawn and dusk, but as the season progresses activity becomes erratic and animals appear to become active during favorable climactic conditions (Figure 4, 5).

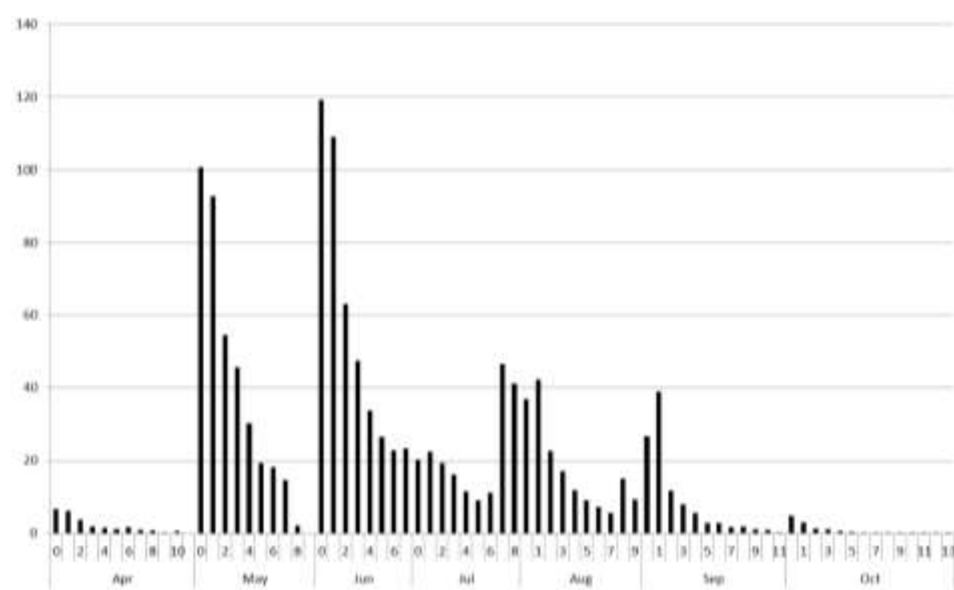

Figure 3 Timing of nightly activity by month during the active season. Numbers are hours after sunset (sunset =0). The y-axis displays average calls recorded across the network within each hour. Data from 112 detectors at 79 sites which recorded data during 1,351 active season months

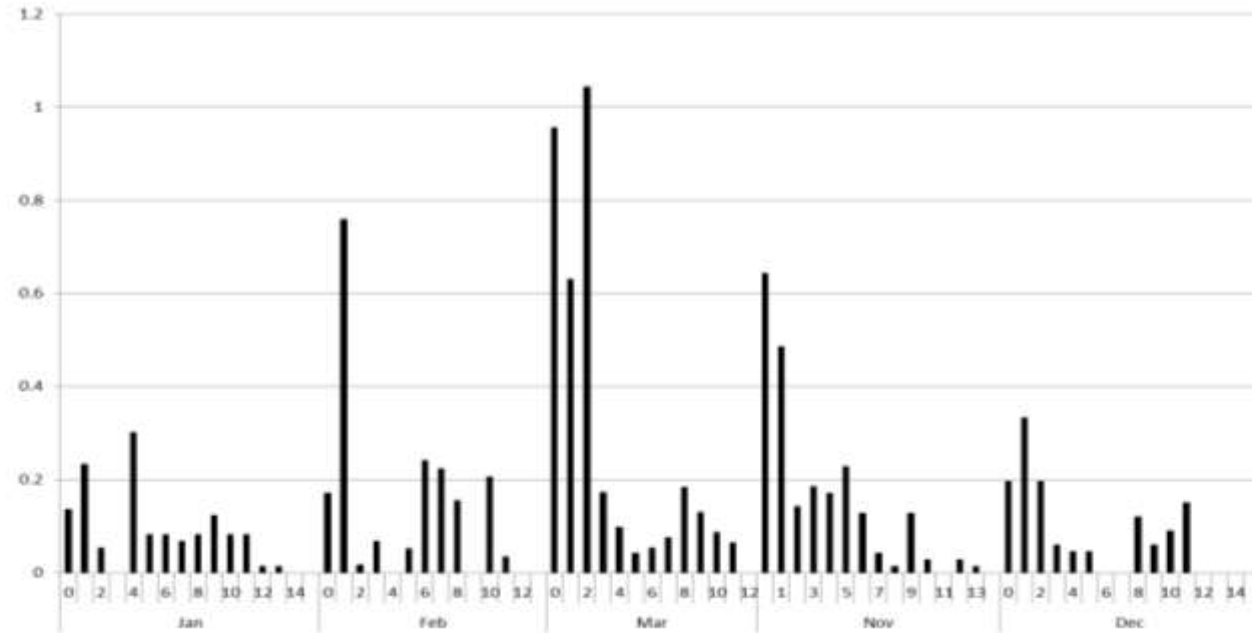

Figure 4. Timing of nightly activity by month during the winter. Numbers are hours after sunset (sunset =0). The y-axis displays average calls recorded across the network within each hour. Data from 112 detectors at 79 sites which recorded data during 939 winter season months

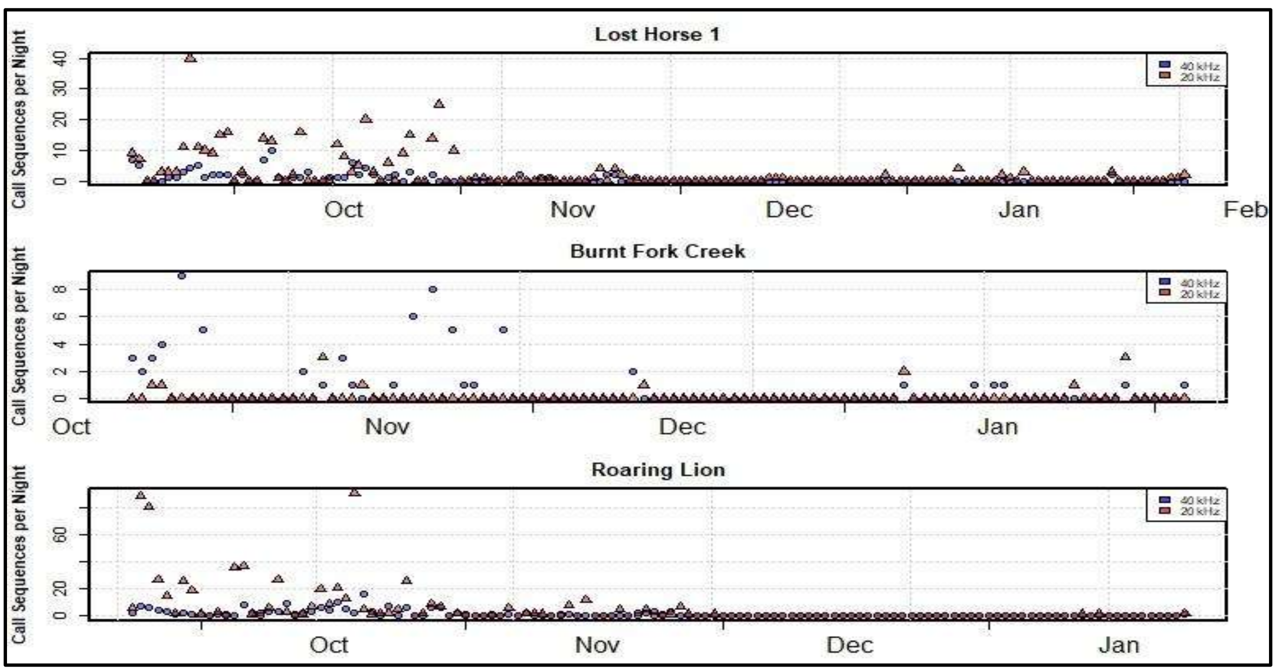

Figure 5. Activity of 20kHz and 40 kHz bats above talus slopes in the Bitterroot and Sapphire Mountains of Western Montana. Detector/recorder units were deployed across the winter to infer if animals were hibernating in proximity to the slopes. Consistent activity of both groups likely indicated that the detectors were near hibernacula.

Landscape Features and Bat Activity

Water

Perhaps one of the most essential resources for bats is accessible water to drink and for some species, forage. In relatively dry areas any area of calm water may be important. Even in areas with abundant surface water, not all waterbodies are accessible to all species of bats. Species vary in maneuverability, and larger, faster fliers such as the Hoary Bat require larger bodies of water or flight paths to smaller pond or pools that allow them to room to maneuver. Smaller more maneuverable species such as those in the genus *Myotis* can exploit smaller pools in more cluttered environments.

Statewide activity of all species is typically highest at large lentic waterbodies (Figure 6). The lowest average activity was recorded at detectors placed adjacent to small lotic waterbodies. Both large lotic and small lentic sites had similar levels of activity and detectors placed at upland sites recorded orders of magnitude less activity than at any waterbody. These patterns in use are likely explained by how animals used these sites. Larger ponds and lakes not only provide room to maneuver and drink, but also abundant insect prey. Low use of smaller streams may be due in part to lack of access for larger species because of the surrounding vegetation structure and areas of rough water which all species avoid.

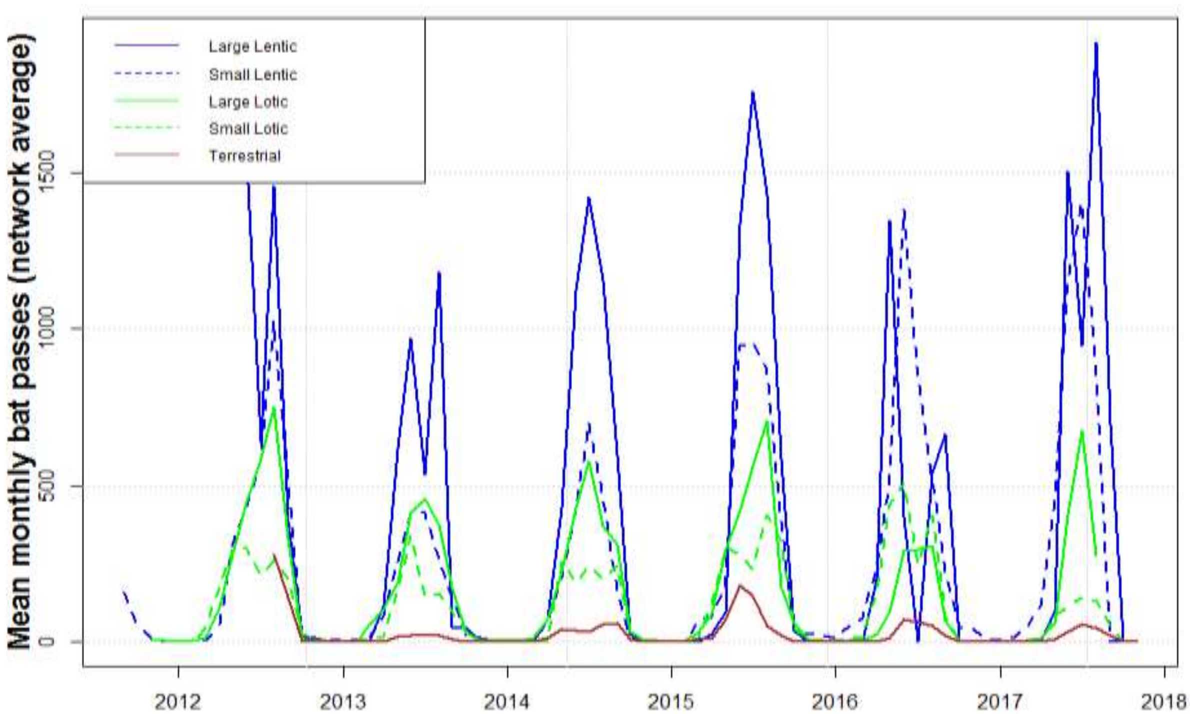

Figure 4 Mean monthly bat passes averaged by detector class across the long-term acoustic detector network. Each detector was classified by placement, lotic (running water), lentic (standing water), and terrestrial. Lotic and lentic sites were further classified by size into large and small. Note that in 2016 and 2017 most sites were decommissioned and trends may be biased. 112 detectors at 79 sites, 62,440 nights recorded with an average of 578.1 nights per detector.

Roost Features and Activity

Roost features used by bats in Montana fall into two general categories in the active season: trees, and crevices (see previous section for full discussion and citations). Species such as Hoary Bat and Eastern Red Bat roost in the foliage, while Silver-haired Bats prefer roosting on or within trees. Myotis bats will also roost under the bark or within other crevices, and often locate maternity colonies in large diameter snags. Similar these crevices in trees other landscape features such as cliffs, talus, and other rock outcrops, badlands, and structures including bridges and houses all provide cracks, crevices, or other protected areas for bats to roost during both the day and nights. The natural features are often found in areas of high topographic ruggedness, and given that most species of bats tend to remain within several kilometers of their roosts, recorded activity at these areas is generally higher than in areas without these features.

Across the network both trees and rugged terrain are correlated with increased activity of all bat species during the active season and winter (Figures 7 & 8). In rugged landscapes, trees do not affect general activity. However, in landscapes that lack topographic ruggedness, forested areas have substantially higher activity levels, likely through providing roosting habitat. During the winter, bat activity is generally associated with rugged landscapes. Landscapes that lack ruggedness, even if forested, have little if any activity. This is almost certainly due to the presence of features that provide suitable climate conditions for overwintering in these rugged landscapes.

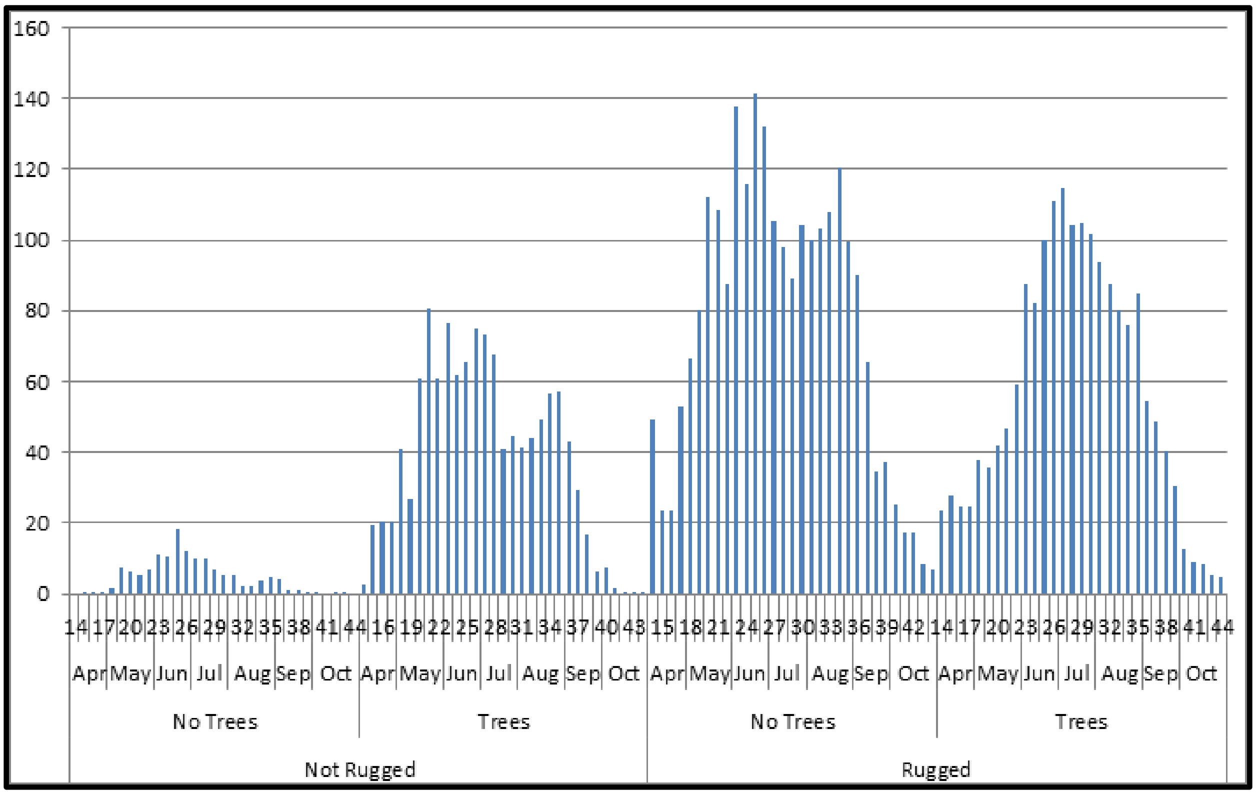

Figure 5. Average nightly activity by week recorded by the long-term detector network across the active season. Detectors are classified as being in Rugged or Not Rugged terrain and being associated with forested areas (Trees) or areas without forests (No Trees). Data from 112 detectors at 79 sites which recorded data during 1,351 active season months.

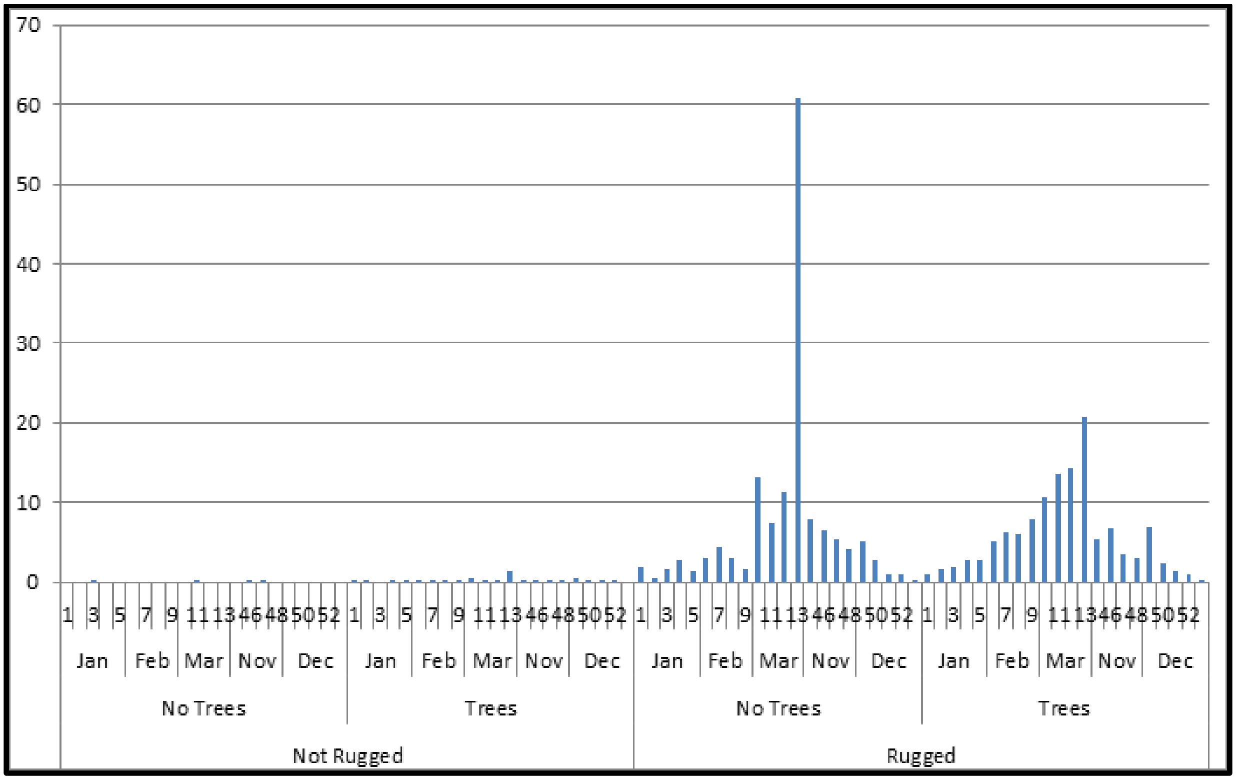

Figure 6. Average nightly activity by week recorded by the long-term detector network across the winter. Detectors are classified as being in Rugged or Not Rugged terrain, and being associated with forested areas (Trees) or areas without forests (No Trees). Note that almost no activity was recorded away from rugged terrain and potential hibernacula. Data from 112 detectors at 79 sites which recorded data during 939 winter season months

Weather and Bat Activity

Wind

Across Montana bat activity increases as wind speeds decrease and animals are most active during periods of calm or low wind. At the average network site, bat activity was greater than expected at random for wind speeds at 1 to 3 meters per second (Figure 9). Wind speeds less than three meters per second accounted for 72% of bat passes while wind speeds less than seven meters per second accounted for 97% of bat passes.

The association between wind and activity presents an opportunity to mitigate one of the most pressing threats for tree roosting species such as Hoary Bat and Silver-haired Bat. These two species have been killed by turbines at wind energy production facilities in the state (TRC Environmental Corporation 2008). The ultimate impact on the long-term persistence of these species is unknown, but the cumulative impact on the populations across North America may cause catastrophic declines in the next 50 years (Frick et. al 2017). However, operational mitigation such as furling the blades and curtailing production when wind speeds are below 6 m/s and bats are most active could help mitigate impacts.

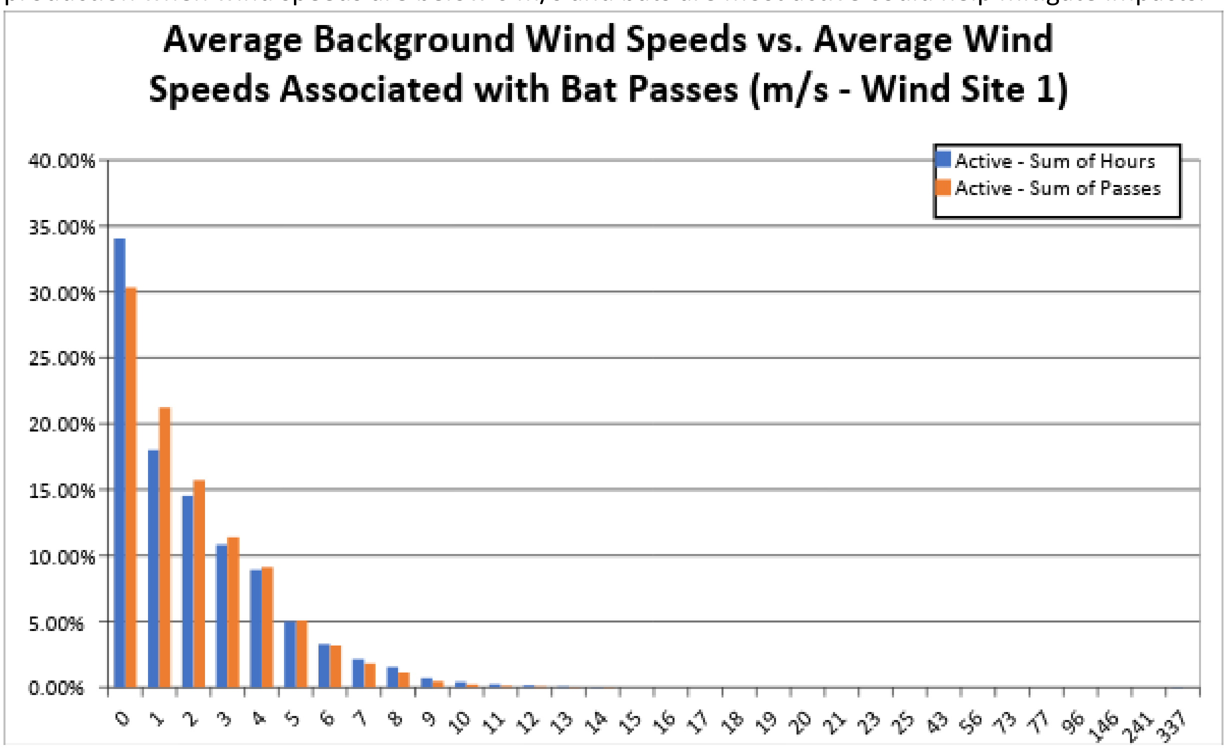

Figure 7. Activity of bats related to wind speed across the long-term acoustic detector network. Each detector hour (blue bars) and detector hours with bat activity (orange bars) are classified by average wind speed, and the proportion of each is displayed. Where orange bars exceed blue bars, bats are more active than would be expected given the available wind speeds. Data from 112 detectors at 79 sites which recorded data during 1,351 active season months

Barometric pressure

Across the state, there is a strong relationship between barometric pressure and activity by bats. In particular, activity generally increases during periods of decreasing pressure (Figure 10). For example, changes of -1 to -2 mb/hr or lower were associated with increased activity. Approximately 73% of bat activity across the network was associated with little to no change (-1 to 1 mb/hr) in hourly barometric pressure. However, bat activity was greater than expected during negative hourly changes (3 to -1 mb/hr) and less than expected with neutral or positive hourly changes (1 to 2 mb/hr) than if activity were randomly distributed.

Decreasing pressure is associated with incoming storm systems, which may help explain the relationship with activity. Bats may increase activity before these fronts in response to favorable foraging conditions. Insect abundance has been shown to correlate with low pressure (Paige 1995), providing bats with favorable foraging conditions. This may be particularly important if the animals have to wait out an extended period of unfavorable weather in torpor. Changes in pressure has resulted in increased mortalities of Hoary Bats at a wind energy facility in Alberta, likely due to increased activity of the bats themselves and their insect prey (Baerwald and Barclay 2011), and operational mitigation at wind energy sites during these pressure changes may also reduce mortalities at turbines.

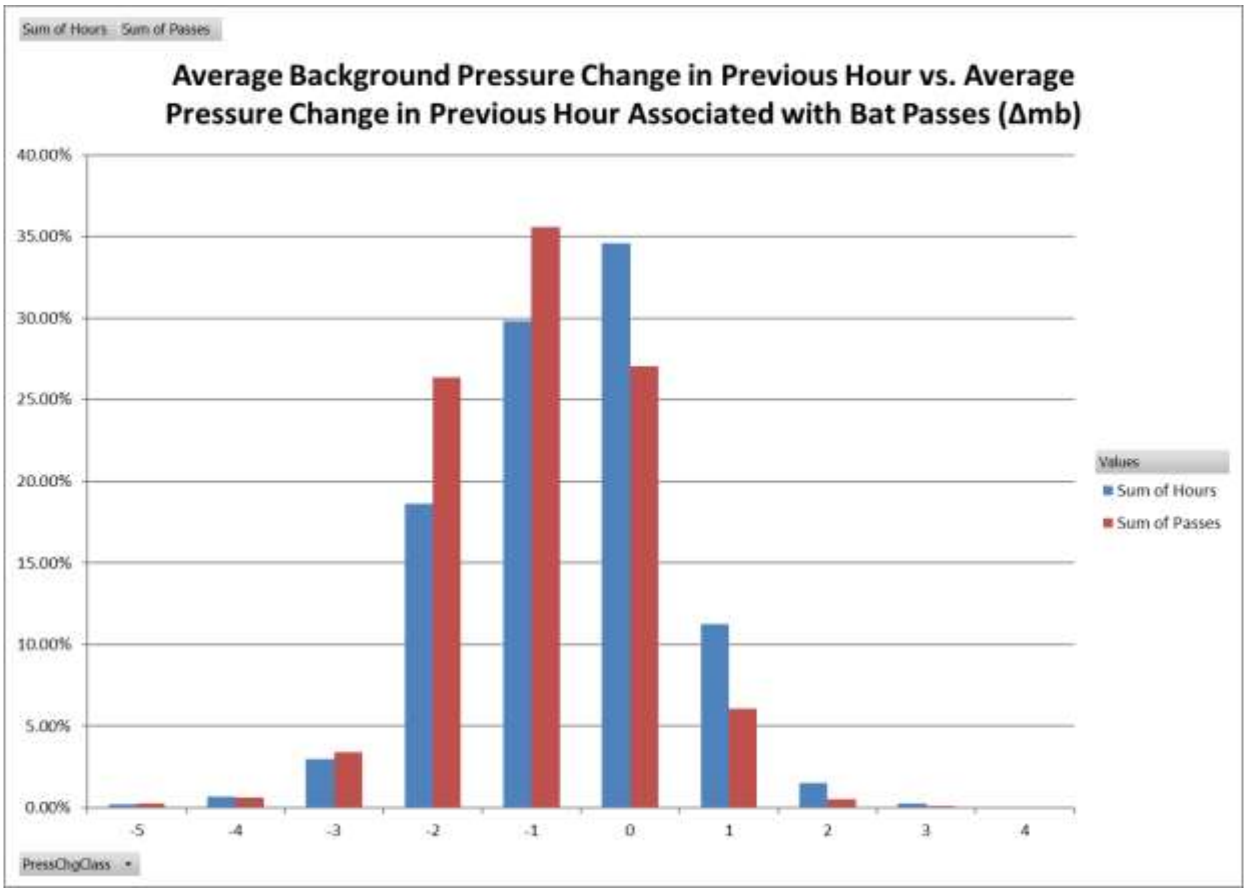

Figure 8. Activity of bats related to hourly changes in barometric pressure across the long-term acoustic detector network. Each detector hour (blue bars) and detector hours with bat activity (red bars) are classified by the difference in pressure (- falling and + increasing), and the proportion of each is displayed. Where orange bars exceed blue bars, bats are more active than would be expected given the change in pressure. Data from 112 detectors at 79 sites which recorded data during 1,351 active season months.

Precipitation

Across the acoustic detector network, bat activity was slightly higher (less than 1%) during hours without precipitation and slightly lower (less than 1%) during hours with precipitation than would be expected if bat activity was randomly distributed across available time (Figure 11). This lack of correlation between precipitation and activity is probably due to difficulty quantifying precipitation at the detector with weather stations near, but not at the sites. During the active season, thunderstorms are common and precipitation can be local, so a detestation may receive precipitation, but a proximal detector may remain dry and vice versa. Given that bats are capable of flight within minutes after the passage of a storm front and precipitation was coded in hourly bins, timing of recorded precipitation may not accurately reflect conditions at detector sites. As such, patterns of bat activity relative to recorded precipitation events at weather stations may not be meaningful at the network scale.

In contrast to these data, observed activity during mist net surveys decreases during periods of precipitation and few animals are captured on nights with consistent rain, although cool temperatures and wind may confound the association between this observed association between precipitation and activity. However, on nights when showers are brief activity quickly resumes at the end of precipitation (D. Bachen personal observation).

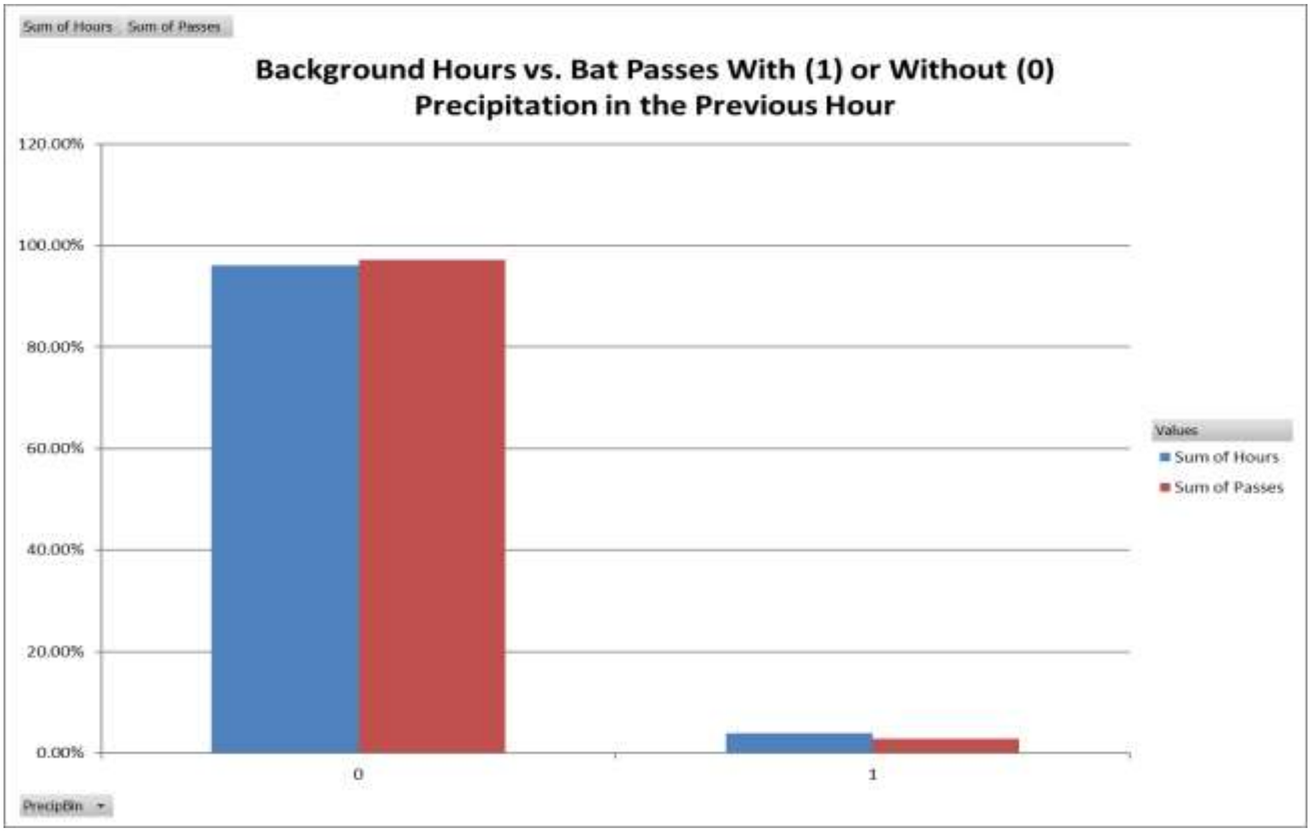

Figure 9. Activity of bats related to precipitation across the long-term acoustic detector network. Each detector hour (blue bars) and detector hours with bat activity (red bars) are classified by precipitation within that hour (0 for no precipitation, 1 for precipitation), and the proportion of each is displayed. Where red bars exceed blue bars, bats are more active than would be expected. Data from 112 detectors at 79 sites which recorded data during 1,351 active season months.

Temperature

In both the active season and winter bats are active during relatively warm periods of time (Figures 12 & 13). However, animals may also be active when the ambient temperatures are quite cold. The minimum temperature associated with a recorded bat passes is -20.5°C recorded in northcentral and southeast Montana. The warmest air temperature at which bats were recorded was 34.5°C in southeast Montana.

Selection for warmer air temperatures appears stronger in the winter than in the active season. In the active season activity peaked between 10 and 15°C, approximately 5°C above the average air temperature for this time period. In the winter activity peaked around 5°C, approximately 10°C higher than the average air temperature.

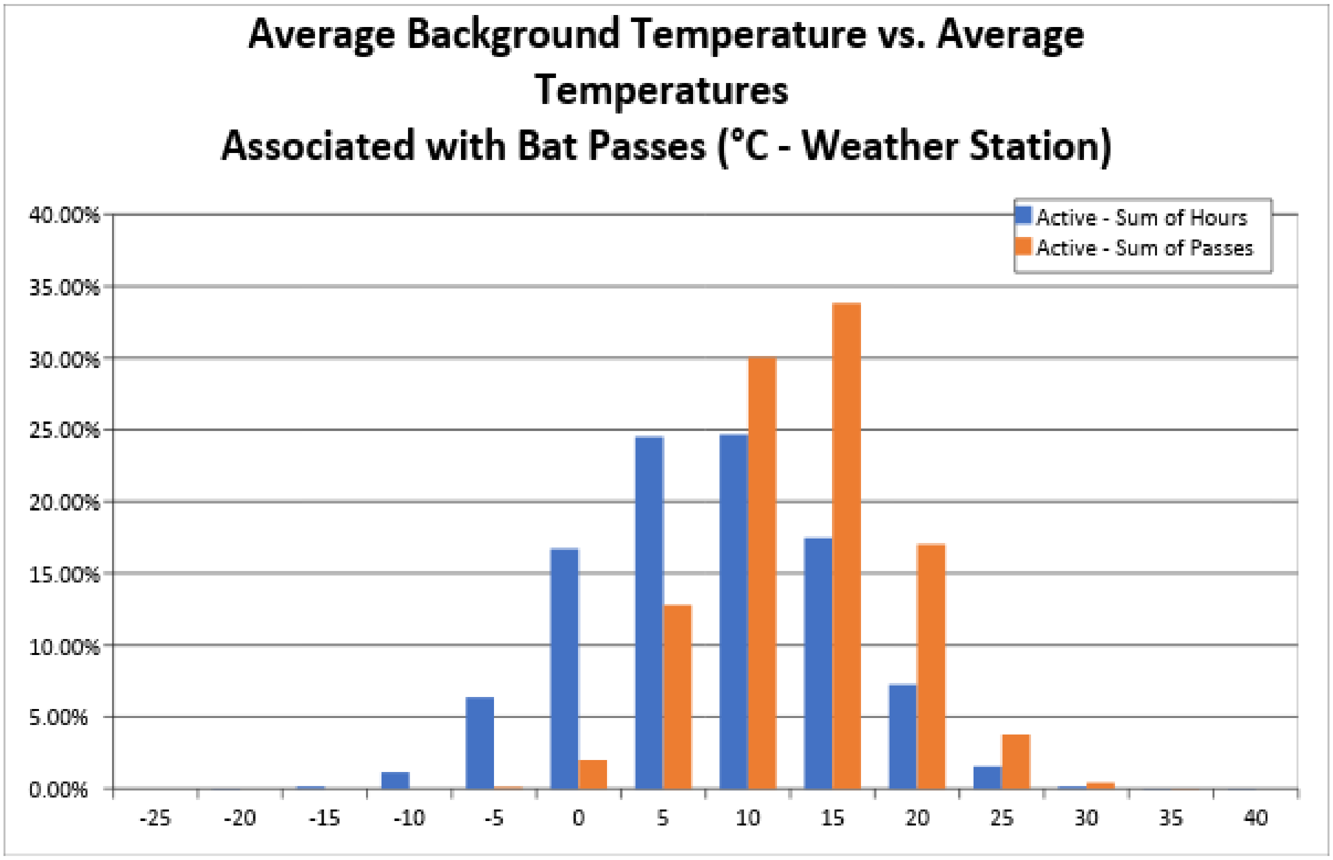

Figure 10. Activity of bats related to temperature across the long-term acoustic detector network during the active season. Each detector hour (blue bars) and detector hours with bat activity (red bars) are classified by average temperature (° C) within that hour, and the proportion of each is displayed. Where red bars exceed blue bars, bats are more active than would be expected at that temperature. Data from 112 detectors at 79 sites which recorded data during 1,351 active season months.

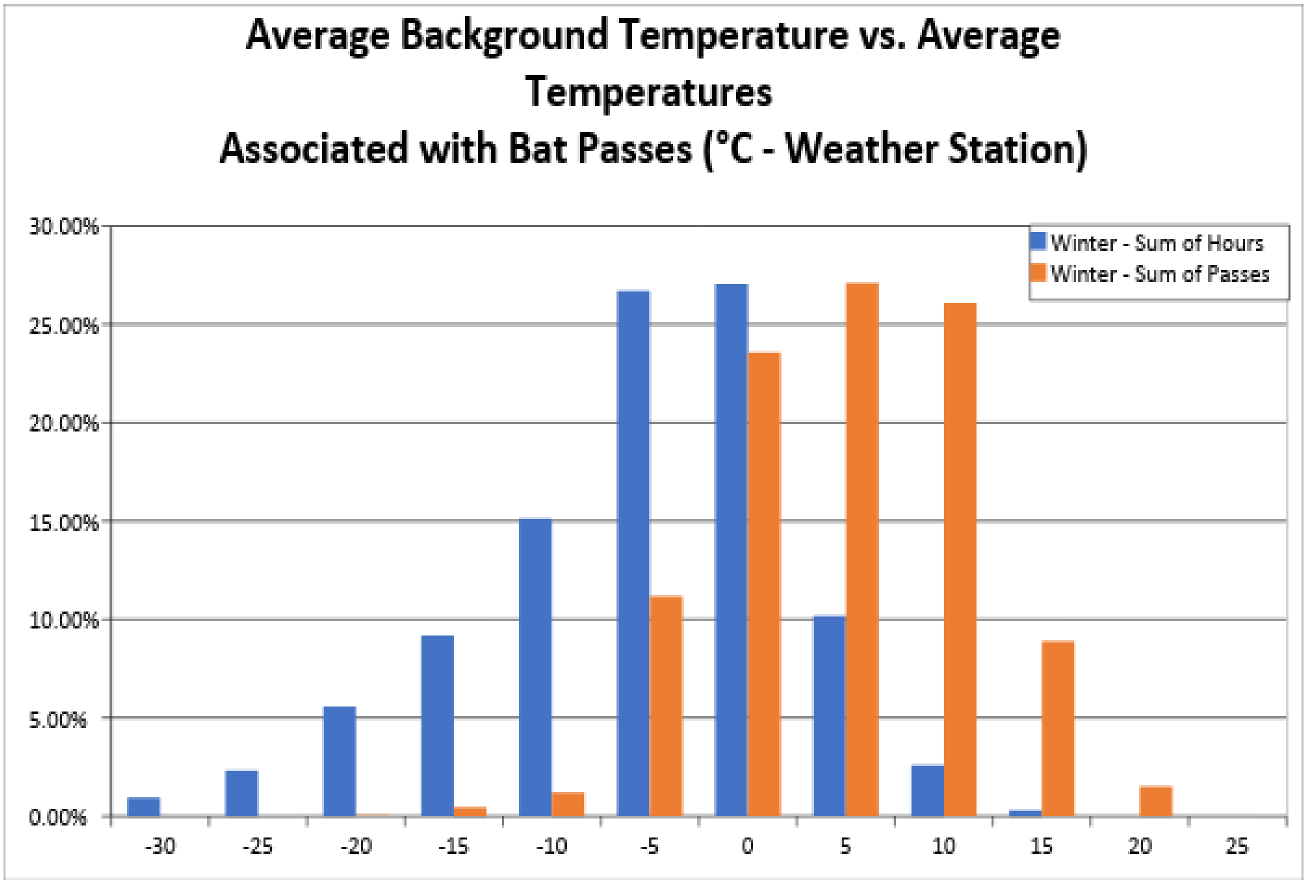

Figure 11. Activity of bats related to temperature across the long-term acoustic detector network during the winter. Each detector hour (blue bars) and detector hours with bat activity (red bars) are classified by average temperature (° C) within that hour, and the proportion of each is displayed. Where red bars exceed blue bars, bats are more active than would be expected at that temperature. Data from 112 detectors at 79 sites which recorded data during 939 winter season months.

Lunar Illumination and Activity

Across Montana bats appeared to become more active during periods of low lunar illumination and less active as illumination increases. During periods of low light when the moon was below the horizon or was new or close to new, bats were more active than would be expected if activity was random in relation to this attribute. Activity generally decreased as moon phase became brighter and above the horizon. Sites in canyons or in proximity to terrain that blocked moonlight, generally had increased activity around the full moon, which may be due to animals selecting areas that provide refuge from bright areas when foraging.

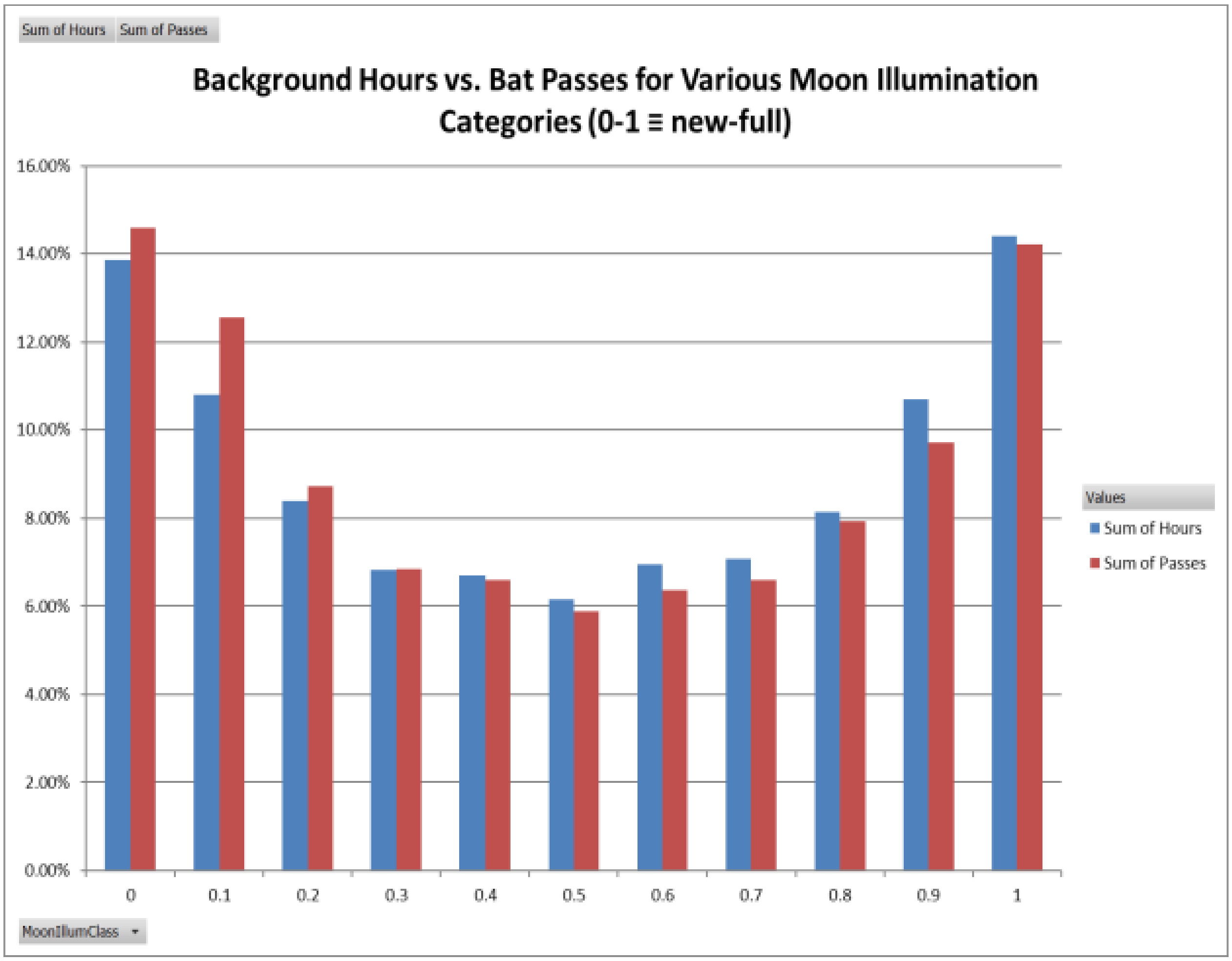

Figure 12. Activity of bats related to lunar illumination across the long-term acoustic detector network. Each detector hour (blue bars) and detector hours with bat activity (red bars) are classified by lunar illumination within that hour, and the proportion of each is displayed. Where red bars exceed blue bars, bats are more active than would be expected. 112 detectors at 79 sites, 62,440 nights recorded with an average of 578.1 nights per detector.

Overview of Roosting Habitat and Home Range / Foraging Distance Documented for Montana Bats

Bryce A. Maxell, Montana Natural Heritage Program - 24 February 2015 ; Updated 2018 by Dan Bachen, Montana Natural Heritage Program

The table, figures, and images below summarize and provide examples of what is known about winter, maternity, and day/night roost habitat use for Montana bat species in the state and/or elsewhere across their ranges. Protection of these cave, mine, cliff, rock outcrop, ground crevice, large tree, bridge, and building habitats with cracks and crevices ranging from $^{1}/_{3}$ to 1 inch in width and associated temperature and humidity regimes, is essential for protection and conservation of Montana's bats. Artificial bat roosts that provide summer maternity, night, and day roosts, can be deployed to serve as a surrogate for large diameter tree and other roosts that have been lost and/or to encourage roosting away from buildings where bats would be in close proximity to sleeping humans. Artificial winter roost habitat is not a viable management option at the present time.

Table 3. Summary of roosting habitat and home range for Montana's bat species including known roost features used within the winter and active seasons and observed home range sizes and foraging distances from the literatures. Sources are cited in this section below the table.

Species / Comments	Winter Roost	Summer Maternity Roost	Summer Day/Night Roost	Home Range/Foraging Distance
Pallid Bat (***Antrozous pallidus***) Low roost site fidelity with 90% of inter-night movements of 50-600 meters.[3] Highly social, often using day and night roosts in groups of 20 or more guided by social vocalizations and odors.[2, 4] Yearling females typically give birth to a single pup, but older females typically give birth to 2 pups.[4, 43]	Not documented in Montana, but likely occurs in deep rock crevices if the species is present.[1, 4]	Not documented in Montana. Elsewhere in vertical and horizontal rock crevices, under rock slabs, in buildings, and on taller and larger diameter live trees and tree snags with loose bark in mature stands with southerly aspects and lower percentages of overstory.[4, 37, 38, 41, 42, 44]	Under rock slabs, in horizontal and vertical rock crevices, and on farm equipment in Montana.[1] Elsewhere occasionally on buildings, bridges, caves, mines, vertical and horizontal rock crevices that are typically on east or southeast aspects, and taller and larger diameter live trees and tree snags with loose bark in mature stands with southerly aspects and lower percentages of overstory.[2, 4, 21, 22, 23, 30, 37, 38, 39, 40, 41, 44]	Lactating females moved an average of 2,450 meters +/- 845 from roost to foraging areas and had an average foraging area size of 1.56 square km +/- 0.88 SE. Post-lactating females moved an average of 210 meters from roost to foraging areas and had an average foraging area size of 5.97 square km +/- 2.69 SE in northern California.[37] Individuals commuted 1 to 4 km between day roosting and foraging areas, 0.5 to 1.5 km between day roosts and night roosts, and switched day roosts often, usually moving <200 meters between roosts (range 25 to 3,660 meters) in eastern Oregon.[38, 39] Individuals typically commuted 1-2 km from day roosts to foraging areas, but one male often used different day roosts separated by 10 km in California.[42]
Townsend's Big-eared Bat (***Corynorhinus townsendii***) High fidelity to maternity and hibernacula roosts, lower interseasonal roost site fidelity, and travel up to 24 km from hibernacula to summer foraging areas.[73] Forage and commute adjacent to vegetation.[72]	Twilight areas of caves, mines, and unused tunnels in Montana.[1, 31, 32, 75, 84] Limestone or lava tube caves and mines are known to be used elsewhere with arousal and movement within or between sites, possibly responding to changing temperature.[5, 73, 74, 82]	Caves and mines, often in twilight areas in Montana.[1, 75] Reported in caves, mines, buildings, and basal tree hollows elsewhere.[2, 5, 72, 73, 81, 82, 83] Females prefer cooler maternity roosts than other vespertilionid bat species.[2]	In Montana, usually in caves and mines, often in twilight areas, but more rarely building attics, root cellars, and pocket/daylight caves.[1, 21, 31, 32, 75] Reported in caves, mines, buildings and large diameter basal tree hollows elsewhere.[2, 5, 72, 81, 82, 83]	Average one-way travel distances between day roosts and foraging areas was 3.2 km +/- 0.5 SD for males and 1.3 km +/- 0.2 SD for females in coastal California; maximum distance traveled from the day roost was 10.5 km.[72]

Species / Comments	Winter Roost	Summer Maternity Roost	Summer Day/Night Roost	Home Range/Foraging Distance
Big Brown Bat (*Eptesicus fuscus*) Males often roost solitarily during summer. Rarely move more than 80 km between summer and winter roosts. [2, 6] Roost switching is common at natural roosts, but show high fidelity to man-made roosts.[64, 65, 71]	Caves, mines, and some evidence for rock crevices which are probably the most widespread winter roost in Montana.[1, 31, 84] Known to use narrow deep rock crevices or erosion holes in steep valley walls on the Canadian prairie and buildings in Ohio.[6, 62]	Buildings, bridges, large diameter trees snags with hollows or loose bark in Montana.[1, 75] Primarily large diameter tree snag hollows and crevices, but also live aspen hollows, in more sparsely spaced stands, deep rock crevices, and older human structures are known to be used elsewhere. [6, 29, 59, 64, 65, 66, 67, 68, 71]	Rock crevices, buildings, bridges, and caves in Montana.[1, 22, 31] Larger diameter tree snags with hollows and crevices and preferential selection for older more sparsely spaced stands, older buildings, and rock crevices with good solar exposure are known to be used elsewhere. [27, 29, 30, 64, 65, 66, 67, 68, 69, 71] Caves and mines known to be used as night roosts elsewhere.[70,]	Average of 1.5 km +/- 0.9 SD (range 0.4 to 1.8 km) from roosts to capture locations with average movement between successive roosts of 1.1 km +/- 0.7 SD (range 0.4 to 2.0 km) in the Black Hills of South Dakota.[29] Average one-way travel distances between day roosts and foraging areas of 1.8 km +/- 0.1 SE) range (0.3 to 4.4 km) in southern British Columbia.[64]
Spotted Bat (*Euderma maculatum*) High roost site fidelity with multiple individuals following the same nightly commuting routes up side canyons to foraging areas at speeds of up to 53 km/hr. [8, 49] Forage over clearings and along cliff rims. [49, 50, 51]	Not documented in Montana. Deep rock cracks and crevices are commonly used elsewhere and caves and human structures are rarely used elswhere.[1, 2, 7, 51]	Not documented in Montana. Rock cracks and crevices in upper portions of tall remote south facing cliffs near perennial waters are used elsewhere. [1, 2, 7, 8, 50]	Buildings and other human structures in Montana. [1, 47] Rock cracks and crevices in upper portions of tall remote cliffs near perennial waters, and, apparently more rarely, cave entrances and buildings elsewhere. [2, 7, 8, 45, 46, 47, 48, 49, 50, 51]	50-60 km round trip flight distances nightly with average home range size of 297 +/- 25 SE (range = 242.5 to 363.8) square km in northern Arizona. [8] Nightly round trip commutes of >77 km between day roosts, foraging areas, and night roosts that differed in elevation by ca. 2,000 meters in northern Arizona.[49] Nightly round trip foraging flights of 12 to 20 km in British Columbia. [50]
Silver-haired Bat (*Lasionycteris noctivagans*)	Not documented in Montana. Known to use loose bark, basal tree cavities, cavities under tree roots, and rock crevices on more southerly aspects and in older stands of trees, elsewhere with retreat to more underground sites at lower temperatures. [93] Use of mines is also known. [94]	Large diameter tree snags with loose bark or cavities in Montana. [1, 9, 26] Hollows and crevices in live aspen and large diameter and taller trees or tree snags in older lower canopy closure stands known to be used elsewhere. [9, 59, 86, 90, 91, 92, 95, 96]	Large diameter tree snags with loose bark or cavities and a building in Montana. [1, 26, 78] Large diameter trees or tree snags in older stands with hollows and crevices are predominant summer roost elsewhere, but rock crevices, buildings, bridges, and other human structures also used.[9, 22, 86, 90, 91, 96]	Distance between capture locations and roost snags ranged from 0.1 to 3.4 km (averages for juvenile males, juvenile females, adult males, and adult females were 1.3, 1.5, 1.8, and 0.5 km, respectively) in northeastern Washington. [96]

Species / Comments	Winter Roost	Summer Maternity Roost	Summer Day/Night Roost	Home Range/Foraging Distance
Eastern Red Bat (*Lasiurus borealis*) Species is a solitary rooster at heights of 1 to 6 meters from the ground, but forage and migrate in groups. [10]	Not documented in Montana and thought to migrate far to the south where they use tree roosts on warmer days and nights and retreat below leaf litter when temperatures dip below freezing. [10, 54]	Maternity roosts or lactating individuals have not been detected in Montana. Elsewhere, known to roost mostly in dense foliage that provides shade and protection from the wind, but also on trunks, of larger diameter mature deciduous and conifer trees, often in riparian areas. [10, 52, 53, 55, 56, 57]	Not documented in Montana. Elsewhere, known to roost mostly in denser foliage, but also on trunks, of larger diameter mature deciduous and conifer trees, often in riparian areas. Also more rarely in shrubs, under leaf litter, and on human structures. [10, 52, 53, 55, 56, 57]	Maximum distances traveled to foraging areas averaged 1.24 km (range 0.19 to 3.28) and foraging areas averaged 94.4 Ha +/- 20.2 SE with no significant differences between sex and age classes in Mississippi. [52] Maximum distances traveled from diurnal roosts to foraging areas ranged from 1.2 to 5.5 km for females and 1.4 to 7.4 km for males with average foraging area size of 334 Ha in Kentucky [53]
Hoary Bat (*Lasiurus cinereus*) Species is a solitary rooster at heights of 3 to 5 meters from the ground, but forage and migrate in groups. [11]	Not documented and thought to migrate far to the south of Montana in the winter. [11]	Only a bridge roost documented in Montana.[1] Known to be a solitary rooster in deciduous and conifer tree foliage that offers shelter from the wind and more southern exposure to the sun elsewhere. [11, 85, 86, 87, 88, 89]	A bridge, and cottonwood and green ash foliage in Montana.[1] Known to roost in deciduous and conifer tree foliage elsewhere. [1, 11, 85, 86, 87]	Females traveled one-way distances up to 20 km from day roosts while on first of up to five nightly foraging bouts in Manitoba Canada.[85]
California Myotis (*Myotis californicus*) Roosts alone or in groups. [12]	Recent acoustic and telemetry data indicates species likely overwinters in rock crevices in Montana.[1, Nate Schwab, personal communication] Rock crevices, caves, mines, tunnels, and buildings are used elsewhere. [2, 12, 25, 61]	Not documented in Montana. Elsewhere known to roost under loose bark or in holes or cracks in more isolated larger diameter tree snags in areas with lower canopy closure.[58, 59] More rarely, known to use buildings elsewhere. [60]	A house and a cellar in Montana. [32] Elsewhere known to roost under loose bark or in holes or cracks in more isolated larger diameter tree snags in areas with lower canopy closure.[58, 59] Also known to use rock crevices, bridges, buildings, and other human structures elsewhere. [12, 21, 22, 30, 60]	*No documentation found.
Western Small-footed Myotis (*Myotis ciliolabrum*) Mostly a solitary rooster, but sometimes aggregates in small groups. Fidelity to roost areas is shown, but roost switching within those areas is frequent [13, 63] Also show a high fidelity to commuting corridors.[63]	Caves and mines documented in Montana.[1, 76, 84] Known to use lava tube caves, deep cracks in ground, deep rock crevices, tunnels, and drill holes in rock elsewhere. [2, 13, 77]	Rock outcrop crevices with good solar exposure in Montana. [1] Known to rely mostly on vertical and horizontal crevices in cliffs and rock outcrops, but also documented using buildings elsewhere. [13, 63]	Rock outcrop crevices, bridges, caves, mines, and buildings in Montana. [1, 31, 32] Known to use rock outcrops, cracks in ground, tree hollows, and trees with loose bark elsewhere. [13, 63] No bats were detected using night roosts in a north central Oregon study.[63]	6 to 24 km round trip travel distances from roosts to foraging areas in north central Oregon. [63]

Species / Comments	Winter Roost	Summer Maternity Roost	Summer Day/Night Roost	Home Range/Foraging Distance
Long-eared Myotis (*Myotis evotis*) Suspected of only traveling short distances between summer and winter roosts. [14] Have low fidelity to individual roosts, but high fidelity to roost areas.[97, 98, 99]	Caves and mines.[1, 75, 84] May also use deeper rock crevices. [14]	Caves, cliff and rock outcrop crevices, and large diameter trees in Montana.[1, 26, 76] Known to use sheltered erosion cavities on stream banks, crevices in basalt, conifer stumps, conifer snags, buildings, and mine tunnels elsewhere. [14, 97, 98, 99]	Large diameter trees, rock outcrops, buildings, and caves in Montana. [1, 26, 31, 79] Known to use buildings, trees/snags with loose bark, trestle bridges, mines, rock crevices, stream bank cavities, and sink holes elsewhere. [14, 21, 27, 97, 98, 99]	Traveled an average of 970 meters (range 35-5,154 meters) between roosts in western Montana.[26] Moved 1 to 812 meters between day roosts and had roosting home ranges that ranged from 0.08 to 1.93 ha in Alberta.[97] Traveled 620 meters from capture sites to day roosts in western Oregon .[98] Traveled an average distance between day roosts of 148.9 m in northeastern Washington.[99]
Little Brown Myotis (*Myotis lucifugus*) Show high fidelity to summer colonies and hibernacula across years, but some individuals relocated between years a median distance of 315 km between hibernacula (range 6 to 563 km) and 431 km between summer roosts (range 25 to 464 km).[100] Males and nonreproductive females occupy cooler roosts than pregnant or lactating females.[15]	Caves and mines with high humidities and temperatures above freezing in Montana and elswhere. [1, 31, 36, 75, 84] May also use deeper rock crevices. [15] Predominantly documented using caves elsewhere. [100]	Attics and roofs of buildings, bridges, and bat houses in Montana. [1] Known to use cracks or hollows in larger diameter tree snags in older stands, rock crevices, and buildings elsewhere. [2, 15, 35, 90, 101, 102, 103]	Large diameter tree, rock crevices, buildings, bridges, caves, and bat houses in Montana. [1, 26, 31, 80] Known to use cracks or hollows in larger diameter tree snags in older stands, wood piles, and rock crevices elsewhere.[15, 35, 90] Caves and mines known to be used as night roosts elsewhere.[70]	Average 970 meters (range 35-5,154 meters) between roosts in western Montana.[26] Traveled 10 to 647 km from hibernacula to summer colonies in Manitoba and northwestern Ontario, Canada.[100] Female home range averaged 30.1 ha +/- 15.0 SD during pregnancy and 17.6 ha +/-9.1 SD during lactation in Quebec, Canada.[101] Males moved and average of 275 m +/- 406 SD between successive roosts, had mean minimum roosting areas of 3.9 ha +/- 7.9 SD, mean minimum foraging areas of 52.0 ha +/- 57.4 SD, mean distance between roosting and foraging areas of 254 m +/- 254.2 SD, and mean distances between capture sites and first roosts of 761 m +/- 623 SD in New Brunswick.[102] Mean home range area was 143 ha +/- 71.0 SE in New York.[103]

Species / Comments	Winter Roost	Summer Maternity Roost	Summer Day/Night Roost	Home Range/Foraging Distance
Northern Myotis (*Myotis septentrionalis*) Low roost site fidelity, but often stay in same general area within a season. May travel up to 56 km between summer and winter roosts. [16]	Only known from a single abandoned coal mine in Montana.[1, 75] Known from caves, with a preference to cluster in deep crevices and possibly move between caves within a winter elsewhere. [16]	Not documented in Montana. Known to use bark and hollows of larger diameter trees, usually in decay, and building crevices and bat houses elsewhere. [16, 29, 35, 69, 102]	Not documented in Montana. Known to use bark and hollows of larger diameter trees, usually in decay, and building crevices and bat houses elsewhere.[16, 29, 35, 69] Caves and mines known to be used as night roosts elsewhere.[70,]	Average of 2.2 km +/- 1.4 SD (range 0.1 to 5.9 km) from roosts to capture locations with average movement between successive roosts of 0.6 km +/- 0.5 SD (range 0.1 to 1.5 km) in the Black Hills of South Dakota.[29] Females/males moved and average of 457/158 m +/- 329/127 SD between successive roosts, had mean minimum roosting areas of 8.6/1.4 ha +/- 9.2/1.4 SD, mean minimum foraging areas of 46.2/13.5 ha +/- 44.4/8.3 SD, mean distance between roosting and foraging areas of 584.6/293.0 m +/- 405.8/282.8 SD, and mean distances between capture sites and first roosts of 1001/402 m +/- 693/452 SD in New Brunswick.[102]
Fringed Myotis (*Myotis thysanodes*) Very sensitive to roost site disturbance. [17] Maintain at least some level of group integrity when switching roosts. [29]	Caves in Montana. Some individuals may migrate south of Montana. [1]	Caves. [1] Known to use cracks and hollows of larger diameter trees, usually in decay, rock crevices on south-facing slopes, and buildings elsewhere. [17, 29]	Caves in Montana. [1, 32] Known to use cracks and hollows of larger diameter trees, usually in decay, rock crevices on south-facing slopes, mines, buildings, and bridges elsewhere. [17, 21, 22, 29]	Average of 1.0 km +/- 0.6 SD (range 0.1 to 2.0 km) from roosts to capture locations with average movement between successive roosts of 0.5 km +/- 0.6 SD (range 0.1 to 2.0 km) in the Black Hills of South Dakota.[29]
Long-legged Myotis (*Myotis volans*)	Caves and mines in Montana and elsewhere. [1, 19, 31, 36, 75, 84]	Large diameter trees in Montana. [1, 26] Elsewhere in taller, but random to normal diameter tree snags with loose bark or cracks, especially in areas with less habitat fragmentation, greater snag density but with greater tree spacing. [28, 33, 34, 35] Also in rock crevices, cracks in the ground, and buildings are known to be used elsewhere with south-facing roosts preferred. [2, 29]	Buildings, mines, caves and large diameter trees in Montana. [1, 26, 31, 32, 78, 79] Elsewhere in taller but random to larger diameter tree snags with loose bark or cracks, especially in areas with less habitat fragmentation, greater snag density but with greater tree spacing, are known to be used elsewhere with south-facing roosts preferred. [27, 28, 29, 30, 33, 34, 35] Also in buildings, cracks in the ground, rock crevices, and caves. [19, 36]	Average of 2.0 km +/- 0.1 SE from roosts to capture locations with average movement between successive roosts of 1.4 km +/- 0.1 SE across four study areas in Washington and Oregon.[28] Average of 1.9 km +/- 1.6 SD (range 0.4 to 3.7 km) from roosts to capture locations with average movement between successive roosts of 0.7 km +/- 0.5 SD (range 0.2 to 1.6 km) in the Black Hills of South Dakota.[29] Average home range size of 647 ha +/- 354 SE (range 16.5 to 3,029 ha) for males, 448 ha +/- 78.7 SE for pregnant females, and 304 ha +/- 53.8 SE for lactating females in Idaho.[33]

Species / Comments	Winter Roost	Summer Maternity Roost	Summer Day/Night Roost	Home Range/Foraging Distance
Yuma Myotis (*Myotis yumanensis*) Sensitive to roost site disturbance.[2]	Not documented in Montana, but acoustic evidence indicates overwintering in rock crevices in cliffs.[1]	Building, bridges, and bat houses in Montana.[1] Buildings, bridges, caves, mines, and abandoned cliff swallow nests are known elsewhere.[2, 20, 21, 22, 25]	Buildings, bridges, and bat houses in Montana.[1, 79] Large diameter trees, buildings, rock/cliff crevices and abandoned cliff swallow nests elsewhere.[2, 21, 22, 23, 24, 25, 30]	Average of 2 km (range 0.59-3.5 km) from roosts to capture locations in California.[24] 4 km from maternity roost to foraging areas in British Columbia.[25]

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A Morphological Key to the Bats of Montana

Identification of bats within our region is best accomplished by first determining if the species is within the genus *Myotis*. Non-*Myotis* bats have easily recognizable features and identification rarely requires detailed morphological analysis. The exception to this is the Big Brown Bat, which may initially appear similar to *Myotis* bats, albeit larger in size.

Separate Myotis Bats from non-*Myotis* species

1a. Mass does not exceed 10g, forearm often less than 41mm in length.**2. *Myotis* Bats**

1b. Mass exceeds 10g and forearm exceeds 41mm in length. **9. Non-*Myotis* Bats**

2. Myotis Bats

2a. Animal has distinct keel on calcar (Figure 15). **3**. **Keeled *Myotis***

2b. Keel indistinct or not present **5. Keel-less *Myotis***

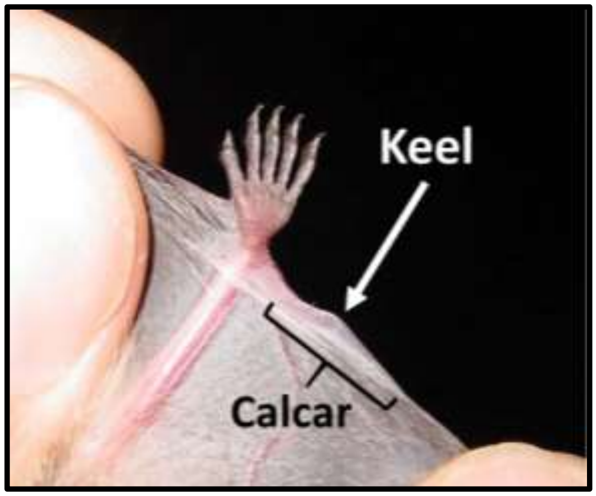


Figure 13. Distinct keel on calcar between hind foot and tail. Note if not initially detected on one side, double check the other to ensure that the feature is not missed. © US Fish and Wildlife Service

3. Keeled Myotis: Three species of *Myotis* have a distinctly keeled calcar (Figure 15.) *M. volans* is easily separated from *M. californicus* and *M. ciliolabrum* based on its larger size (forearm greater than 36mm, mass greater than 6g). The latter species are small and easily confused and detailed examination of the pelage, muzzle, and tail are necessary for identification. Where range overlaps, genetic confirmation of species identity should be considered.

3a. Fur present on underside of wing extending to elbow (Figure 16). Usually dark chocolate in color. Forearm is at least 36mm in length. **Long-legged Myotis** (***Myotis volans)***

3b. Forearm less than 35mm and mass does not exceed 6g. **4**

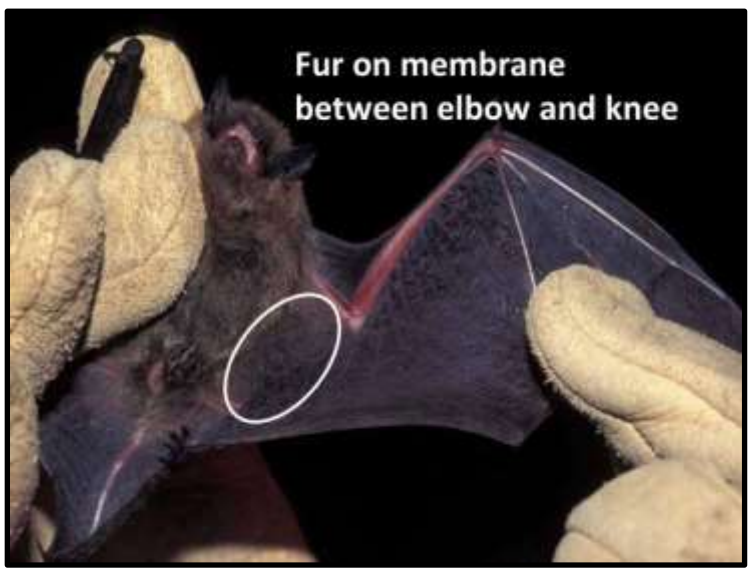


Figure 14. Location of diagnostic fur on underwing of Long-legged Myotis (M. volans). ©Kristi DuBois

4a. Bare snout length 1.5 times distance between nostrils (Figure 17, left). Tail extends well beyond membrane (Figure 17, right). Pelage blond, dark ears and face give the appearance of a mask. **Western Small-footed Myotis** (***M. ciliolabrum)***

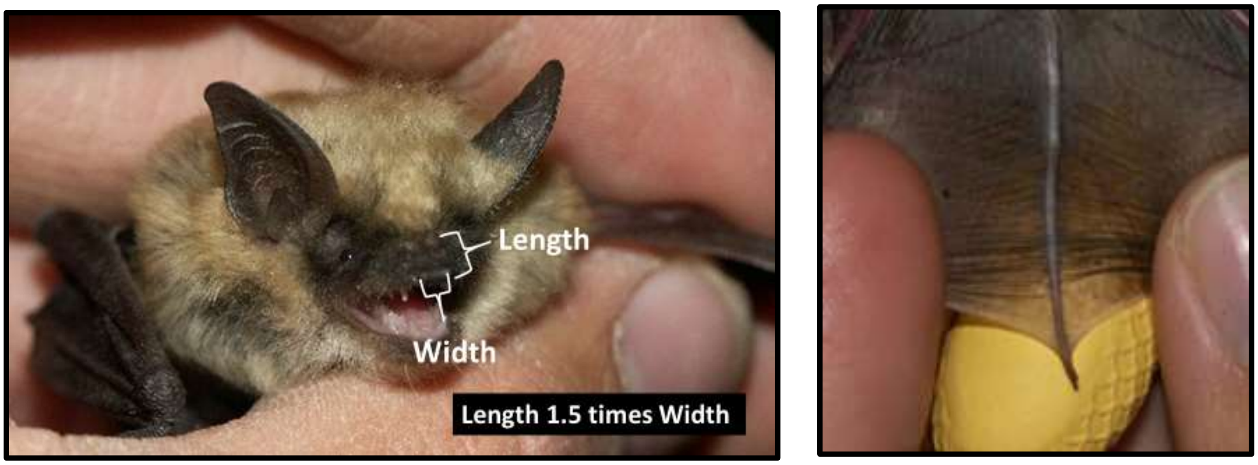


Figure 15 Definitive characteristics of the Western Small-footed Myotis (M. ciliolabrum) used to separate it from California Myotis (M. californicus). © Adam Messer

4b. Bare snout length same length as distance between nostrils (Figure 18, left). Tail barely extends beyond membrane (Figure 18, right). Known to be present in western Montana and mountainous areas in central and southern Montana east to the Pryor Mountains. **California Myotis** (***M. californicus)***

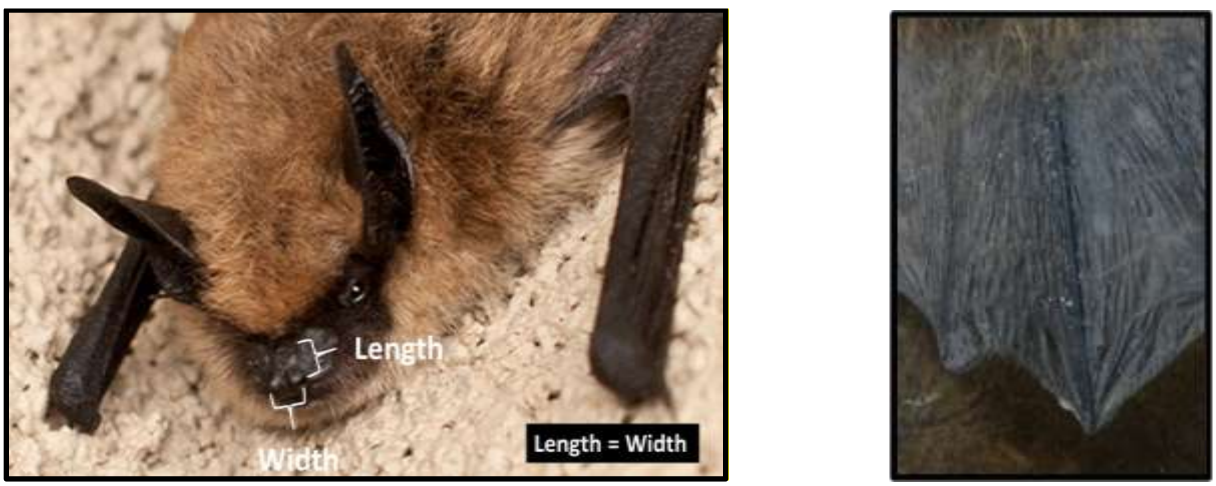


Figure 16. Definitive characteristic of the California Myotis (M. californicus) used to separate it from the Western Small-footed Myotis (M. ciliolabrum). ©Frank Carey, some rights reserved

5. Keel-less Myotis: This group is comprised of the easily-confused Long-eared Myotis species and the closely related *M. lucifugus*/*yumanensis* group.

5a. Ears 14mm or greater. When gently pressed forward, ear tips extend past the end of the muzzle. **6**. **Long-eared Myotis Species**

5b. Ears less than 14mm and do not extend beyond muzzle when pressed forward. **8.** ***M. lucifigus/ M. yumanensis***

6. Long-eared Myotis Species:

6a. Ear 14-16mm and when gently pressed forward, extends 3-5mm beyond end of muzzle. Tragus 8-10mm in length and tapers to narrow point (Figure 19). Membranes and pelage brown, rarely black. Area around eye between ear and mouth often sparsely haired with light brown/ pink skin. Known from forested areas along Yellowstone and Missouri rivers near the North Dakota Border. **Northern Myotis a.k.a Northern Long-eared Bat** (***M. septentrionalis***). *Due to federal status and ease of confusion with similar species, genetic verification of species identity is strongly recommended.*

Figure 17. A comparison of the profile of the Northern Myotis (M. septentrionalis, left panel) and Long-eared Myotis (M. evotis, right panel). Note the subtle difference in tragus shape. The tragus of the M. septentrionalis tapers to a narrow point while the tragus of M. evotis ends in a broad point. Photos © Mike McGrath USFW (left), Kristi DuBois (right)

6b. Not as above. Forearm greater than 37mm. **7**

7a. Uropatagium may have sparse soft hair on margin, but this is only visible with close examination. Ear greater than 5mm beyond end of muzzle when gently pressed forward (total length 16-25mm). Tragus ends in a broad point. Forearm generally 40mm or less. **Long-eared Myotis** (***M. evotis)***

7b. Uropatagium has bristle-like hairs on the margin apparent without detailed examination (Figure 20). Ears 14-18mm. Forearm generally 40mm or greater, but always greater than 38mm. **Fringed Myotis (*M. thysanodes)***

Figure 18. Bristle like hairs on the uropatagium of M. thysanodes. Upon close examination, all Myotis bats have some hair on the margin of this membrane. M. thysanodes is the only Myotis species in this region to have stiff hairs that are easily seen. A general rule of thumb is that if you have to look hard for this attribute, the animal is most likely a M. evotis. *© Adam Messer*

8. *M. lucifugus / M. yumanensis*: Species very similar in morphology and appearance. West of the Continental Divide, significant overlap exists with M. yumanensis and identification of individuals with intermediate morphological characteristics often requires use of acoustic equipment. For some individuals, genetic identification is the only means of accurately assessing species (see Figure 21).

8a. Forearm length greater than 36.5mm is definitive. If forearm is shorter, a call sequence with a characteristic frequency of less than 44kHz is diagnostic. For individuals that do not meet these criteria, genetic identification is required (see Figure 21). Found across Montana. **Little Brown Myotis (*M. lucifugus*)**

8b. Forearm length less than 36.5mm in length and a characteristic frequency of greater than 47kHz are definitive for this species. Genetic identification is required for all other individuals (see Figure 21)**.** Currently known to be present along, and west of, the Continental Divide. **Yuma Myotis (*M. yumanensis*)**

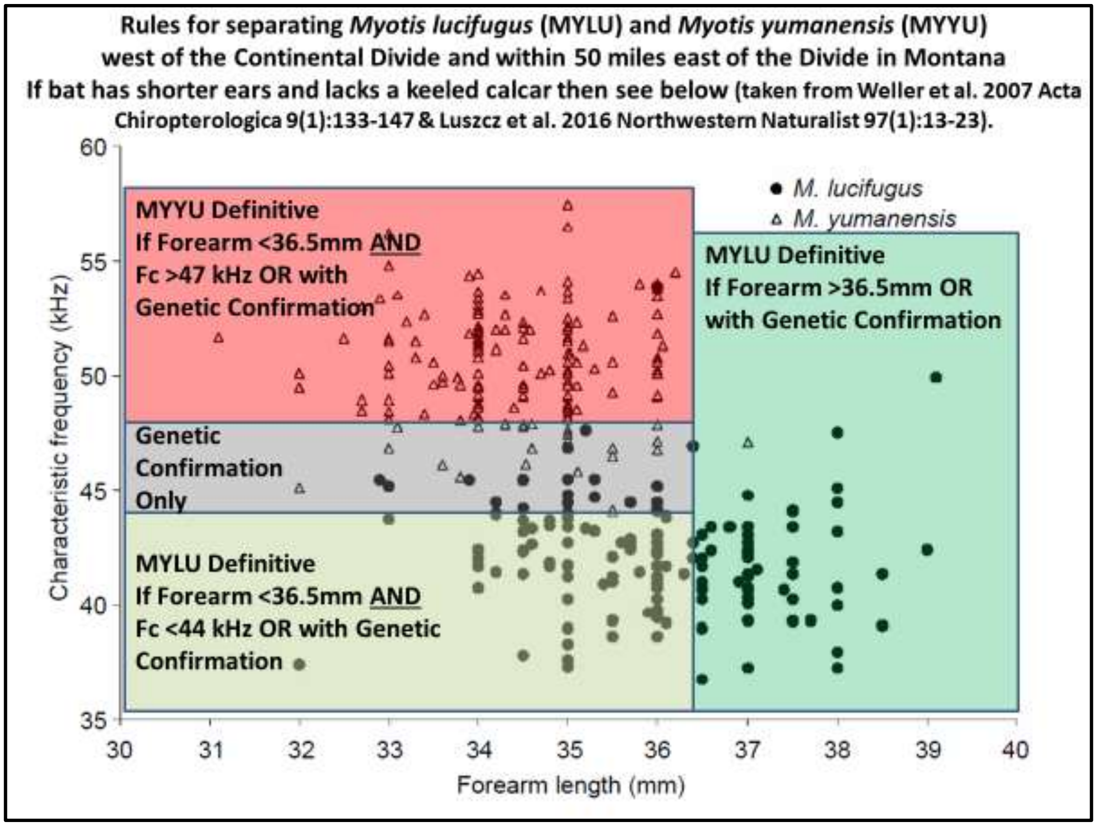


Figure 19. Rules for separation of Yuma Myotis (M. yumanensis) from Little Brown Myotis (M. lucifugus).

9. Non-Myotis Bats

9a. Ear length 20mm or greater. **10**

9b. Ear length less than 20mm. **12**

10a. Distinct black pelage with white spots (Figure 22). **Spotted Bat (*Euderma maculatum*)**

10b. Pelage uniform in color. **11**

11a. Ears 30mm or greater and forearm less than 50mm. Pelage grey to dull brown. Distinct glands giving the rostrum a "lumped" appearance (Figure 23). **Townsend's Big-eared Bat (*Corynorhinus townsendii*)**.

11b. Ears less than 28mm, and forearm 55mm or greater. Light colored pelage. Nostrils distinctly pig-like in appearance (Figure 24). Captured in xeric forest or desert environments. **Pallid Bat (*Antrozous pallidus*)**

Figure 20. Spotted Bat (Euderma maculatum). ©Dick Dede, Jr.

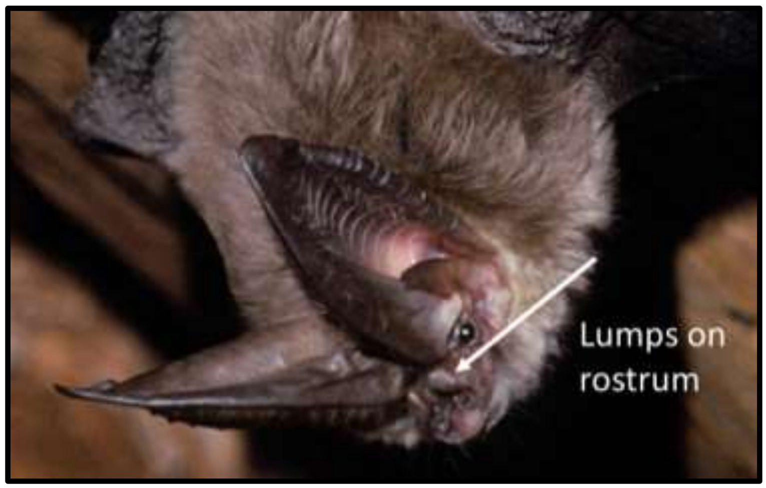


Figure 21. Townsend's Big-eared Bat (Corynorhinus townsendii) © Kristi DuBois

Figure 22. Pallid Bat (Antrozous pallidus). Note the shape of the nostrils and muzzle, which may help distinguish it from the Townsend's Big-eared Bat (Corynorhinus townsendii). © Bryce Maxell

12a. Uropatagium well furred (Figure 25), pelage either dark with white tips or brick red. **13**

Figure 23. Levels of fur on the uropatagium. Left panel shows well-furred uropatagium while the right panel shows a uropatagium lacking fur. © Susan Lenard and Bryce Maxell (left), Kristi Dubois (right

12b. Mass exceeds 10g for adults and forearm is over 42mm and often over 45mm. Uropatagium not furred. Superficially similar to *Myotis* in appearance, but larger. Muzzle is "dog-like" in appearance. Pelage color variable from light blond to dark brown (Figure 26). **Big Brown Bat** (***Eptesicus fuscus***)

Figure 24. Big Brown Bat (Eptesicus fuscus). ©Kristi DuBois

13a. Forearm at or less than 45mm. Mass 15g or less. Pelage may either be black (older individuals) or black with white/silver tips (younger individuals). Anterior edge of ear is light in color, contrasting with dark pelage and membranes (Figure 27). **Silver-haired Bat (*Lasionycteris noctivagans*)**

13b. Forearm greater than 45mm and pelage dark at base with grey/white tips. If forearm less than 45mm, pelage yellow to brick red in color. **14. *Lasiurus* bats**

Figure 25. Silver-haired Bat (Lasionycteris noctivagans) © Kristi DuBois

14a. Pelage orange to red with dark wing membranes (Figure 28). Captured infrequently in forested areas or over water east of the Continental Divide. **Eastern Red Bat (*Lasiurus borealis)***

14b. Forearm at or exceeds 50mm. Mass greater than 18g but often at or greater than 24g. Distinct white patches on wrists and elbows (Figure 15). **Hoary Bat (*Lasiurus cinereus*)**

Figure 26. Eastern Red Bat (Lasiurus borealis). © Susan Lenard and Bryce Maxell

Figure 27. Hoary Bat (Lasiurus cinereus). Note white patches on wrist and elbows. ©Kristi Dubois

Measurements of Adult Bats from Montana, Northern Idaho, and Western South Dakota

The following tables and figures show the distribution of measurements, and age, sex, and status information collected from 3,222 bats representing 14 species captured between 1994 and 2016 across Montana, northern Idaho, and western South Dakota by biologists working with or for the Montana Natural Heritage Program, Montana Fish, Wildlife, and Parks, the U.S. Forest Service, and the Bureau of Land Management. We have compiled this information as a supplement to *A Morphological Key to the Bats of Montana*, to aid in identification of bats of the region, and allow comparisons of species' morphologies. In many of the data tables and figures, we have combined measurements from both male and female animals and do not account for physical condition such as pregnancy or sexual status in order to simplify display of information for use in species determinations.

Although common species such as the Little Brown Myotis (*Myotis lucifugus*) are well represented within these data summaries, other species have rarely been captured and have very few observations. Additionally, some measurements such as weight and forearm length have frequently been recorded, while others such as tragus length have been recorded less commonly. Due to the dearth of measurements for some species and features, we recommend that future studies record all measurements listed here. In particular tragus length should be measured on all Long-eared Myotis (*Myotis evotis*) captures, and thumb length should be recorded for all Western Small-footed Myotis (*Myotis ciliolabrum*) and California Myotis (*Myotis californicus*) captures.

Table 4. The number of adult individuals captured in Montana, Idaho or South Dakota used to determine the mean measurements and range for each feature. Note some species have been captured infrequently so these statistics may be biased due to low sample size.

Species*	4-letter Code*	Total	Weight	Forearm	Ear	Tragus	Thumb	Foot
Antrozous pallidus	**ANPA**	7	4	5	3	0	0	0
Lasiurus cinereus	**LACI**	230	192	205	68	31	42	38
Euderma maculatum	**EUMA**	0	0	0	0	0	0	0
Eptesicus fuscus	**EPFU**	379	307	324	128	60	77	76
Corynorhinus townsendii	**COTO**	29	27	26	12	0	0	0
Lasiurus borealis	**LABO**	7	6	7	3	3	3	3
Lasionycteris noctivagans	**LANO**	410	334	363	3	39	54	54
Myotis volans	**MYVO**	294	257	285	138	31	55	124
Myotis ciliolabrum	**MYCI**	125	109	117	50	22	42	52
Myotis californicus	**MYCA**	38	29	38	23	1	1	12
Myotis septentrionalis	**MYSE**	24	24	24	3	2	2	2
Myotis evotis	**MYEV**	483	425	456	316	57	81	92
Myotis thysanodes	**MYTH**	22	13	21	20	2	7	5
Myotis lucifugus	**MYLU**	889	773	818	293	117	132	136
Myotis yumanensis	**MYYU**	21	20	21	16	7	4	11

*Throughout this document 4-letter species codes are the first two letters of genus and species names.

*Table 5. Definitive features and measurements for Montana Bat species. The 5th to 95th quantiles are shown for each measurement with the mean in parentheses. See sample sizes in table above and box and whisker plots below for each measurement; * indicates too few measurements to display.*

Species	Keeled Calcar	Forearm (mm)	Weight (g)	Ear (mm)	Tragus (mm)	Thumb (mm)	Foot (mm)	Other Key Identifying Features
Larger easily identified bats								
LANO	N	39.5-43.5 (41.4)	9-14.5 (11.7)	9.6-14 (11.7)	3-6 (3.7)	4.7-7.3 (6)	5-9 (7.2)	Black pelage with more silver highlights in younger animals. Light color at base of small rounded black ears.
EPFU	Y	43.4-49 (46.1)	14-24.7 (18.8)	11-15 (13.1)	3-8 (5.2)	6-9 (7.4)	7-11 (9)	Doglike muzzle. Pelage light blond to dark brown.
LACI	Y	50.7-56.1 (53.2)	20.1-31.1 (25.4)	10.7-15 (12.9)	4-8 (6.1)	9-12 (10.9)	7-12 (9.6)	Grizzled dorsal fur contrasting with yellowish collar and white elbow patches. Small rounded ears.
LABO	Y	39.3-43 (41.2)	11.2-20.5 (16.2)	*	*	*	*	Reddish color with dark wing membranes. Small rounded ears, resembles small red LACI.
ANPA	N	55.4-59.8 (57.4)	20.2-22.8 (21.2)	*	*	*	*	Doglike muzzle with forward facing pig like nostrils having horseshoe shaped ridge. Large ears, pale in color, musky odor.
COTO	N	42.8-46.9 (44.4)	8.9-14 (10.8)	30.1-33.9 (31.8)	*	*	*	Very large ears joined on forehead. Two prominent lumps on nose.
EUMA	N	*	*	*	*	*	*	Large ears, distinct black pelage with 3 white patches.
Myotis Species: use calcar keel, forearm length, and then other key features listed. Bold lines are used to group morphologically similar species								
MYVO	Y	36.8-40.8 (38.9)	6.5-9.3 (7.9)	9-12.9 (10.9)	3-7 (4.8)	5-7 (6.2)	6-9 (7.3)	Fur on underside of wing extending to elbow. Usually dark chocolate in color.
MYCI	Y	30.1-33.9 (32.1)	4-5.7 (4.7)	10-13 (11.4)	3-6 (4.7)	4-6 (4.8)	5-8 (6)	Bare snout length 1.5 times distance between nostrils. Tail extends well beyond membrane. Light color with contrasting black mask.
MYCA	Y	31.9-34.5 (33.3)	4.3-6 (5.1)	9-13 (11.3)	*	*	5-6.8 (6)	Bare snout length same length as distance between nostrils. Tail barely extends beyond membrane.
MYSE	N	33.1-37.4 (35.0)	7-9 (8)	14-17 (15.7)	6-10 (8.3)	6.3-8.5 (7.25)	7-9 (8)	Ear 14-17mm in total length extends <5mm beyond tip of nose. Tragus long and slender. If caught collect guano or tissue sample for genetic verification.
MYEV	N	36.7-40.5 (38.6)	5.5-8.5 (6.7)	16-20 (18)	6.5-11 (8.8)	6-9 (7.2)	6.5-10 (8.2)	Ear >16mm extends beyond tip of nose > 5mm. Ear length variable. Fine hair may be present on edge of tail membrane, but is NOT a conspicuous fringe.
MYTH	N	38.8-43.6 (40.9)	6.1-10 (7.9)	14-19 (16.2)	*	5-7 (6.2)	7.2-10.7 (8.8)	Conspicuous fringe of stiff hairs extending from edge of tail membrane.
MYLU	N	35.1-39 (37)	5.5-10 (7.2)	10-13 (11.6)	4-7 (5.5)	5-8 (6.1)	6.5-10 (8.4)	Forearm > 36.5mm or forearm <36.5 AND characteristic frequency <44 kHz separates from MYYU, otherwise genetic confirmation needed.
MYYU	N	34.5-36.8 (35.6)	5.8-8 (6.5)	9.7-13.2 (11.5)	3.2-6 (4.6)	*	6.3-9.5 (8.3)	Forearm <36.5mm AND characteristic frequency >47 kHz separates from MYLU, otherwise genetic confirmation needed.

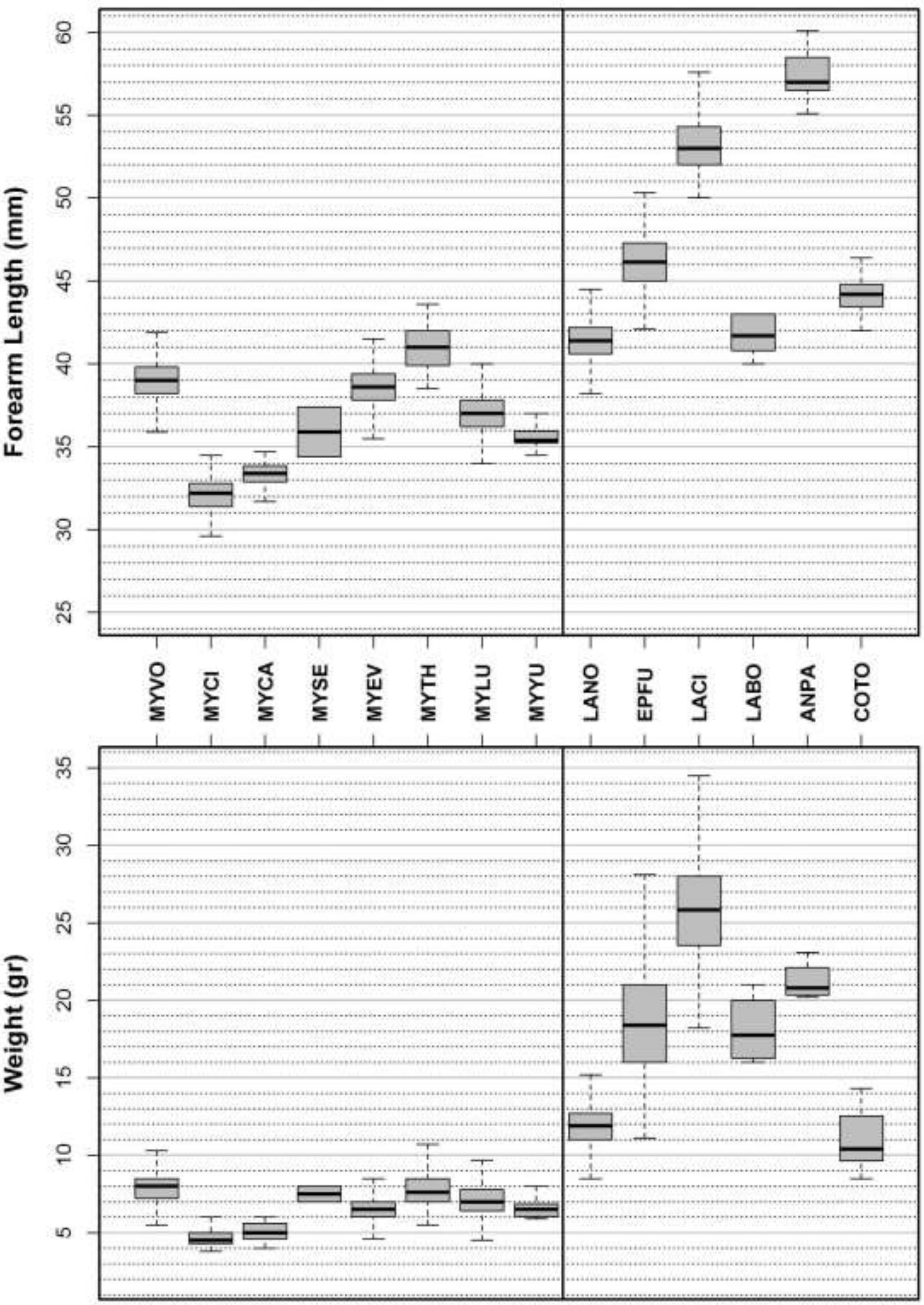


Figure 28. A comparison of the distribution of measurements for forearm length and weight of bats found in Montana. Note that the corresponding species names can be found in Table 4.

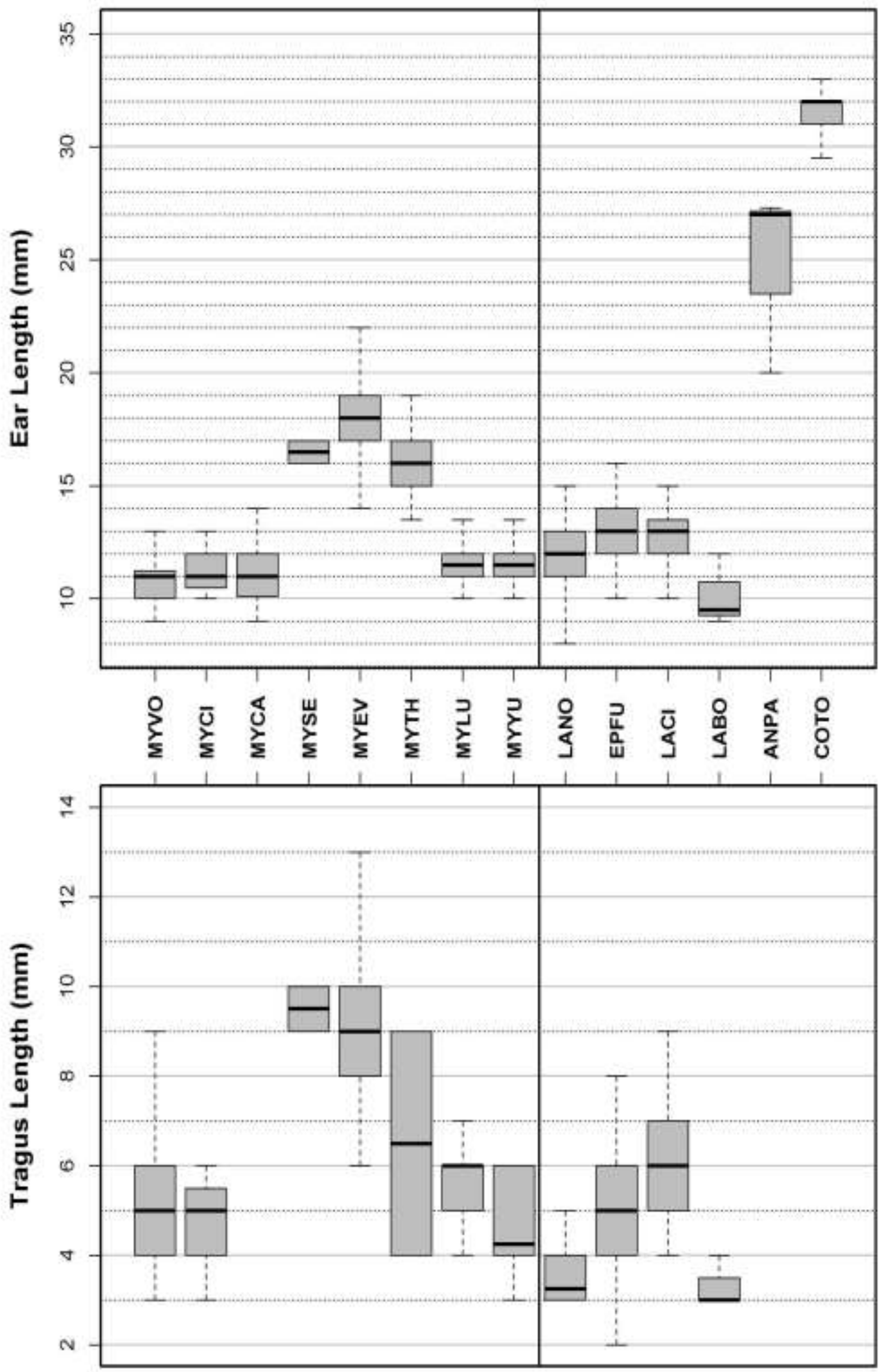


Figure 29. A comparison of the distribution of measurements of ear and tragus lengths for bats found in Montana. Note that the corresponding species names can be found in Table 4

Echolocation Call Characteristics of Montana Bats

Table 6. Frequency characteristics and diagnostic criteria for bat species found in Montana. Mean frequencies are shown in bold for each feature and the range of measurements is displayed below in each box. Call sequences analyzed to produce this table are from Humbolt State University Bat Lab and the Montana Bat Call Reference library.

	species	f_c	low f	high f	f_{max}	dur	Upper slope	Lower slope	Total slope	Diagnostic[2] and Special characteristics	Hand-Class Priorities[3]	MTNHP Notes[3]	Search Phase call intervals[3]
50	***Myotis yumanensis***	**49.2**	**45.6**	**90.0**	**55.2**	**5.5**	**16.6**	**4.4**	**8.1**	**Pronounced knee, dur >6 ms, upprSlp <16, lwrSlp <3, f_c >47 kHz diagnostic within known range** (95% CI for MYVO)**. Sometimes insert longer duration calls within sequence of short duration calls.** Power focused around fc; gradually builds up to peak and attenuates rapidly. Typically exhibit only a hint of a tail. Limited geographic range in MT (west of Continental Divide).	f_c > 50 kHz dur > 6 ms	Date range: Year round	90-175 ms
	Yuma Myotis	44.8-54.8	42.4-48.4	64.0-116.0	46.0-78.8	3.3-7.9	5.4-27.4	1.6-9.4	2.2-17.9				
	Myotis californicus	**49.1**	**45.3**	**99.6**	**52.8**	**3.8**	**28.0**	**7.4**	**15.1**	**FM sweep a smooth curve** (i.e., no inflection), beginning steeply and then increasing in curvature*. **Often a well-defined downward tail. Sometimes a lower inflection; with the appearance of a "ledge" or "shelf" or "secondary change in slope" before f_c. Peak power of call typically persists for at least 1 ms on non–saturated calls. f_c >48 kHz diagnostic** (95% CI for MYCI). Limited geographic range (western MT). *some calls may have an inflection, but the smoothly curved variant is diagnostic.	f_c > 50 kHz dur < 5 ms	*D calls should have:* f_c > 48 kHz uppr slp >20 total slp > 10 dur < 4 ms tail > 3 kHz Date range: Year round	75-125 ms (occ. >175 ms)
	California Myotis	44.9-52.9	40.7-48.7	78.4-122.4	45.0-65.2	2.0-5.6	14.0-42	2.4-12.6	3.9-26.9				
40	***Myotis ciliolabrum***	**44.3**	**40.6**	**95.1**	**49.1**	**3.2**	**33.5**	**9.6**	**16.9**	**FM sweep a smooth curve** (i.e., no inflection), beginning steeply and then increasing in curvature*. **Often a well-defined downward tail. Peak power of call typically persists for at least 1 ms on**	f_c > 42 kHz dur < 5 ms Kaleido Accurate	*D calls should have*: f_c > 42 kHz uppr slp >25 total slp > 12 tail > 3 kHz Date range: Year	75-125 ms

	species	f_c	low f	high f	f_{max}	dur	Upper slope	Lower slope	Total slope	Diagnostic[2] and Special characteristics	Hand-Class Priorities [3]	MTNHP Notes[3]	Search Phase call intervals[3]
	Western Small-footed Myotis	39.7-47.7	37.4-43.4	76.9-112.9	42.9-54.9	1.8-4.6	20.5-46.5	4.4-14.4	7.1-27.1	**non–saturated calls, f_c <45 kHz diagnostic if within MYCA geographic range** (95% CI for MYCA). *some calls may have an inflection, but the smoothly curved variant is diagnostic.		round	
	Myotis septentrionalis	**43.2**	**37.0**	**104.0**	**51.3**	**3.9**	**24.2**	**11.7**	**18.6**	**Calls may have up to 100 kHz of bandwidth.** Shaped like MYEV or MYTH but distinguished by f_c. FM sweep may be nearly linear making f_c difficult to recognize. Quiet but consistent calls. Examine sequence in real time and confirm consistent search phase call intervals across the sequence to rule out approach phase calls from other Myotis spp. **Distribution in Montana very limited - capture and genetic analysis needed to confirm ID.**	fc > 40 kHz	Look for Fc >40 kHz and ensure they aren't approach-phase calls from other Myotis by confirming consistent search phase call intervals across the sequence.	unknown
	Northern Long-eared Myotis	36.8-50.8	27.0-47.0	86.0-124.0	30.7-72.7	2.3-5.3	11.8-35.8	3.1-20.3	9.4-29.4				
	Myotis volans	**41.6**	**36.9**	**89.6**	**48.0**	**4.8**	**15.1**	**7.7**	**12.0**	**May exhibit an upward sweep into the call; uncommon, but diagnostic when present on steep calls.** May have subtle lower slope or backward bend at higher frequencies. End of call may exhibit a rounded, lazy drop. Generally has shorter, steeper calls than MYLU in uncluttered areas. Note that alias harmonics may resemble upsweeps if sonogram is truncated (e.g. 96 kHz maximum for SM2s with FS = 192 kHz).	f_c > 35 kHz	Date range: Year round	80-160 ms?
	Long-legged Myotis	36.4-46.4	31.1-43.1	66.4-112.4	39.0-60.0	2.4-7.0	6.9-22.9	1.1-14.3	4.0-22.0				
	Myotis lucifugus	**40.8**	**38.1**	**74.5**	**44.5**	**6.0**	**13.1**	**3.9**	**6.2**	Can make the longest duration and lowest slope calls of all Myotis. **Dur >7 ms** (95% CI for MYVO) **and lwrSlp <3 diagnostic among 40 kHz Myotis; f_c <44 kHz diagnostic**	dur > 6 ms	Date range: Year round	100-200 ms

	species	f_c	low f	high f	f_{max}	dur	Upper slope	Lower slope	Total slope	Diagnostic[2] and Special characteristics	Hand-Class Priorities[3]	MTNHP Notes[3]	Search Phase call intervals[3]
	Little Brown Bat	37.2-43.2	33.9-41.9	51.5-97.5	36.0-53.5	3.2-8.6	2.7-26.9	0.8-9.1	1.6-13.8	**west of Continental Divide** (95% CI for MYYU). Calls may have abrupt upturn at end (unlike smooth LABO upturn). Sometimes with multiple power centers making calls look clumpy.			
	Lasiurus borealis Eastern Red Bat	**40.4** 31.6-47.6	**40.2** 33.8-45.8	**67.6** 40.4-94.4	**43.8** 34.2-54.2	**6.8** 3.2-11.4	**10.0** 0.1-22	**2.0** 0.0-4.4	**4.4** 0.1-9.8	**U-shaped calls; up-turn at end of call; may exhibit variable f_c across sequence.** Power smoothly centered in call. Typically 32-40 kHz calls with dur >10 ms are LABO, but look at shape. fc > 30 kHz in sequences with characteristic variation in frequencies (as opposed to LACI <30 kHz). Limited geographic range in MT (eastern plains).	Kaleido Accurate, dur > 9-11 ms	Date range: June 14 - Oct 26	100-250 ms (occ. >300 ms)
30	***Myotis evotis*** Long-eared Myotis	**34.3** 31.7-37.7	**28.1** 23.9-33.9	**78.5** 49.5-107.5	**39.1** 31.0-46.9	**3.7** 2.1-5.3	**20.5** 6.1-35.5	**8.7** 2.3-15.3	**13.5** 4.9-24.5	Calls may have up to 100 kHz of bandwidth. Shaped like MYTH and MYSE but distinguished by **f_c = 32-36** (upper range boundary for MYTH, 95% CIs for MYVO and MYSE). FM sweep may be nearly linear making f_c difficult to recognize. **Harmonics converge toward primary call component.**	f_c = 33-36 kHz dur < 3-4 ms; Sonobat= EPFU and dur <5 ms	Date range: Year round	90-200 ms
	Eptesicus fuscus Big Brown Bat	**28.2** 25.8-31.8	**27.2** 24.8-30.8	**56.6** 43.4-69.4	**31.9** 25.0-40.1	**7.8** 2.8-12.2	**8.5** 2.5-15.5	**2.1** 0.3-4.3	**4.0** 0.6-7.6	Variable; calls with high f below 60 kHz can be confused with LANO. **Calls with high f >65 kHz distinguish from LANO** (range boundary for LANO)**, duration >12 ms to distinguish from ANPA where species coexist** (range boundary for ANPA). May produce nearly flat calls (with fc as low as 23 kHz) but never 100% flat at any point in call. Parallel harmonics. Some calls may have inflection.	f_c = 28-32 kHz dur > 6 ms	Look at longer calls if in ANPA geographic range, but note that long calls (>10ms) may have call/sec < 6 Date range: Year round	100-150 ms (150-250 ms for long, low calls)

	species	f_c	low f	high f	f_{max}	dur	Upper slope	Lower slope	Total slope	Diagnostic[2] and Special characteristics	Hand-Class Priorities[3]	MTNHP Notes[3]	Search Phase call intervals[3]
	Antrozous pallidus Pallid Bat	**28.0** 26.0-30.0	**26.2** 23.8-29.8	**54.5** 41.5-67.5	**31.0** 25.0-37.0	**6.8** 3.8-10.0	**8.1** 3.0-15.9	**2.7** 0.6-5.1	**4.3** 2.1-7.9	Often simple curved FM sweep, sometimes with knee in center. **Distinguish from short, steep EPFU calls by looking for call intervals >180 ms for ≥1 second (<6 calls/sec)**. Note that MYTH & MYEV can also be <6 calls/sec. No Myotis-like tail, but calls may end in a foot-like arch or "dog paw". Parallel harmonics. **Presence of social calls diagnostic** (see ref. calls). Limited geographic range (southeastern MT).	dur < 10 ms calls/sec < 6 f_c < 35 kHz	*Probables:* Sequences of short, steep calls with >200 ms intervals *Defintives:* Social calls, must view "unfiltered" to see these Date range: Apr 1 - Sept 23	150-300 ms?
20	***Lasionycteris noctivagans*** Silver-haired Bat	**26.5** 25.5-27.5	**25.4** 22.6-28.6	**41.5** 26.0-58.5	**28.8** 24.0-33.2	**9.2** 2.3-16.8	**5.2** 0.0-12.6	**1.3** 0.0-3.7	**2.5** 0.0-6.7	Some call variants can be confused with EPFU. **Flat calls with f_c ≥26 kHz diagnostic.** Shorter calls reverse J–shaped; often with a **distinct inflection**. **Short search phase calls (<7 ms) with harmonics do not exceed 55kHz.** Parallel harmonics. Flat LACI calls are lower in f_c, but shorter LACI approach calls may overlap short LANO calls (examine entire sequence and call interval). Low slope calls with f_c = 25–26 kHz may be distinguished from LACI by the presence of an inflection. EPFU typically has more FM, with smooth curvature (no inflection), but may produce nearly flat calls (with fc as low as 23 kHz).	f_c < 28 kHz	Date range: Year round	200-500 ms (100-200 ms for short, steep calls)
	Myotis thysanodes	**24.5**	**19.8**	**72.4**	**30.7**	**3.9**	**19.0**	**9.2**	**13.9**	Calls may have up to 100 kHz of bandwidth. Shaped like MYEV but distinguished by f_c. FM sweep may be nearly linear making f_c difficult to recognize. Want to have presence of harmonics to distinguish from COTO if high f <50 kHz. **Continuous steep shape and**	f_c < 24 kHz, dur 3-5 ms, and/or Kaleido Accurate	Date range: Mar 28 - Oct 31	100-160 ms

	species	f_c	low f	high f	f_{max}	dur	Upper slope	Lower slope	Total slope	Diagnostic[2] and Special characteristics	Hand-Class Priorities[3]	MTNHP Notes[3]	Search Phase call intervals[3]
	Fringed Myotis	21.5-27.5	14.2-24.2	41.6-103.6	24.0-39.3	1.9-5.9	7.1-33.0	3.1-16.8	4.9-24.1	**f_c down into the 20s is diagnostic: totalSlp >15, f_c <28 kHz, and low f <24 kHz diagnostic or totalSlp >10, f_c <28 kHz, and low f <24 kHz diagnostic if harmonics converge toward primary call component.**			
	Corynorhinus townsendii Townsend's Big-eared Bat	**23.4** 18.6-28.6	**21.4** 17.0-24.6	**42.5** 37.5-47.5	**31.1** 24.9-36.9	**4.6** 1.7-8.0	**7.1** 0.2-18.9	**4.9** 1.5-8.3	**5.0** 2.0-8.0	Low intensity, difficult to record; harmonics may be present. Call-shape **simple linear FM sweep** (sometimes with upsweep or flat at onset - no knee or upward facing curvature toward end of call unless a connected squiggle). **Squiggle calls diagnostic (5-7 ms period); rare, likely social and used near roosts.** f_{max} may alternate between primary call component and second harmonic. For search phase calls, COTO will have high f <50 kHz, f_c <32 kHz, and $f$max <41kHz (upper range boundaries). *Examine entire call sequence and look for upward facing curvature on any call; if found, likely not COTO. LACI and LANO approach calls and some linear MYTH fragments can mimic COTO.	f_c < 35 kHz	Date range: Year round	70-120 ms (occ. >150 ms)
	Lasiurus cinereus Hoary Bat	**20.1** 16.0-23.9	**19.7** 16.3-24.3	**26.0** 17.0-36.0	**20.8** 17.0-25.2	**11.0** 4.0-19.0	**2.2** 0.1-6.0	**0.4** 0.0-1.2	**0.7** 0.0-2.1	**Pronounced or subtle U–shape or very flat calls (<20 kHz). Low f & f_c may vary across sequence;** power builds toward center then gradually declines. Short calls can be confused with LANO or EPFU. f_c < 30 kHz in sequences with characteristic variation in frequencies (as opposed to LABO >30 kHz).	f_c < 20 kHz and/or Kaleido Accurate	Date range: Mar 22 - Nov 15	250-400 ms (occ. >500 ms)

	species	f_c	low f	high f	f_{max}	dur	Upper slope	Lower slope	Total slope	Diagnostic[2] and Special characteristics	Hand-Class Priorities[3]	MTNHP Notes[3]	Search Phase call intervals[3]
10	***Euderma maculatum*** Spotted Bat	**10** 8.6-12.0	**9.6** 8.2-10.4	**14.5** 12.0-17.5	**12.5** 10.0-15.5	**3.2** 1.6-6.0	**2.2** 0.1-5.2	**1.5** 0.1-3.1	**1.7** 0.9-2.7	**Simple linear FM sweep,** sometimes with a mild inflection. Short calls at low frequency. Harmonics often present, with second harmonic persisting beyond primary call component. **f_c = 7-10 kHz and dur = 3-8 ms diagnostic.**		Process separately in Kaleidoscope, view "unfiltered" Date range: Mar 10 - Nov 12	200-500 ms

[1] data from Humbolt State University Bat Lab (Eastern and Western US Bats 2011); numbers represent means and approximate 95% confidence intervals - if the 95% CI exceeded the observed range of a characteristic, the range boundary was used.
[2] diagnostic characteristics for determination of species identification are bolded in text.
[3] filters and notes represent work in progress or draft guidelines to speed hand review of call sequences; seasonal range dates are from either definitively identified calls or captures in the Montana Point Observation Database as of February 2017.

Important Characteristic/Sonogram Terminology[1]

Primary call: the component of an echolocation sound emitted by a bat with the lowest frequency, also called the fundamental; typically the most powerful and sometimes the only part of the call visible on a sonogram

Harmonic: multiple, typically subtle components of the call, existing at higher frequencies but roughly parallel to the primary call component; presence may indicate higher call quality unless a call is oversaturated

The characteristics below refer to attributes of the primary call. In rare cases, a harmonic may be the most powerful component of a call; these characteristics and their corresponding values in this key are not applicable to those measured from a harmonic component.

low *f*: lowest frequency (kHz)

high *f*: highest frequency (kHz)

$\boldsymbol{f_c}$: characteristic frequency, the frequency of the call at its lowest slope (kHz)

$\boldsymbol{f_{max}}$: the frequency where the power is greatest (kHz)

dur: duration (ms) from the start to the end of a call

Upper slope: the slope of the call (kHz/ms) between the high *f* and the knee; abbreviated: upprSlp

Lower slope: the slope of the call (kHz/ms) between the knee and the f_c; abbreviated: lwrSlp

Total slope: the slope of the call (kHz/ms) between the high *f* and the low *f*; abbreviated: totalSlp

Other terms used to describe calls:

FM: frequency modulation, change in frequency over time; most calls start at a high frequency and sweep down to a lower frequency

power: amplitude or sound energy (i.e. volume)

oversaturation: powerful calls may exceed the microphone/recorder capability and produce anomalies in the sonogram such as full spectrum "noise" (clipping) or alias harmonics (upside-down harmonics resulting from truncation of the upper portions of calls due to sampling frequency limitations); peak power duration cannot be accurately estimated

inflection or knee: pronounced change in slope; some calls may not have an obvious knee if very steep or smoothly curved

flat: a call or portion of a call with very low or no slope (horizontal), i.e. constant frequency (CF)

sequence: a series of bat calls, produced as a bat flies past the detector

calls/sec: the number of calls per second for a given period; note that Sonobat's calculation of this characteristic may be incorrect due to multiple bats in a recording, low intensity calls, and dead air space in a sequence – ms between calls should be examined and calls should be looked at in real time to accurately estimate this characteristic if needed

Note that all frequencies should be interpreted as apparent or observed frequencies. These values may vary from the frequency emitted by the bat due to distance to detector (decreasing call power or volume). Call volume may have a noticeable effect on all frequencies recorded depending on the location of the power in the call (>5 kHz).

Call Types[2]

The values for the characteristics listed in this key are based on search phase calls. Therefore, it is important to make sure that search phase calls are examined and analyzed during hand classification.

Search phase calls: used for general navigation and searching in uncluttered areas, generally consistent call characteristics, approximately 3-12 calls per second; bats may be able to detect objects >10 meters away with these calls[3]

Approach phase calls: used when approaching either prey or a landing site or in cluttered airspace, such as when flying around vegetation; these calls are typically steeper and shorter than search calls and frequencies may shift up significantly, often 10-25 calls per second

Feeding buzz: also called terminal phase calls, used for close proximity object location during prey pursuit/capture, may exceed 100 calls per second[4]; very steep and short calls that can mimic other species if interpreted as search calls, but can be much lower in volume/power; not useful for species ID

Social calls: used to communicate with other bats, often lower in frequency than search phase calls for a species and may contain complex frequency modulation patterns; may be very helpful for identifying some species (e.g. ANPA) but are irregularly recorded

How to Use the Key for Montana Bats[1]

Tip: Put bat detector in an open, uncluttered environment so that it is more likely to detect bats using search phase calls.

1. Load auto-identification analysis results into a database in order to expedite hand review of calls by sorting calls to species or species groups and/or sorting on call characteristics.
2. Look at search phase calls (not approach calls, feeding buzzes, or social calls) within a sequence.
3. Choose noise free calls with harmonics so that you are more likely to see the whole call instead of just a portion. Note that some calls may be oversaturated if the bat closely approached the microphone and these should be avoided if possible.
4. Look at the entire sequence in both compressed and real time views. This will help you see the whole picture (Are there multiple bats? Are there feeding buzzes or other non-search phase calls?). This is particularly important for differentiating EPFU vs. ANPA, MYLU vs. LABO, and for COTO in general since many other species may have calls that mimic COTO.

5. Look at the standard view for multiple calls within a sequence. BE AWARE that Sonobat sometimes identifies incorrect characteristics, analyzes strong harmonics instead of the primary call, and occasionally includes noise along with the primary call of interest.

[1] Adapted from Humbolt State University Bat Lab. 2011. Eastern and Western US Bat Keys.

[2] Reviewed in Fenton, M. B. 2013. Questions, ideas and tools: lessons from bat echolocation. Animal Behaviour 85, 869-879. Originally described in Griffin, D. R., et al. 1960. The echolocation of flying insects by bats. Animal Behaviour 8, 141-154.

[3] Fenton, M. B. 2004. Bat Natural History and Echolocation. *In* Brigham, R. M.,et al., eds. Bat Echolocation Research: tools, techniques, and analysis. Bat Conservation International, Austin, TX.

[4] Elemans, C., et al. 2011. Superfast Muscles Set Maximum Call Rate in Echolocating Bats. Science 333, 1885-1888.

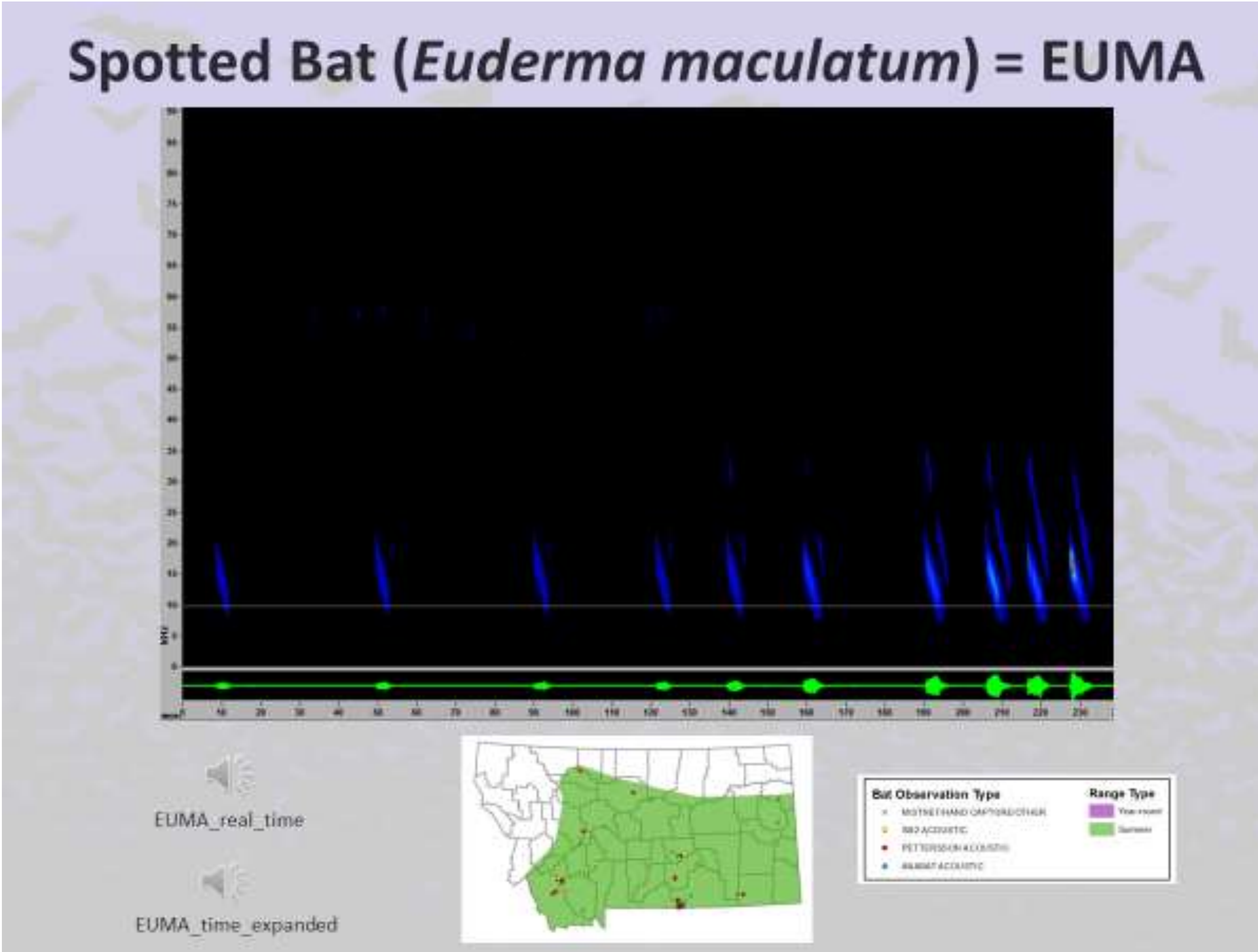


Figure 30. Example calls for the Spotted Bat (Euderma maculatum, EUMA)

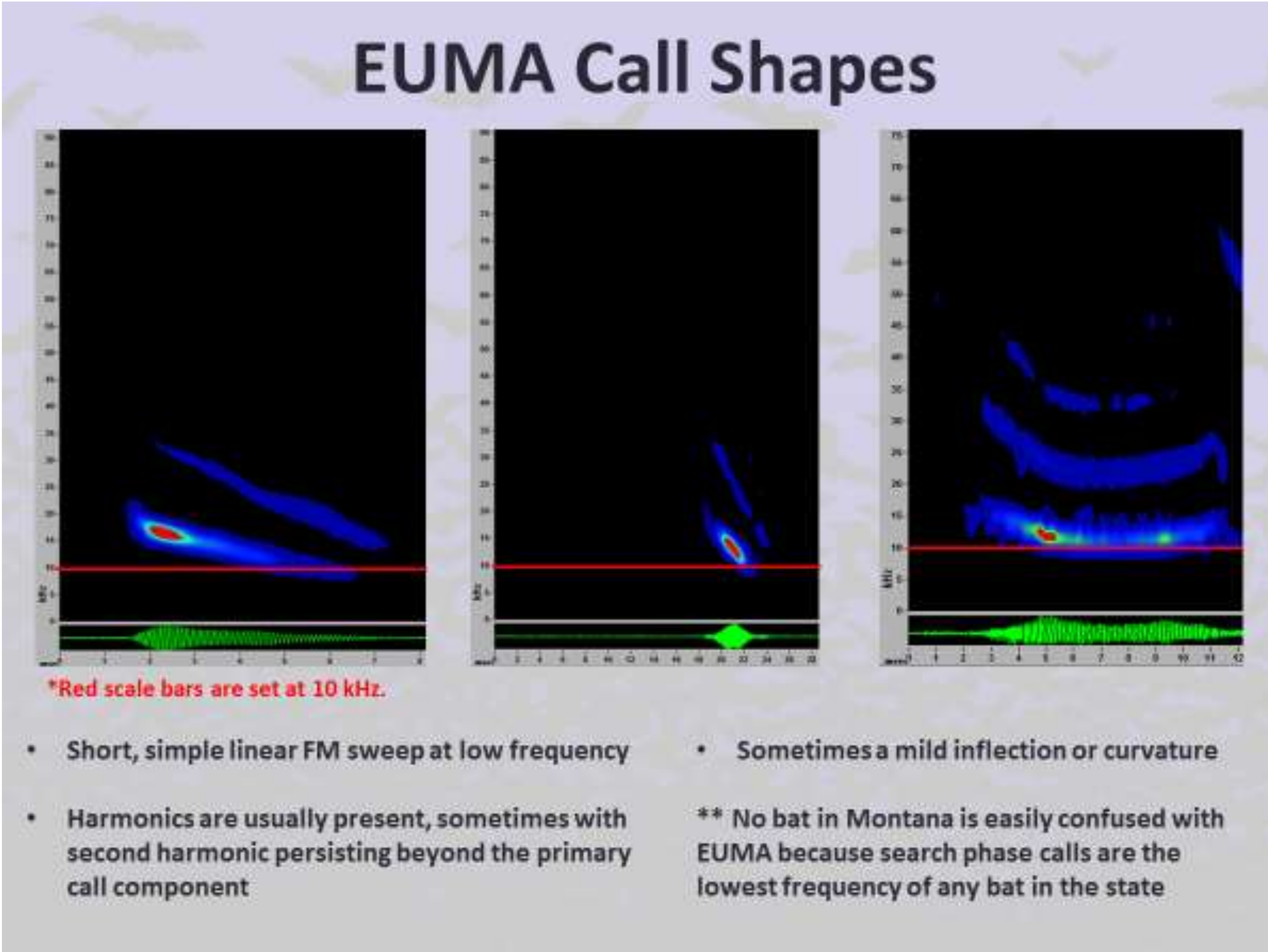


Figure 31. Call shapes of the Spotted Bat (Euderma maculatum, EUMA)

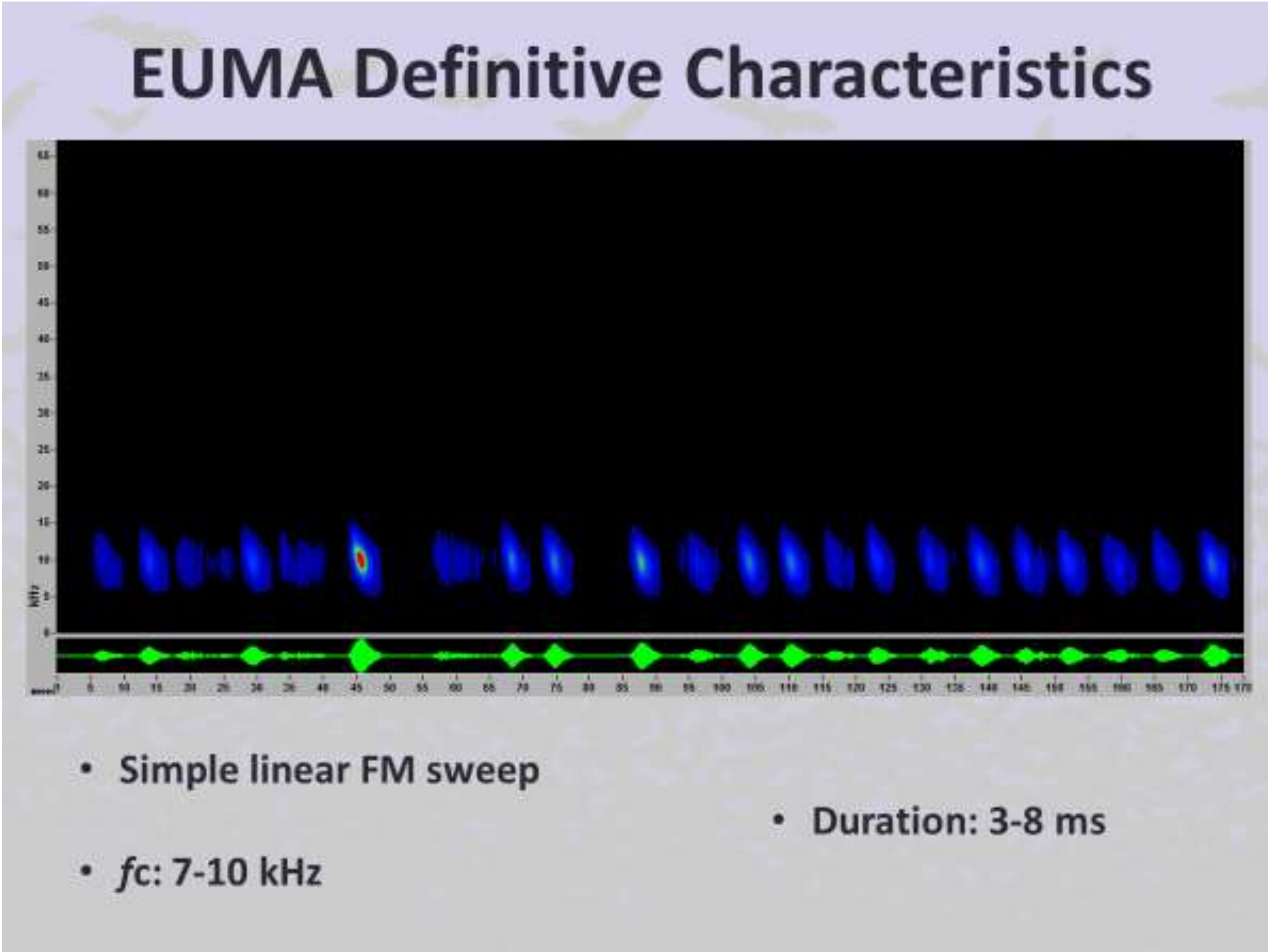


Figure 32. Difinative characteristics for the Spotted Bat (Euderma maculatum, EUMA)

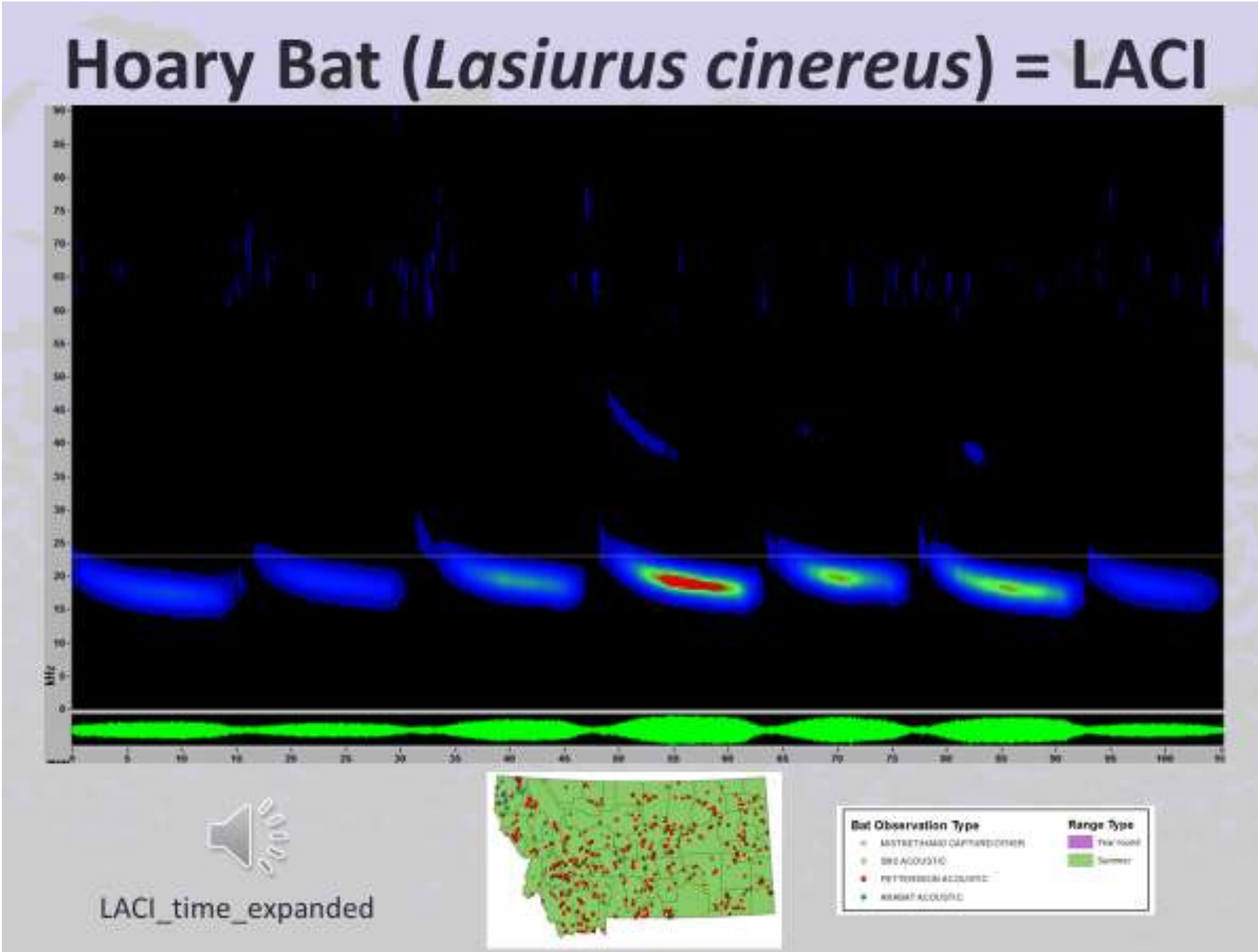


Figure 33. Example calls for the Hoary Bat (Lasiurus cinereus, LACI)

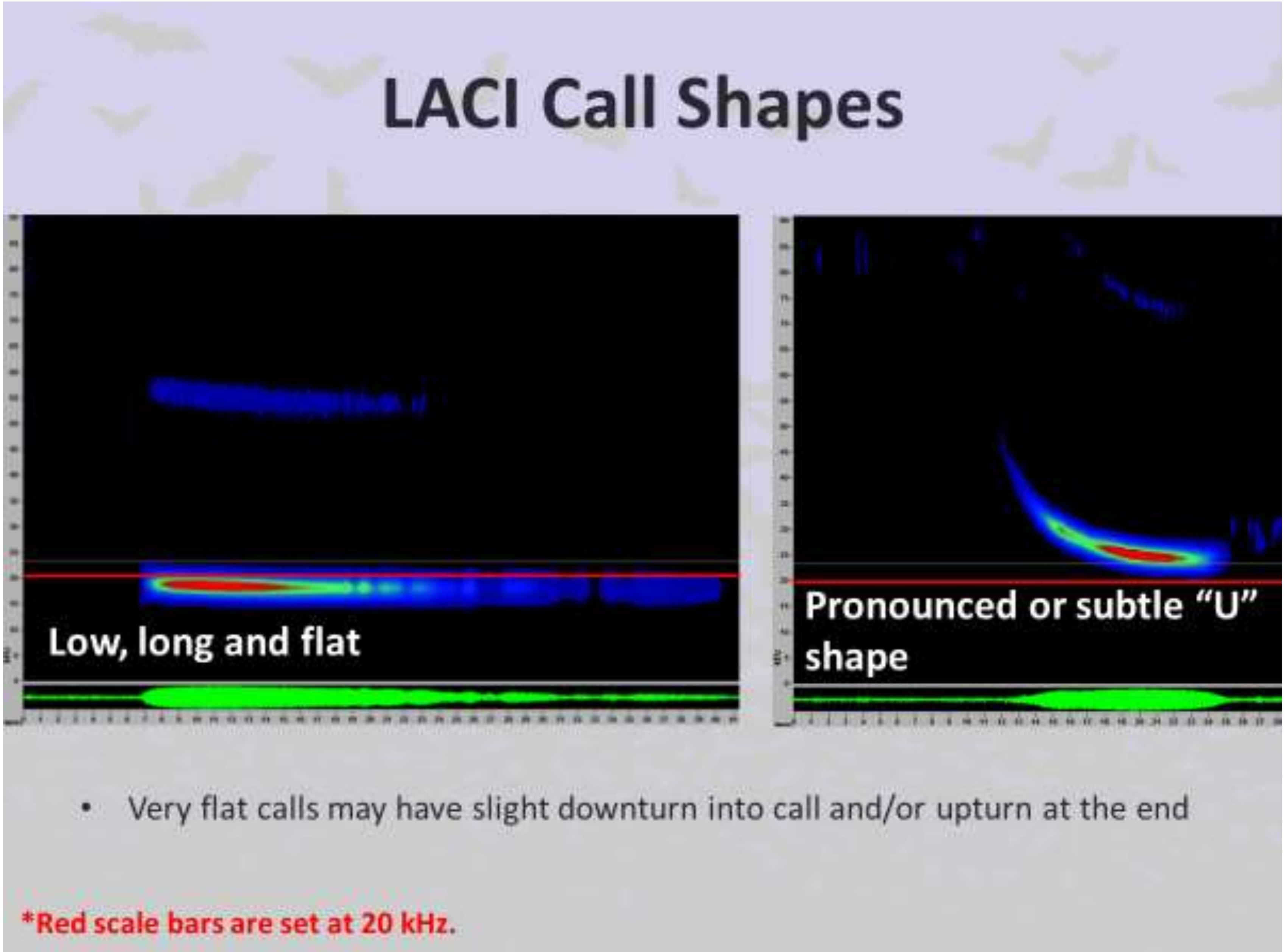


Figure 34. Call shapes of the Hoary Bat (Lasiurus cinereus, LACI)

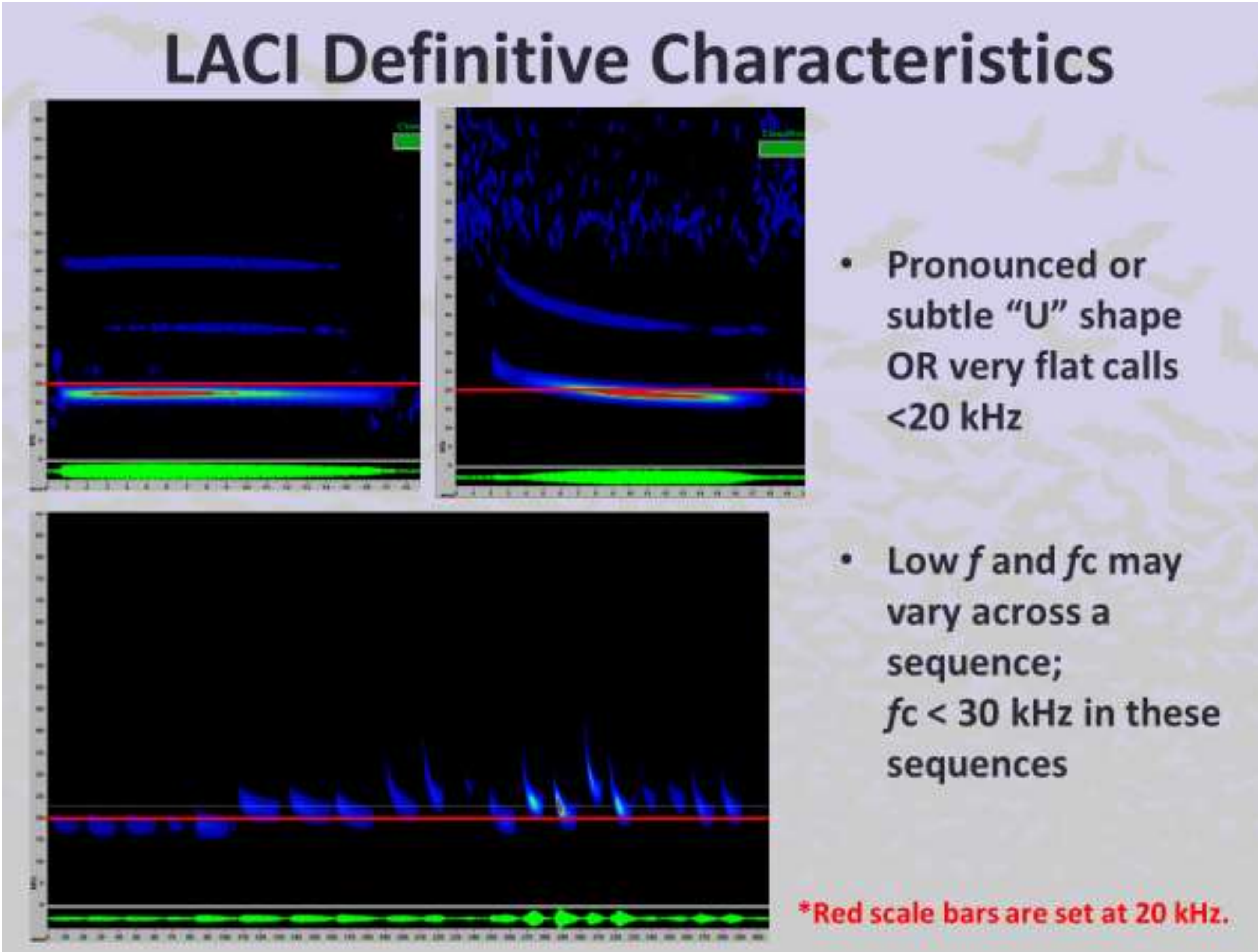


Figure 35. Definitive call characteristics for the Hoary Bat (Lasiurus cinereus, LACI)

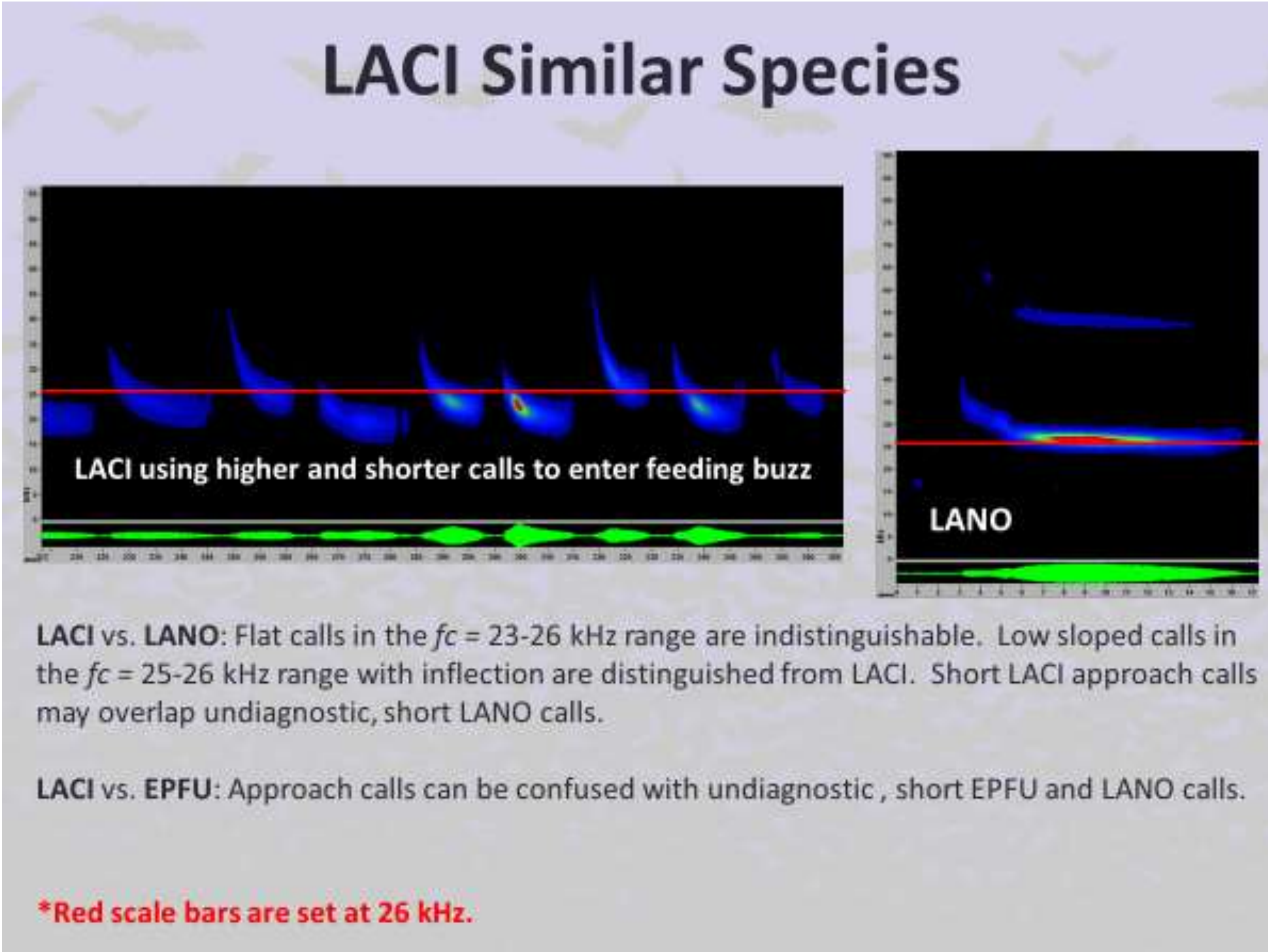


Figure 36. Call sequences produced by other species that may be confused with the Hoary Bat (Lasiurus cinereus, LACI)

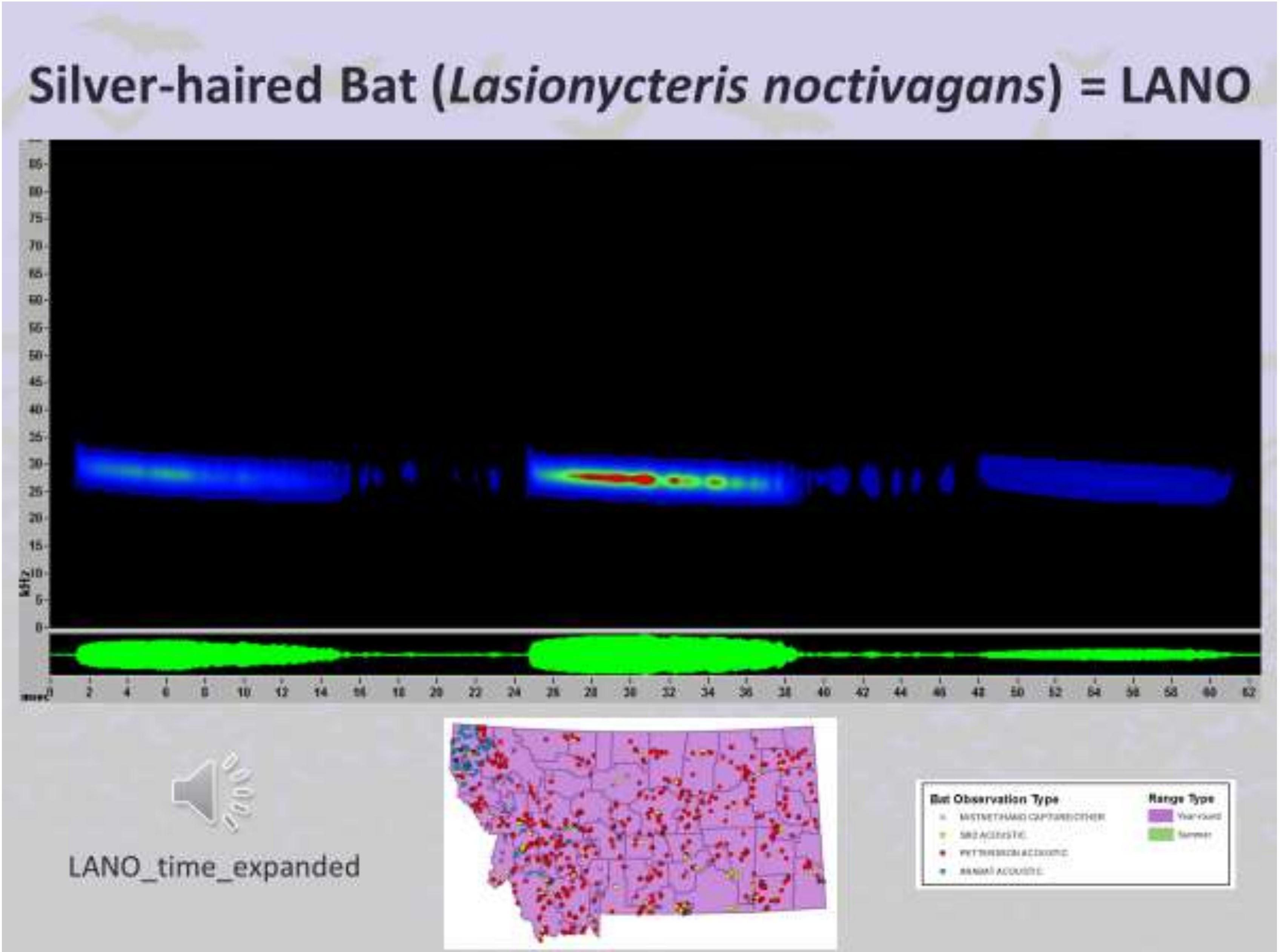


Figure 37. Example call sequence for the Silver-haired Bat (Lasionycteris noctivagans, LANO)

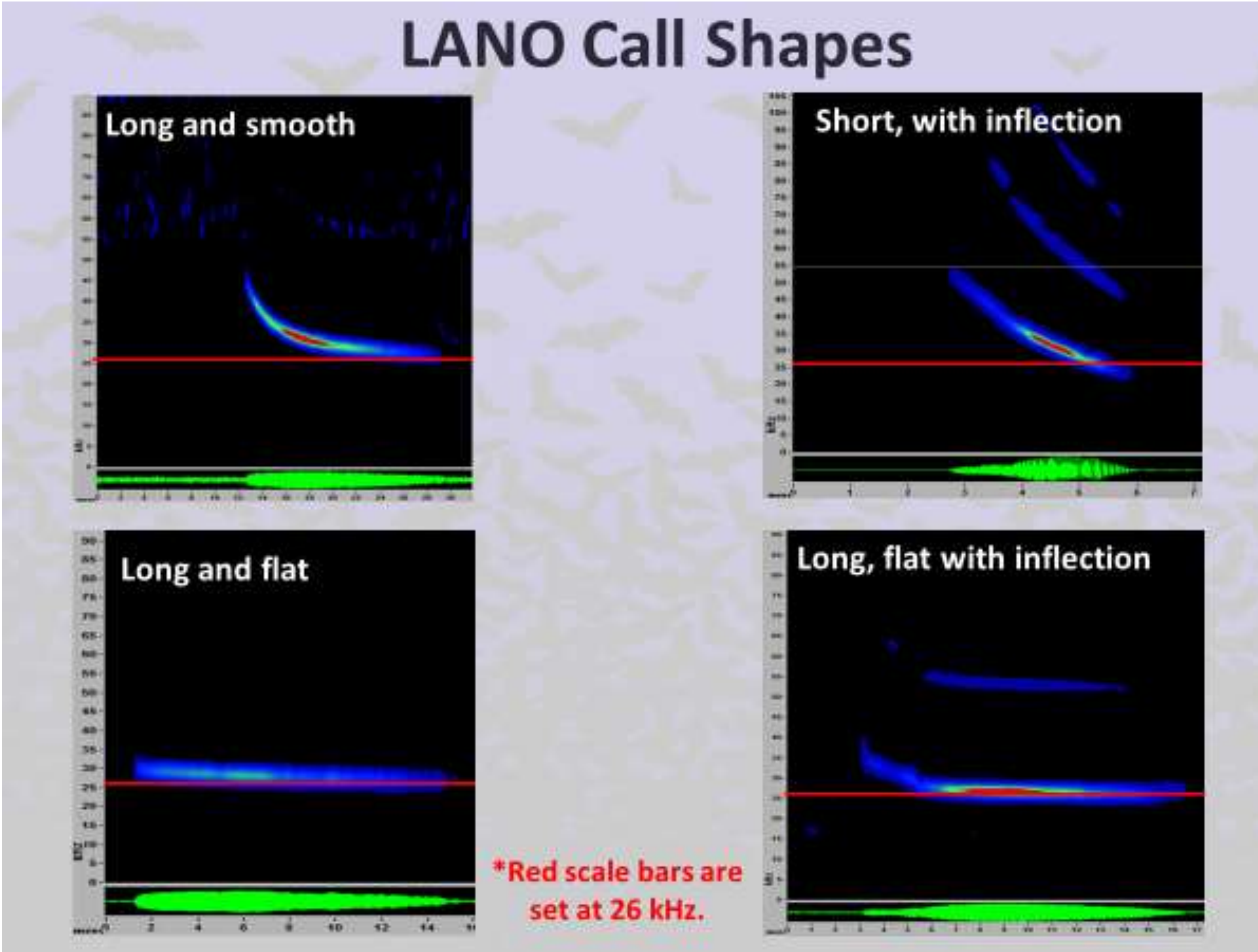
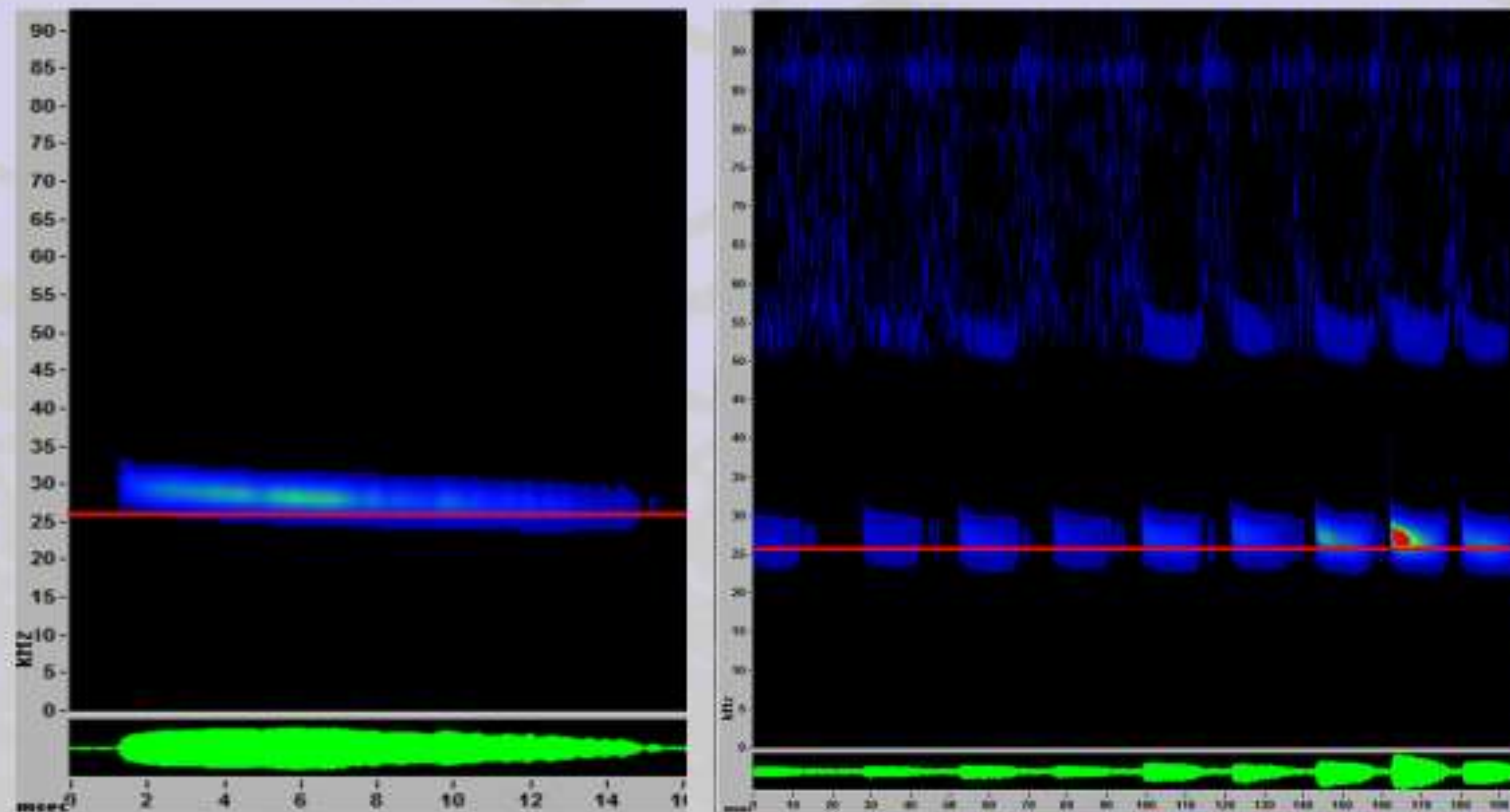


Figure 38. Call shapes of the Silver-haired Bat (Lasionycteris noctivagans, LANO)

LANO Definitive Characteristics



*Red scale bars are set at 26 kHz.

- Flat calls with *f*c >26 kHz
- Long, flat calls with some frequency modulation have a distinct inflection between upper and lower portions of call

Figure 39. Definitive characteristics of call sequence for the Silver-haired Bat (Lasionycteris noctivagans, LANO)

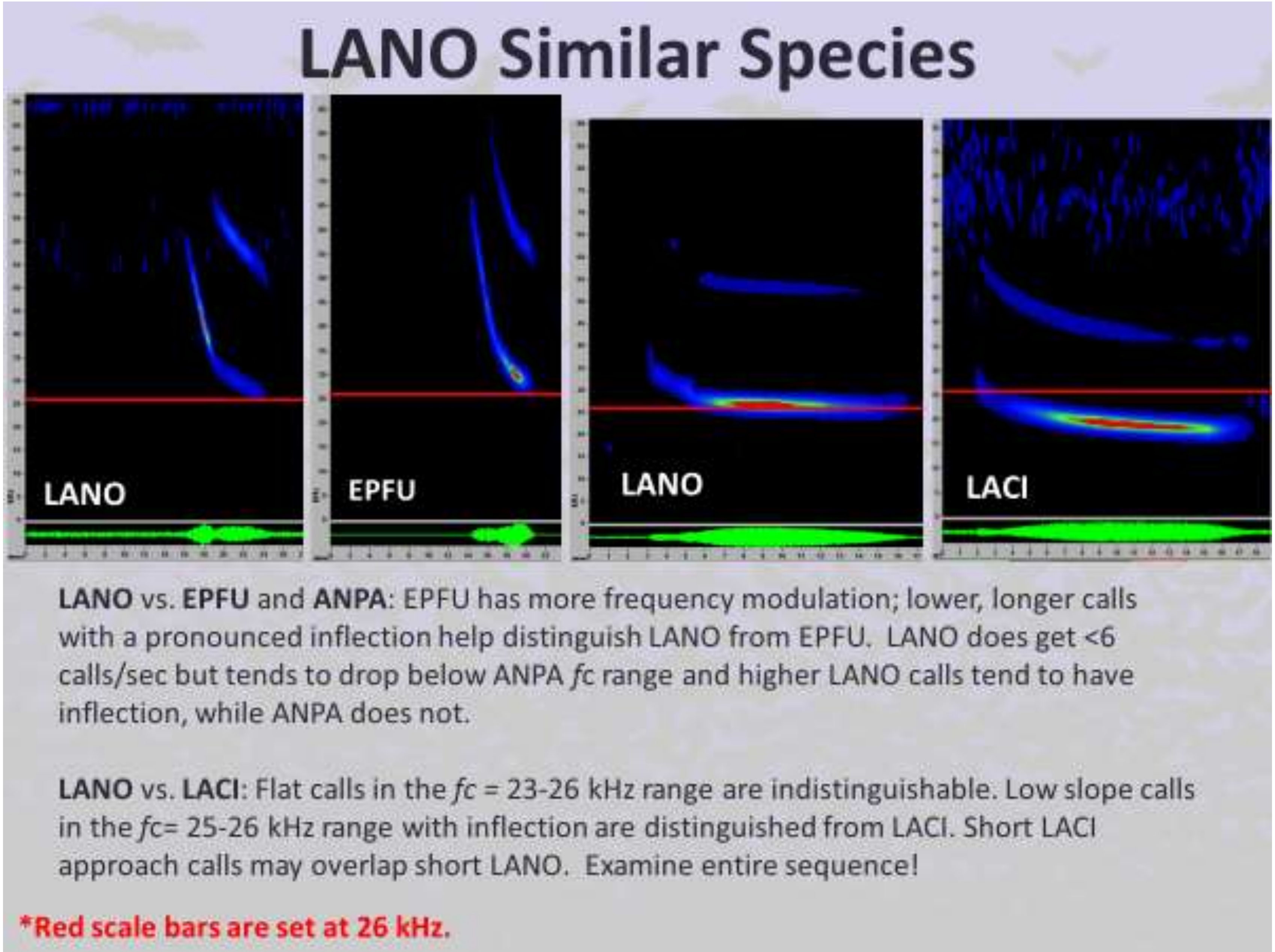


Figure 40. Calls sequences produced by other species that may be confused with the Silver-haired Bat (Lasionycteris noctivagans, LANO)

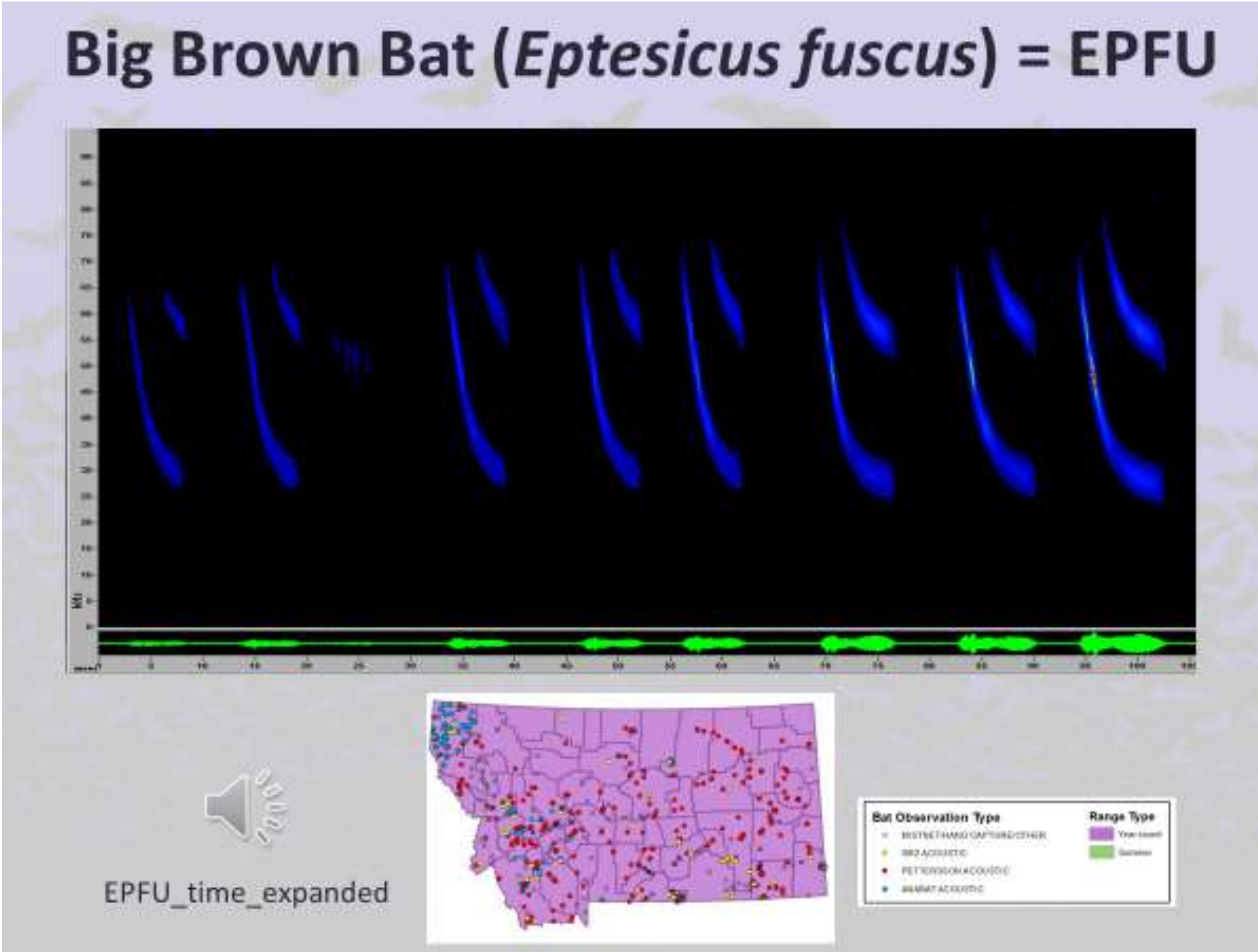


Figure 41. Example call sequence for the Big Brown Bat (Eptesicus fuscus, EPFU)

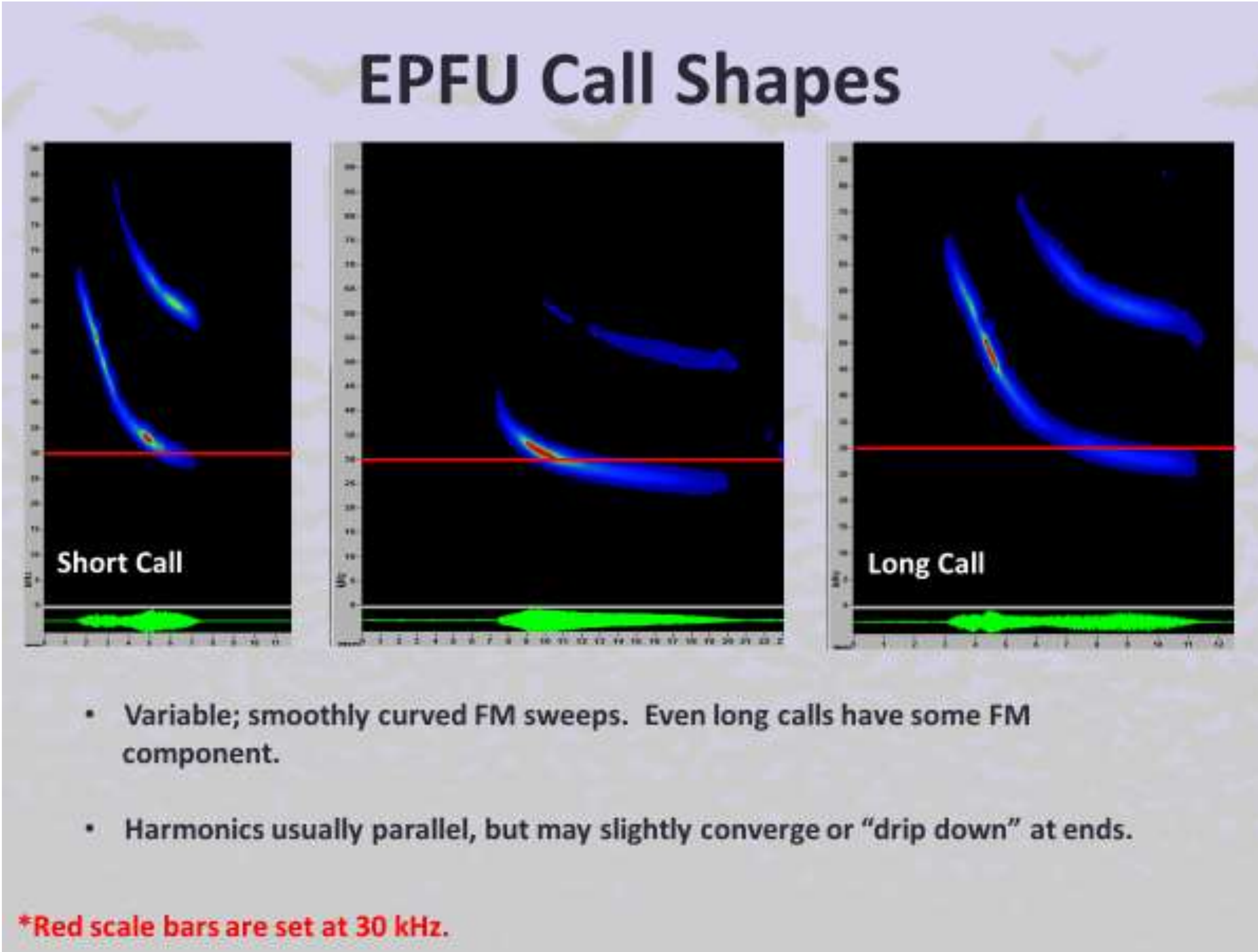


Figure 42. Call shapes of the Big Brown Bat (Eptesicus fuscus, EPFU)

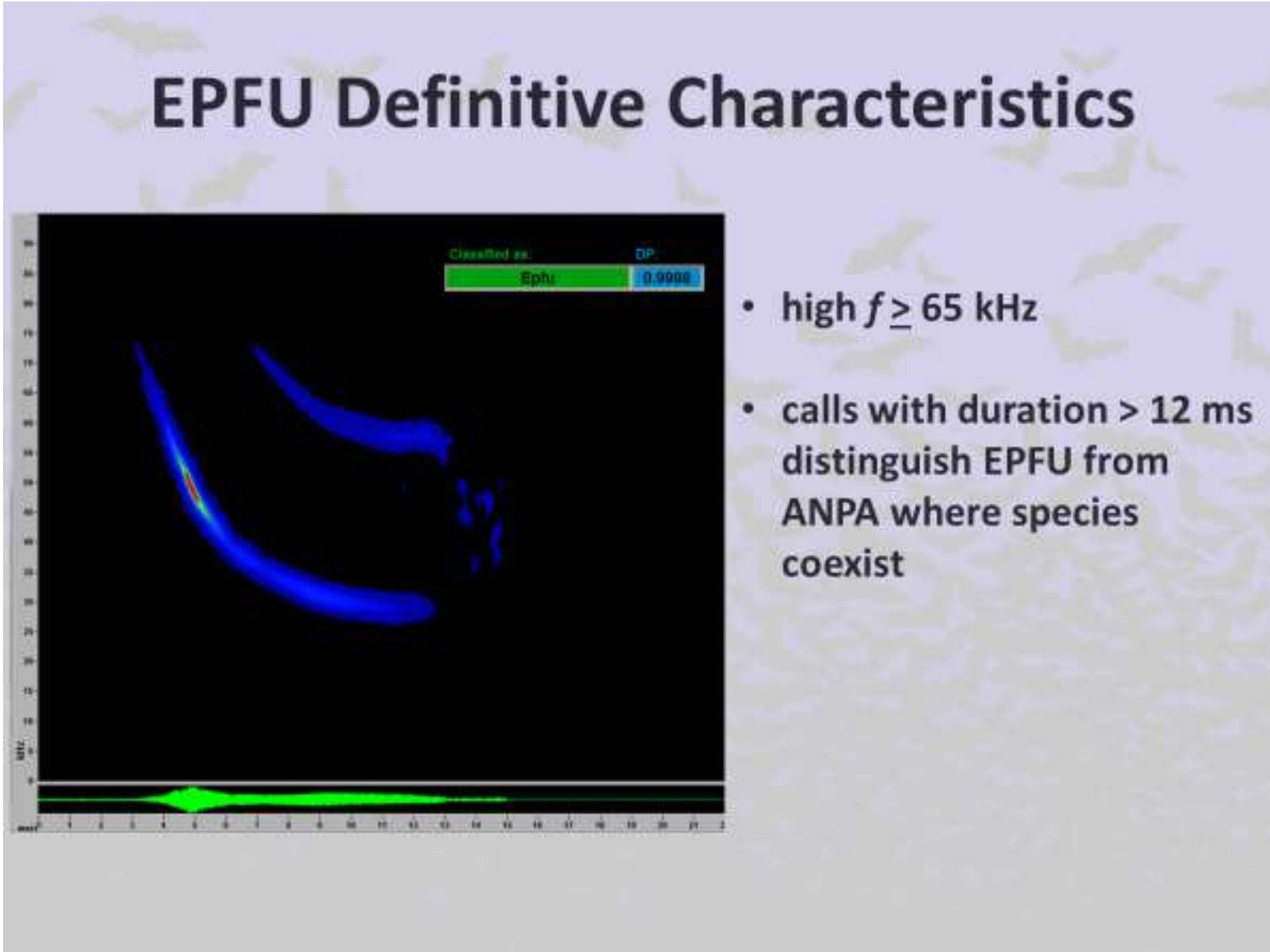


Figure 43. Definitive characteristics of call sequence for the Big Brown Bat (Eptesicus fuscus, EPFU)

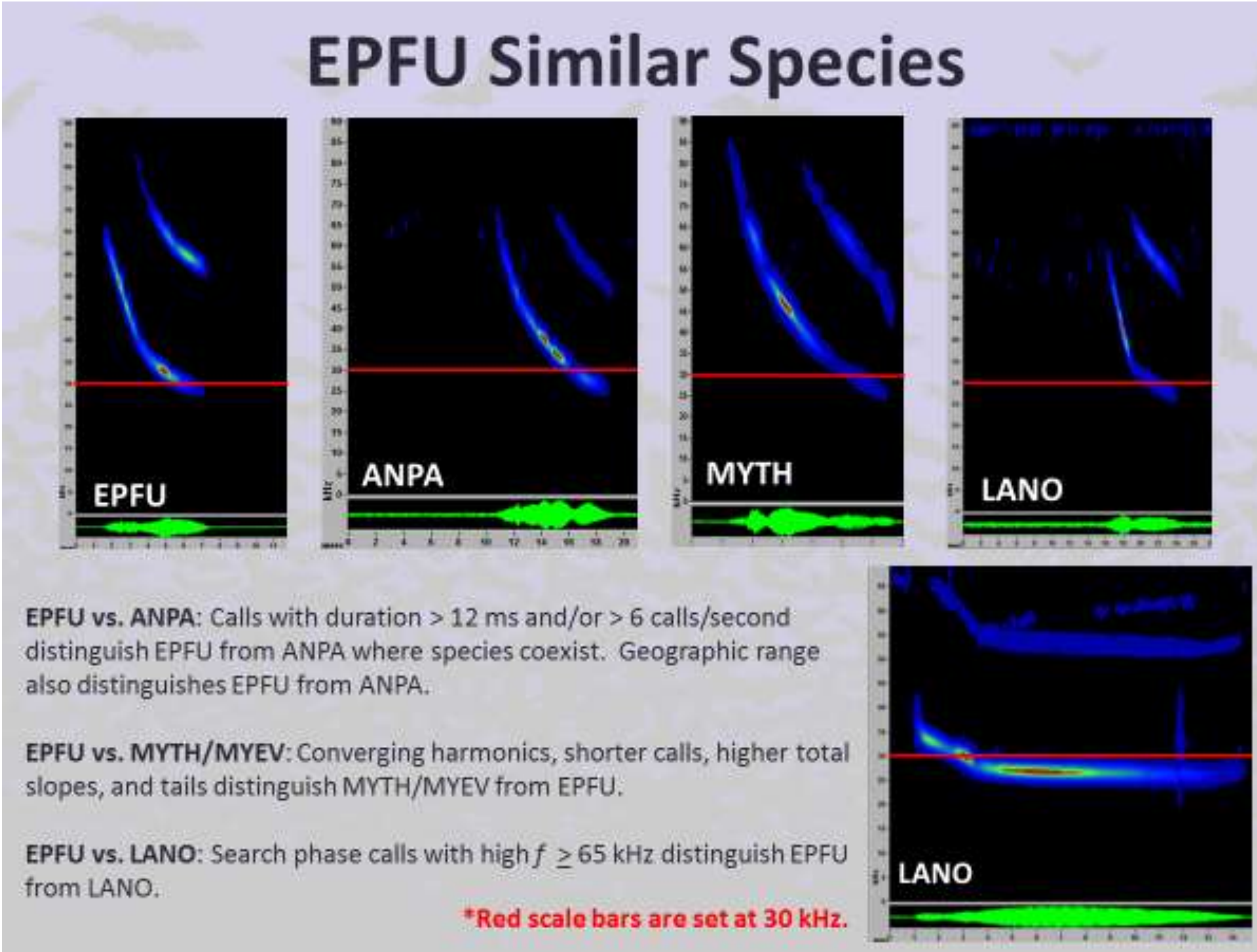


Figure 44. Calls sequences produced by other species that may be confused with the Big Brown Bat (Eptesicus fuscus, EPFU)

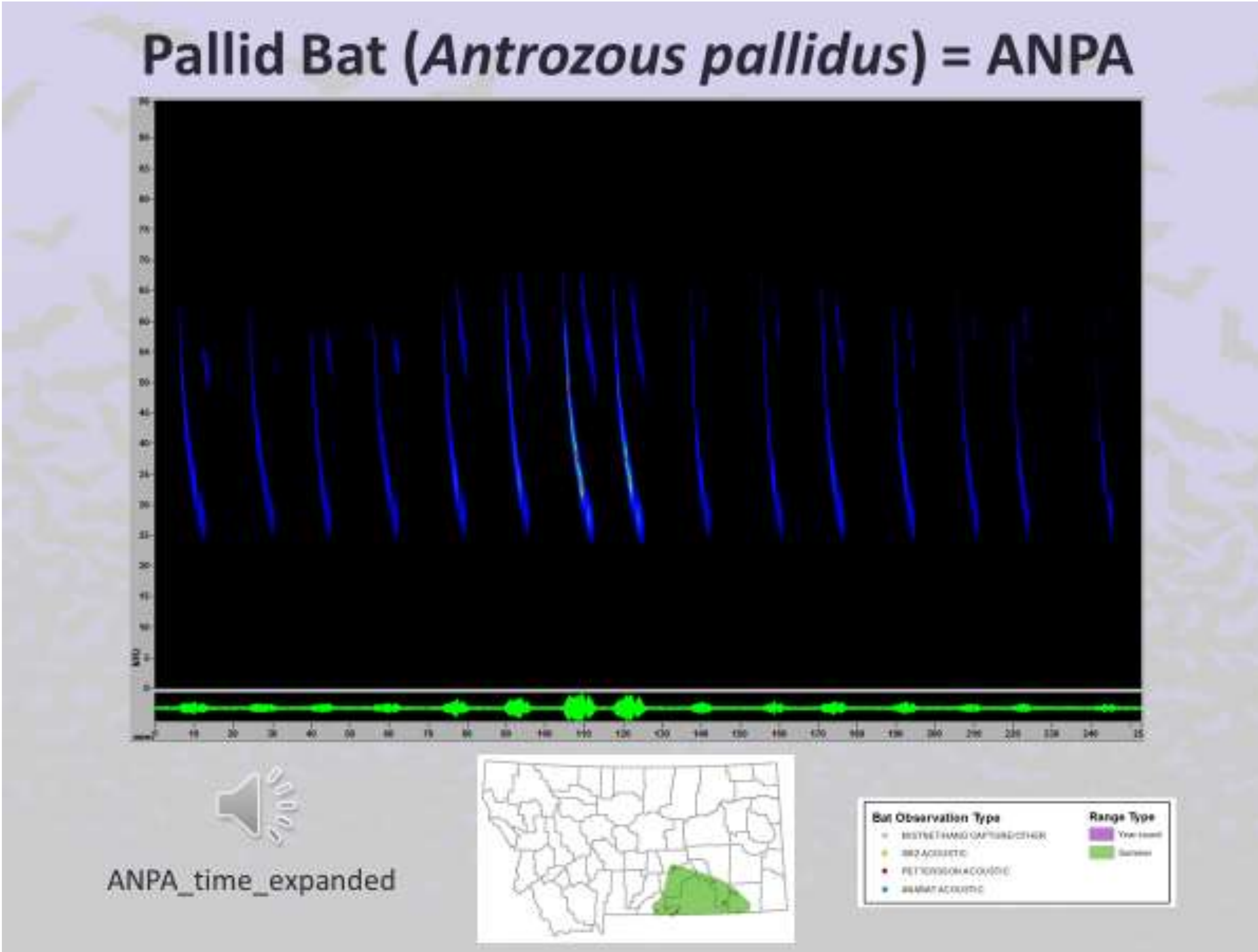


Figure 45. Example call sequence for the Pallid Bat (Antrozous pallidus, ANPA)

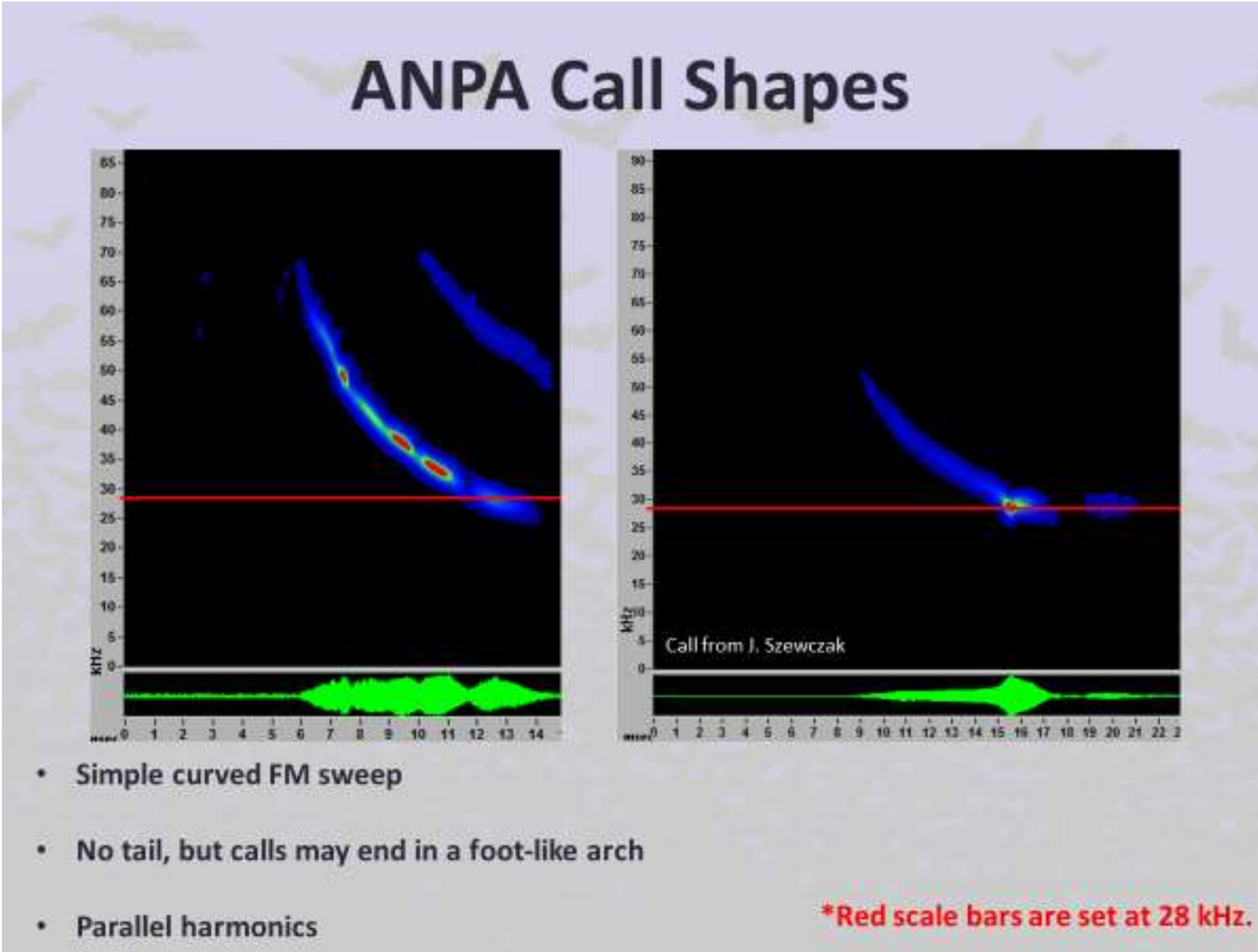


Figure 46. Call shapes of the Pallid Bat (Antrozous pallidus, ANPA)

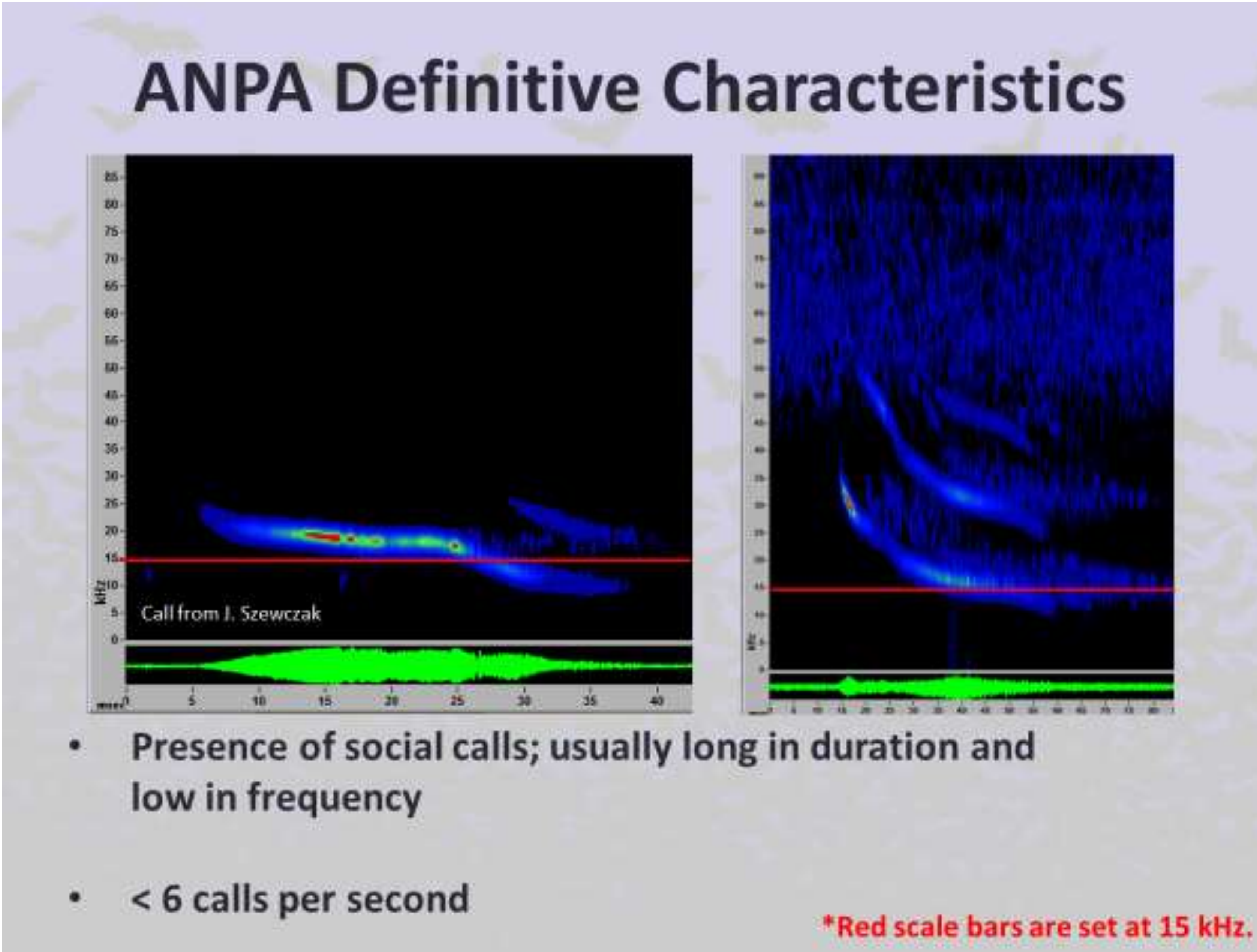


Figure 47.Definitive characteristics of call sequence for the Pallid Bat (Antrozous pallidus, ANPA)

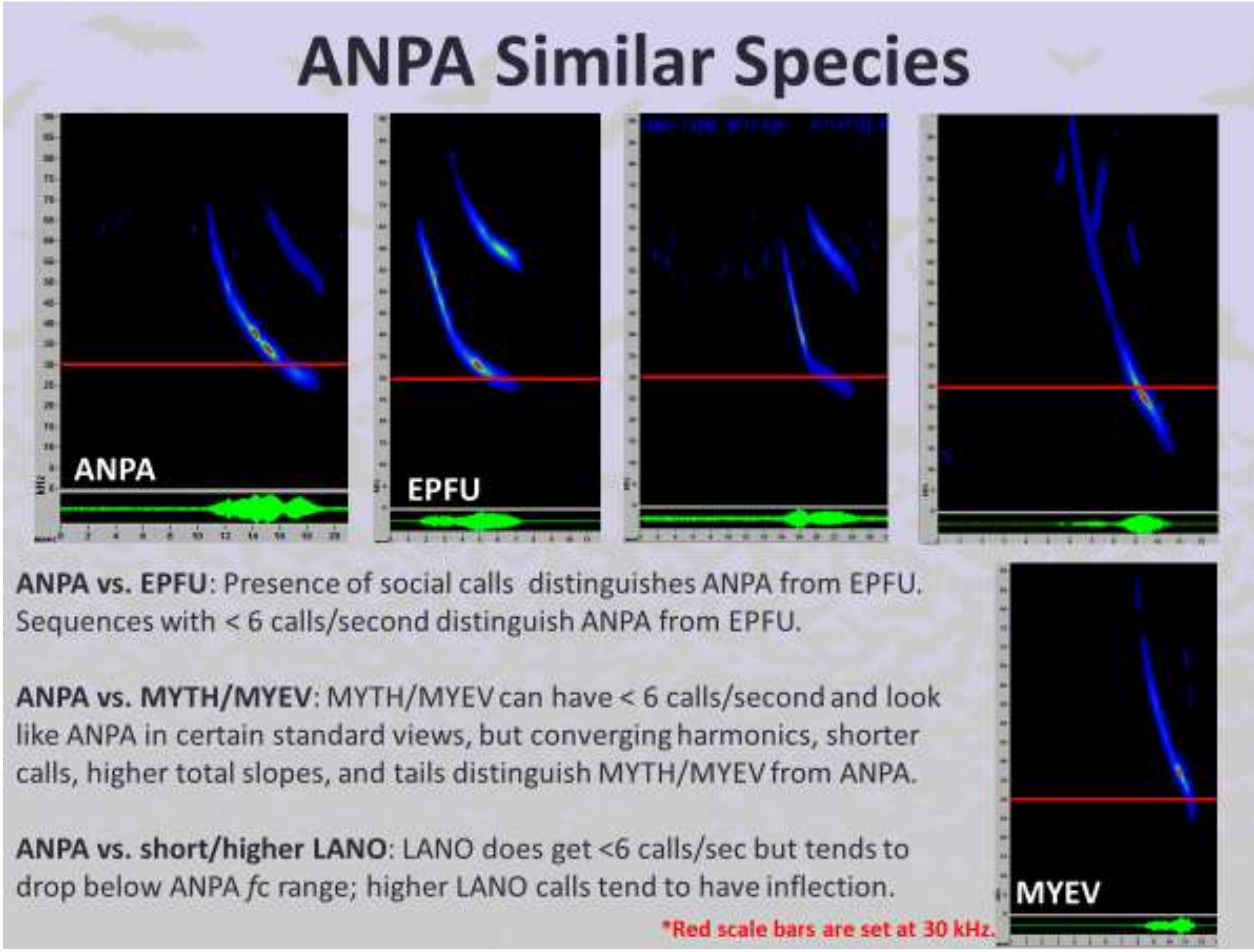


Figure 48. Calls sequences produced by other species that may be confused with the Pallid Bat (Antrozous pallidus, ANPA)

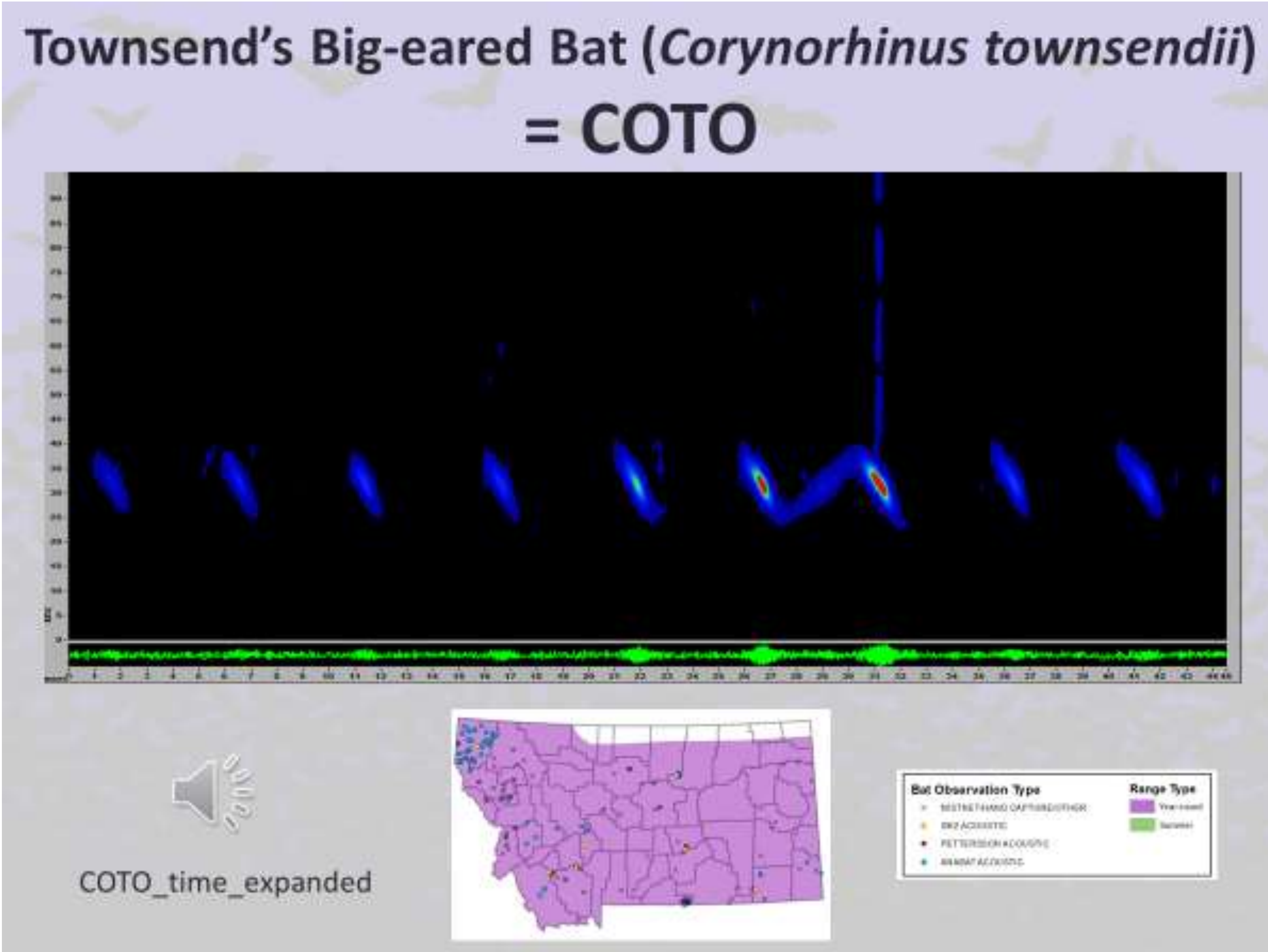


Figure 49. Example call sequence for the Townsend's Big-eared Bat (Corynorhinus townsendii, COTO)

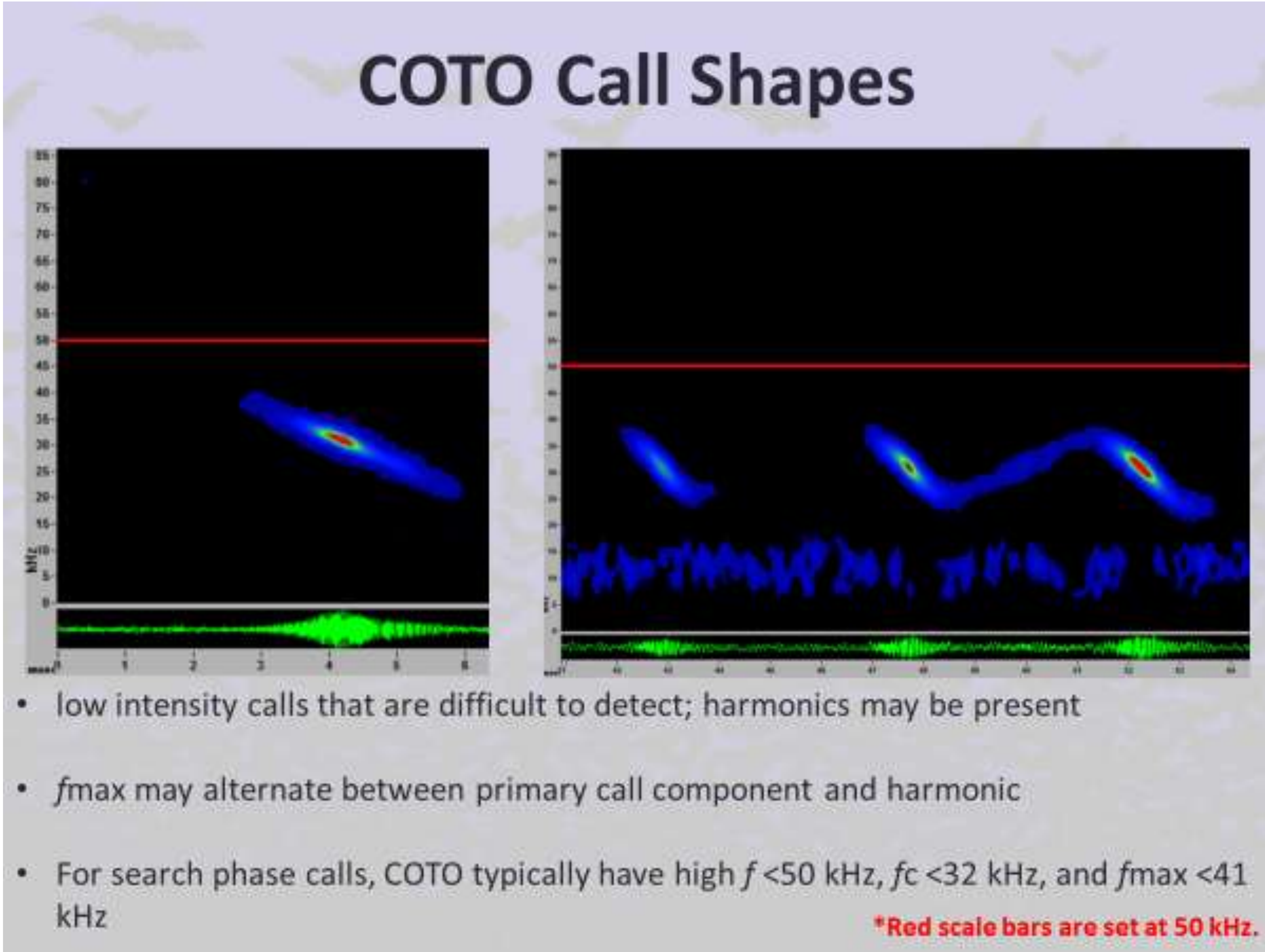


Figure 50. Call shapes of the Townsend's Big-eared Bat (Corynorhinus townsendii, COTO)

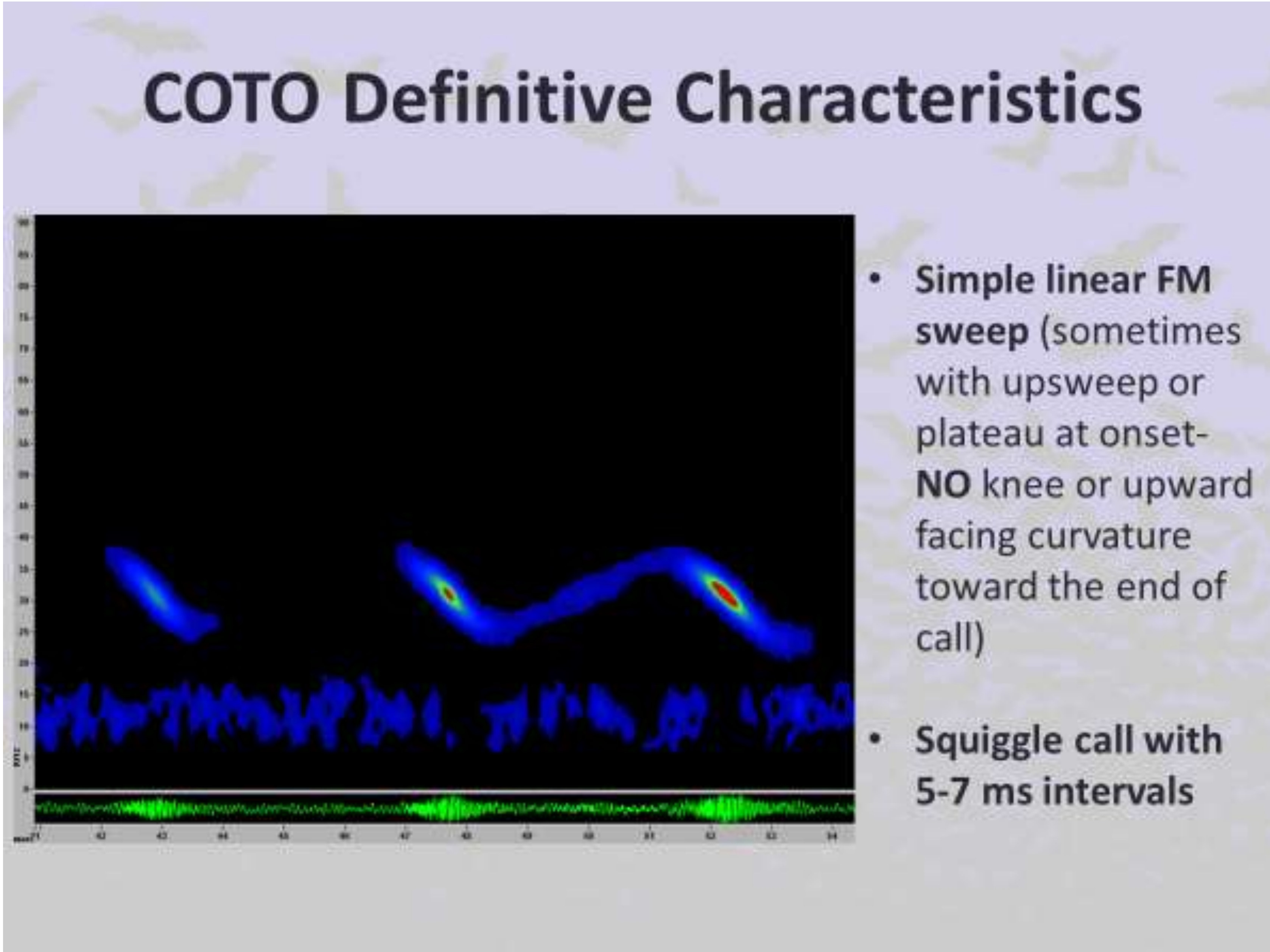


Figure 51. Definitive characteristics of call sequence for the Townsend's Big-eared Bat (Corynorhinus townsendii, COTO)

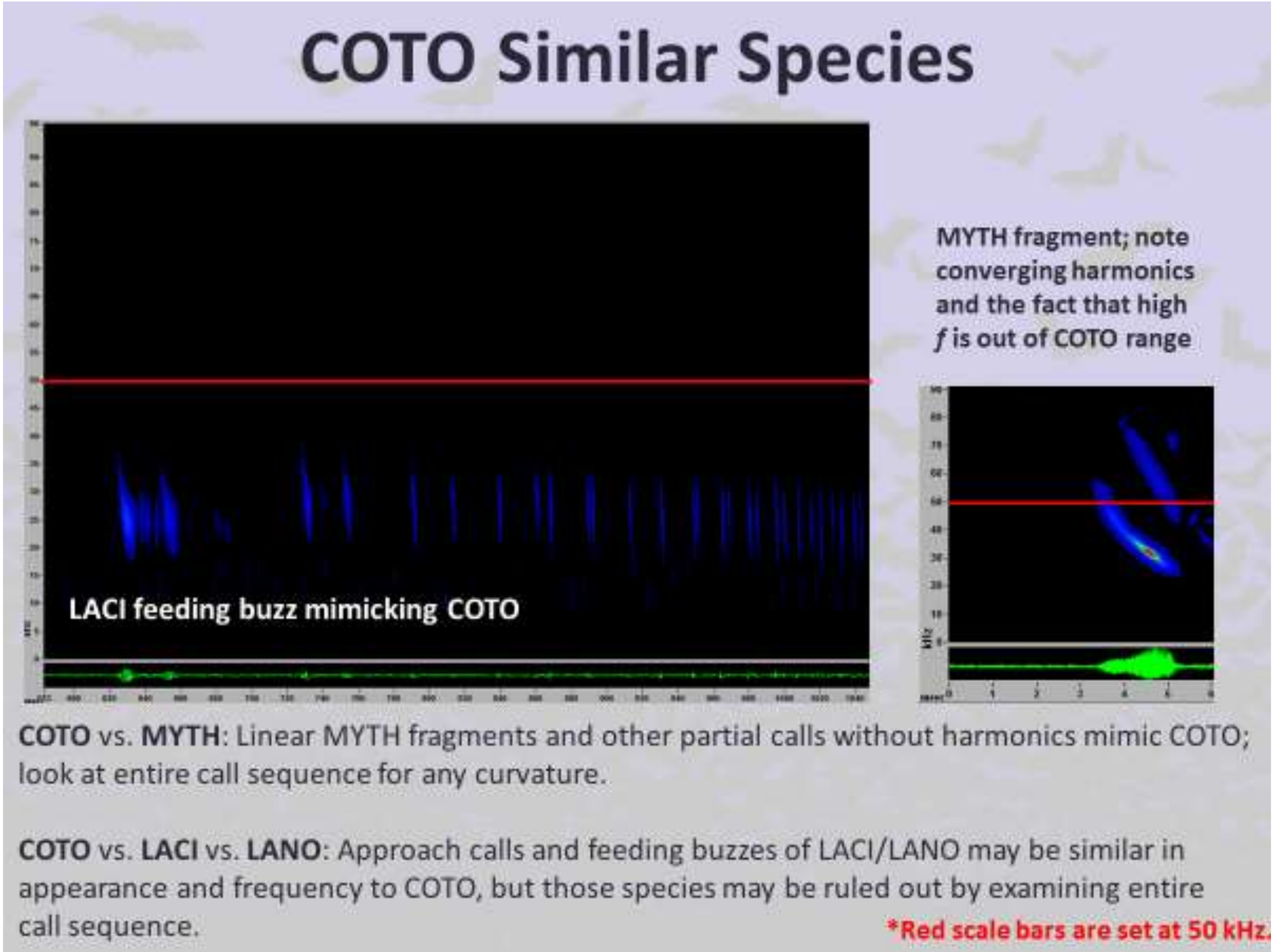


Figure 52. Calls sequences produced by other species that may be confused with the Townsend's Big-eared Bat (Corynorhinus townsendii, COTO)

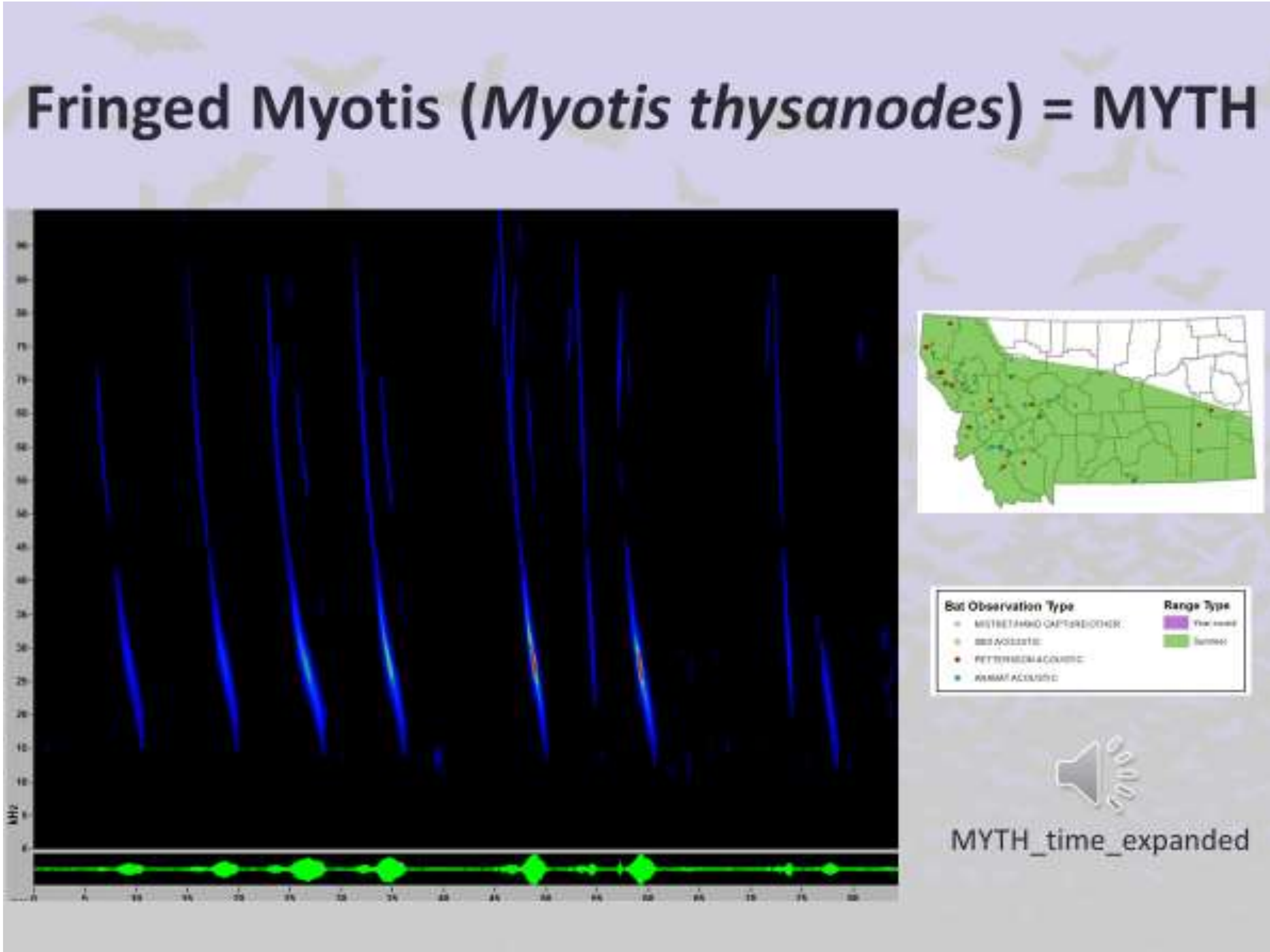


Figure 53. Example call sequence for the Fringed Myotis (Myotis thysanodes, MYTH)

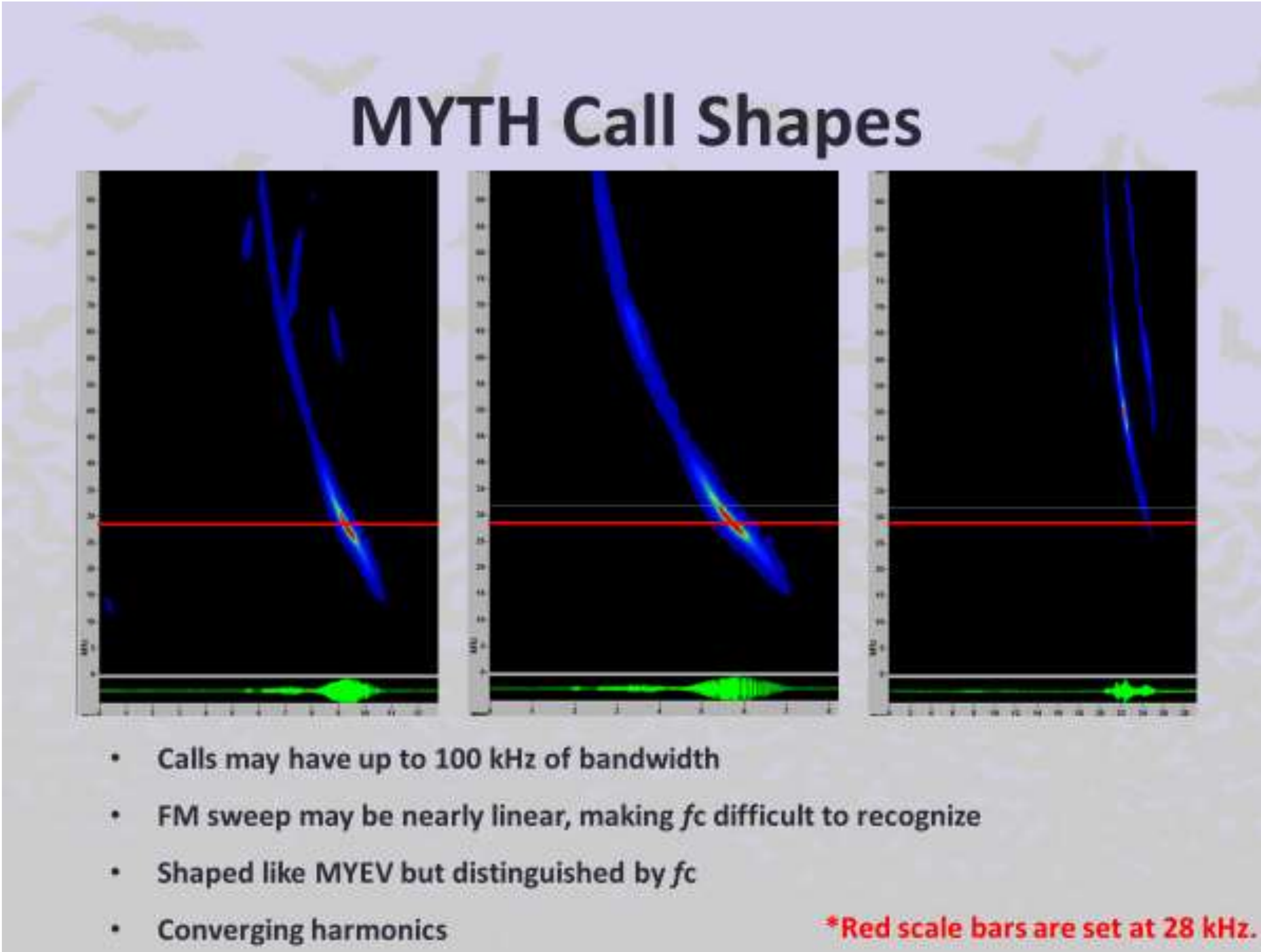


Figure 54. Call shapes of the Fringed Myotis (Myotis thysanodes, MYTH)

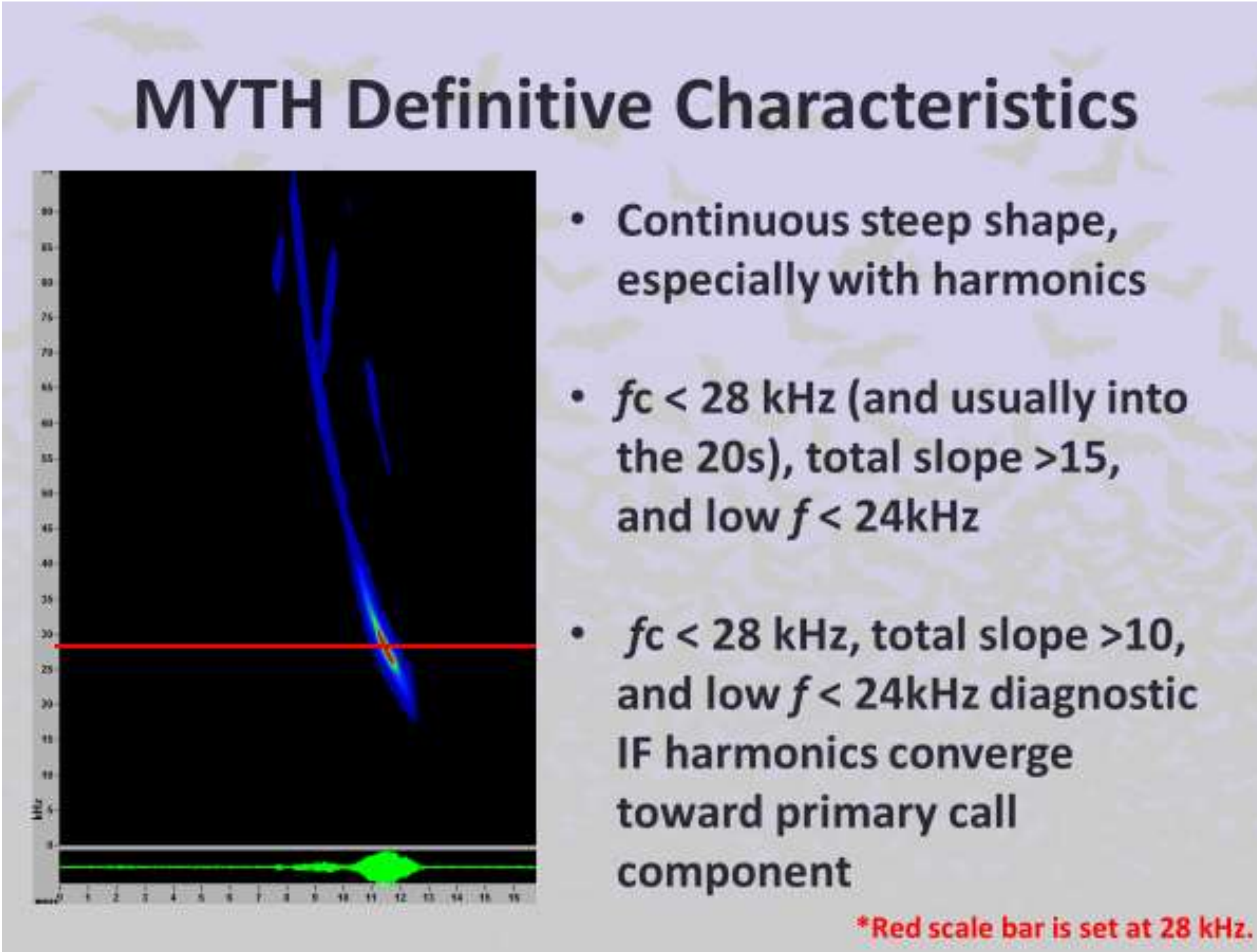


Figure 55. Definitive characteristics of call sequence for the Fringed Myotis (Myotis thysanodes, MYTH)

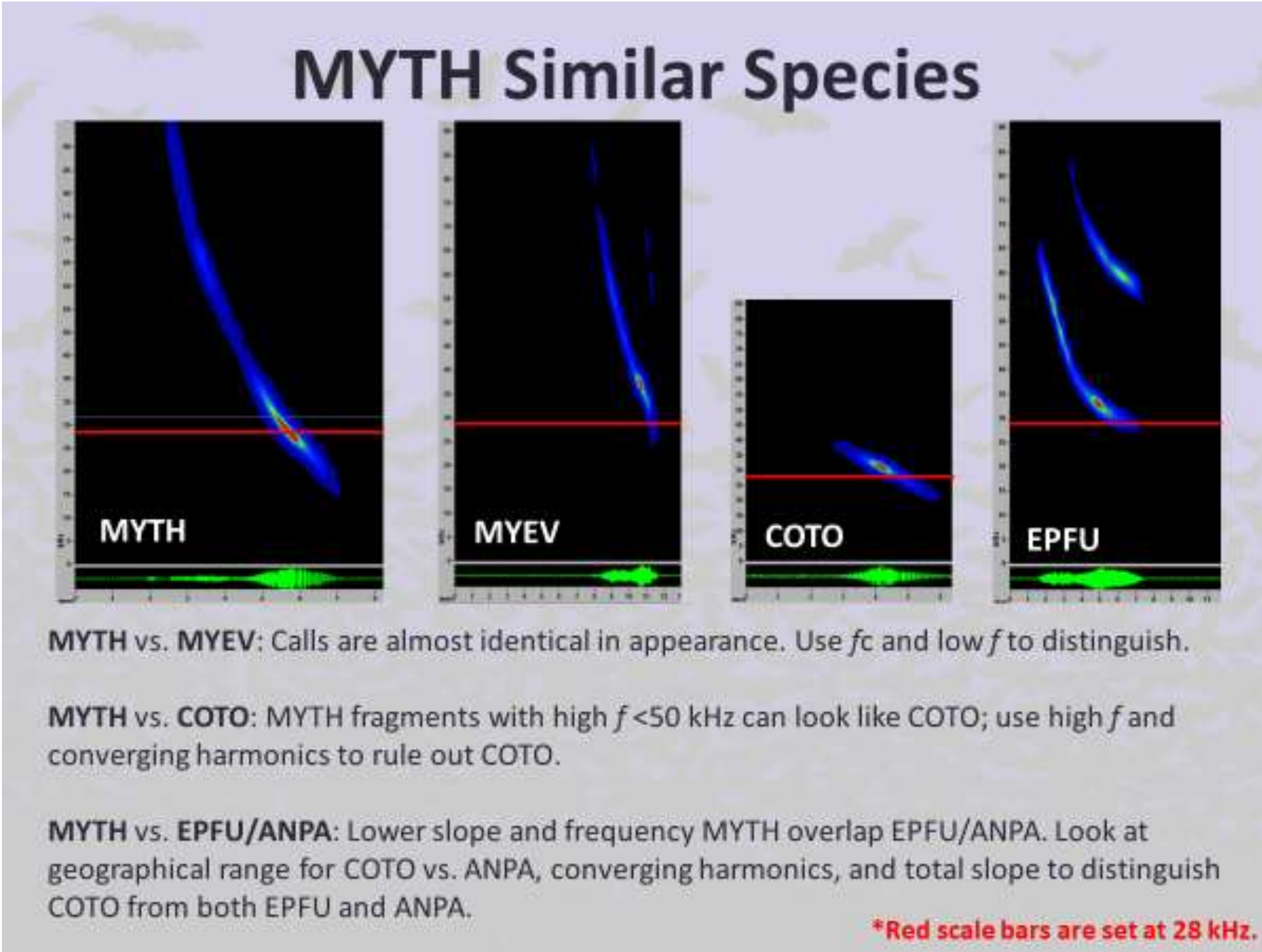


Figure 56. Calls sequences produced by other species that may be confused with the Fringed Myotis (Myotis thysanodes, MYTH)

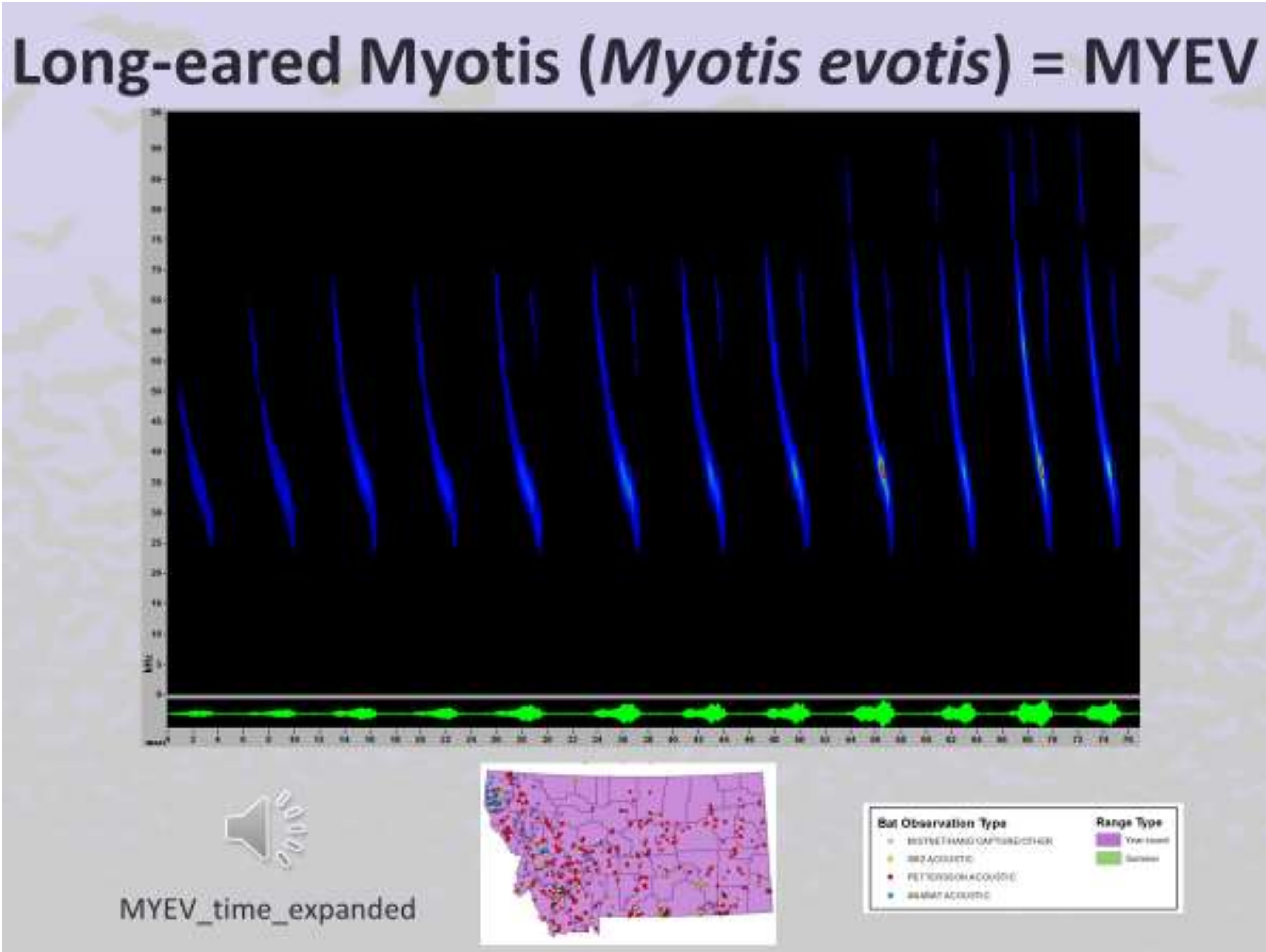


Figure 57. Example call sequence for the Long-eared Myotis (Myotis evotis, MYEV).

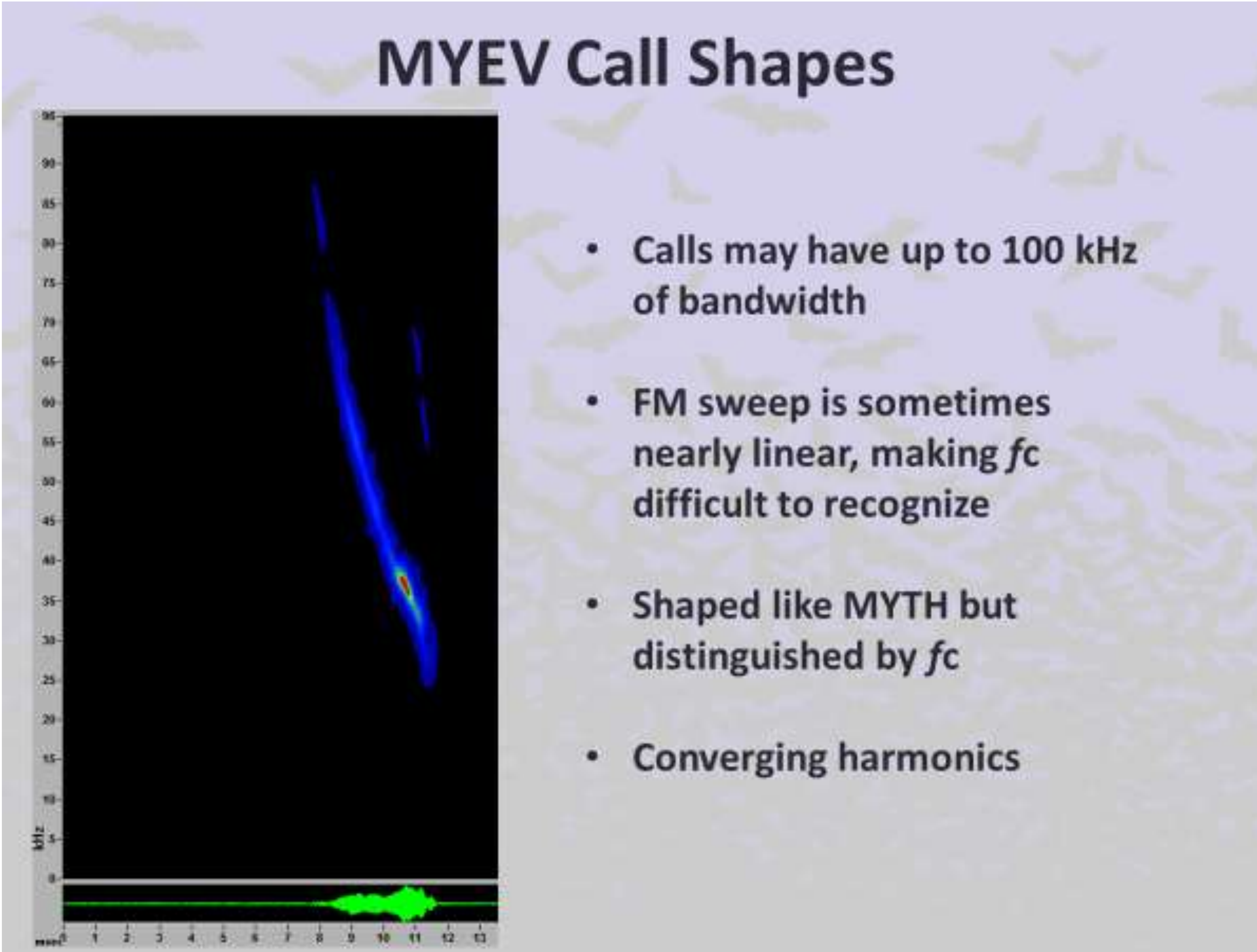


Figure 58. Call shapes of the Long-eared Myotis (Myotis evotis, MYEV)

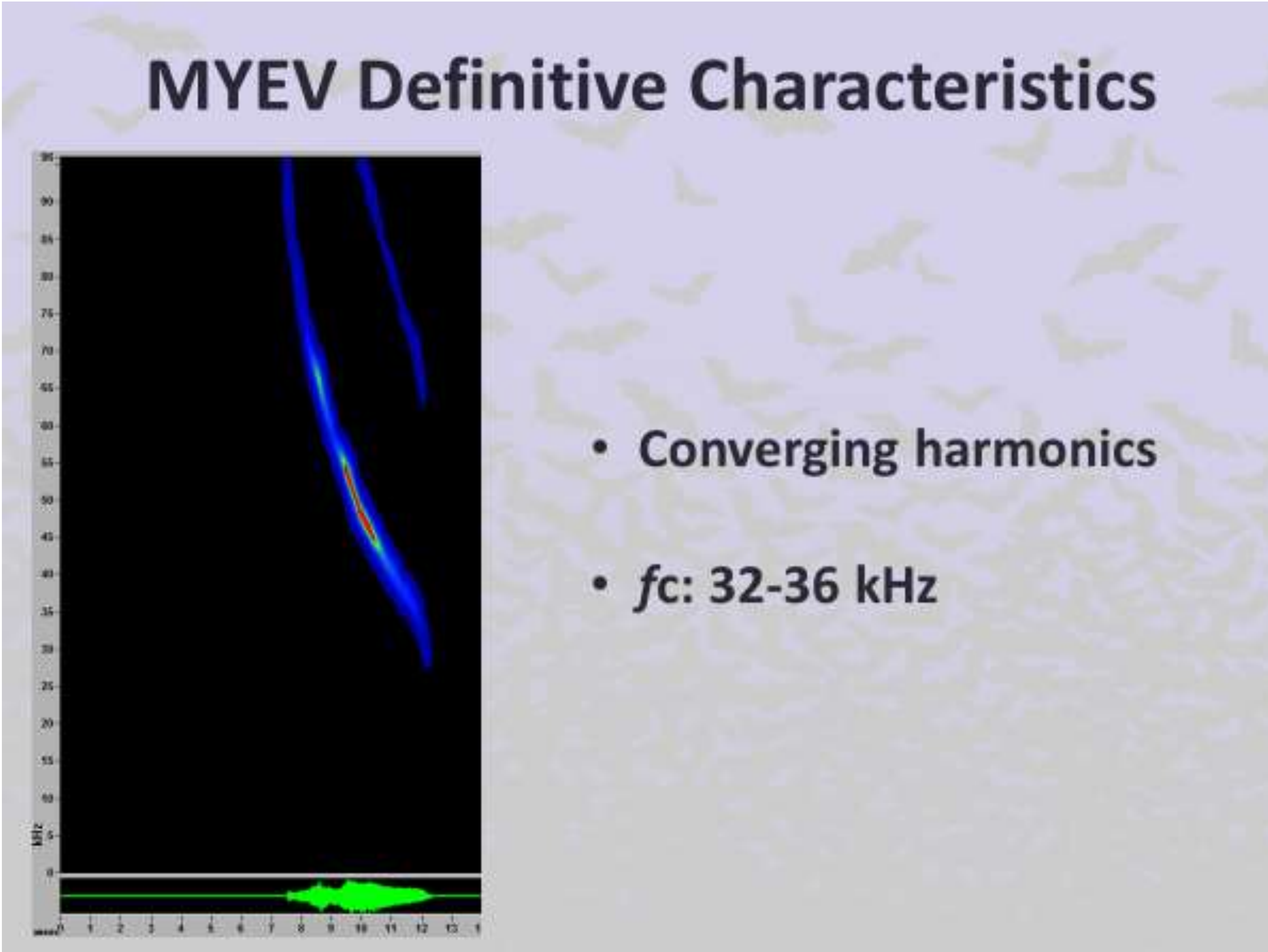


Figure 59. Definitive characteristics of call sequence for the Long-eared Myotis (Myotis evotis, MYEV)

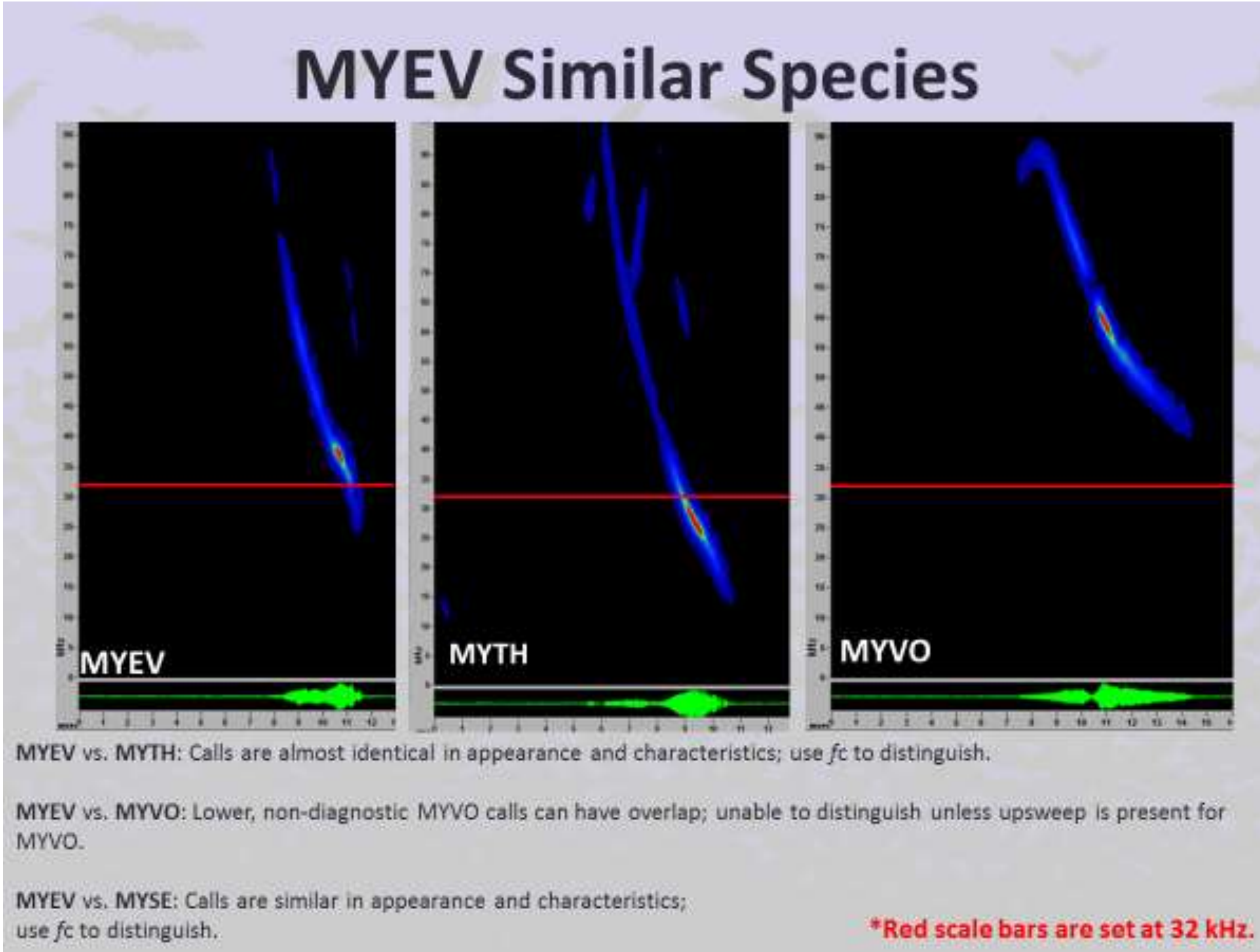


Figure 60. Calls sequences produced by other species that may be confused with the Long-eared Myotis (Myotis evotis, MYEV)

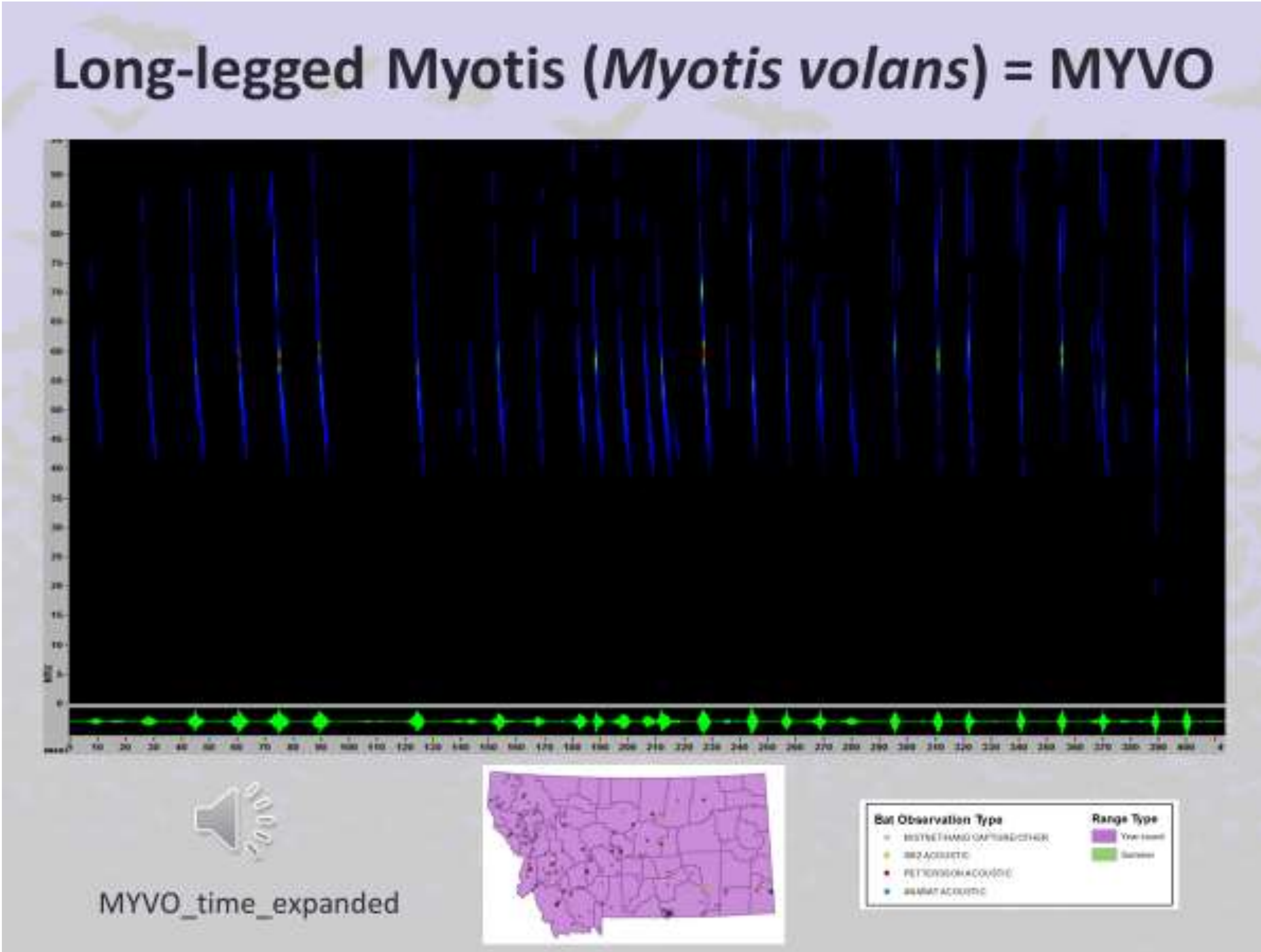


Figure 61. Example call sequence for the Long-legged Myotis (Myotis volans, MYVO)

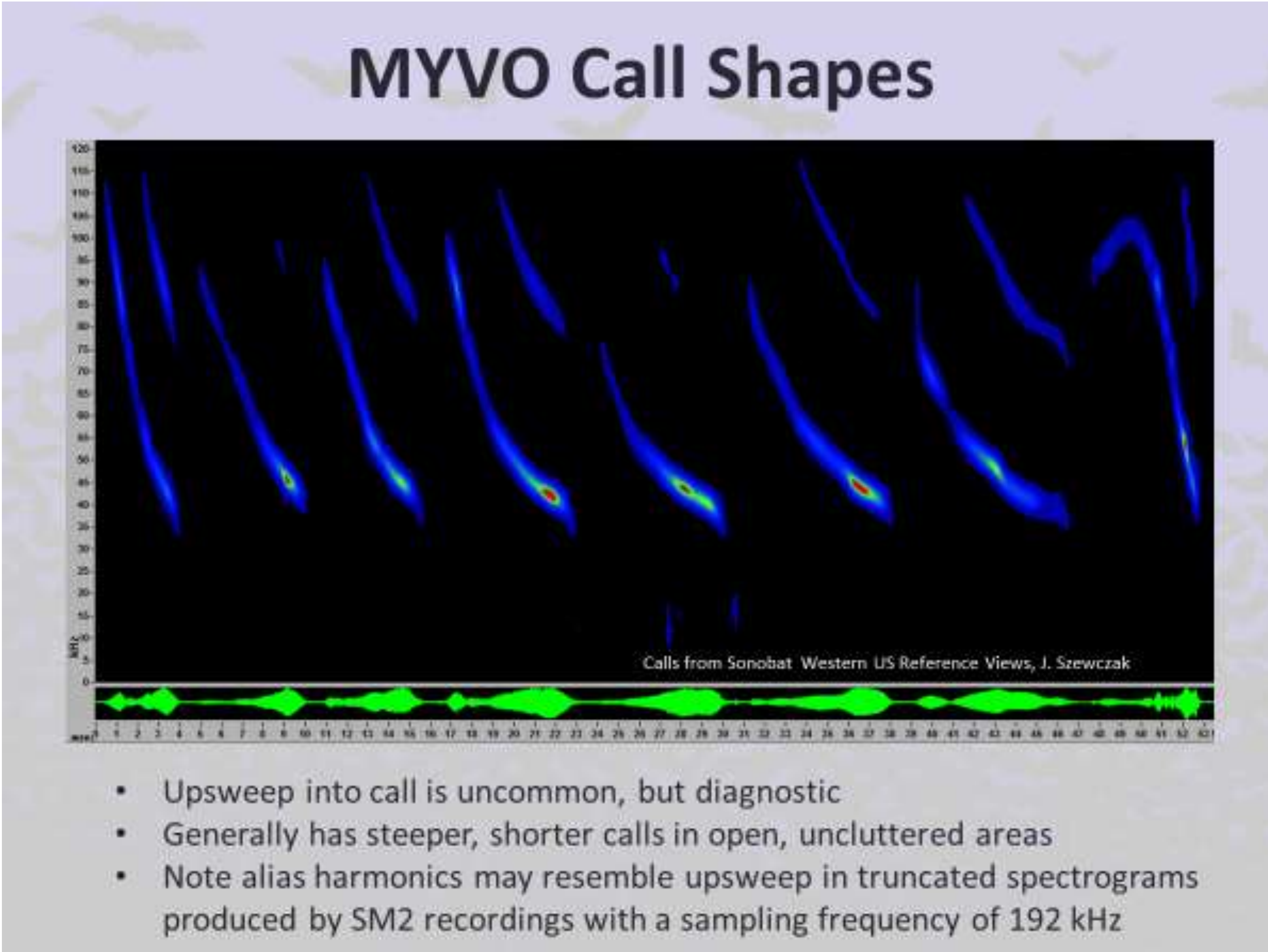


Figure 62. Call shapes of the Long-legged Myotis (Myotis volans, MYVO)

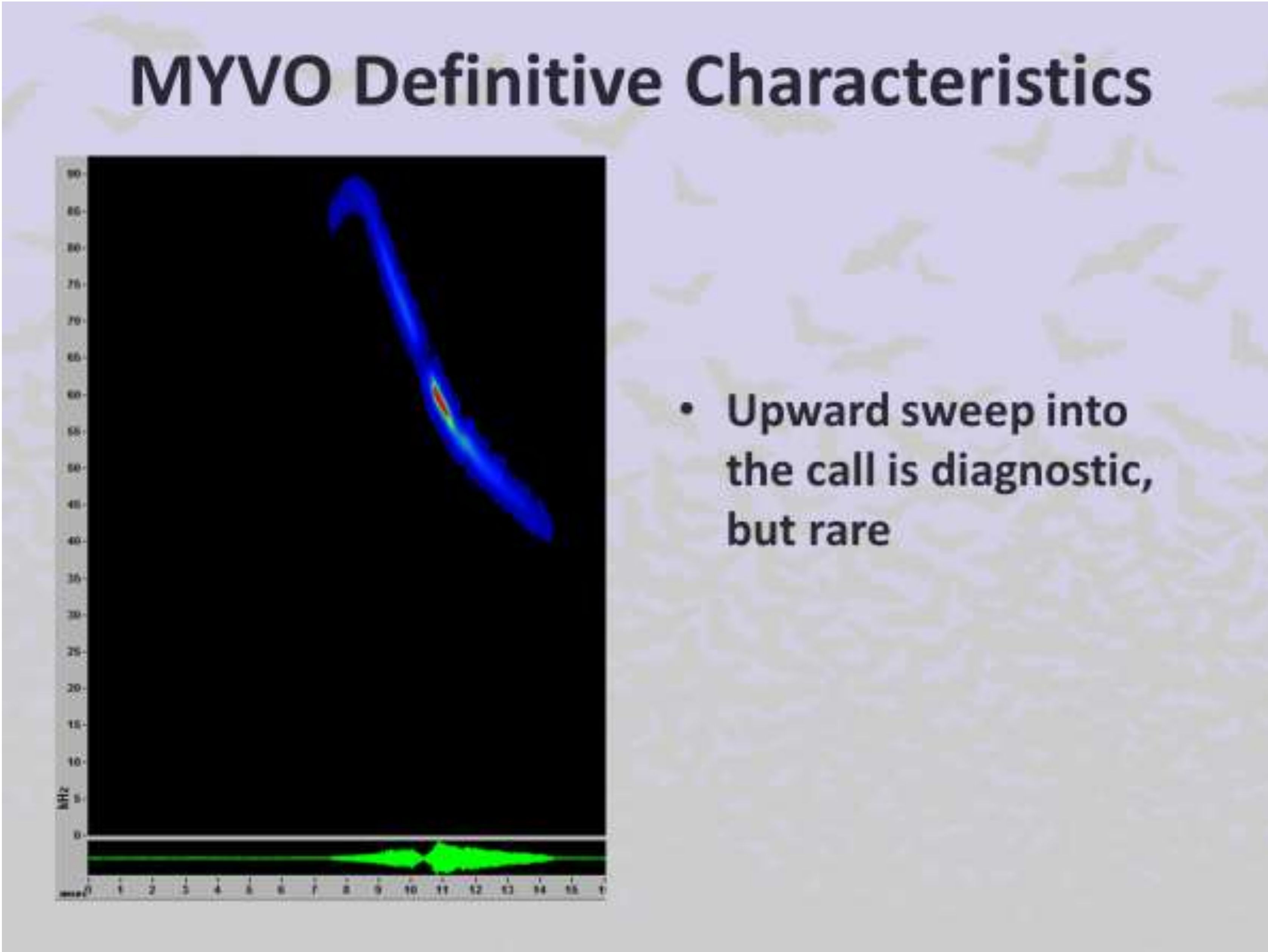


Figure 63. Definitive characteristics of call sequence for the Long-legged Myotis (Myotis volans, MYVO)

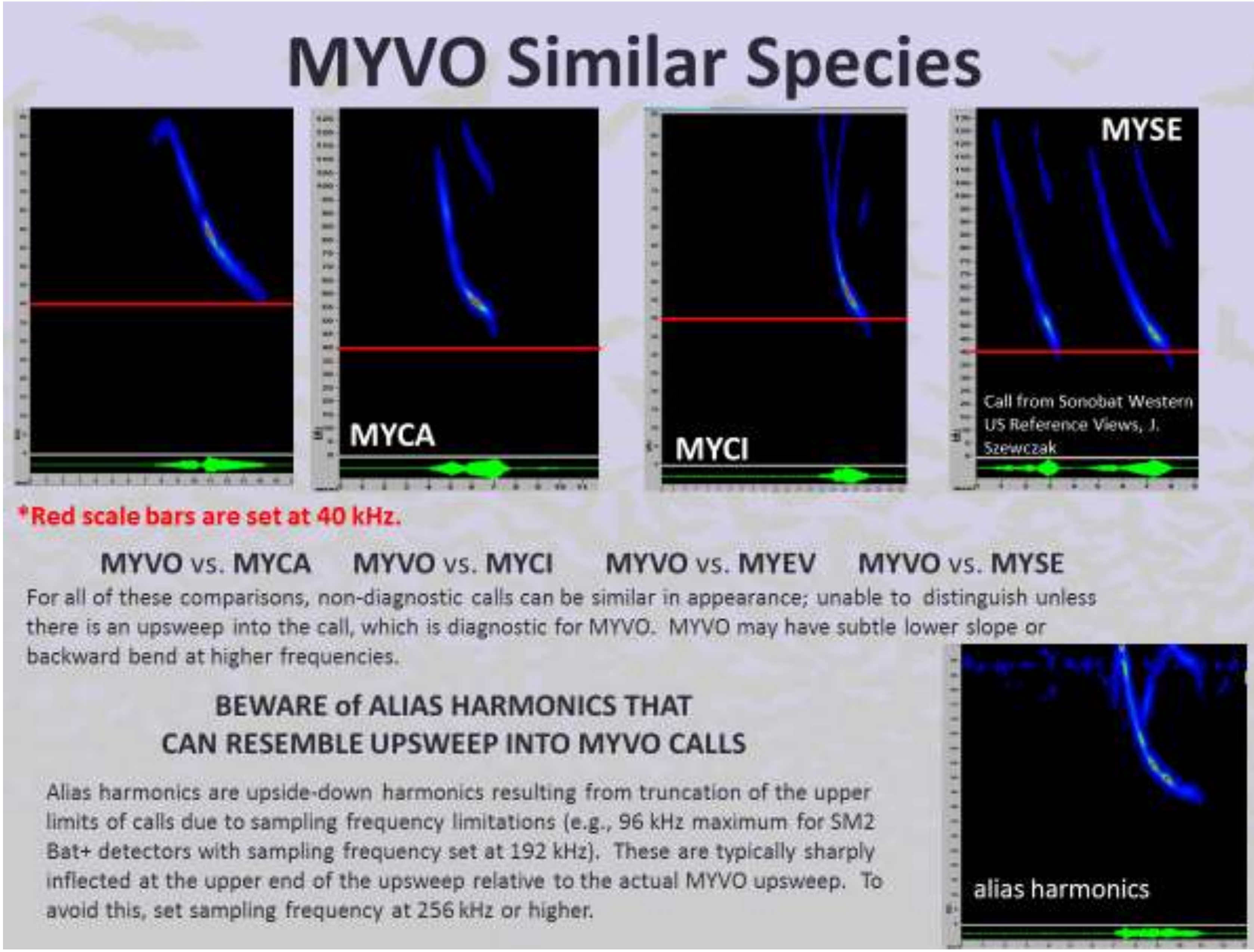


Figure 64. Calls sequences produced by other species that may be confused with the Long-legged Myotis (Myotis volans, MYVO)

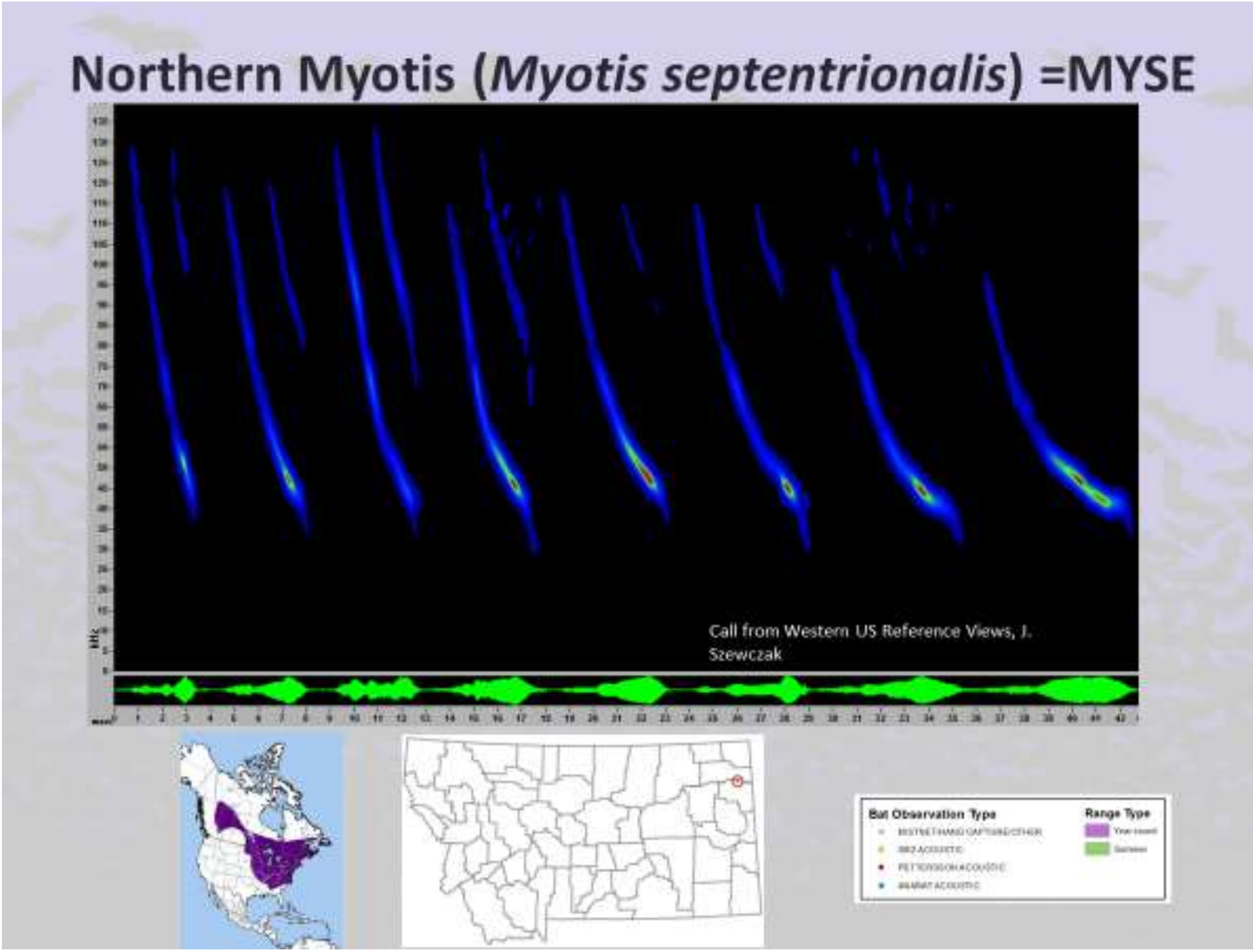


Figure 65. Example call sequence for the Northern Myotis (Myotis septentrionalis, MYSE)

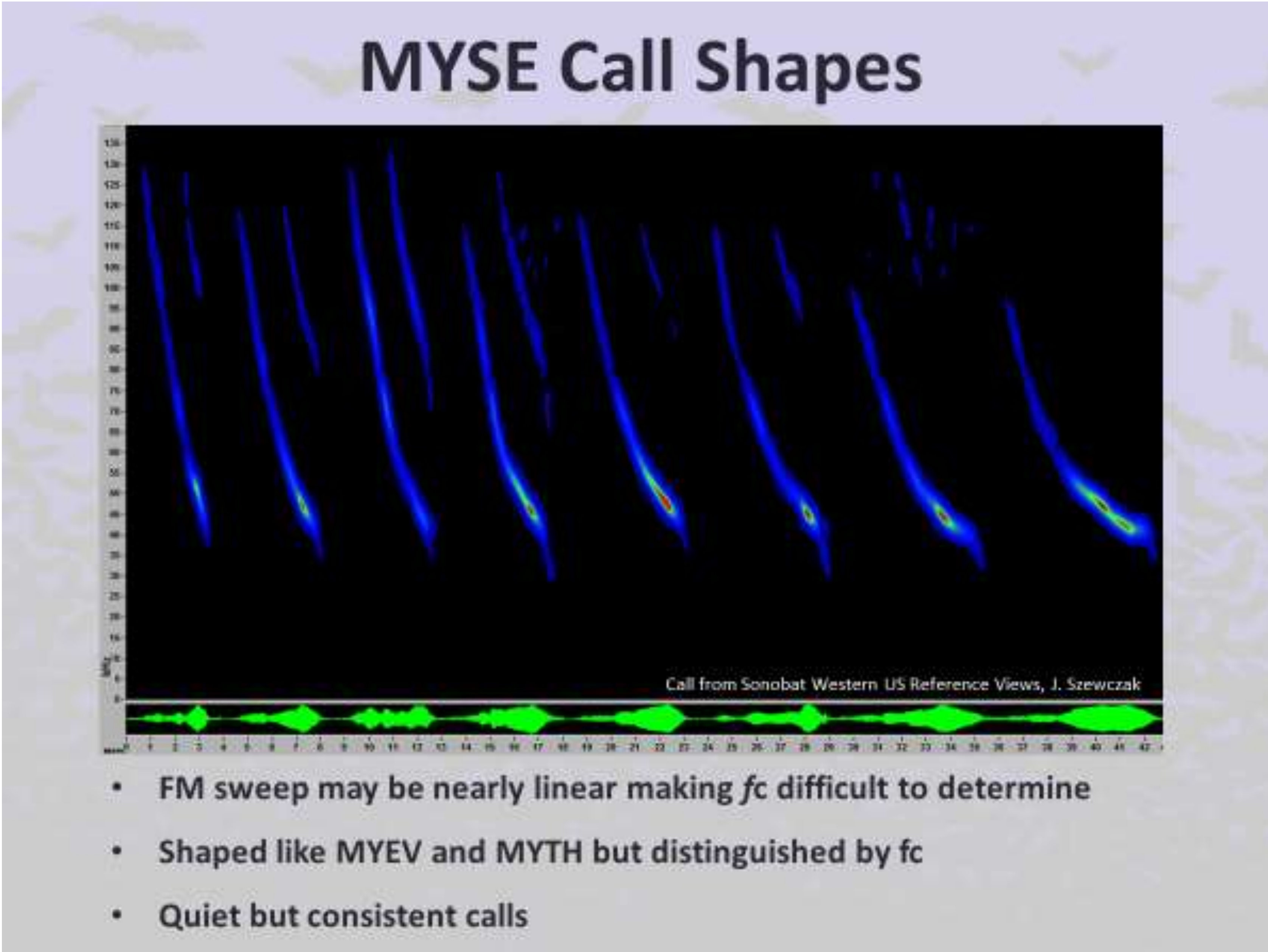


Figure 66. Call shapes of the Northern Myotis (Myotis septentrionalis, MYSE)

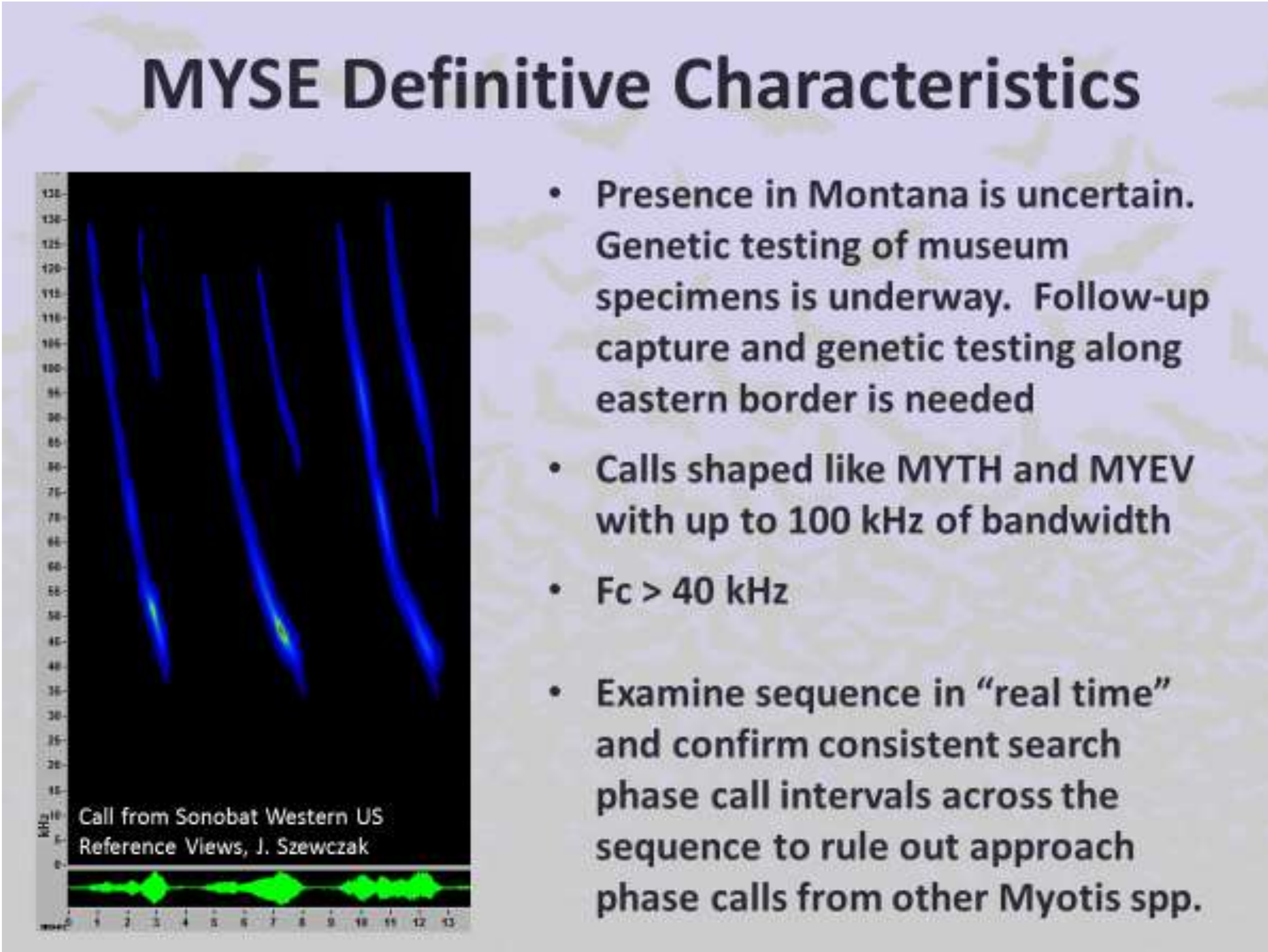


Figure 67. Definitive characteristics of call sequence for the Northern Myotis (Myotis septentrionalis, MYSE)

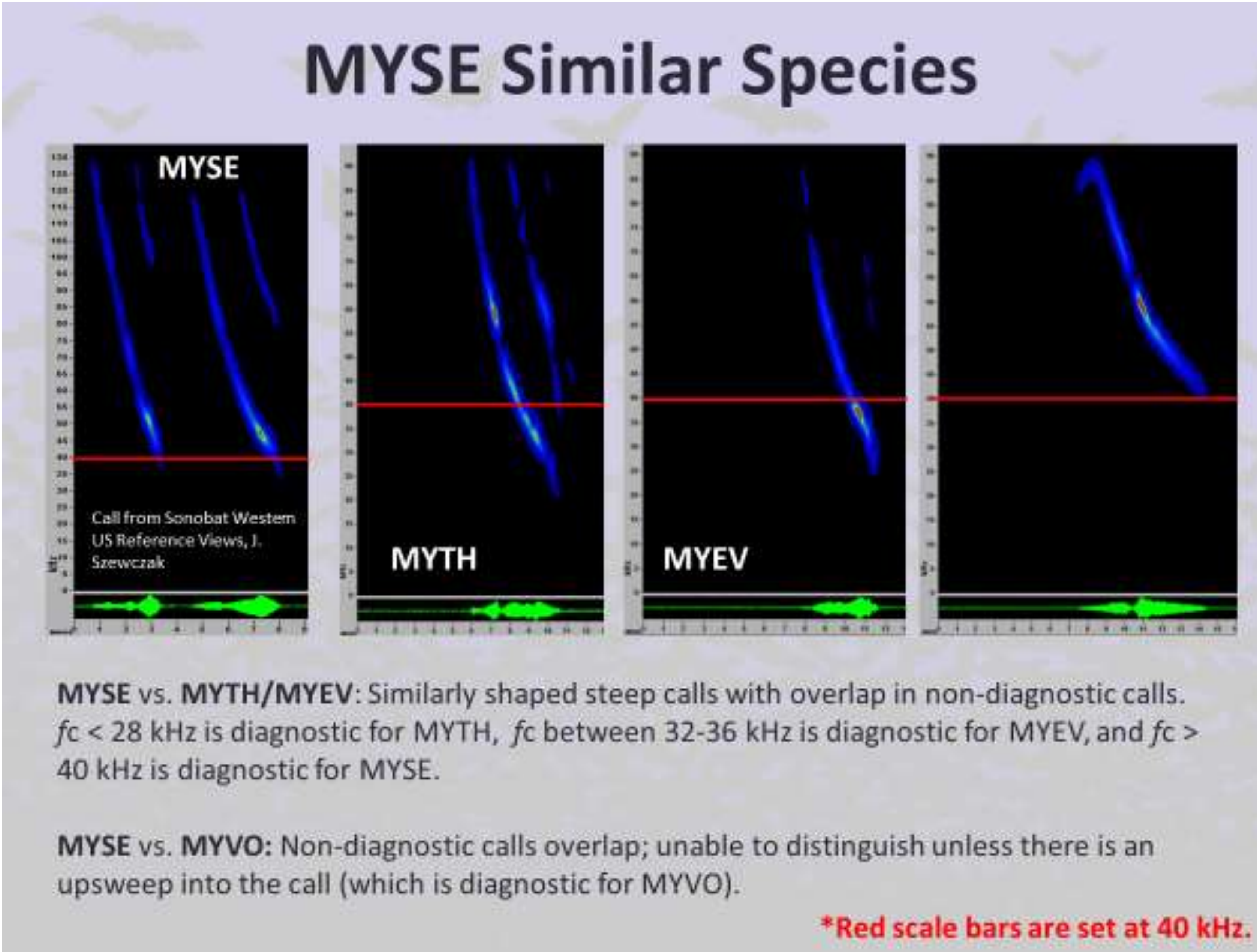


Figure 68. Calls sequences produced by other species that may be confused with the Northern Myotis (Myotis septentrionalis, MYSE)

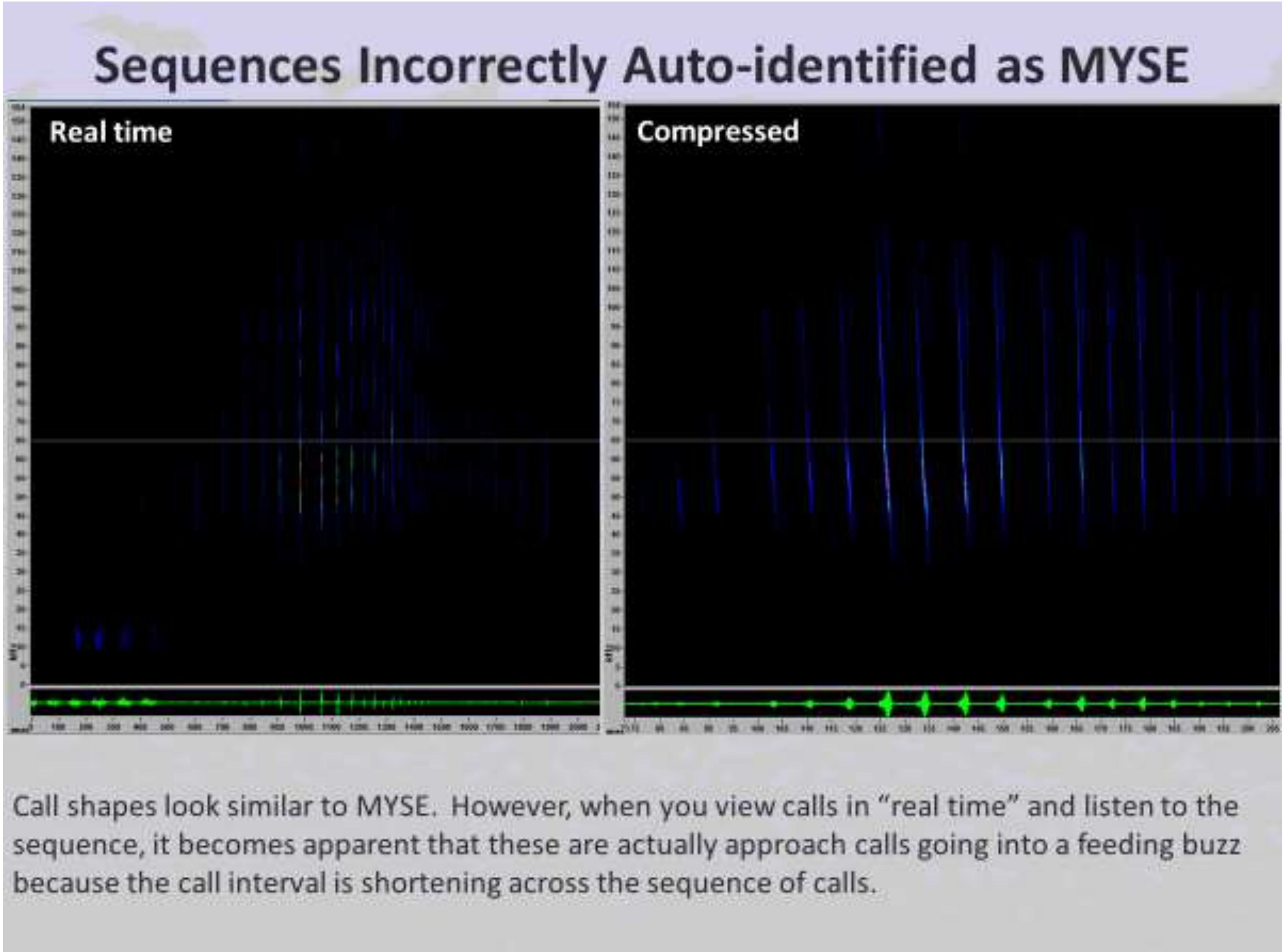


Figure 69. Example of the similarity between a feeding buzz produced by a Myotis bat and the call sequence of a Northern Myotis

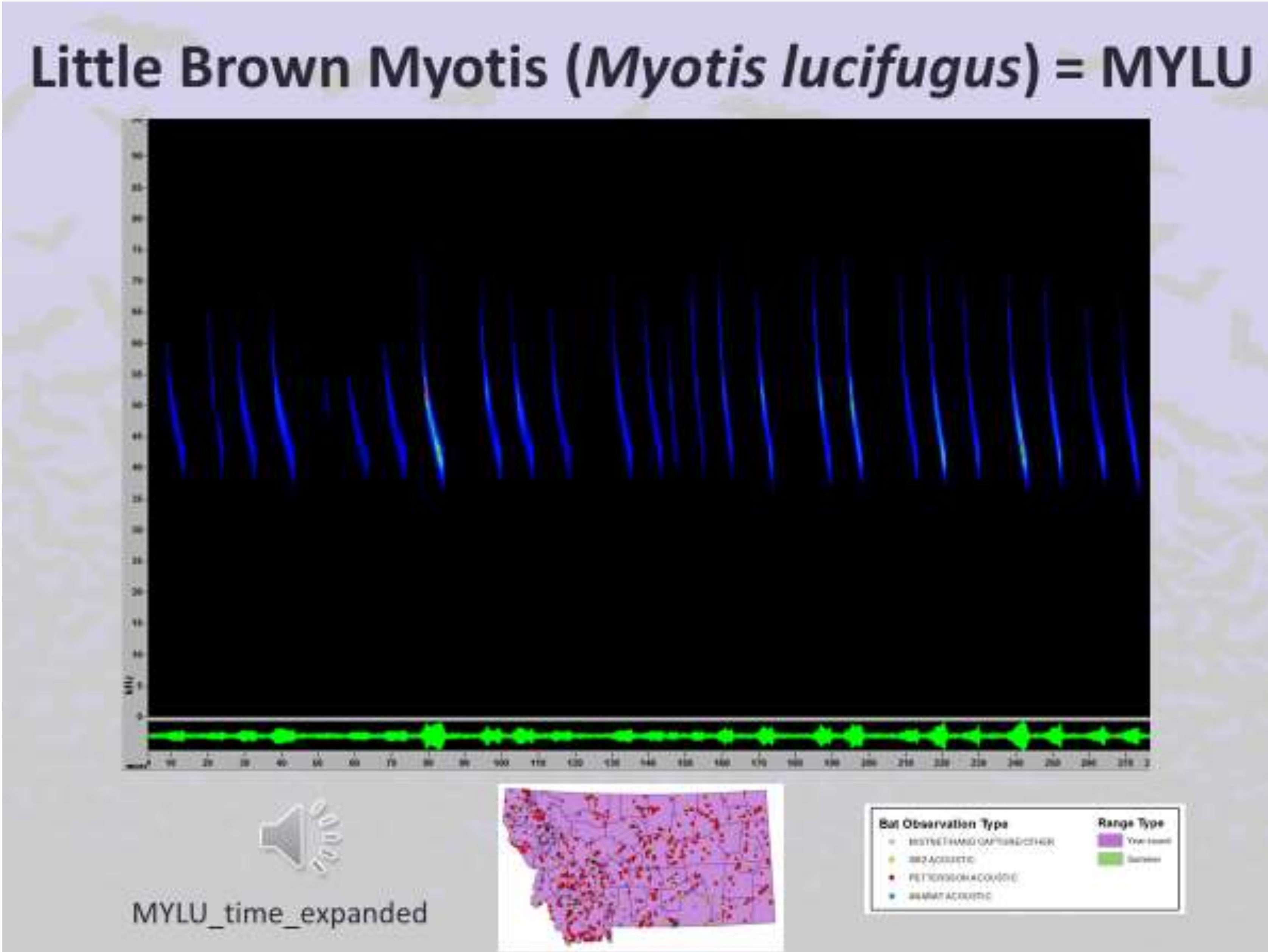


Figure 70. Example call sequence for the Little Brown Myotis (Myotis lucifigus, MYLU)

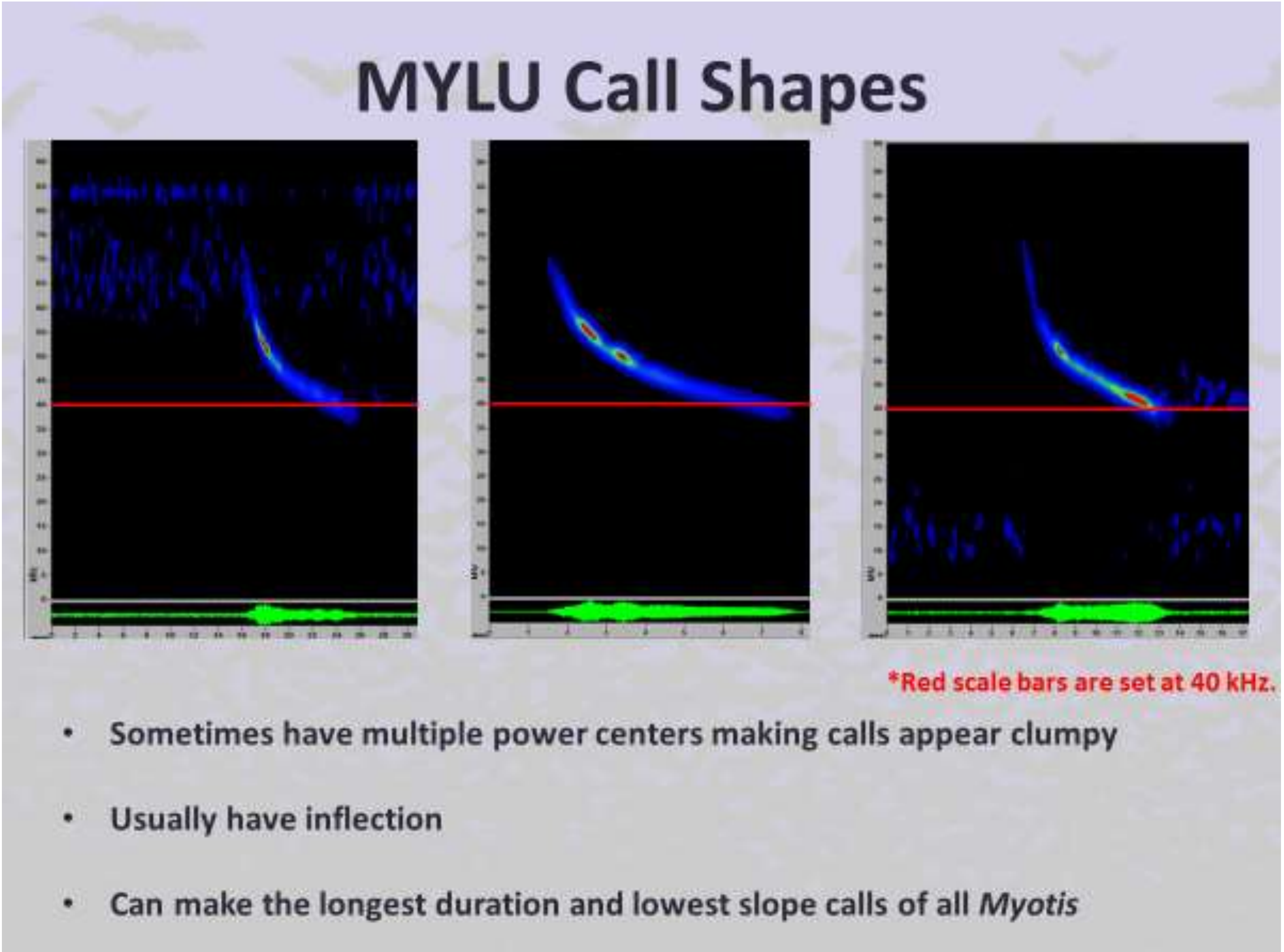


Figure 71. Call shapes of the Little Brown Myotis (Myotis lucifigus, MYLU)

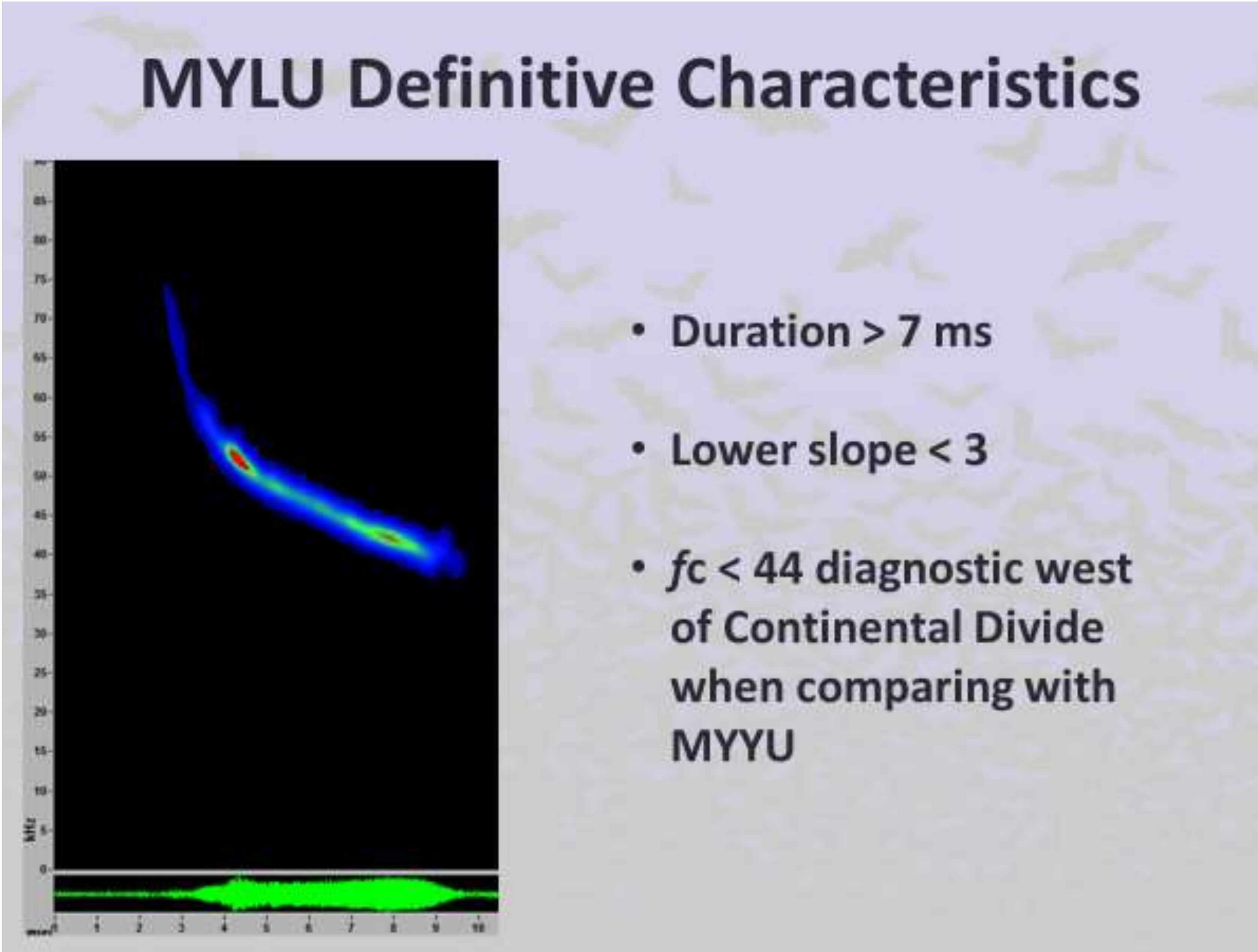


Figure 72. Definitive characteristics of call sequence for the Little Brown Myotis (Myotis lucifigus, MYLU)

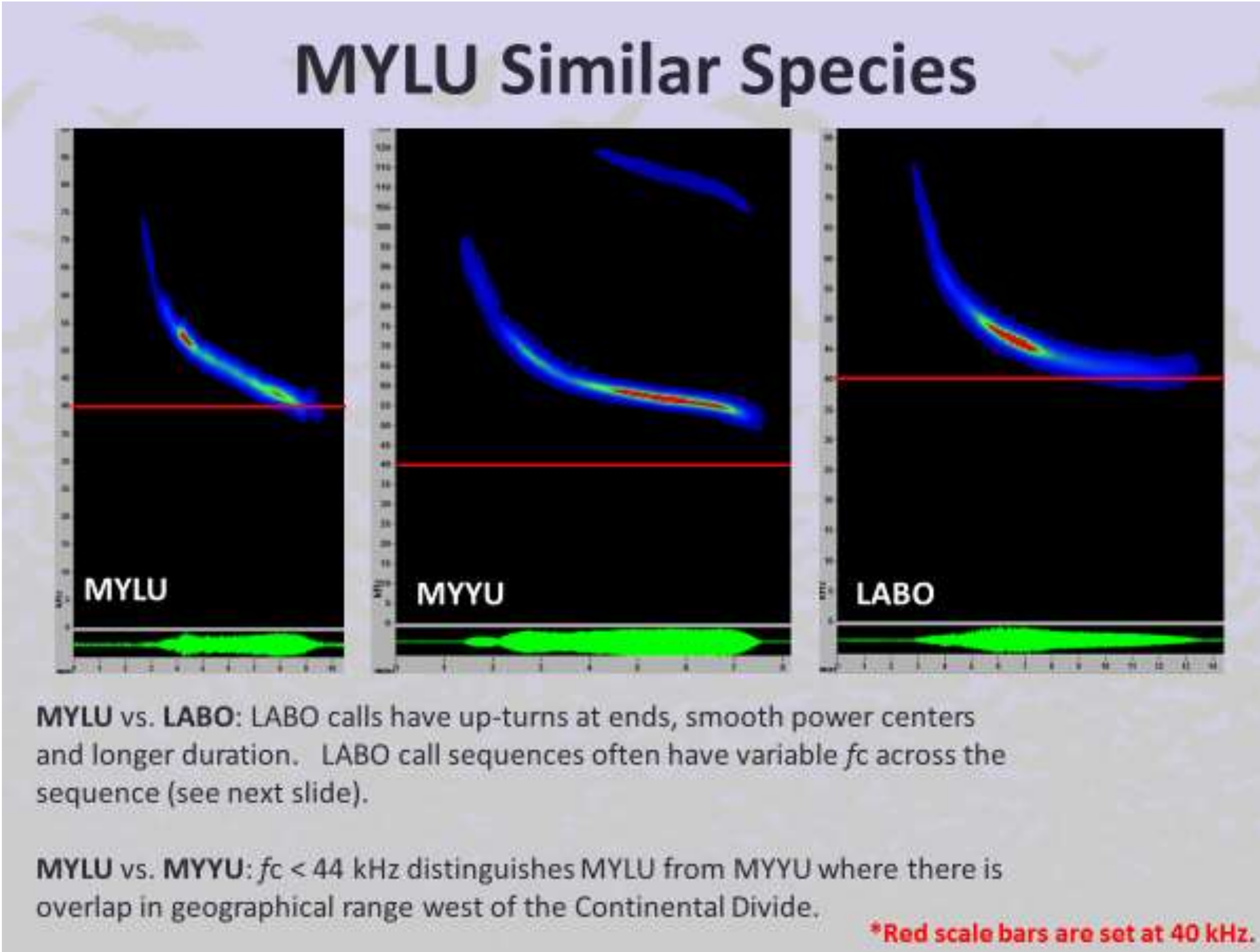


Figure 73. Calls sequences produced by other species that may be confused with the Little Brown Myotis (Myotis lucifigus, MYLU)

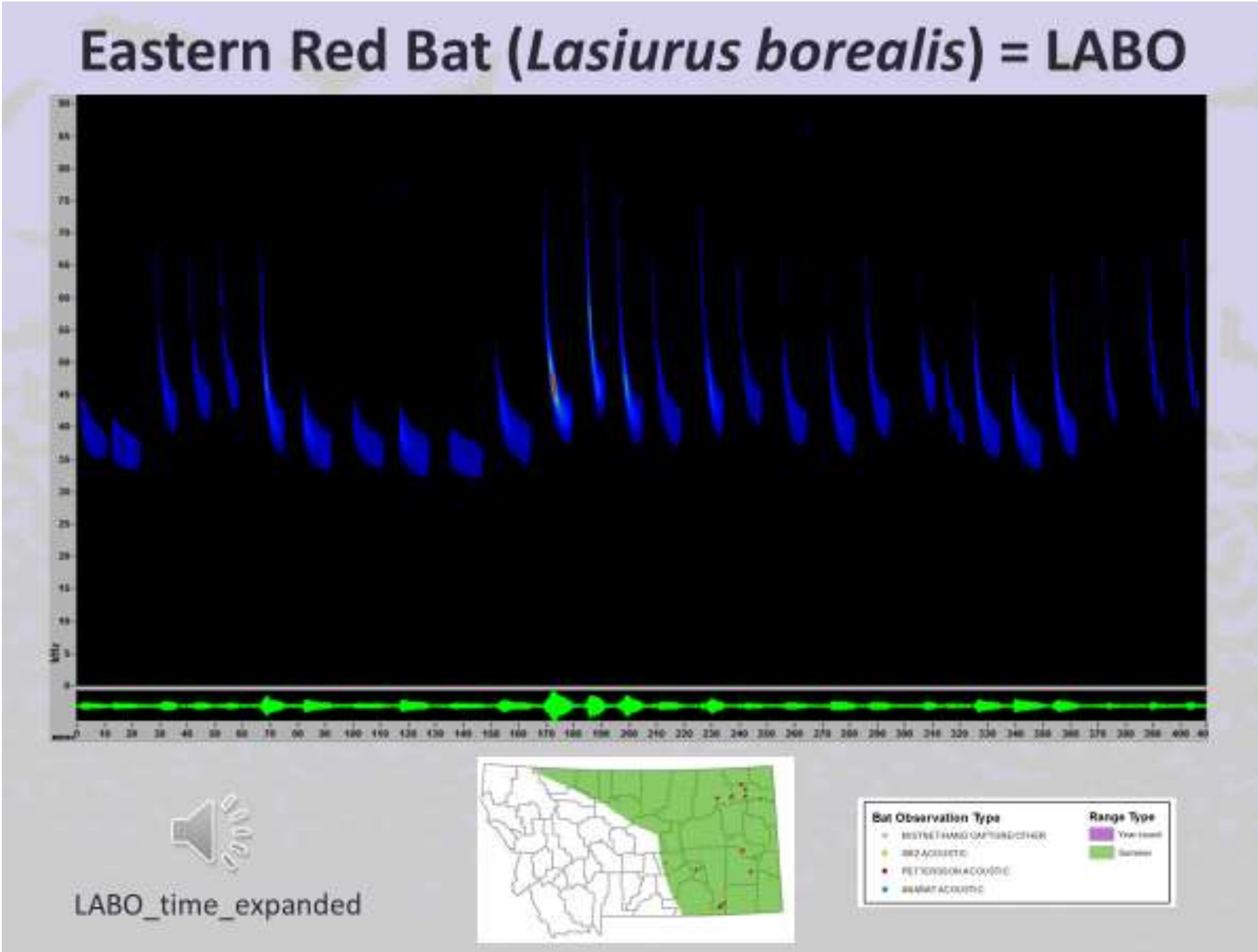


Figure 74. Example call sequence for the Eastern Red Bat (Lasiurus borealis, LABO)

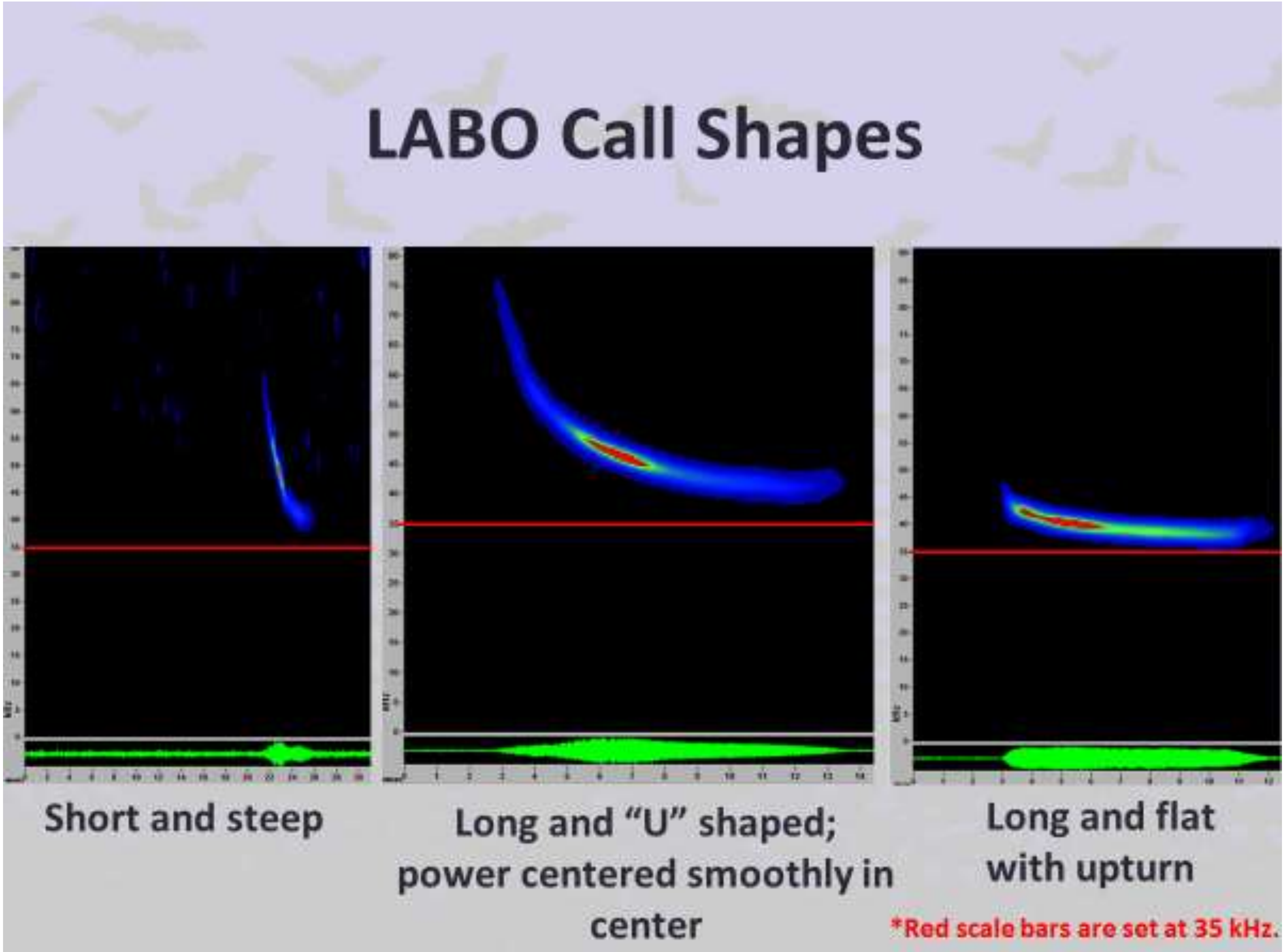


Figure 75. Call shapes of the Eastern Red Bat (Lasiurus borealis, LABO)

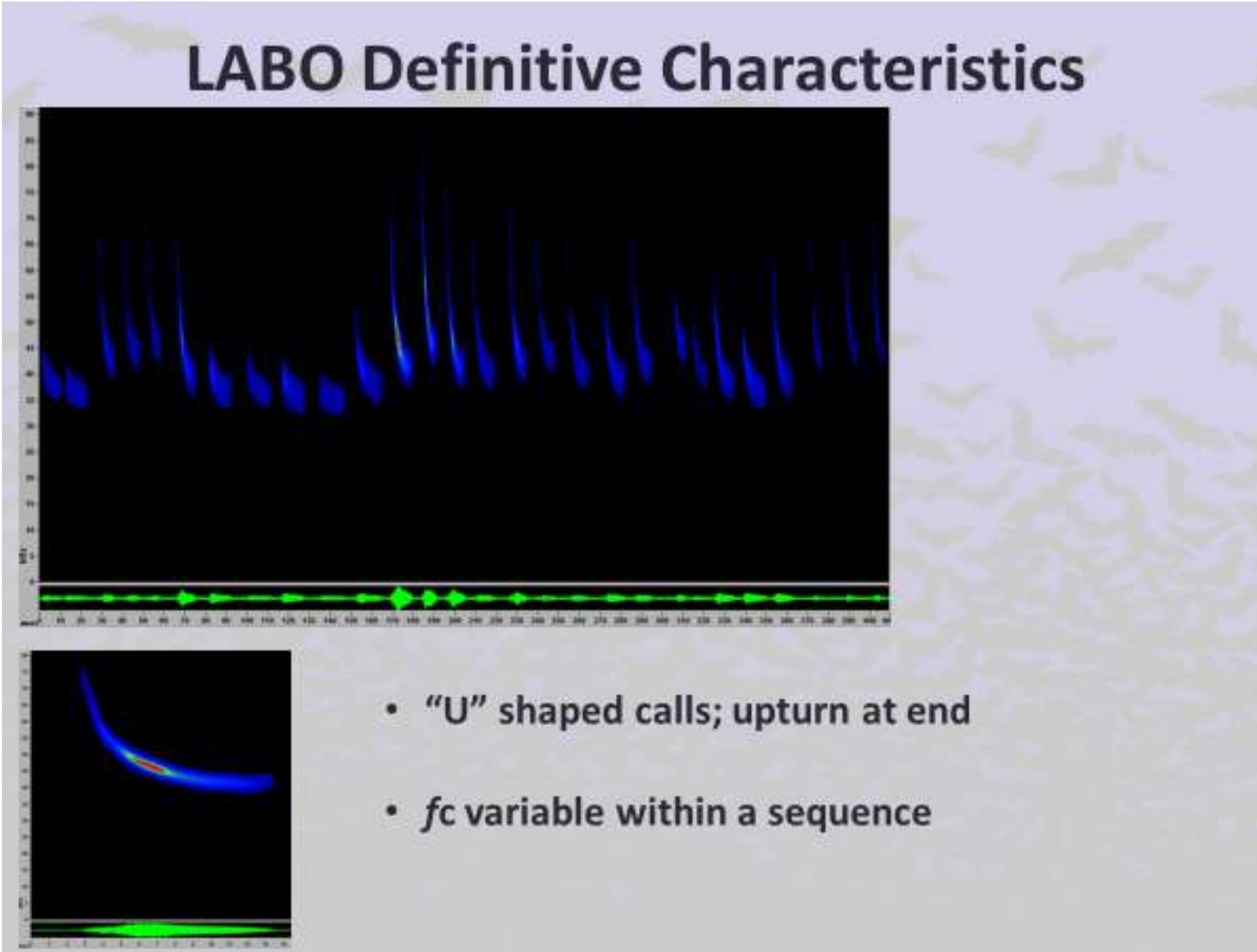


Figure 76. Definitive characteristics of call sequence for the Eastern Red Bat (Lasiurus borealis, LABO)

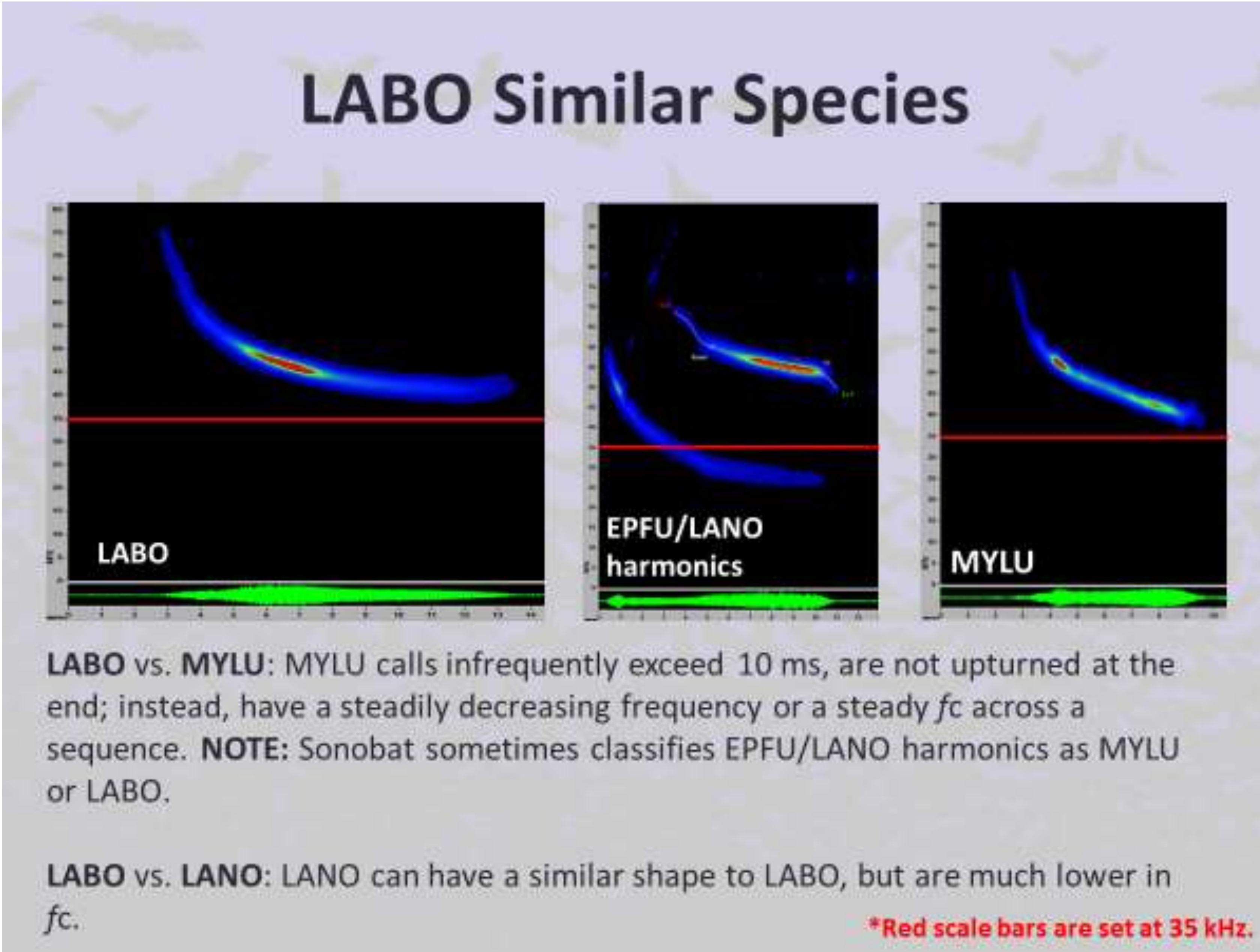


Figure 77. Calls sequences produced by other species that may be confused with the Eastern Red Bat (Lasiurus borealis, LABO)

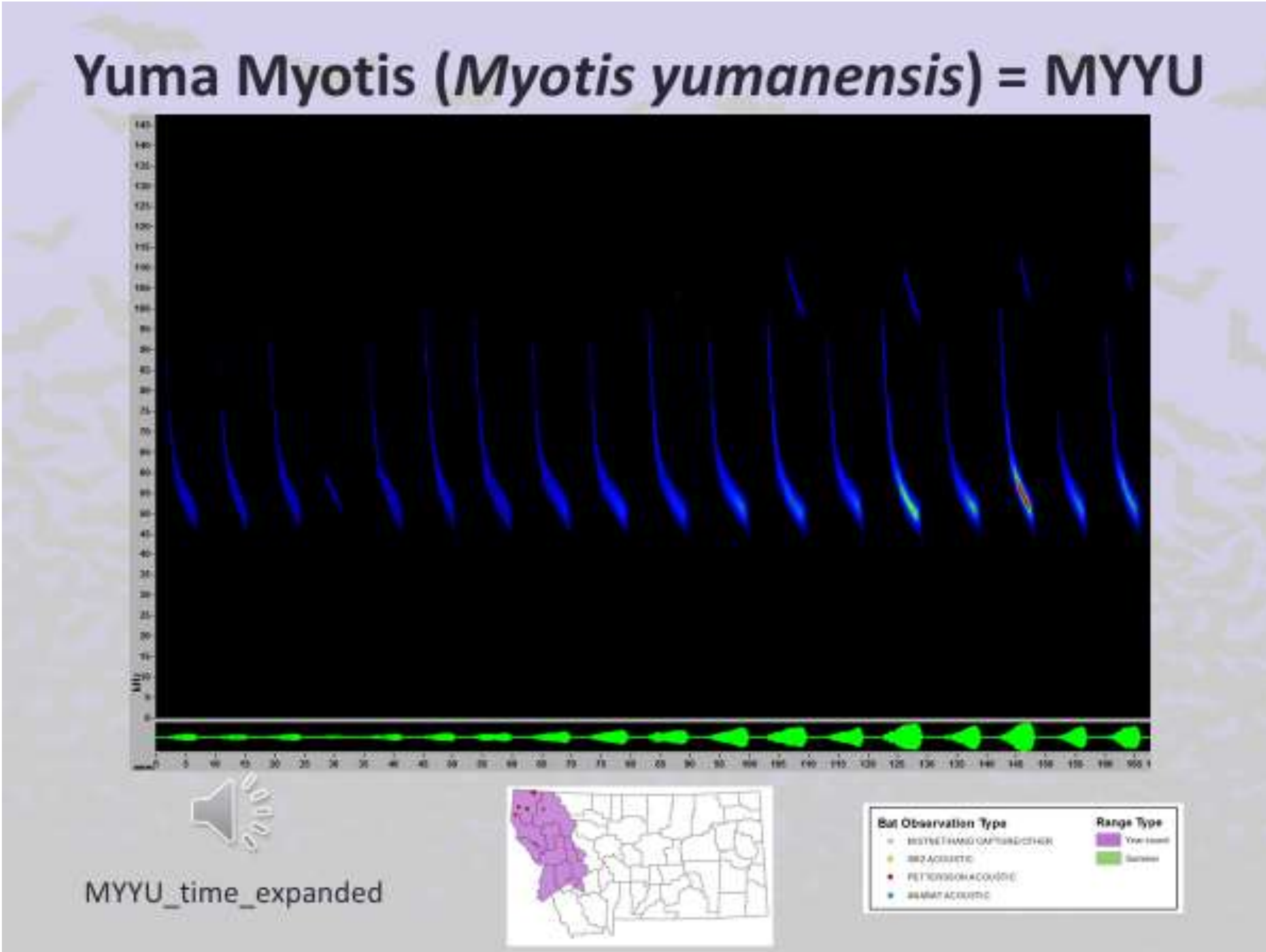


Figure 78. Example call sequence for the Yuma Myotis (Myotis yumanensis, MYYU)

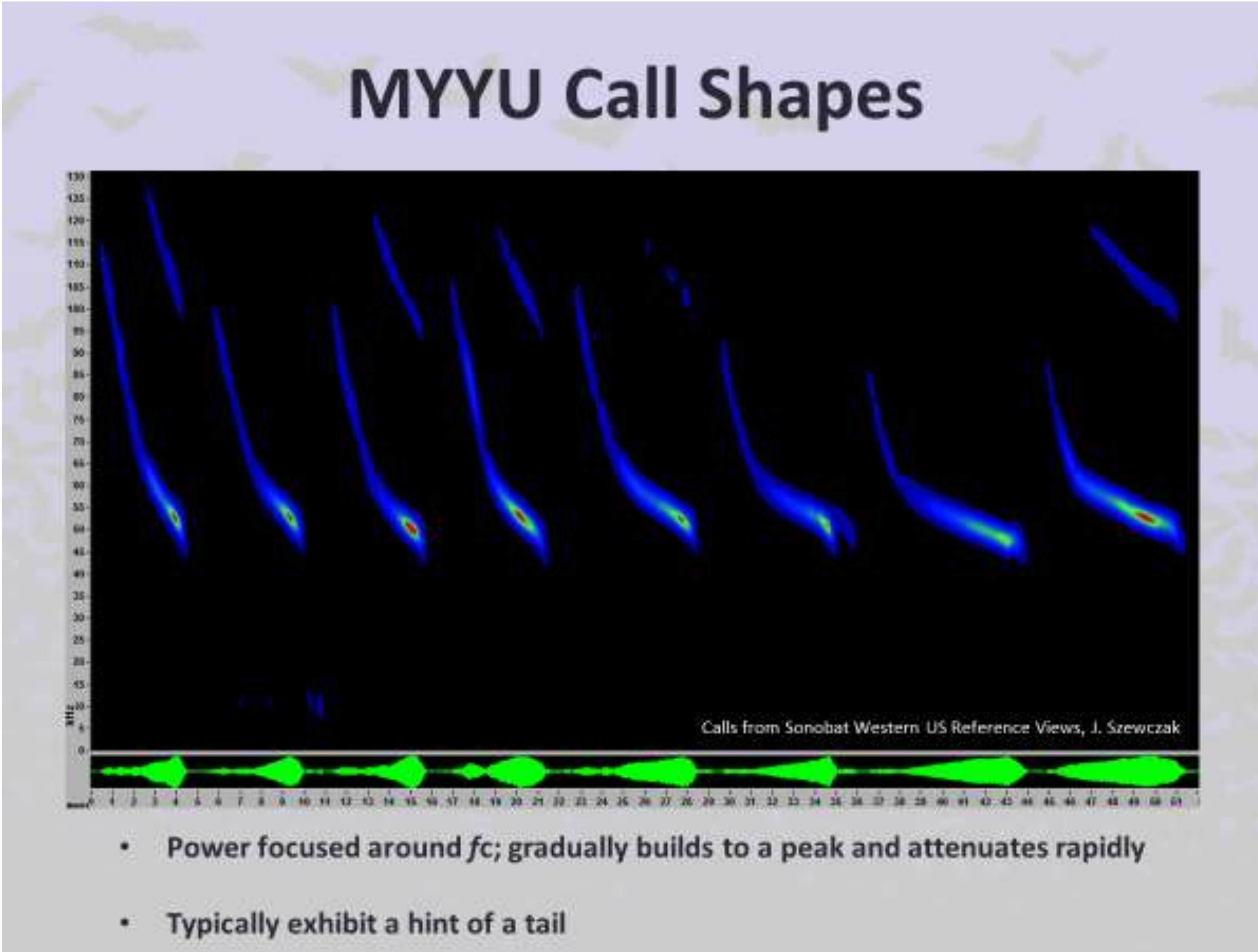


Figure 79. Call shapes of the Yuma Myotis (Myotis yumanensis, MYYU)

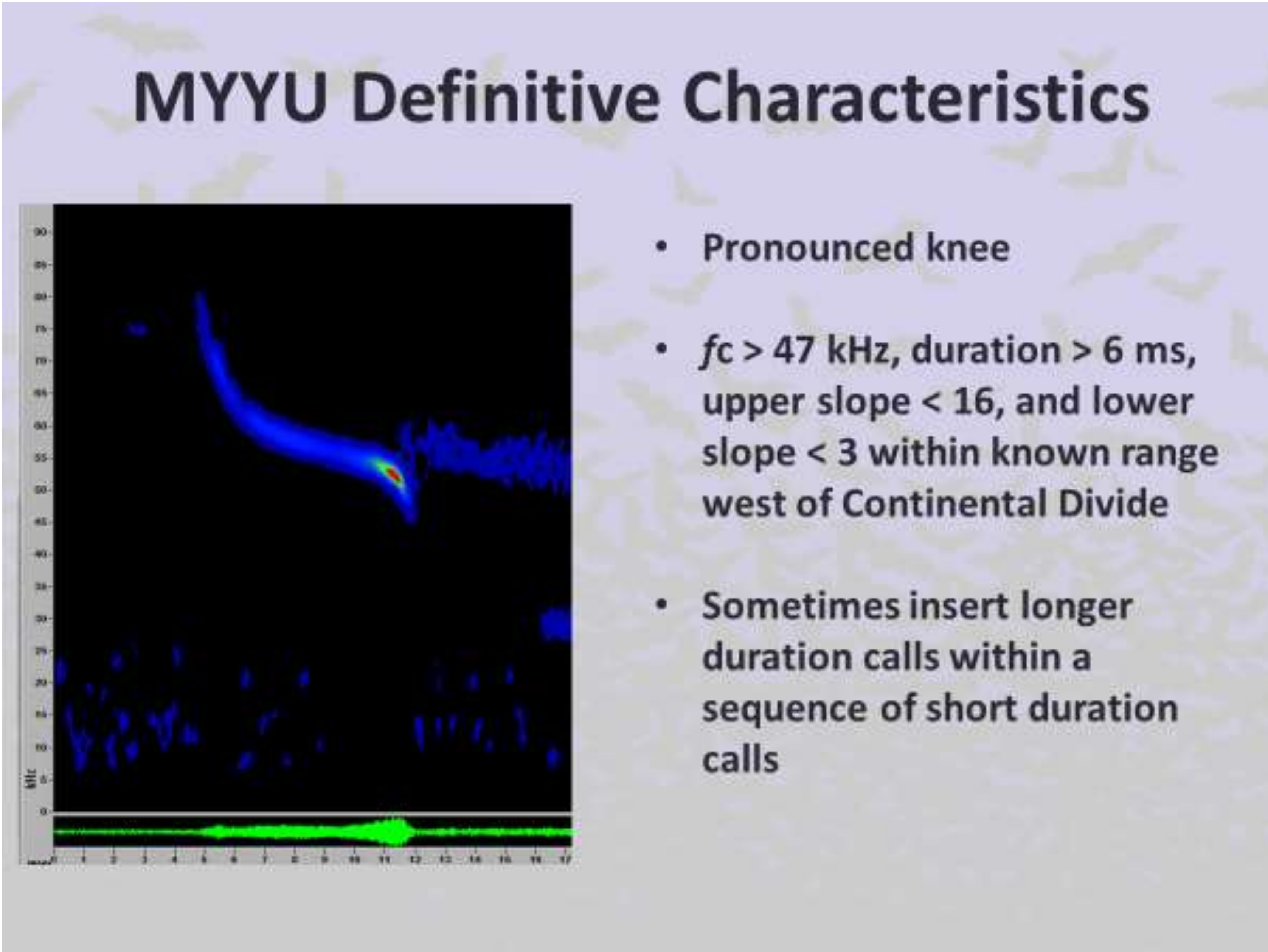


Figure 80. Definitive characteristics of call sequence for the Yuma Myotis (Myotis yumanensis, MYYU)

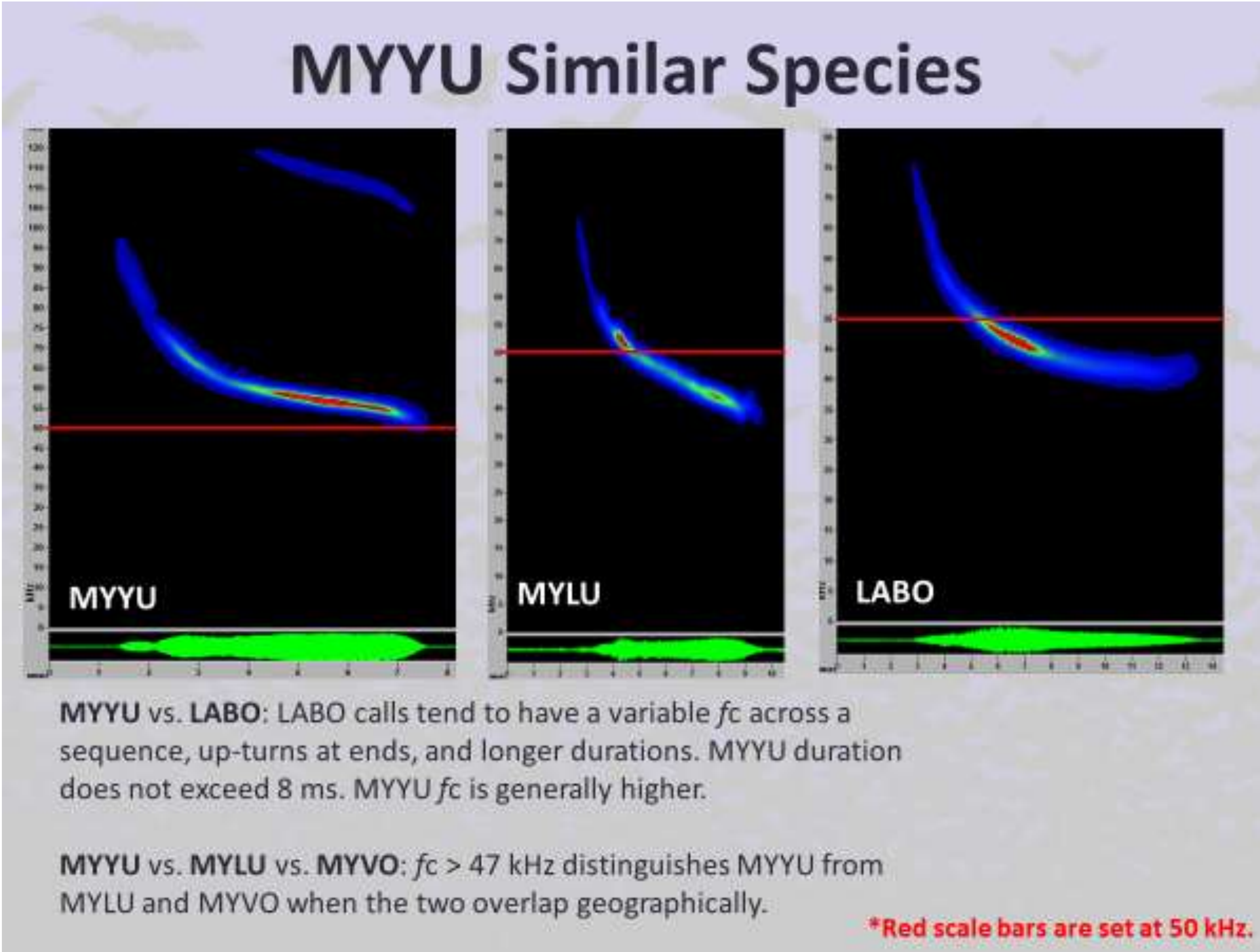


Figure 81. Calls sequences produced by other species that may be confused with the Yuma Myotis (Myotis yumanensis, MYYU)

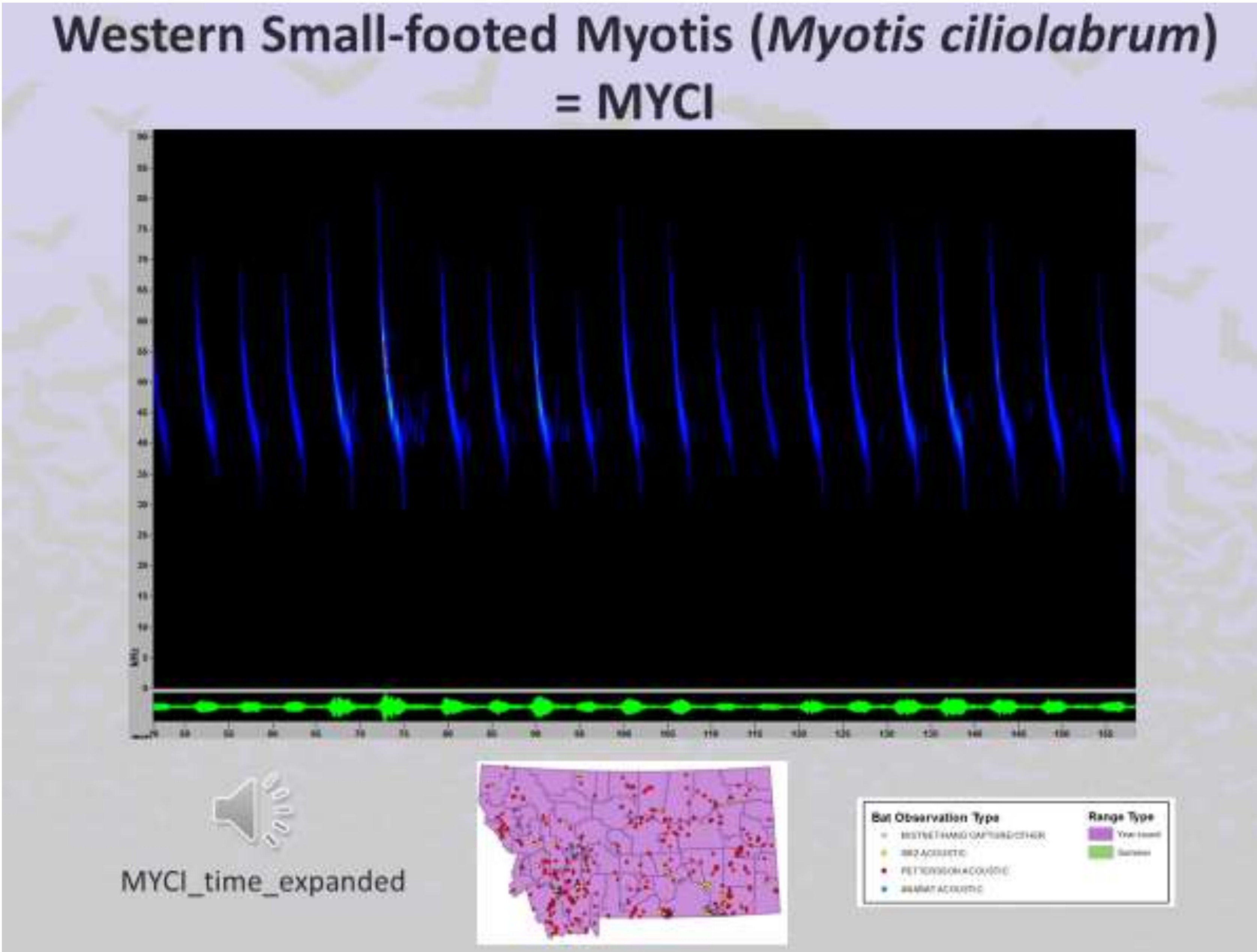


Figure 82. Example call sequence for the Western Small-footed Myotis (Myotis ciliolabrum, MYCI)

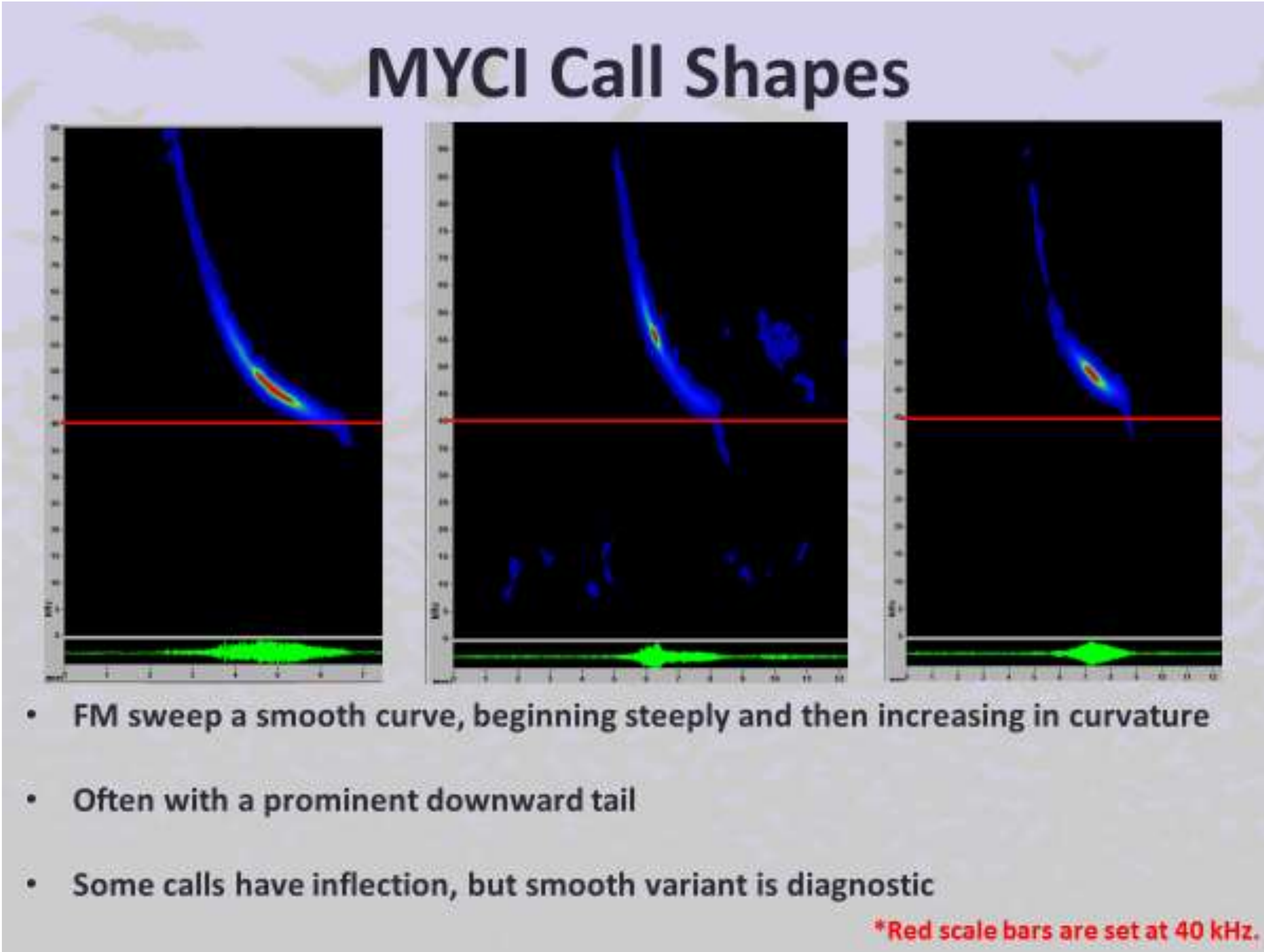


Figure 83. Call shapes of the Western Small-footed Myotis (Myotis ciliolabrum, MYCI)

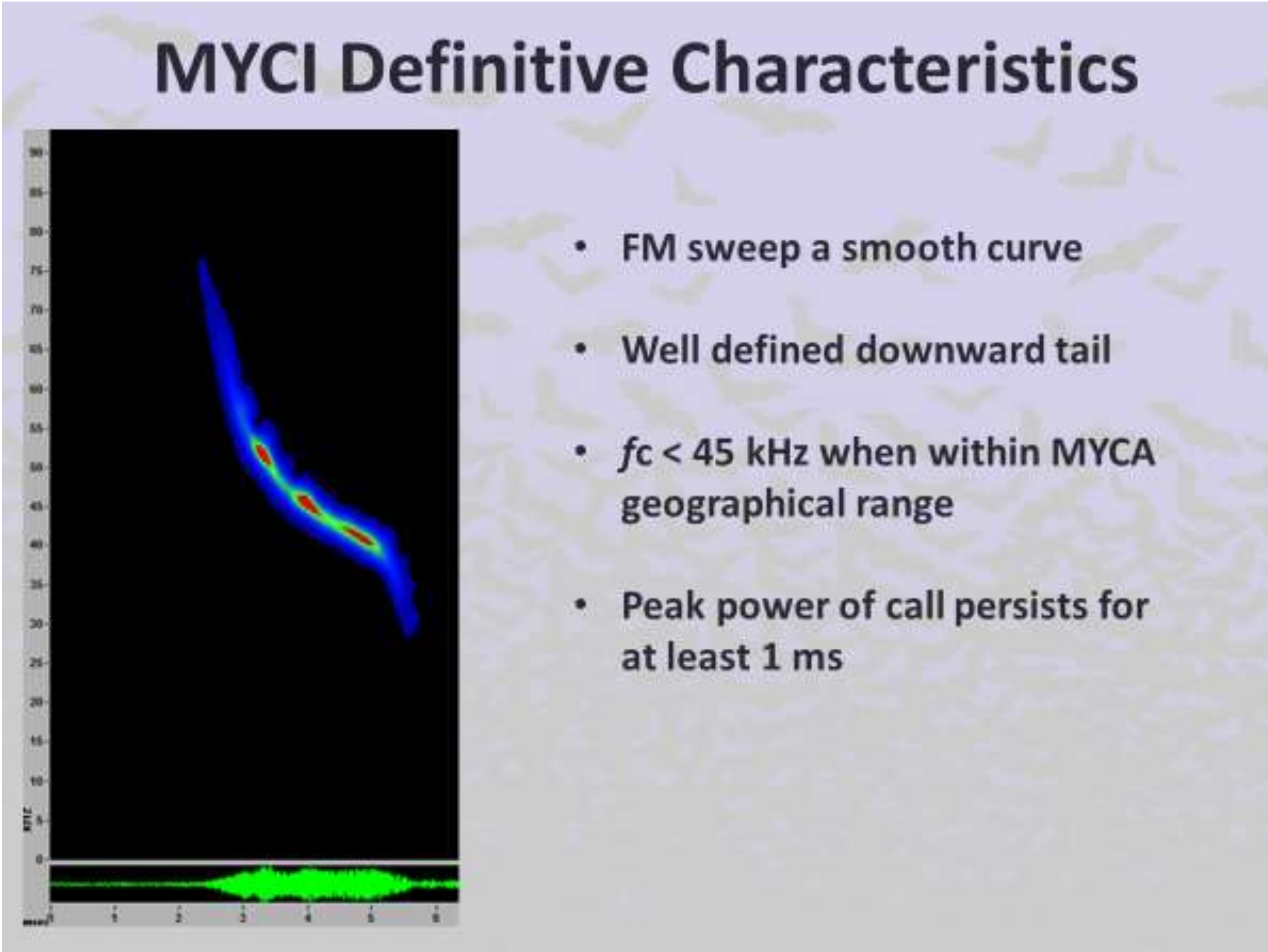


Figure 84. Definitive characteristics of call sequence for the Western Small-footed Myotis (Myotis ciliolabrum, MYCI)

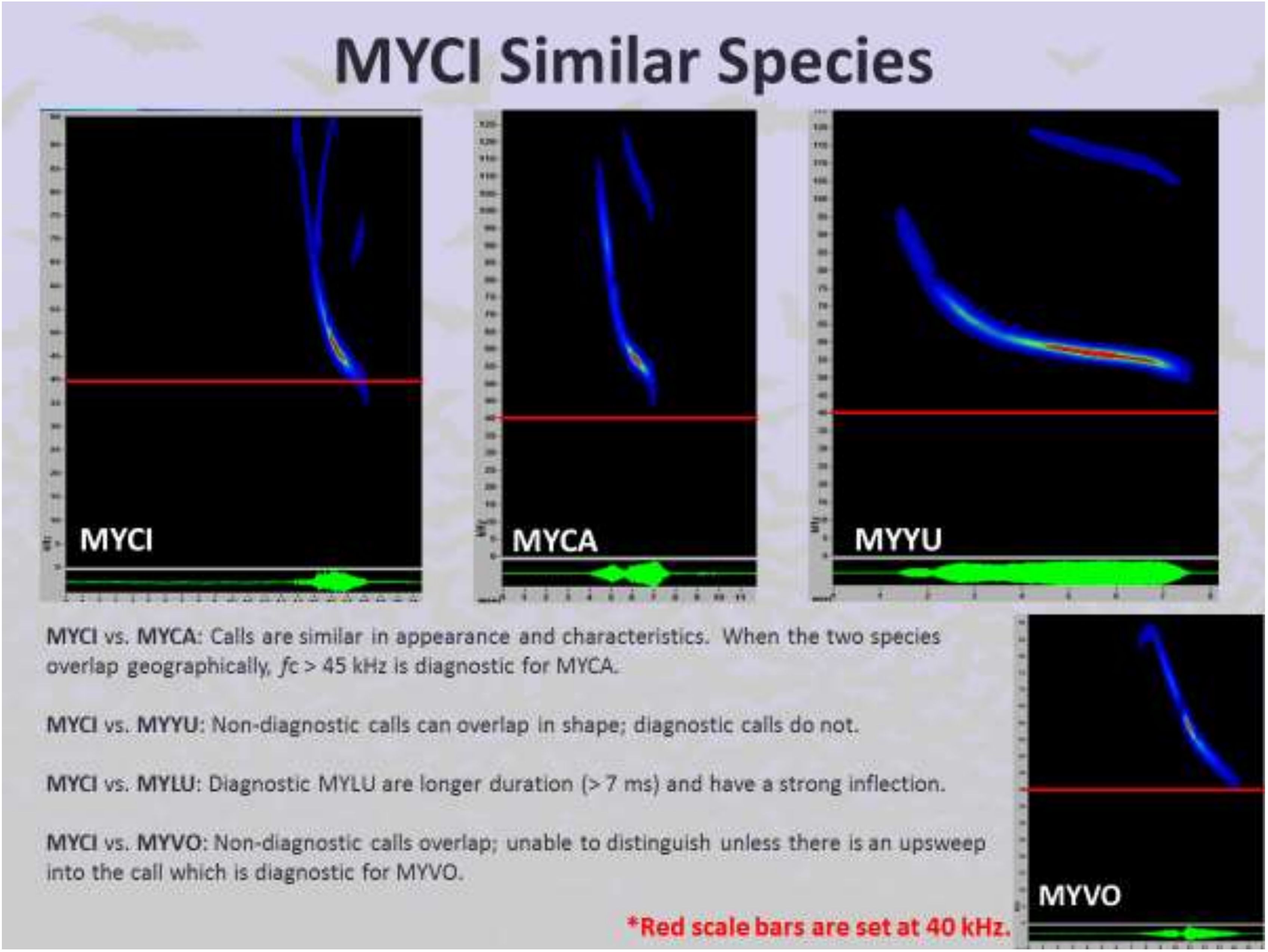


Figure 85. Calls sequences produced by other species that may be confused with the Western Small-footed Myotis (Myotis ciliolabrum, MYCI)

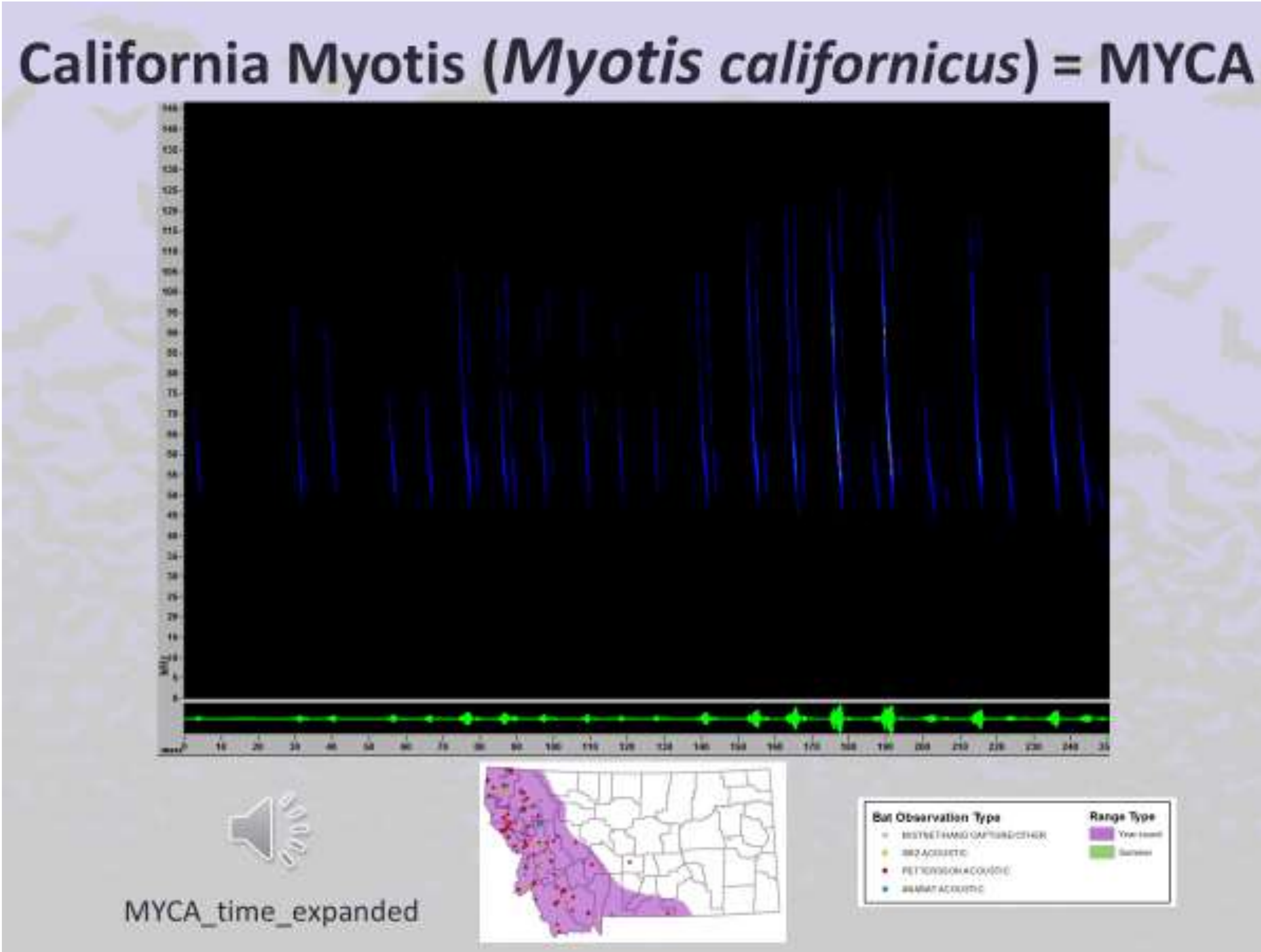


Figure 86. Example call sequence for the California Myotis (Myotis californicus, MYCA)

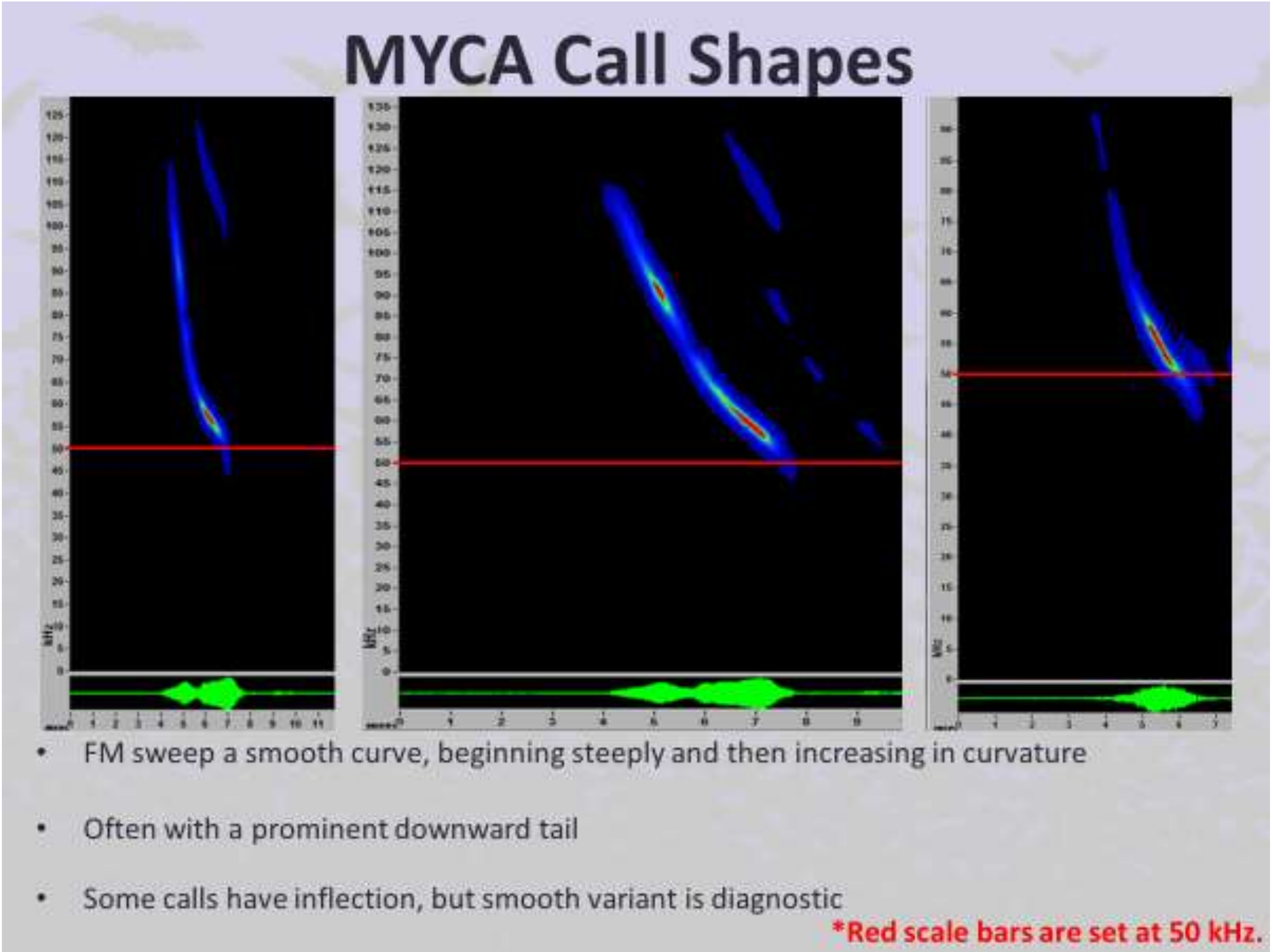


Figure 87. Call shapes of the California Myotis (Myotis californicus, MYCA)

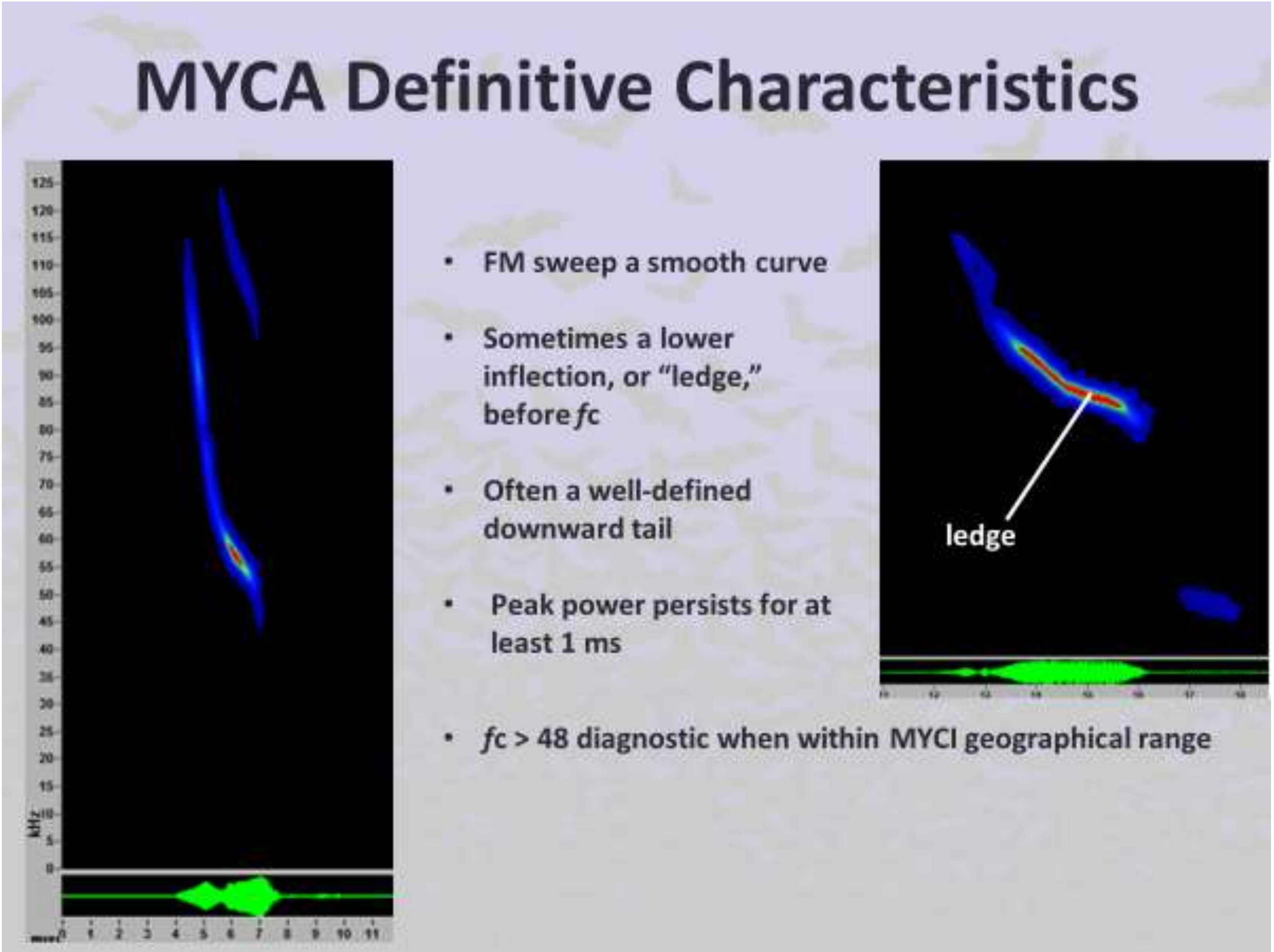


Figure 88. Definitive characteristics of call sequence for the California Myotis (Myotis californicus, MYCA)

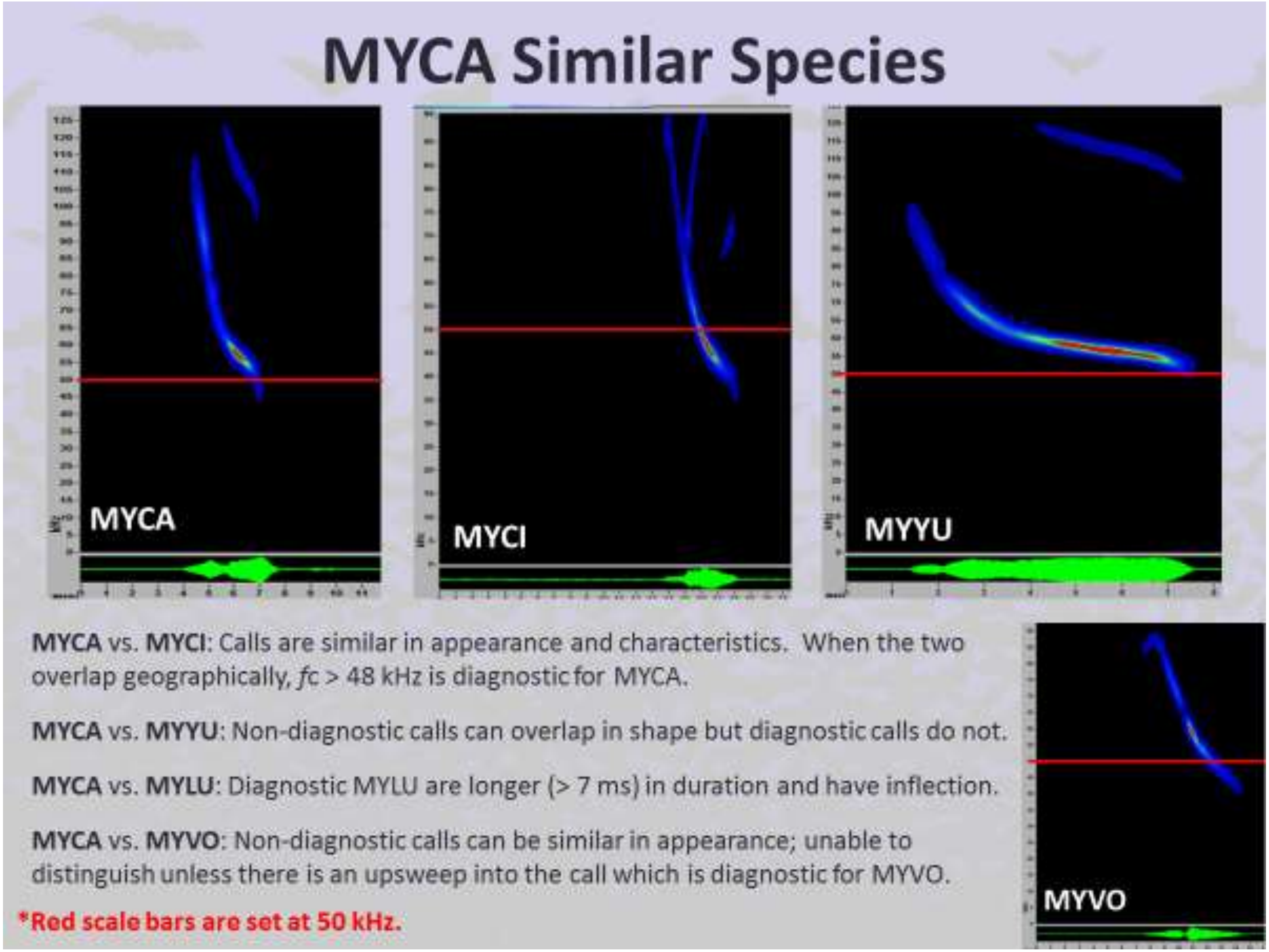


Figure 89. Calls sequences produced by other species that may be confused with the California Myotis (Myotis californicus, MYCA)

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