bioacoustics@aims 2025

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structure

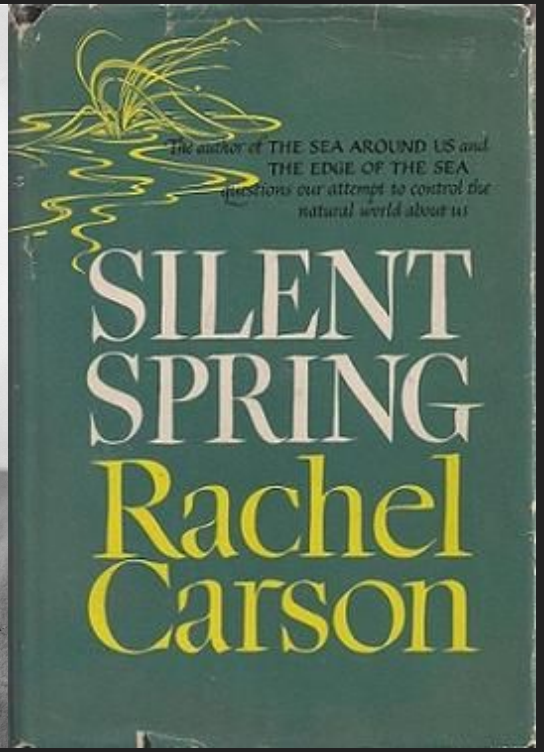
introduction to bioacoustics

Huckins sent a letter of outrage to the *Boston Herald* in January 1958. Here is an excerpt:

The mosquito control plane flew over our small town last summer. Since we live close to the marshes, we were treated to several lethal doses as the pilot crisscrossed our place. And we consider the spraying of active poison over private land to be a serious aerial intrusion.

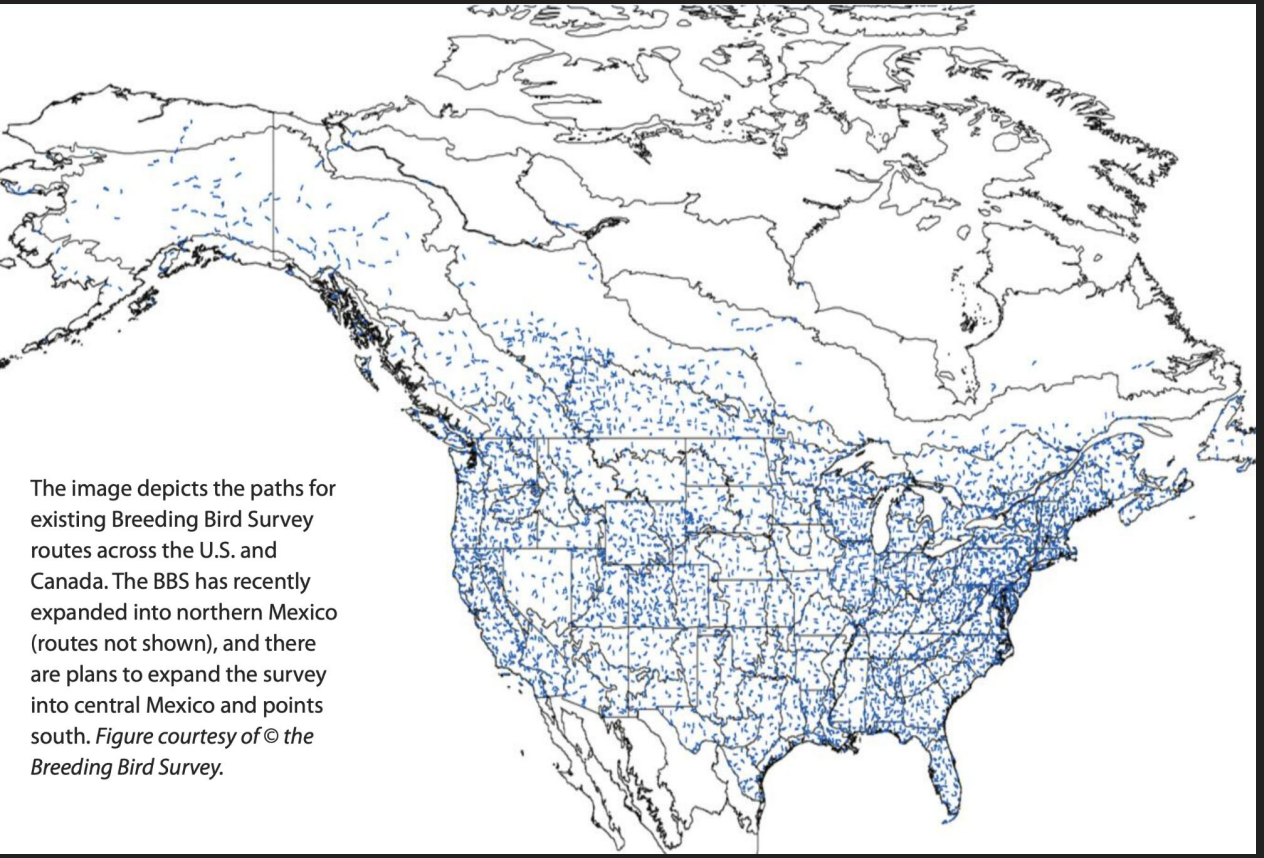
The "harmless" shower bath killed seven of our lovely songbirds outright. We picked up three dead bodies the next morning right by the door. They were birds that had lived next to us, trusted us, and built their nests in our trees year after year. The next day three were scattered around the birdbath. (I had emptied it after the spraying but YOU CAN NEVER KILL DDT.) . . .

All of these birds died horribly and in the same way. Their bills were gaping open, and their splayed claws were drawn up to their breasts in agony.

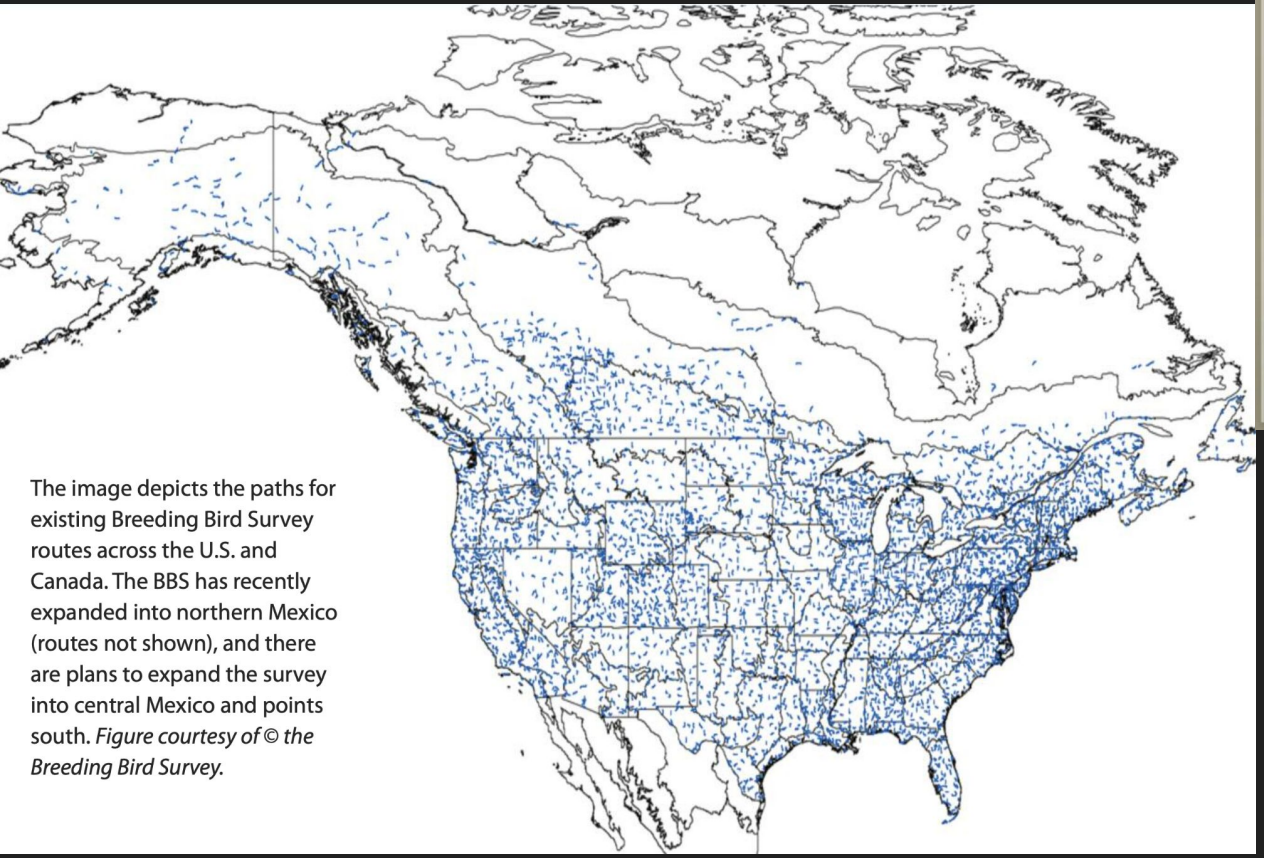


"No responsible person contends that insect-borne disease should be ignored. The question that has now urgently presented itself is whether it is either wise or responsible to attack the problem by methods that are rapidly making it worse. The world has heard much of the triumphant war against disease through the control of insect vectors of infection, but it has heard little of the other side of the story—the defeats, the short-lived triumphs that now strongly support the alarming view that the insect enemy has been made actually stronger by our efforts. Even worse, we may have destroyed our very means of fighting."

-Carson, 1962



The image depicts the paths for existing Breeding Bird Survey routes across the U.S. and Canada. The BBS has recently expanded into northern Mexico (routes not shown), and there are plans to expand the survey into central Mexico and points south. *Figure courtesy of © the Breeding Bird Survey.*



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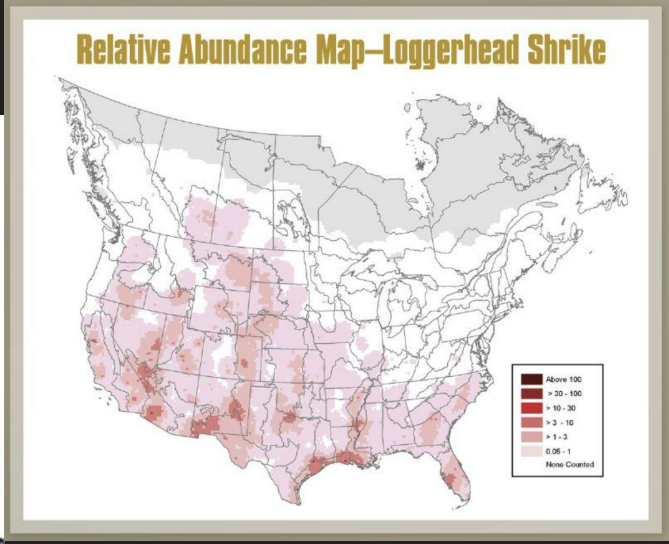

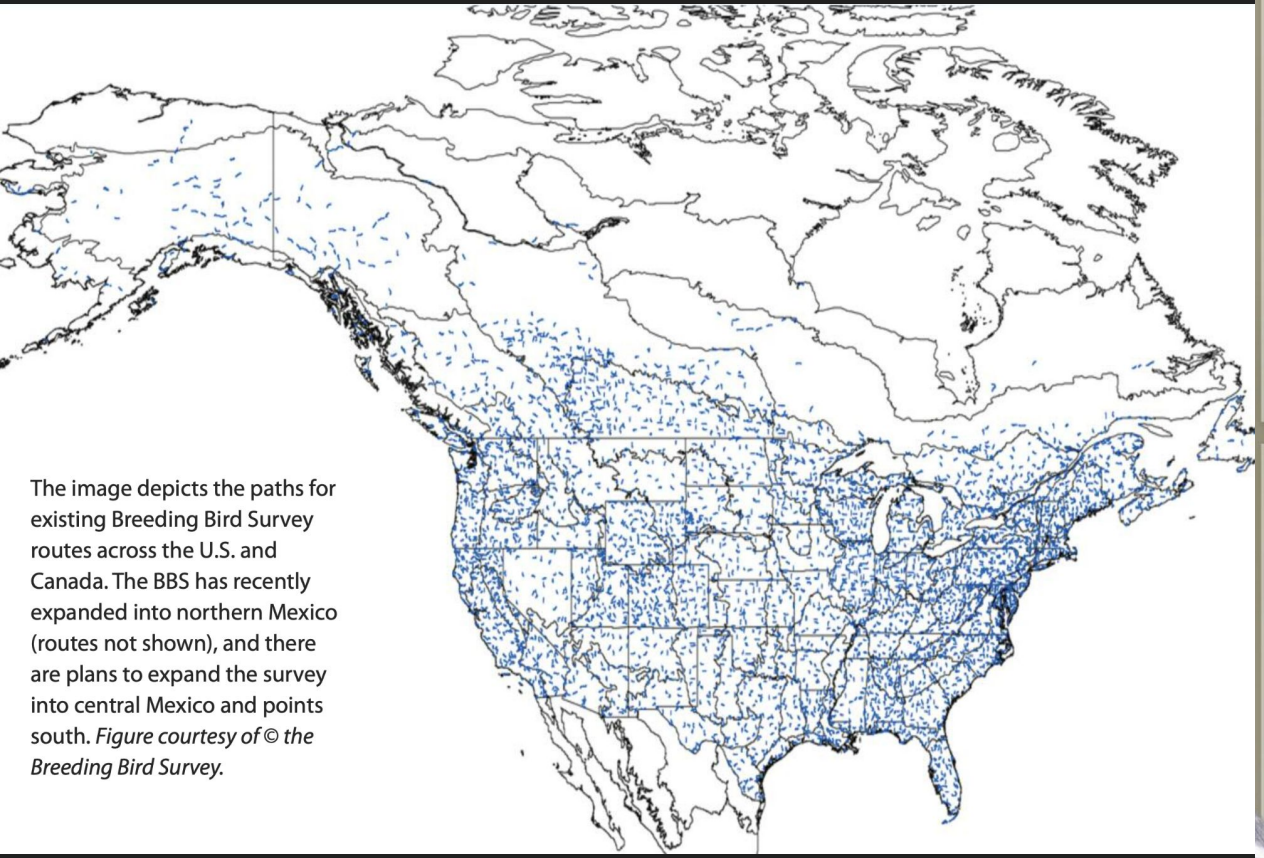

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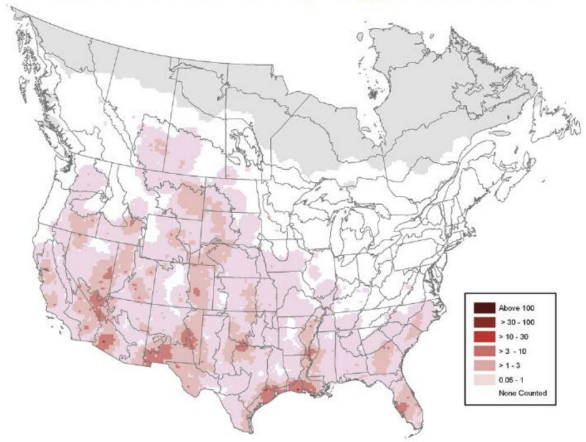
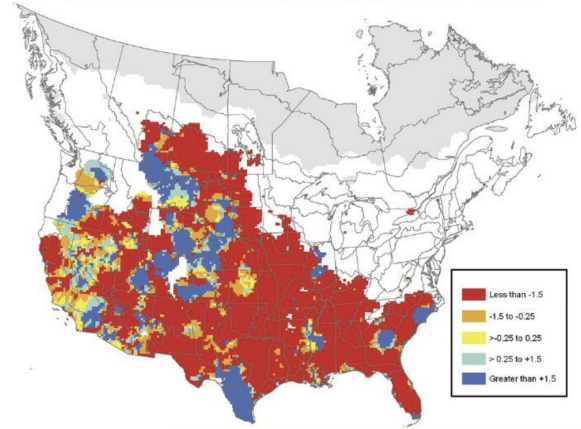
Relative Abundance Map–Loggerhead Shrike



Population Trend Map–Loggerhead Shrike



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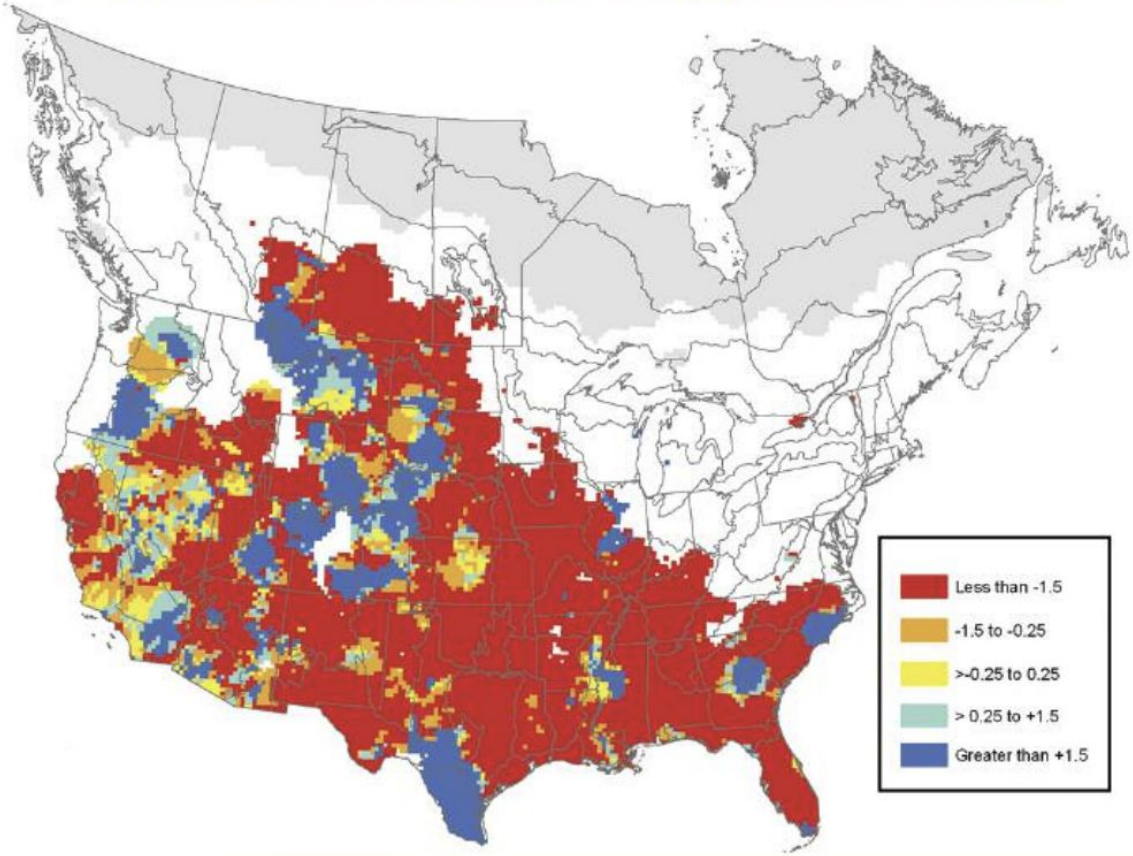
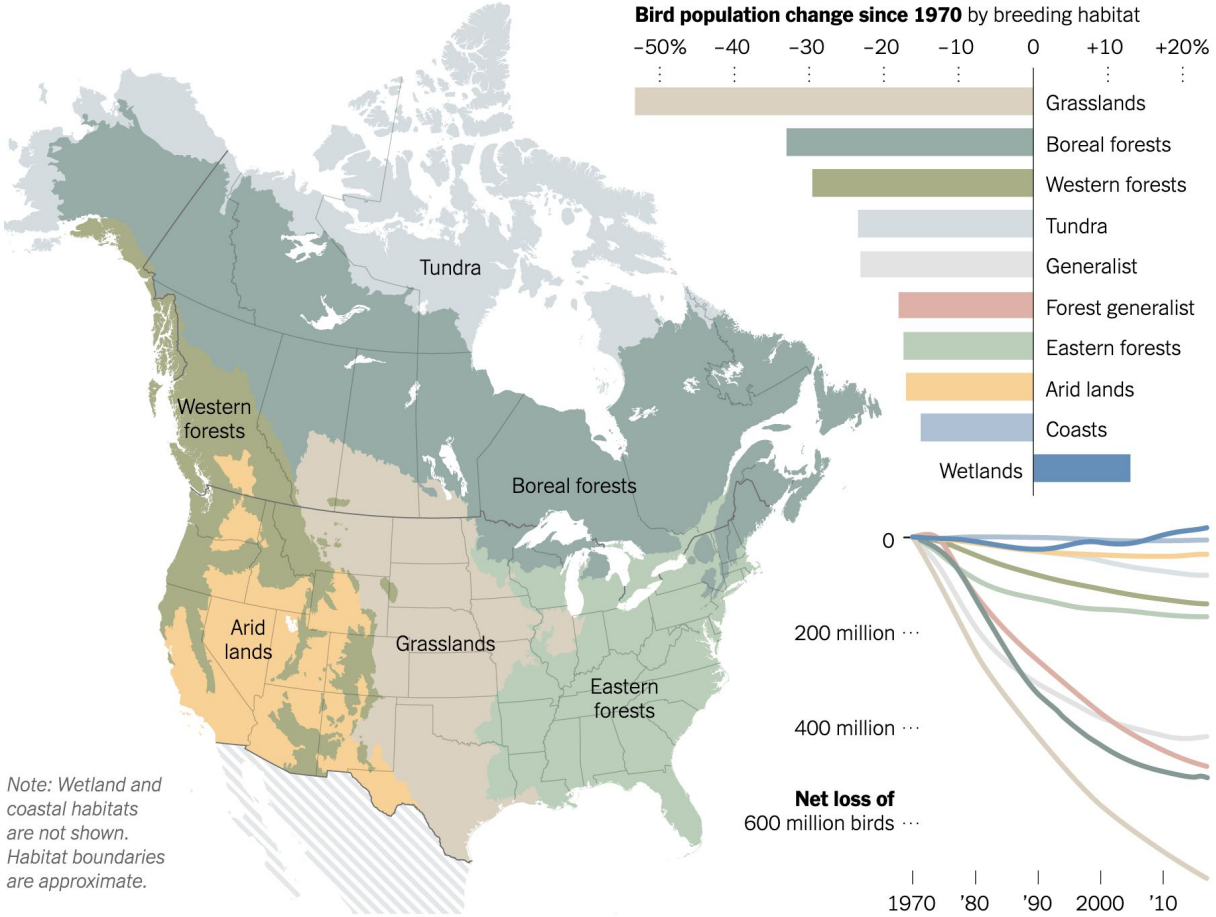


Three Billion Birds

A survey of 529 bird species in the United States and Canada found that bird populations have fallen by 29 percent since 1970, a loss of nearly three billion birds.



By The New York Times | Source: Science

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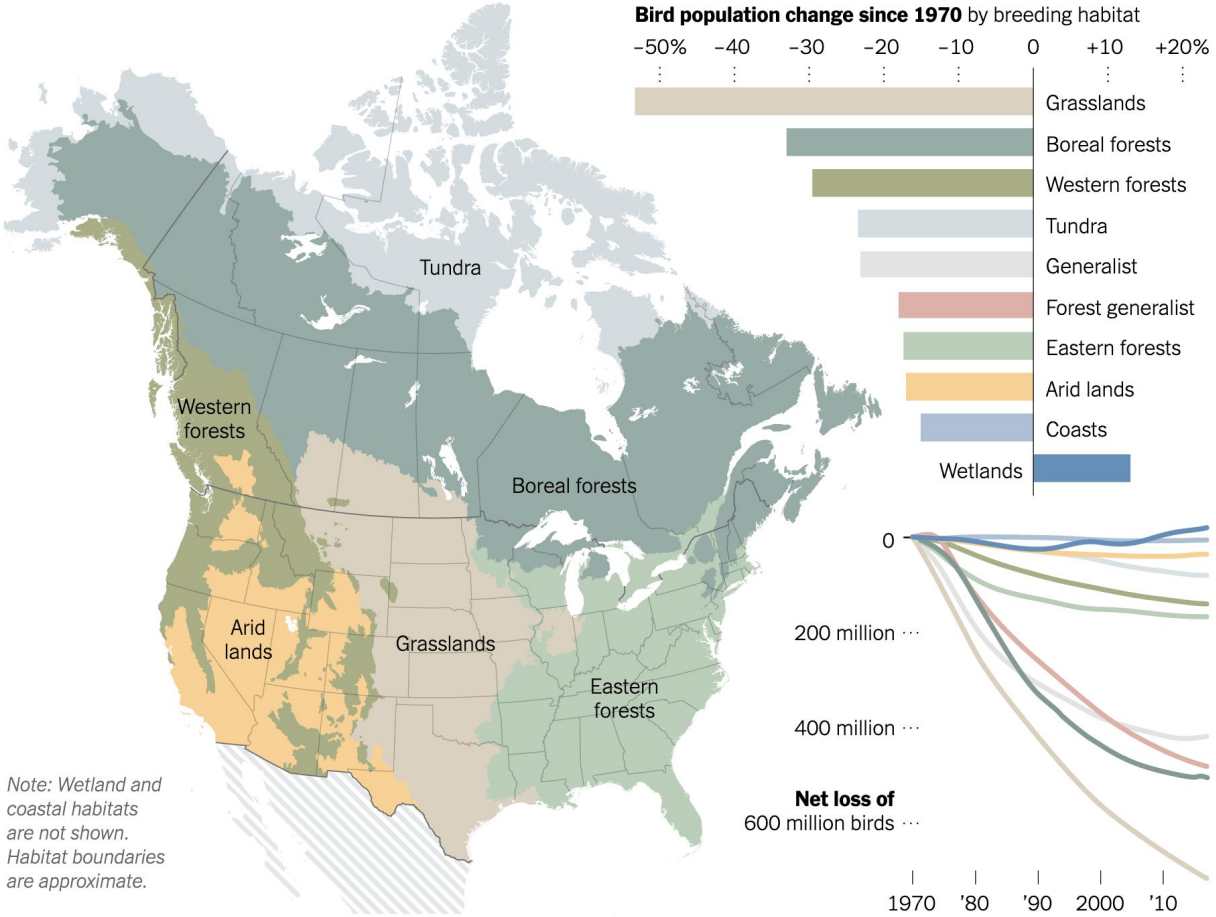

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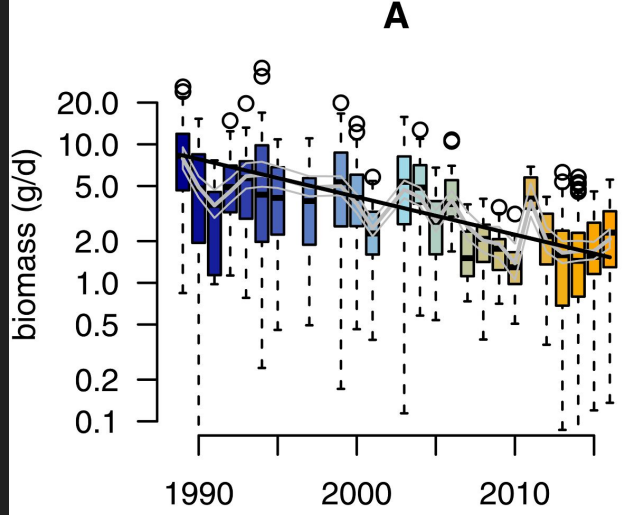
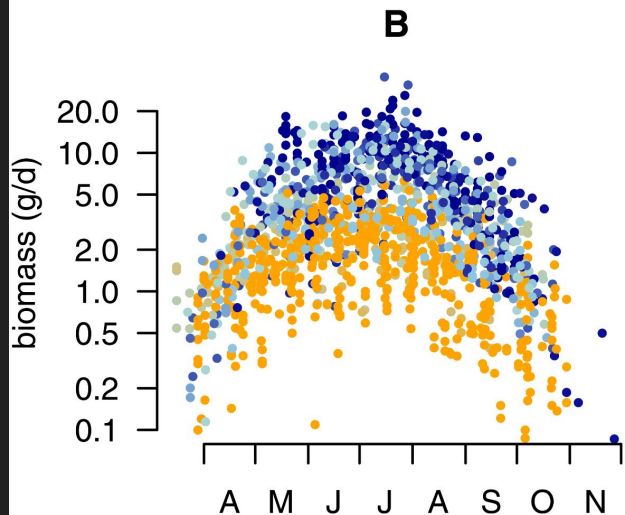
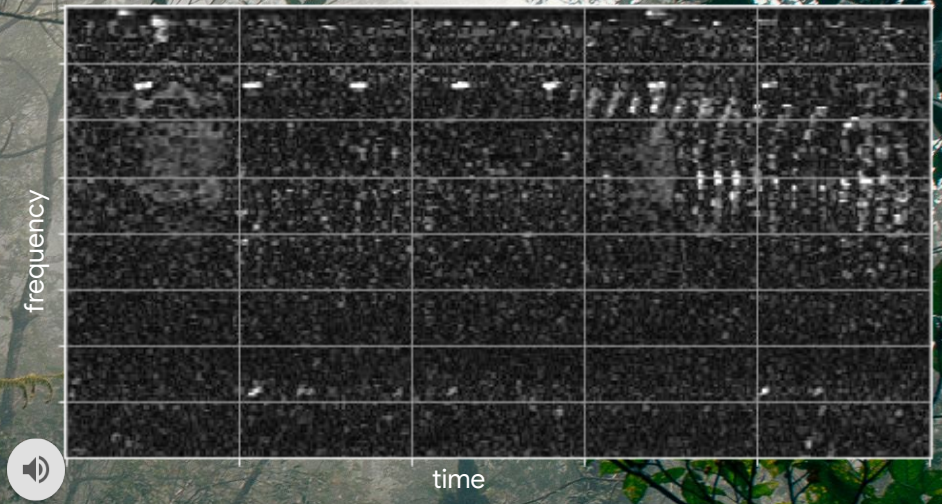




You hear

10x

what you see




Autonomous
Recording Units

High Impact Questions for Conservation

What is the **most important land to protect or restore**?

- 30-by-30: Protect 30% of land and sea by 2030.
- Bush Heritage + Australian Wildlife Conservancy, The Nature Conservancy

How can we find and protect **threatened species** populations?

How do we effectively monitor for **destructive human activity**?

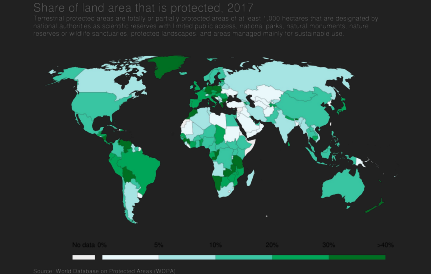
- Logging and deforestation, bomb fishing, poachers, etc.

How can we efficiently monitor for **broad biodiversity**?

- Biodiversity credits and certifications: Audubon, Nestle, AstraZeneca

How can we proactively detect **invasive species**?

- Rat eradications on pacific islands, Australian cane toads, etc.



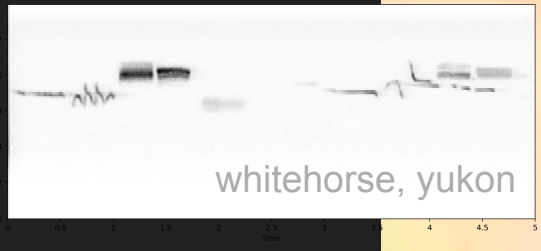


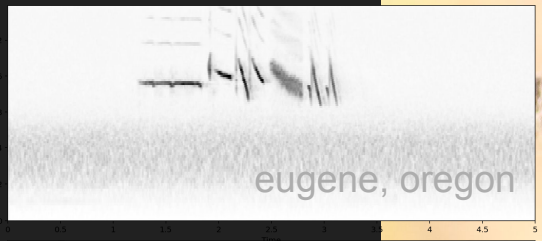


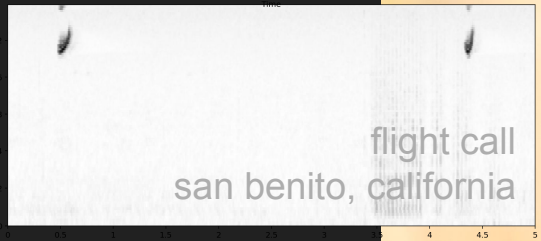


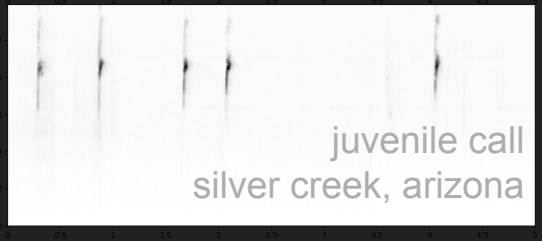


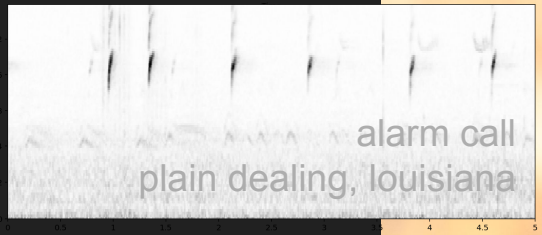

White-Crowned Sparrow









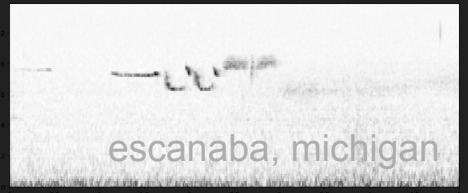


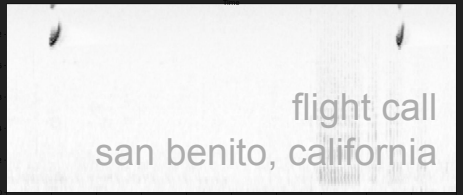
"The other day, I was asked how I could tell the difference between the calls of White-throated Sparrows and White-crowned Sparrows. The first explanation was easy: White-throated Sparrows have the catchy mnemonic "Oh-sweet-Canada-Canada" to remember their call. **White-crowned sparrows on the other hand left me stumped**—the first response I could come up with is, **they just sound like White-crowned Sparrows**."

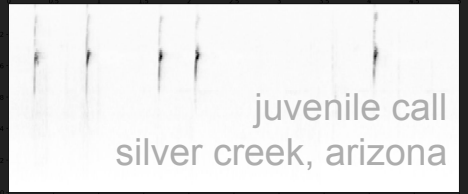
-emma raasch

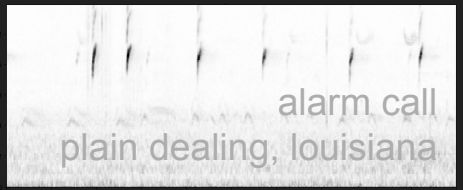
Observations

- All species have **multiple calls**.
- Vocalizations serve **multiple functions**.
  - Songs have more structure,
    calls are shorter / less descript.
  - Songs often relate to mating+territoriality,
    calls serve a wide range of functions.
- Significant **geographic** and
  individual variation in songs.
- **Overlapping vocalizations**
  in both time and frequency are common.



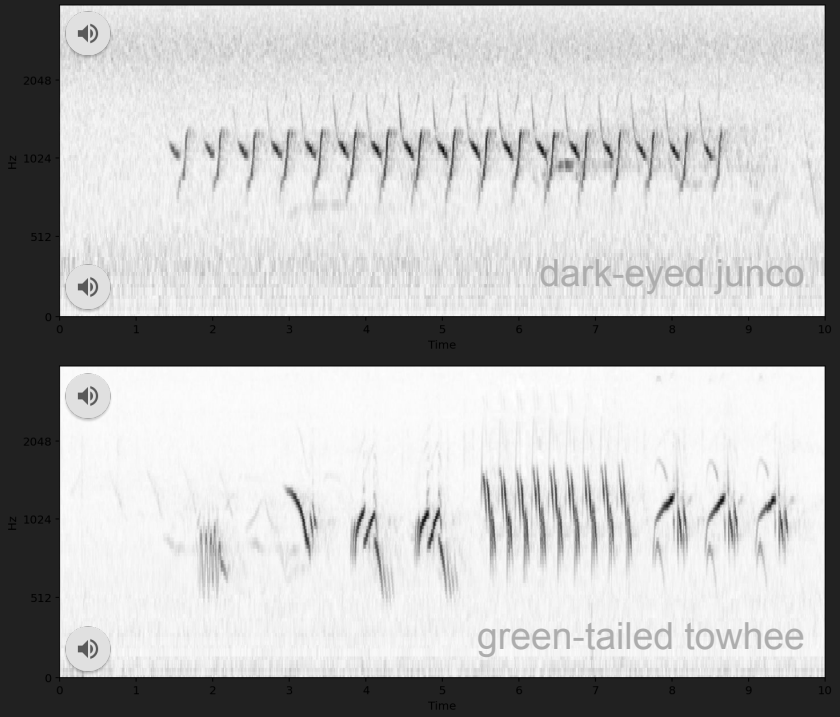






A Couple More Birb++ Facts…

- Dooling: Songbird audio time perception may be **2-4x finer than human**.
- Birds have a syrinx, which allows producing **polyphonic notes**.
- **>10k bird species** worldwide. Also >5k frogs, >20k orthoptera, ~1,400 bats, ~400 primates…



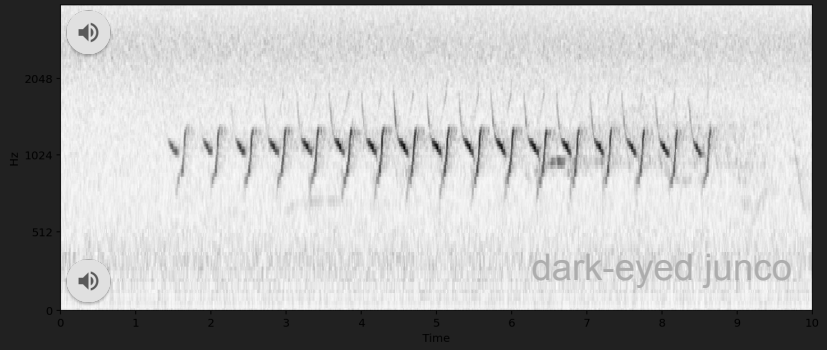
spectrograms

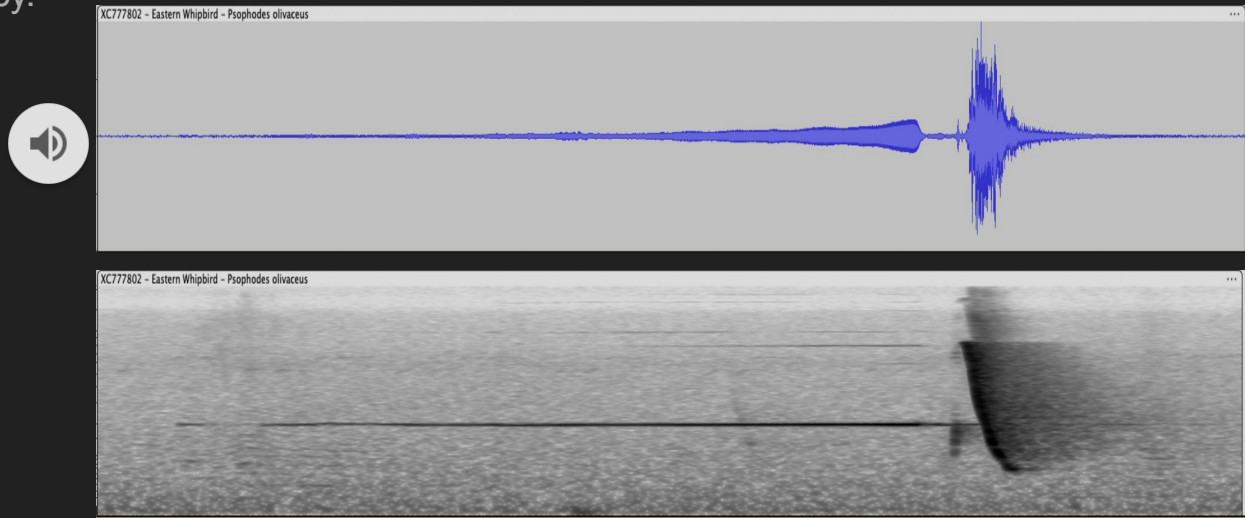
Images of Sound

The spectrogram is a 2D image combining **time, frequency** and **amplitude** information.

It reveals information which is not obvious from the raw waveform.

The x-axis is time, y-axis is frequency.

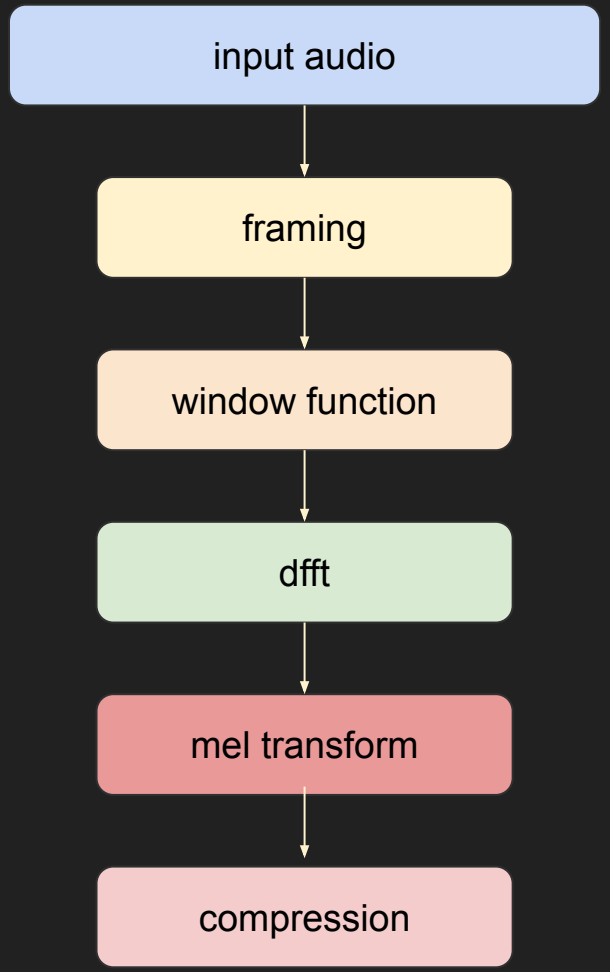




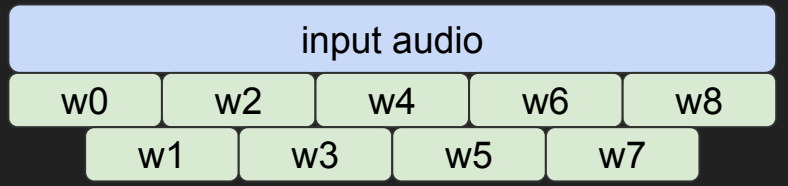
Creating a mel-spectrogram

The spectrogram is created through a sequence of computational steps. Each step has important choices to make!

- **Input audio** [a] has a sample rate **s**.
  The maximum frequency is half the sample rate.
- **Framing** converts the audio to a sequence of short windows. The window size and hop length determine the array shape: approximately [a//h, w].
- The **window function** shapes the windows to avoid discontinuities and emphasize the middle.
- The **dfft** converts to the frequency domain. [a//h, w//2]
- The **mel transform** and **compression** steps convert the audio to log frequency and log amplitude.

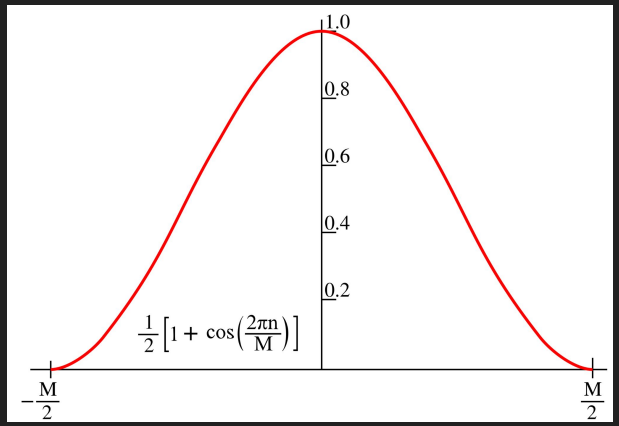


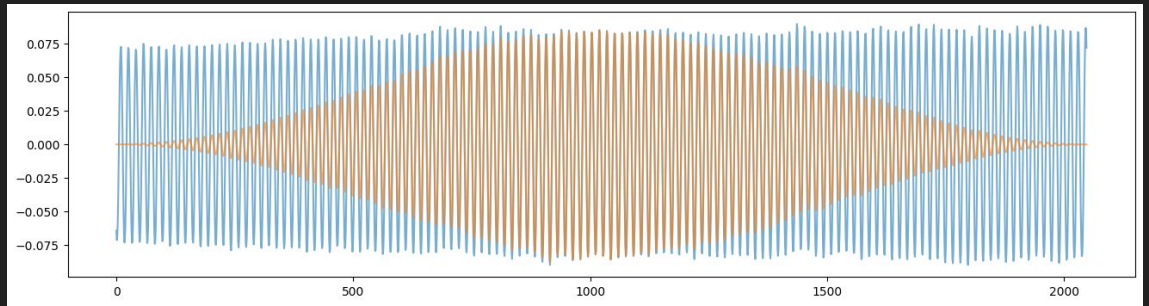
Framing and Window Function



Framing the audio breaks it up into smaller windows.
Two parameters:
Window size - number of samples per window, and
Hop size - number of samples to move forward.

Usually, we choose hop size = ½ window size,
giving 50% overlap between windows.
(This is a good choice for signal reconstruction,
meaning that there is little data loss in subsequent steps.)





mel spectrogram

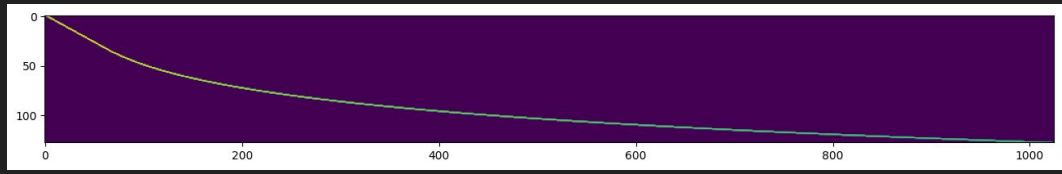
Originally designed for speech, useful for two reasons:

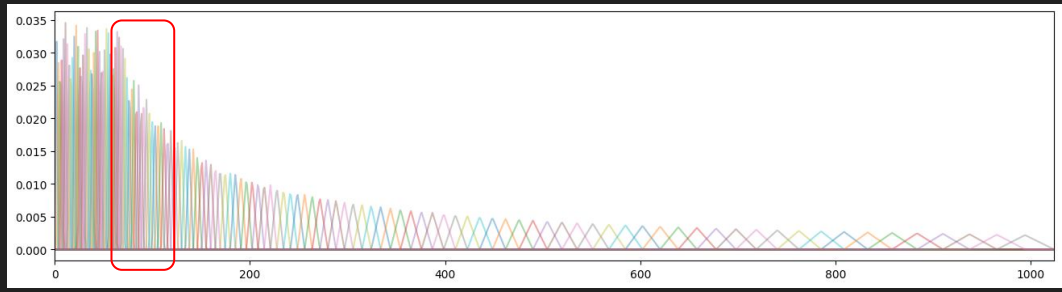
- **Log-like scaling of frequencies.**
- **Noise reduction.**

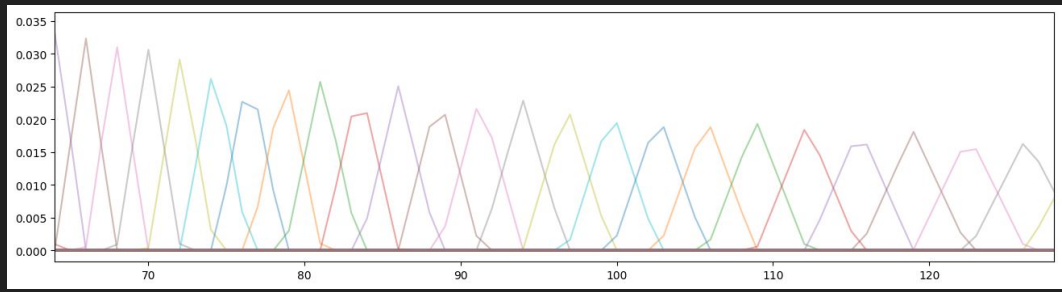
Triangular filters: Each filter is a weighted sum of adjacent channels.

Triangles get (exponentially) wider as we go to higher frequencies - creates log-linear frequency scaling.

Typically convert from ~window_size to a fixed size like 128 frequency channels.







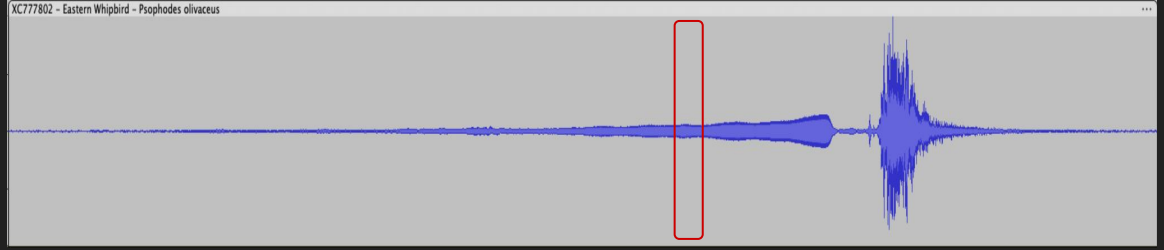
input audio

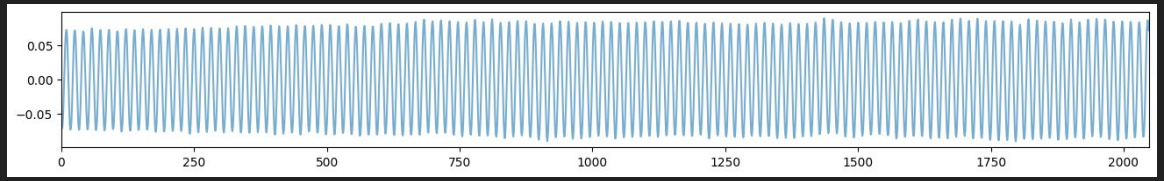
framing

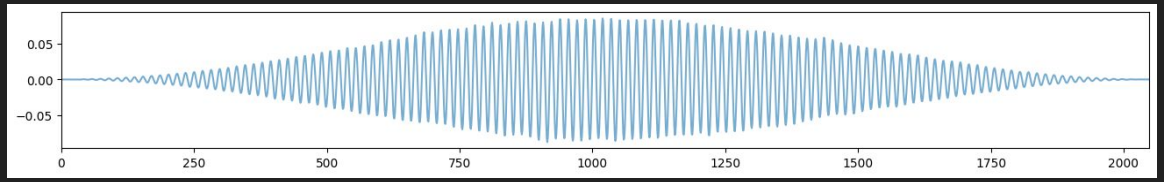
window function

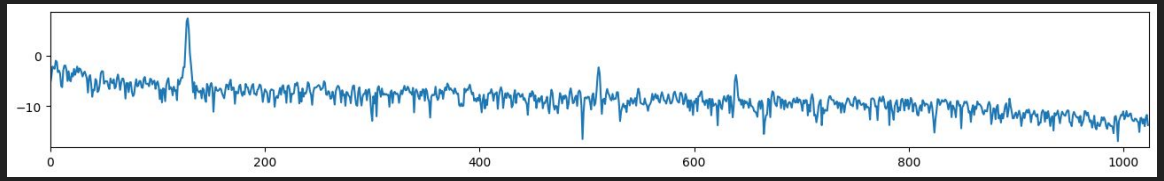
dfft

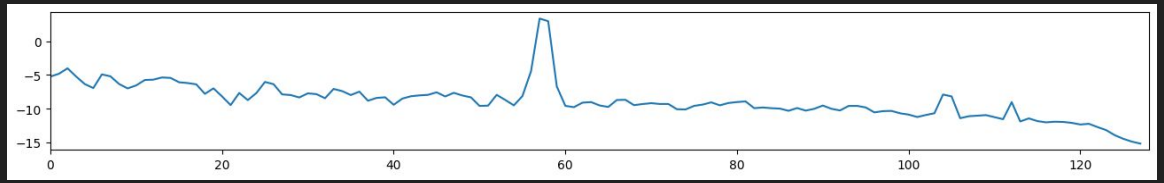
mel transform











Important Choices…

- **Sample Rate**
  Max frequency is half the sample rate. When SR is too high, we get too much data. Too low, and we miss important sounds.

- **Hop Size + Window Size**
  Want >50% overlap.
  Too-long windows have less "local" information.
  Too-short windows bad for low-freq sounds.

- **Compression Options**
  MelSpec is *fine*, though other options exist.
  Can use log or PCEN for amplitude scaling.