Modeling the Spatial and Temporal Variability of the Winter Soundscape on the Kenai National Wildlife Refuge, Alaska

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What is a Soundscape?

- Biological Sounds
  - Biophony
- Geophysical Sounds
  - Geophony
- Anthropogenic Sounds
  - Anthrophony

Properties of a Soundscape

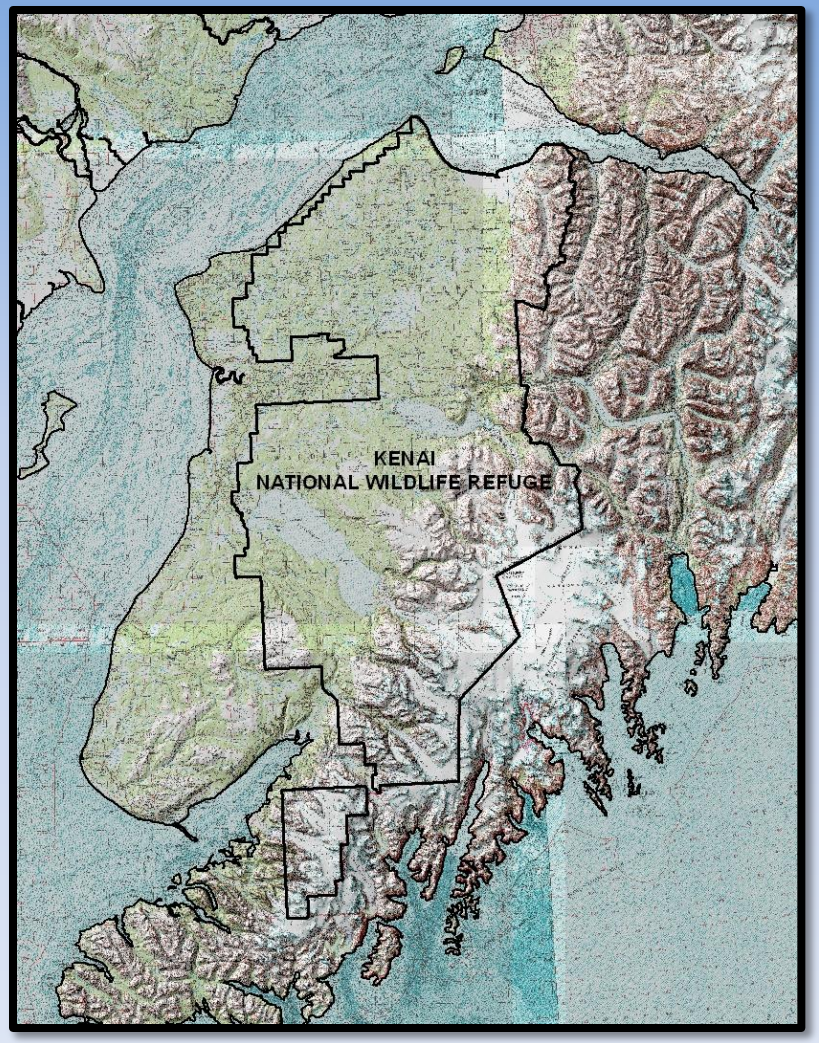
1) **Acoustic Composition**
   - frequency (Hz) and amplitude (dB) of sound
2) **Temporal Patterns**
   - Time period when sounds occur
3) **Spatial Variability**
   - Where sounds occur
4) **Acoustic Interactions**
   - biophony, geophony, and anthrophony

Significance of the Soundscape

- Sound serves as a means of communication
  - Among individuals and between species
  - Can identify species distributions and occupancy
- Human enjoyment of the outdoors and natural sounds
- Anthropogenic sounds can significantly change natural soundscapes and can effect human experience

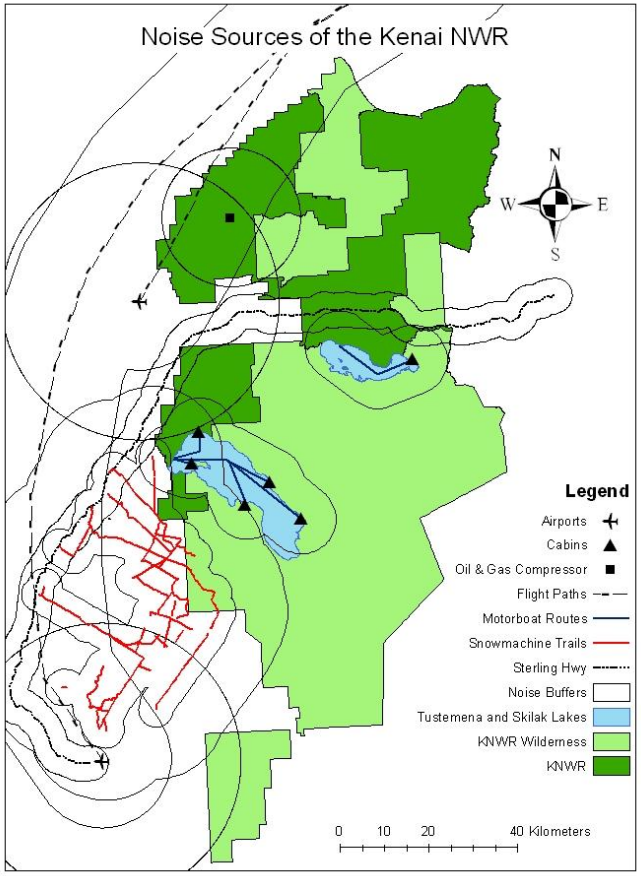
Kenai National Wildlife Refuge

- 2 million acres
- 1.3 million acres of Congressionally Designated Wilderness
- Conflicting Mandates:
  - Wilderness Act 1964
    - Wilderness Character
  - ANILCA 1980
    - provide motorized access for traditional use in wilderness



Kenai NWR and Sources of Anthrophony

- Along Sterling Highway
  - Over 1.4 million vehicles per year
- Major flyway for commercial and non-commercial aircraft
- Oil and gas compressor plants
- Boating and snowmachining



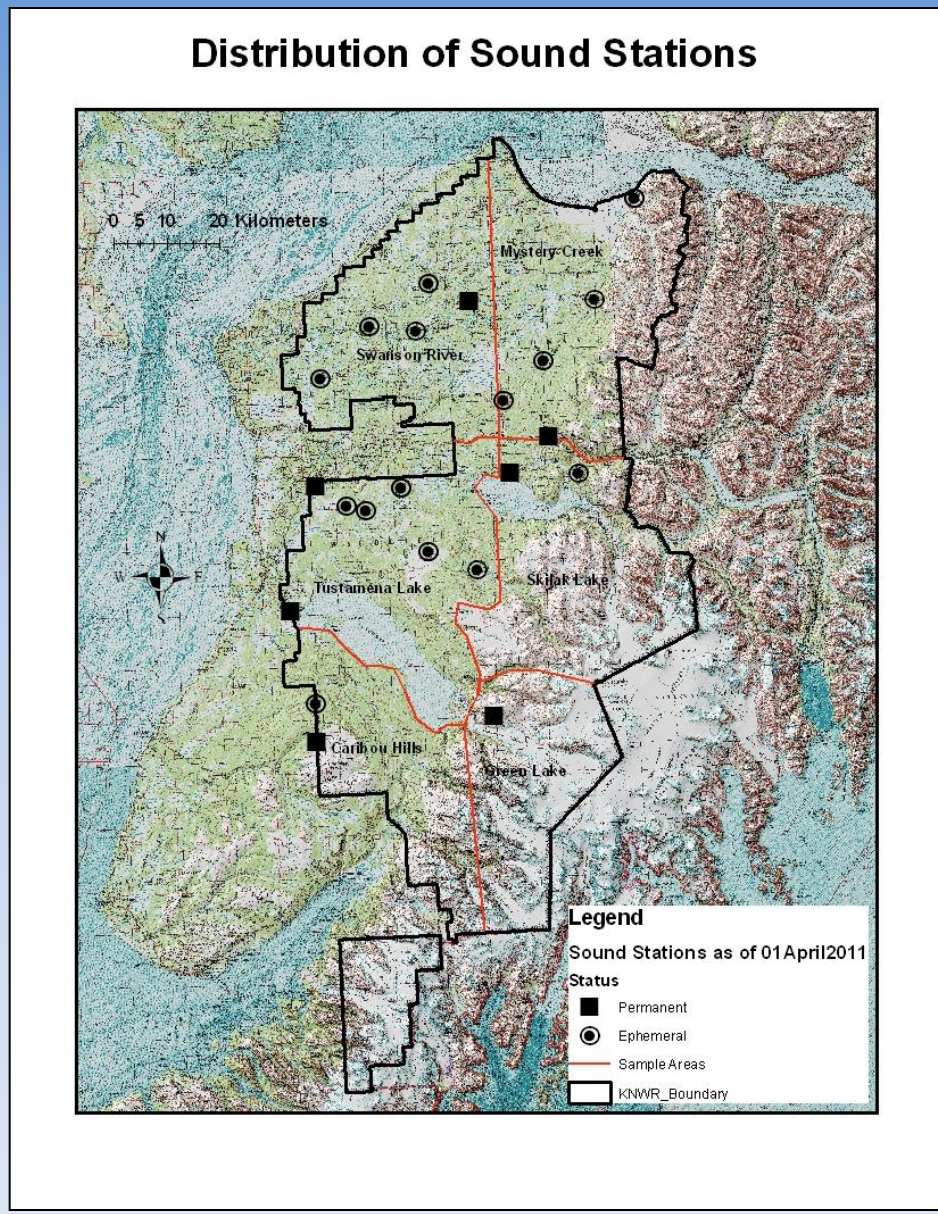
Objectives

1) Determine the temporal variation of biophony and anthrophony

2) Create a spatially explicit model identifying areas of anthrophony

Methods and Materials

- **Sampling sound in the landscape:**
  - Split the Refuge into 6 regions
  - 6 sound stations (3 LD831, 4 SM-2) were set out at permanent recording sites within each region
  - 6 additional stations (SM-2) were set out at temporary sites and moved to new locations every 2-3 weeks
  - Sampled 22 sound station locations
  - Ambient sounds were recorded for 20 seconds every 15 minutes



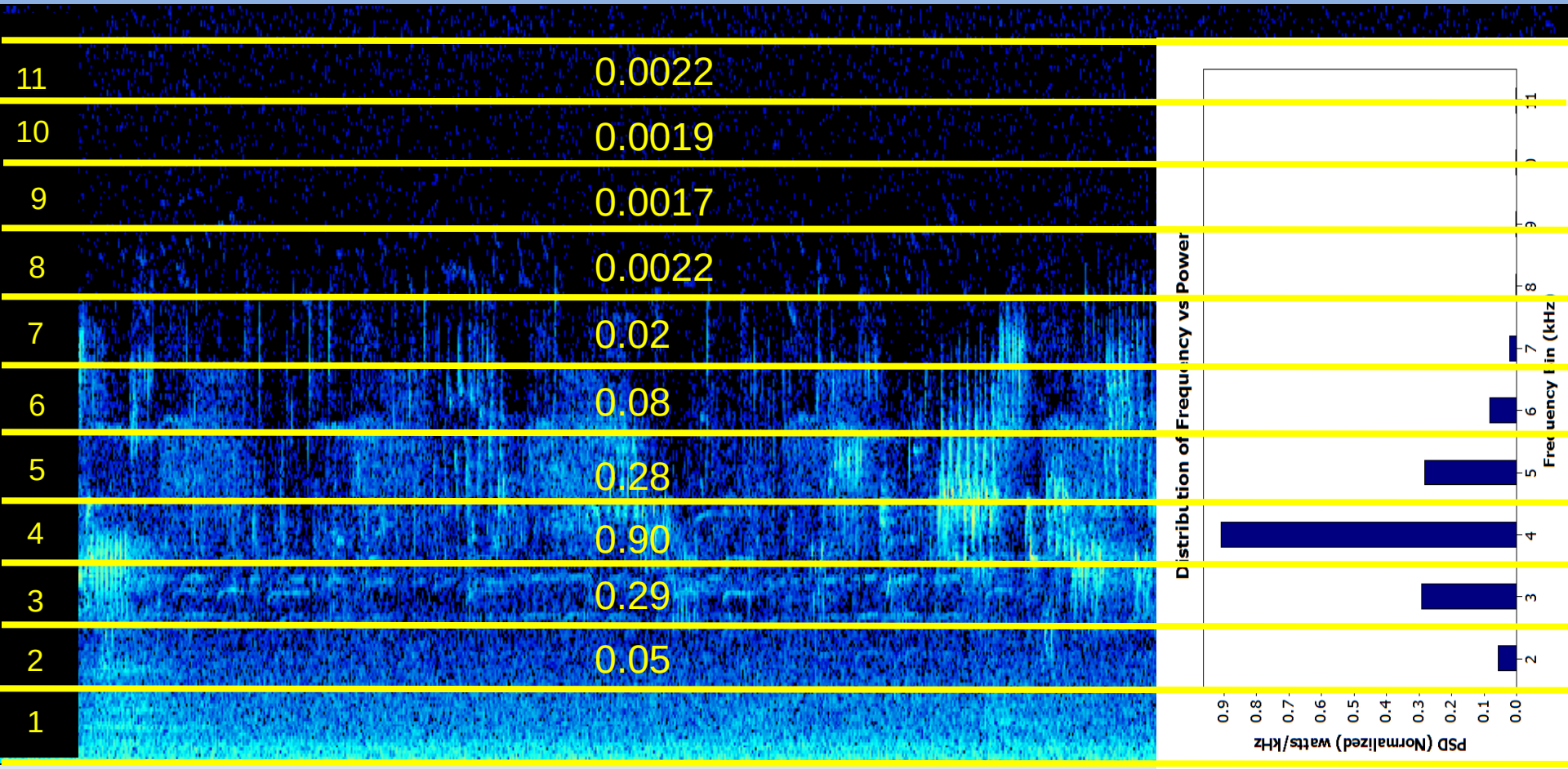
Methodology

- Analyzing Sound Data
  - Over 63,000 Sound files were entered into the **R**emote **E**nvironmental **A**ssessment **L**aboratory's (REAL) sound library (http://real.msu.edu/)
    - An automated system for caluclating biophony and anthrophony
  - Sound files (.wav) are converted into spectrograms and separated into 1 kHz frequency band widths (bins)
  - Welch (1968) algorithm for calculating Power Spectral Density (PSD) for each bin
  - PSD indicates the degree of saturation of sound within a bin
  - PSD is also the amount of energy emitted by a sound in each bin

Sound Power Partitioning

Sound Frequency Bins (1 kHz) intervals	Power Spectral Density (PSD) normalized values (watts/kHz)
11	0.0022
10	0.0019
9	0.0017
8	0.0022
7	0.02
6	0.08
5	0.28
4	0.90
3	0.29
2	0.05
1	

Power Spectral Density pattern



PSD=Welch (1968)

Time (Seconds)

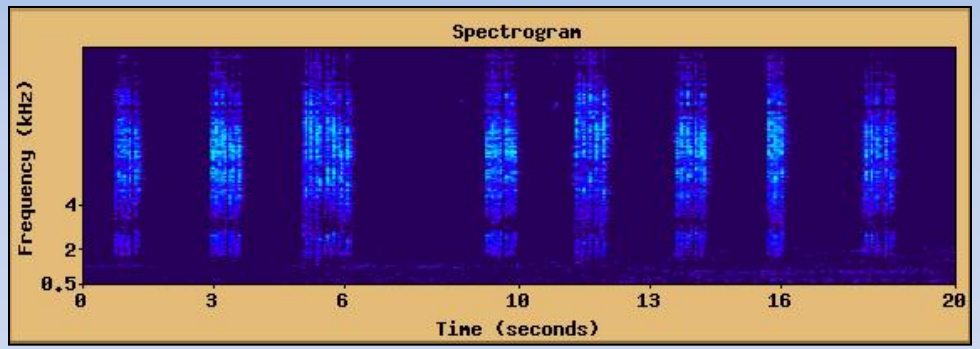
Analysis

Biophony

- the total PSD occurring at > 2 kHz = biological sounds

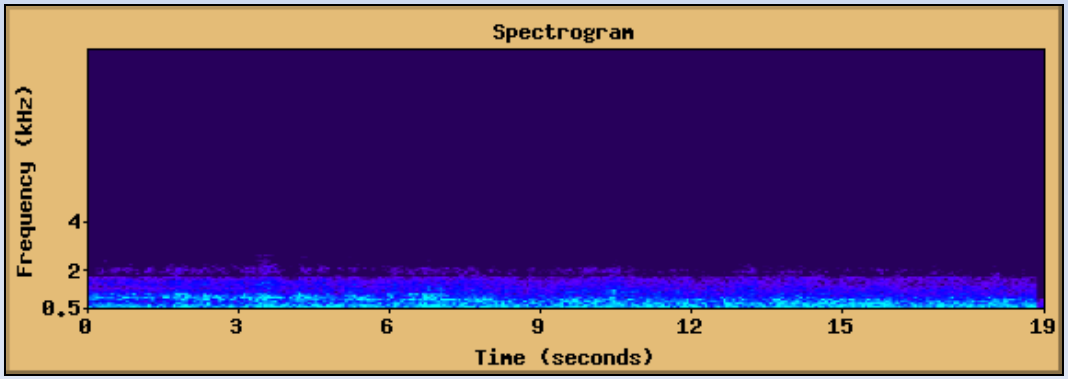
Anthrophony

- the total PSD occurring at 1-2 kHz = anthropogenic sounds



Gray Jay

Airplane

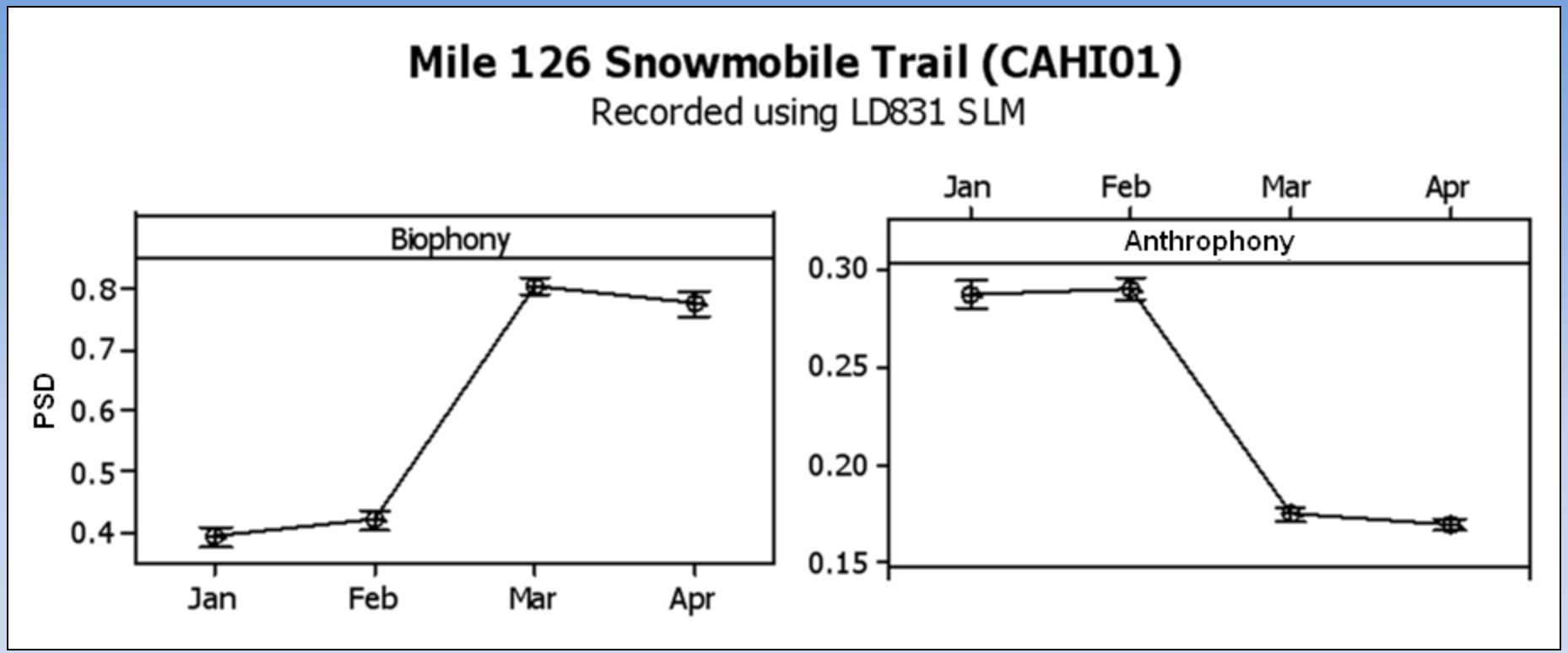


Temporal and Spatial Analysis

1. Analyzed the temporal variation of biophony and anthrophony at 6 permanent sound stations

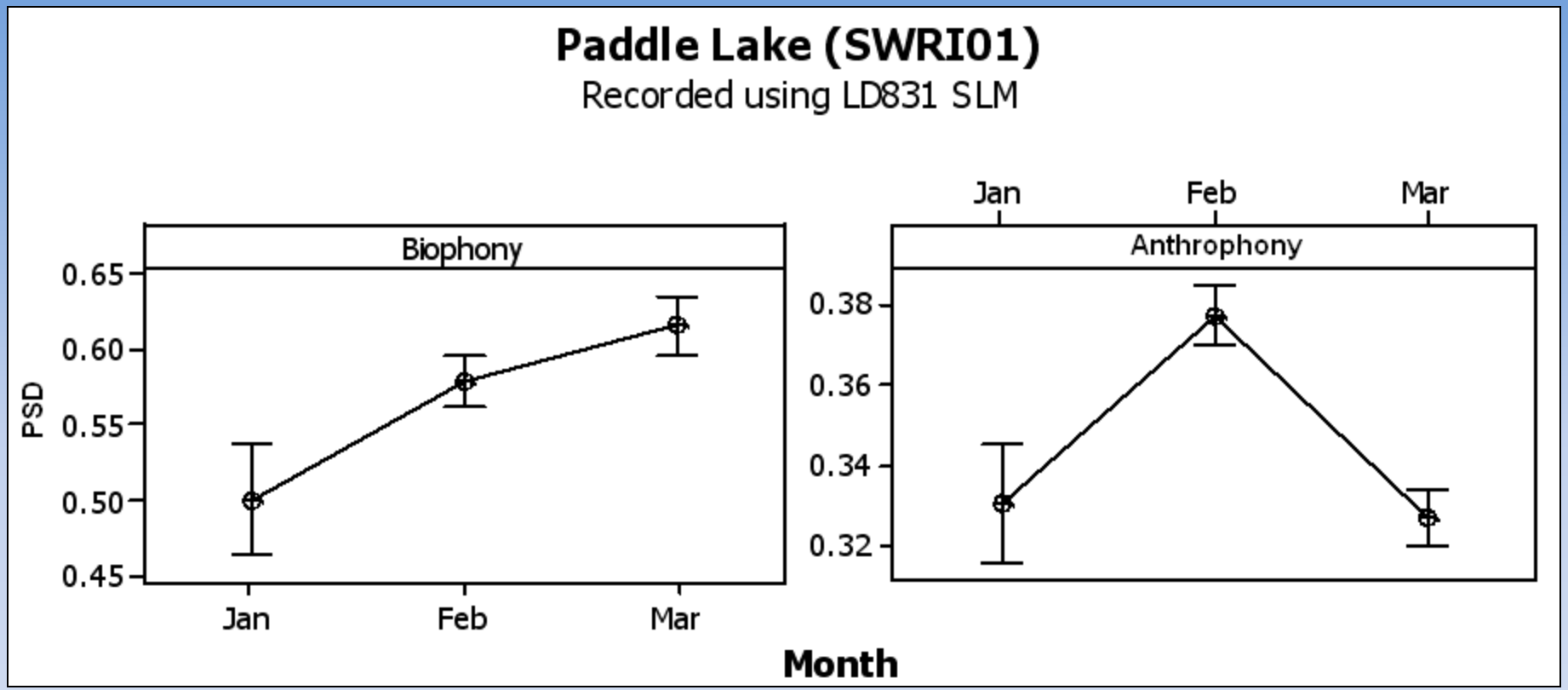
2. Modeled the spatial distribution of anthrophony for all 22 stations

Temporal Results



- Located in designated wilderness open to snowmachines
- Area has a relatively higher saturation of biophony compared to anthrophony
- Biophony increases over winter as anthrophony decreases
  - Coincides with snowmachining season (Dec to Mar)

Temporal Results

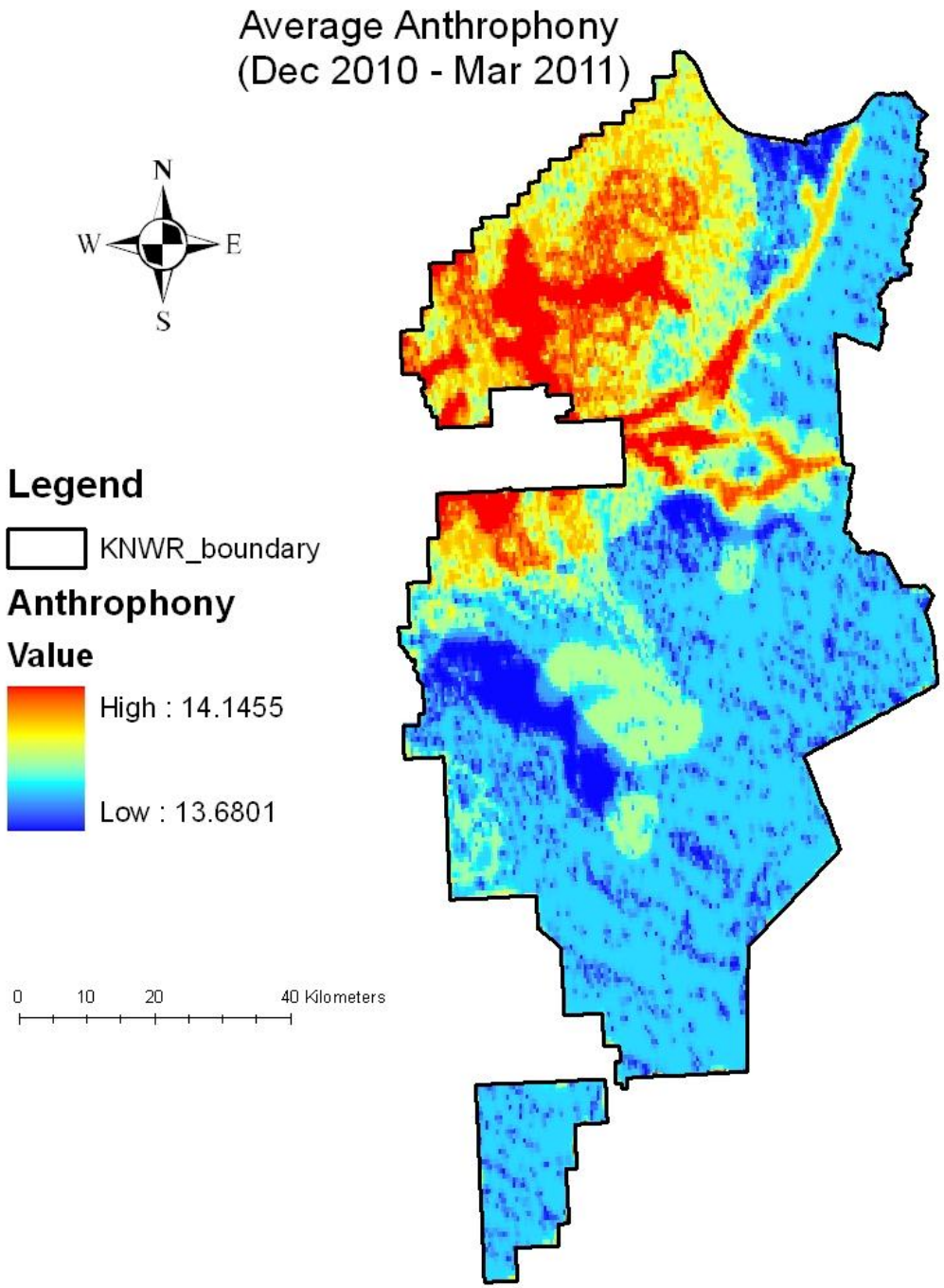


- Located in designated wilderness closed to snowmachines
- Biophony increases over winter
- Anthrophony hits peak in February
  - Due to increased air traffic

Spatial Modeling Results

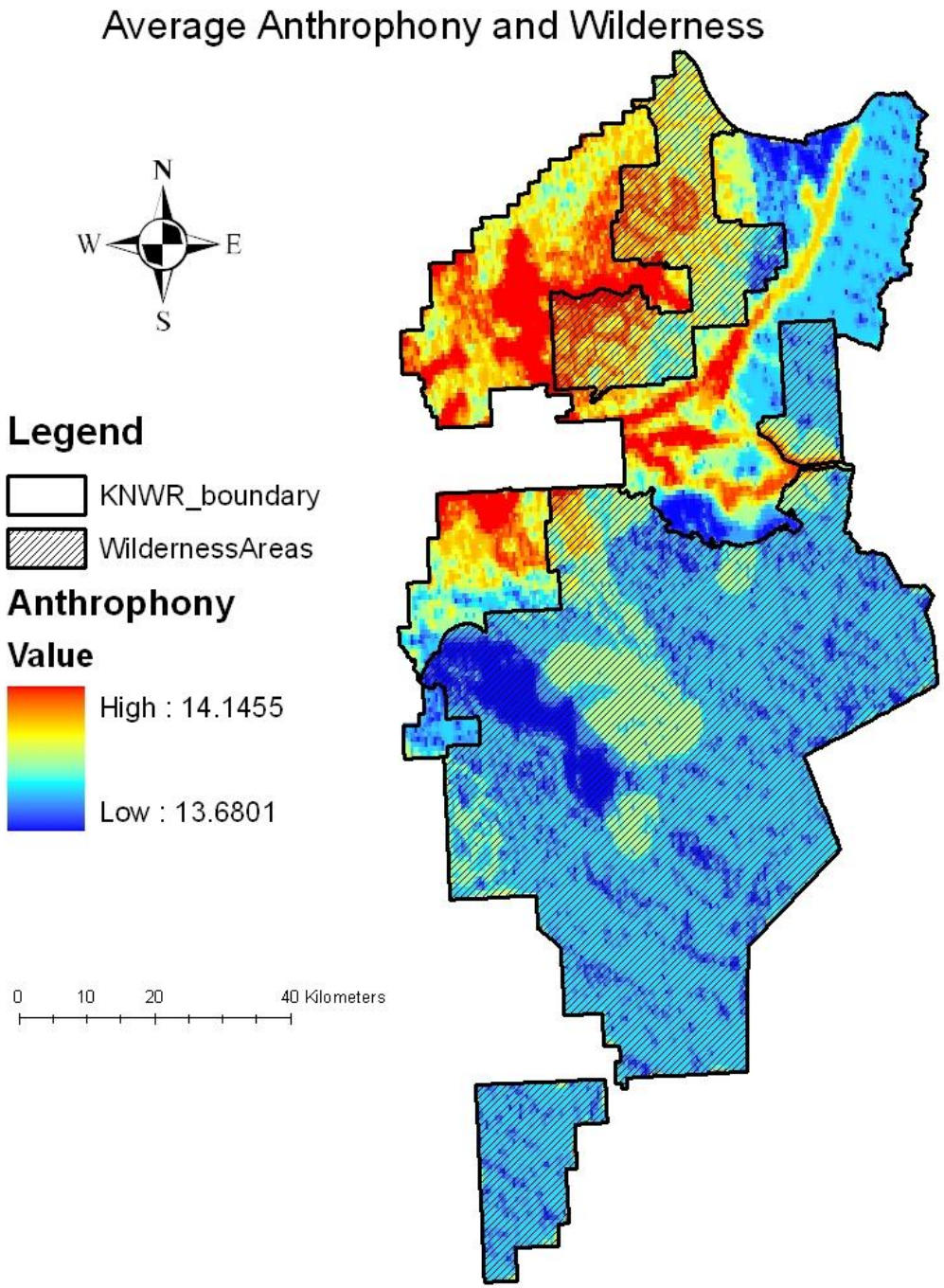
- Higher anthrophony localized to northwestern part of Refuge

- Hot spots:
  - -Soldotna
  - - Kenai
  - - Oil and Gas field
  - - Swanson River area
  - - Sterling Hwy
  - - Mystery Creek Rd



Anthrophony and Wilderness

- Northernmost wilderness bordered and occupied by high anthrophony
- Central and southern wilderness generally lower anthrophony

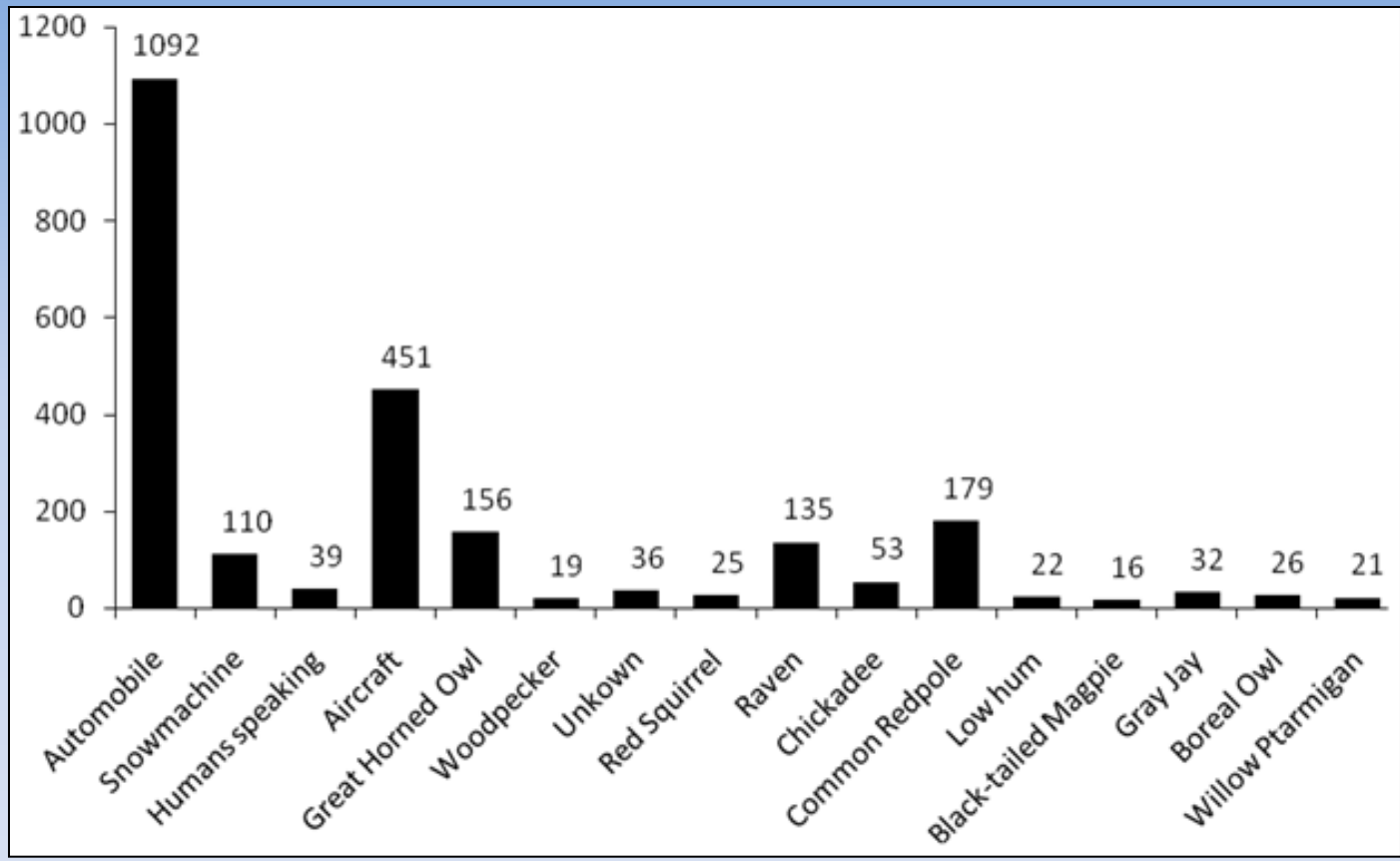


Most Common Sound Sources

- Determine what sound sources were contributing to the soundscape

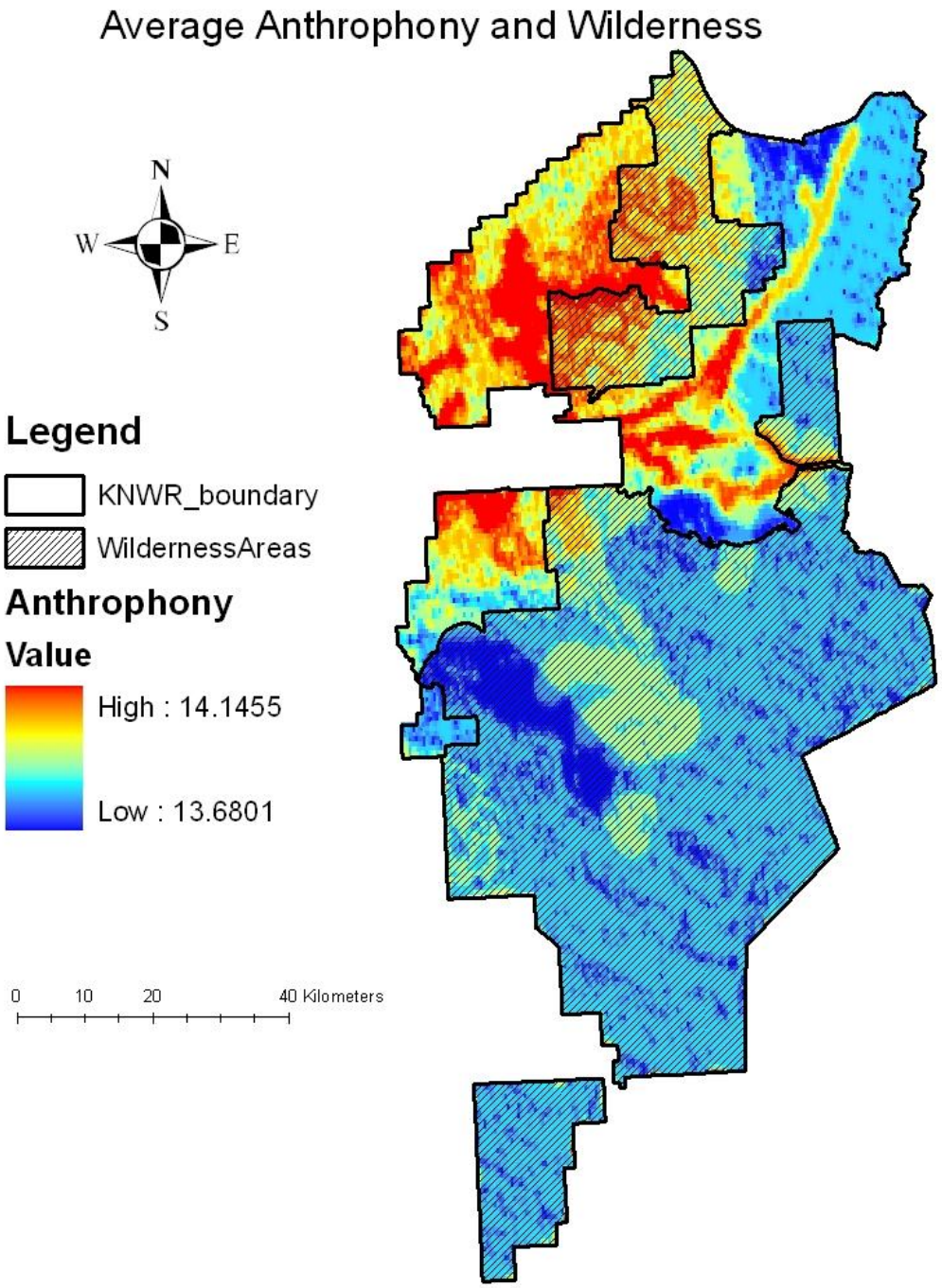
- Listened to ~ 10,000 sound files from 6 permanent sound stations

- Automobiles and aircraft were significant contributors



Preliminary Conclusions

- Biophony still dominates majority of Refuge throughout the winter
- Anthrophony is localized but intruding into Wilderness
- Inaccessible areas of Refuge have lower amounts of anthrophony
- Vehicle traffic and aircraft can affect outdoor experience in more accessible areas of Wilderness



Next Steps for Winter 2011-2012

1) **Increase spatial sampling**
   - **27 total sound recorders**
   - **12 permanent stations**
   - **15 stations moved to new locations every 10 days**

2) **Identifying "quiet" areas (i.e., absence of anthrophony)**
   - **Parse out sound files with absence of sound**

3) **Create models of anthrophony and biophony**

4) **Build time series models to show temporal variation spatially**
   - **Average over Dec, Jan, Feb, Mar**

Acknowledgements

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QUESTIONS?

Biophony Sound Sources within the Range of Anthrophony

Sound Source	kHz
Anthrophony Sources	
Human voices	1-2
Airplane	1-2
Automobile	1-2
Chain Saw	1-2
Snowmachine	1-2
Biophony Sources	
Great Horned Owl	1-2*
Raven	1-2*
Black-billed Magpie	>2
Chickadee	>2
Golden Crowned Kinglet	>2
Gray Jay	>2
Red Breasted Nuthatch	>2
Red Poll	>2
Red squirrel	>2
White Winged Crossbill	>2