

Ecoacoustics Theory & Soundscape Ecology in Alaska's Wilderness

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AQC
Soundscape Workshop
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Sound in Earth's History

- Earth sounds have existed for over 4 billion years
- Animal sounds have existed for 400 million years
- Machine noise has existed for over 300 years
- Sound is used by every animal on Earth in some form
- Sound is present in nearly all terrestrial, aquatic, and marine systems

Noise & The Extinction of Natural Sounds

An aerial photograph of a winding asphalt road through a mountainous landscape. The road is filled with a long line of cars, indicating a traffic jam. The surrounding terrain is covered in patches of snow and dense evergreen forests. In the background, large, snow-capped mountains rise under a clear blue sky.

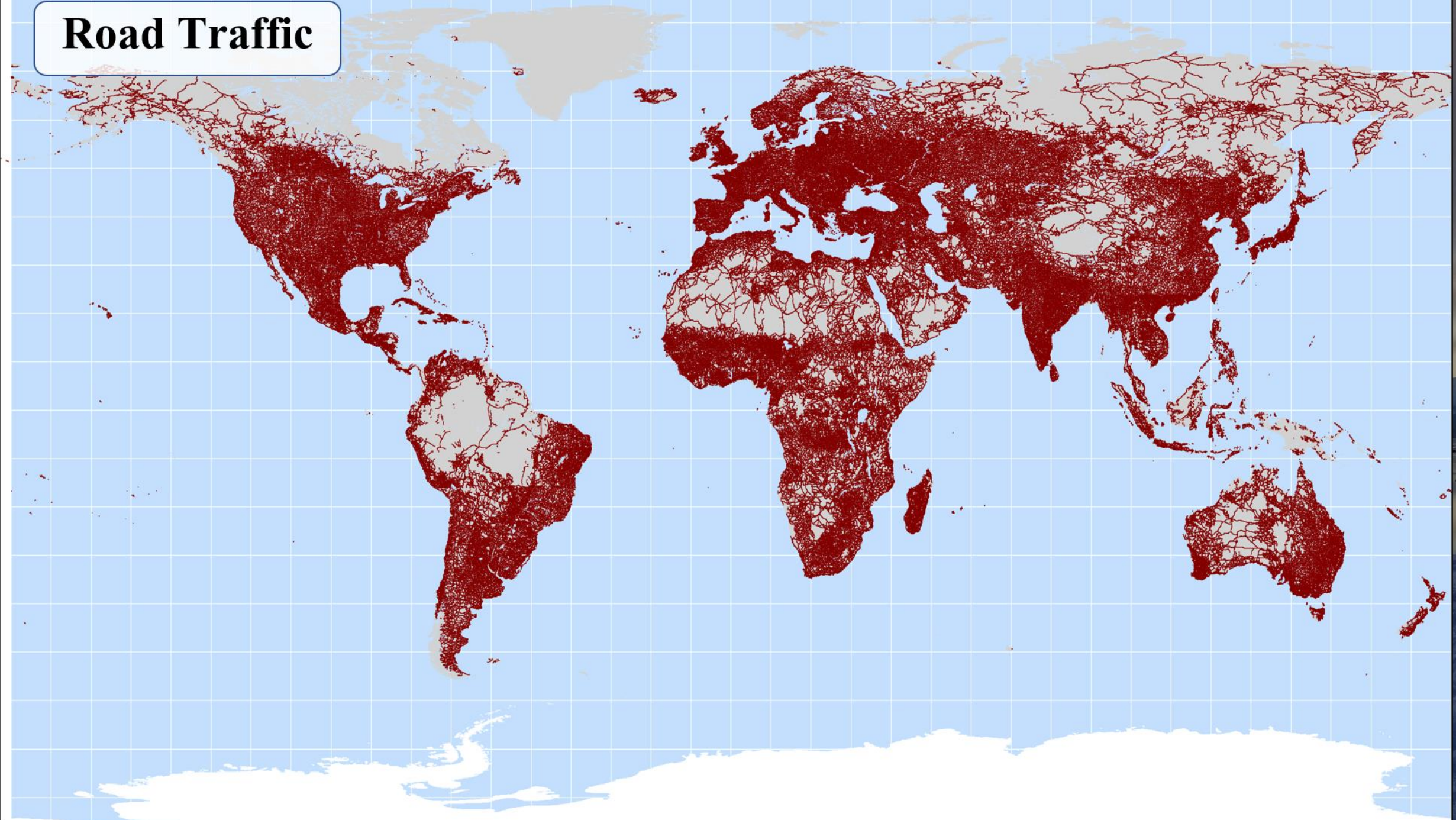
- Noise is a human-created problem from our prolific use of machines

Road Traffic

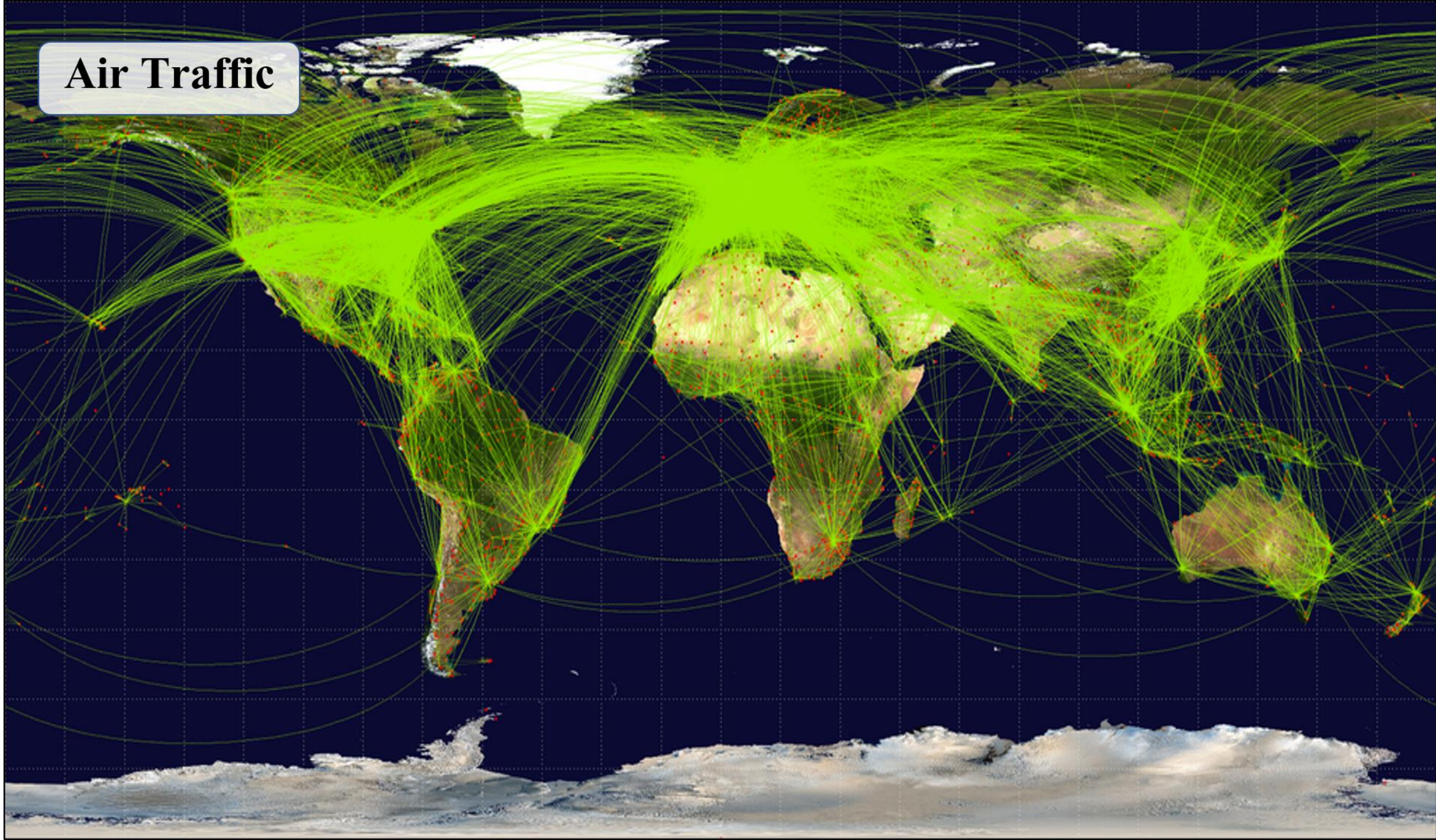
Air Traffic

Sea Traffic

Road Traffic



Air Traffic



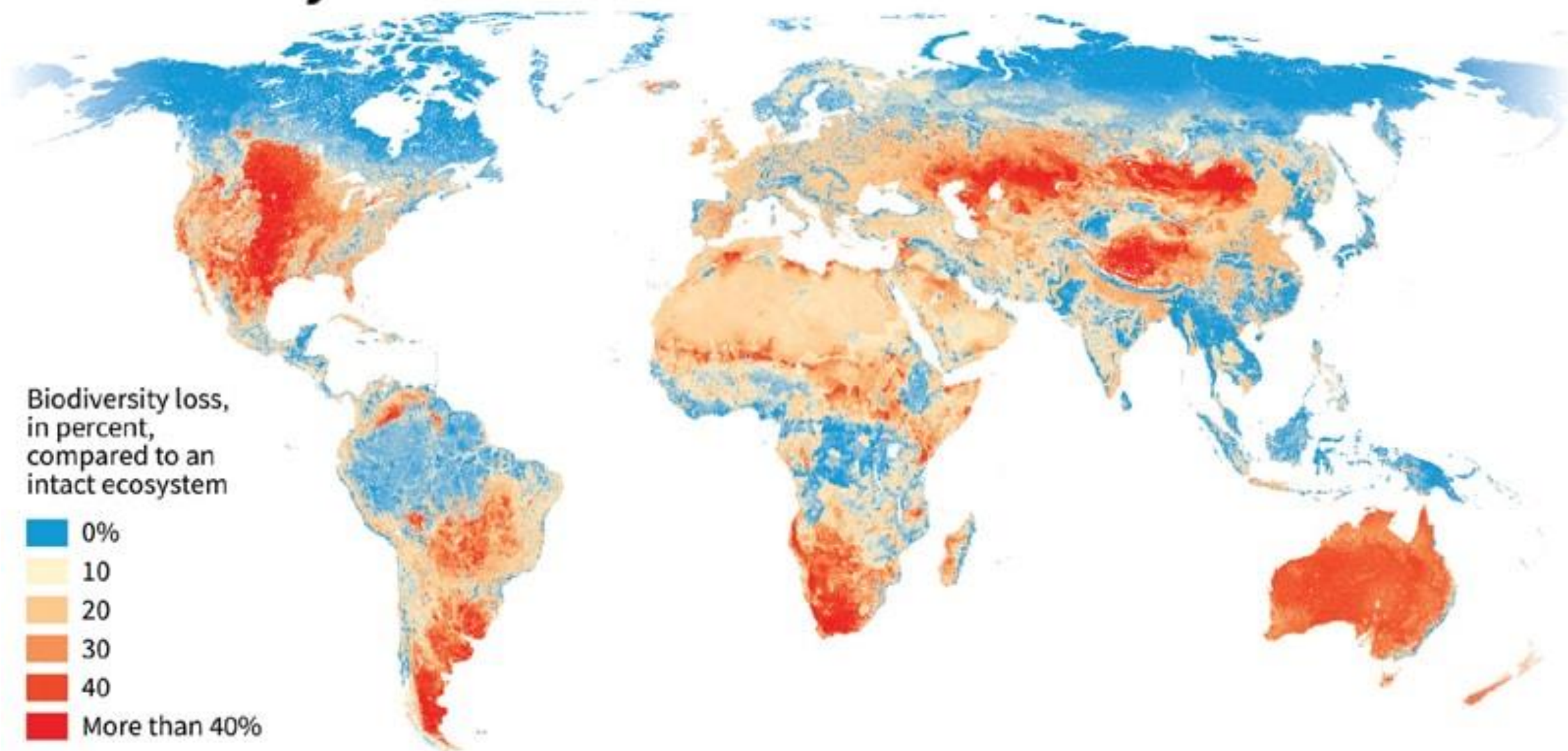
Sea Traffic

S03°30'48.31
E126°30'53.93
(-03.5134, 126.5150)

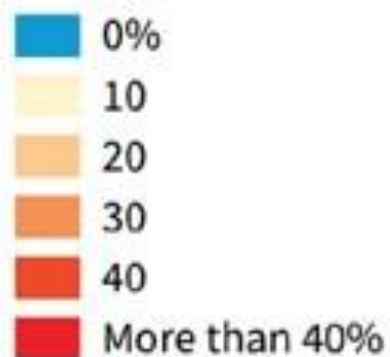


3000 km
2000 mi

Biodiversity loss



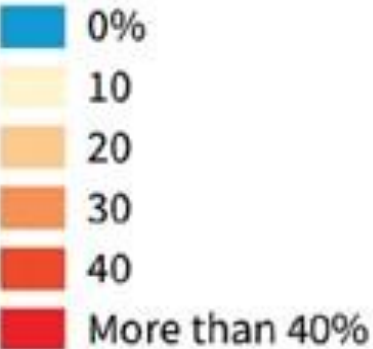
Biodiversity loss,
in percent,
compared to an
intact ecosystem



Source: National History Museum Data Portal. Data from 2016

Biodiversity loss

Biodiversity loss,
in percent,
compared to an
intact ecosystem



Group	Endangered
Amphibians	1,393
Reptiles	578
Birds	683
Mammals	708
Fish	1,098
Invertebrates	2,150
Total	6,032

Source: National History Museum Data Portal. Data from 2016

The Question: What is the Ecological Role of Sound?

Ecoacoustics (est. 2014)

Ecological processes in nature

Species communication

Human-Nature Relationships

Noise impacts

Human culture & psychology



Sound is Information

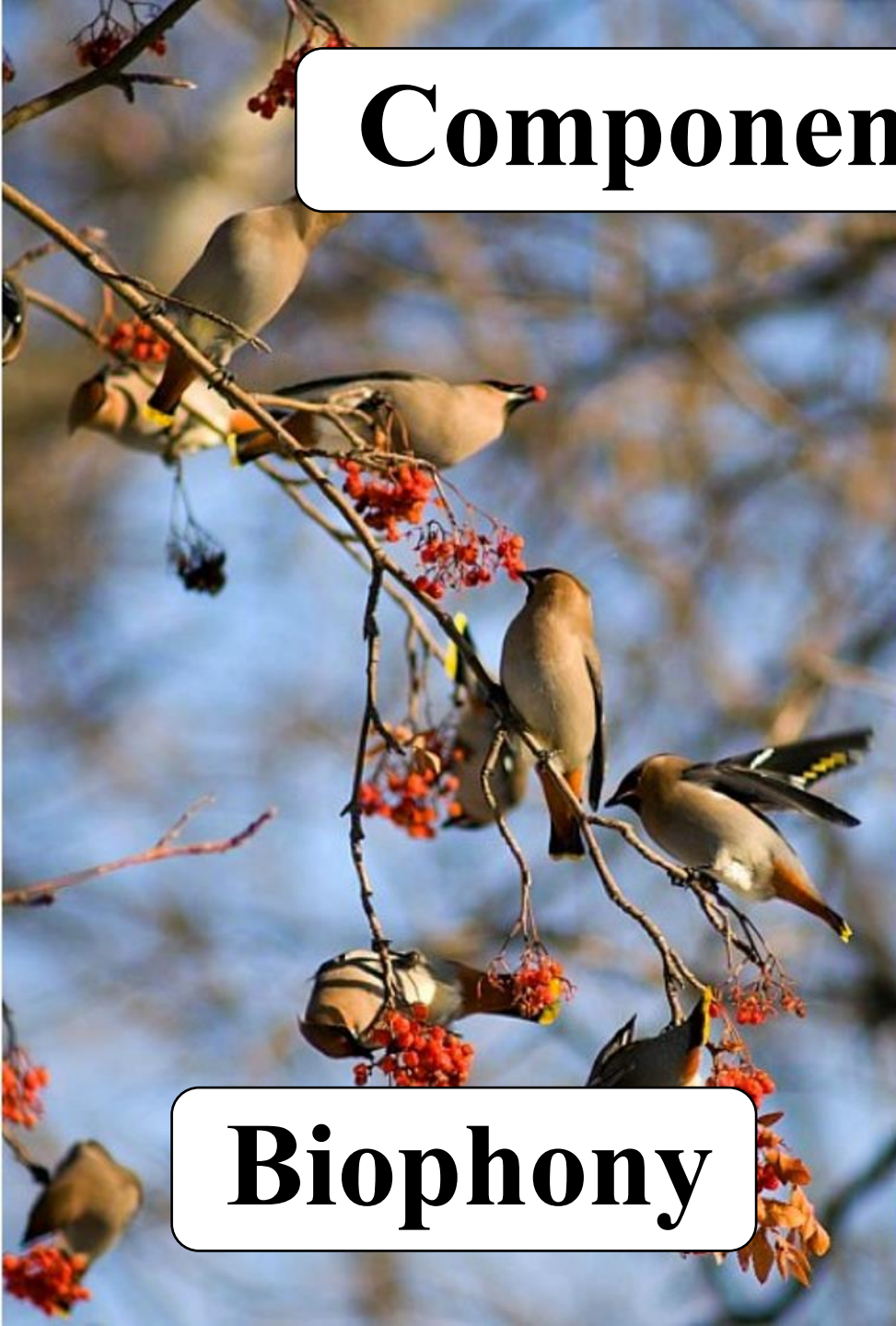
- Animals are knowledgeable & aware of their environment
- Sense organs enable animals to acquire information & interact
- Sound is information within a template of other ecological information, called the **Eco-Field**

Acoustic Eco-Field

- It is safe to say for sound-dependent species the Acoustic Eco-field is vital to their existence
- Sounds in Nature are used for:
 - Communication
 - Habitat selection
 - Prey location
 - Risk assessment
- Noise disturbance can significantly affect animal behavior



Components of Sound in Nature



Biophony

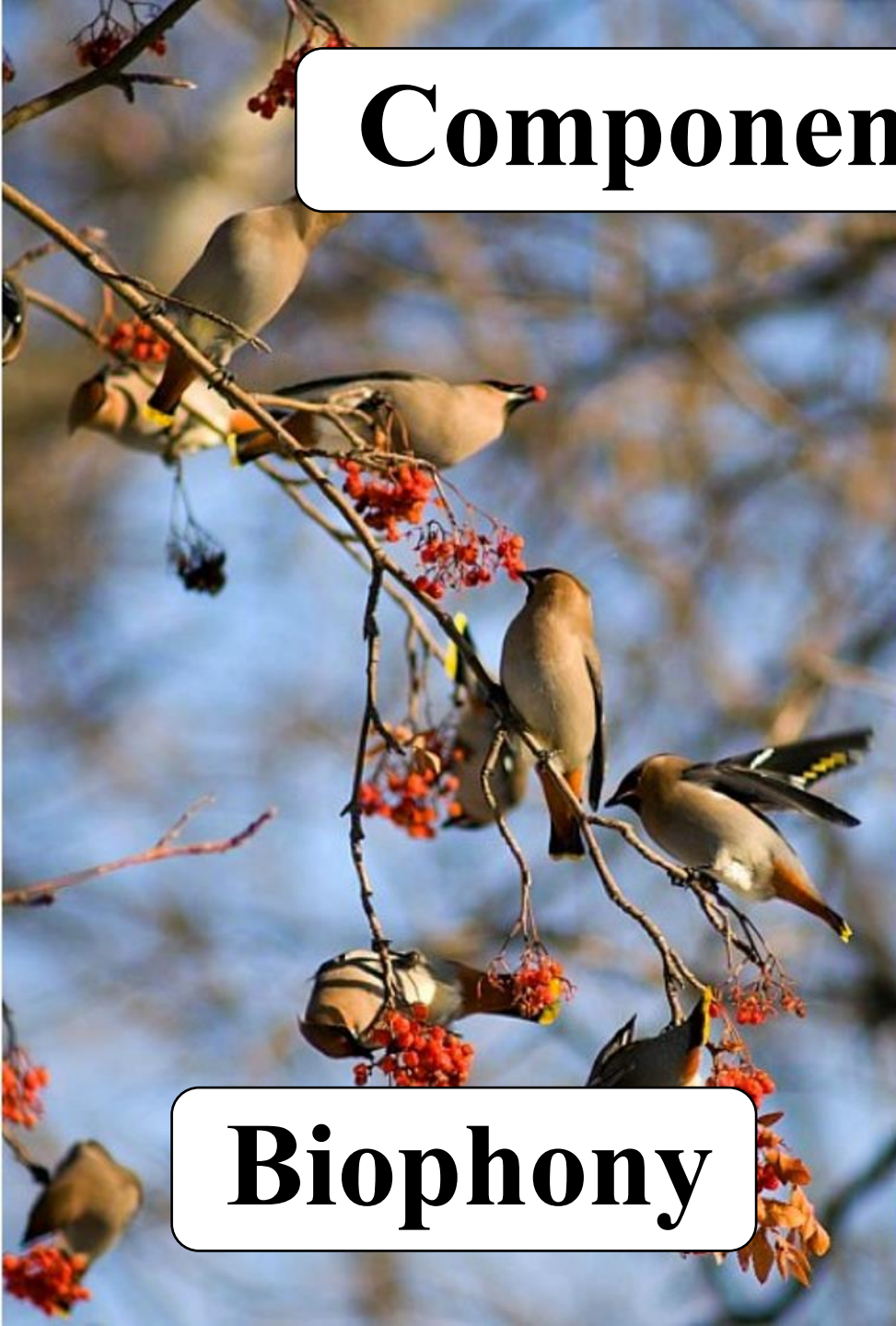


Geophony



Anthrophony

Components of Sound in Nature



Biophony



Geophony



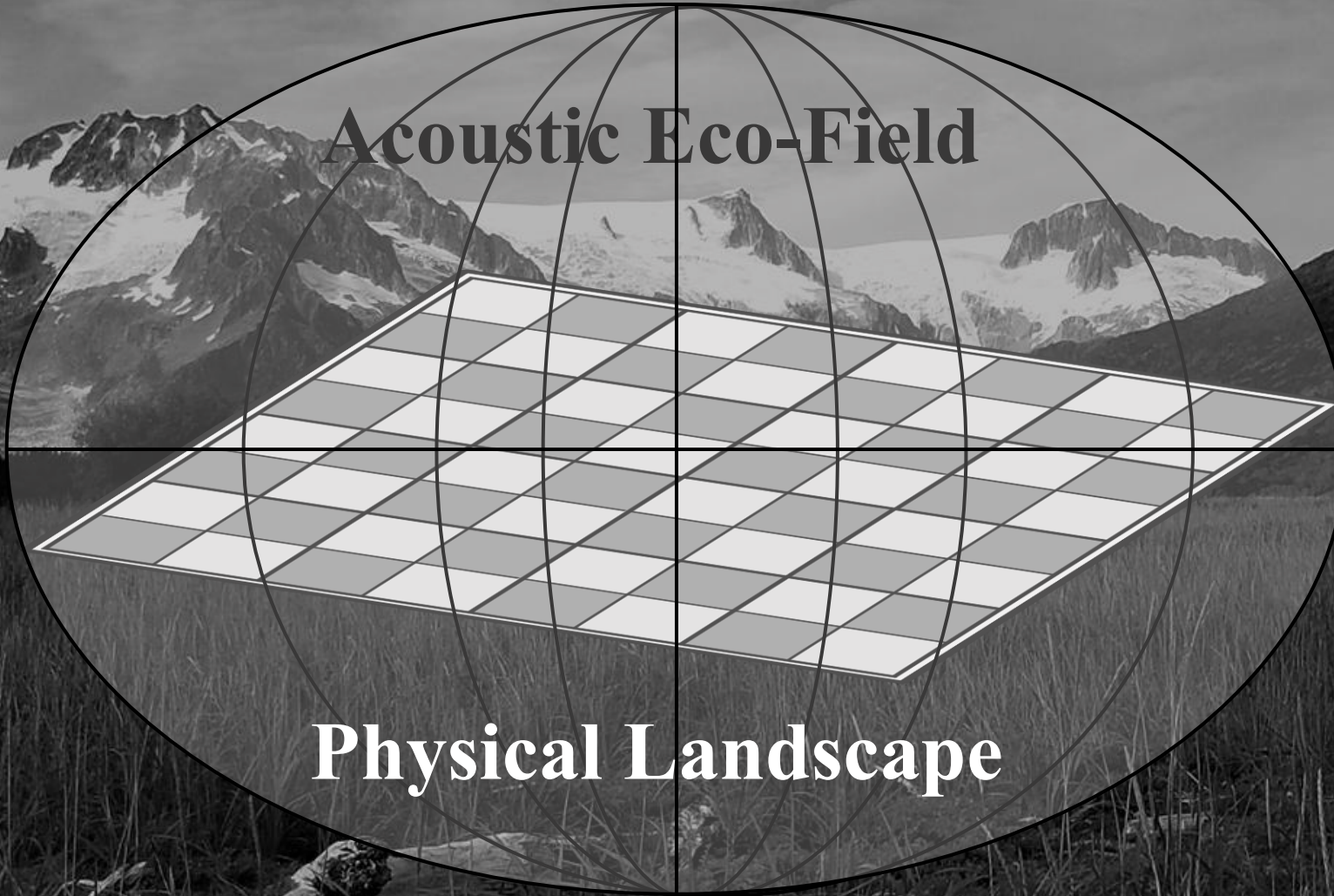
Technophony

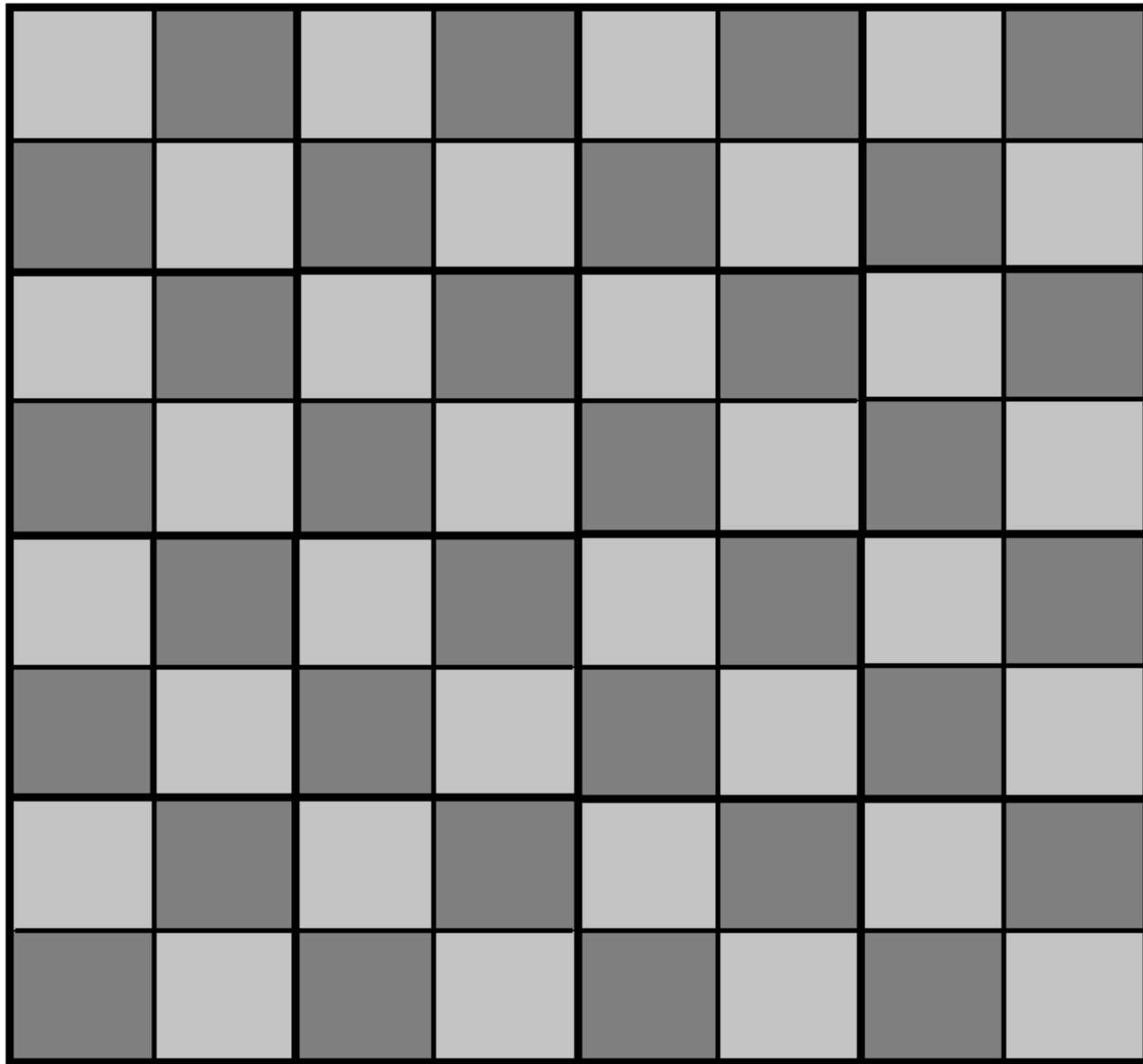
Acoustic Space: The Area Sound Occupies

Acoustic Space

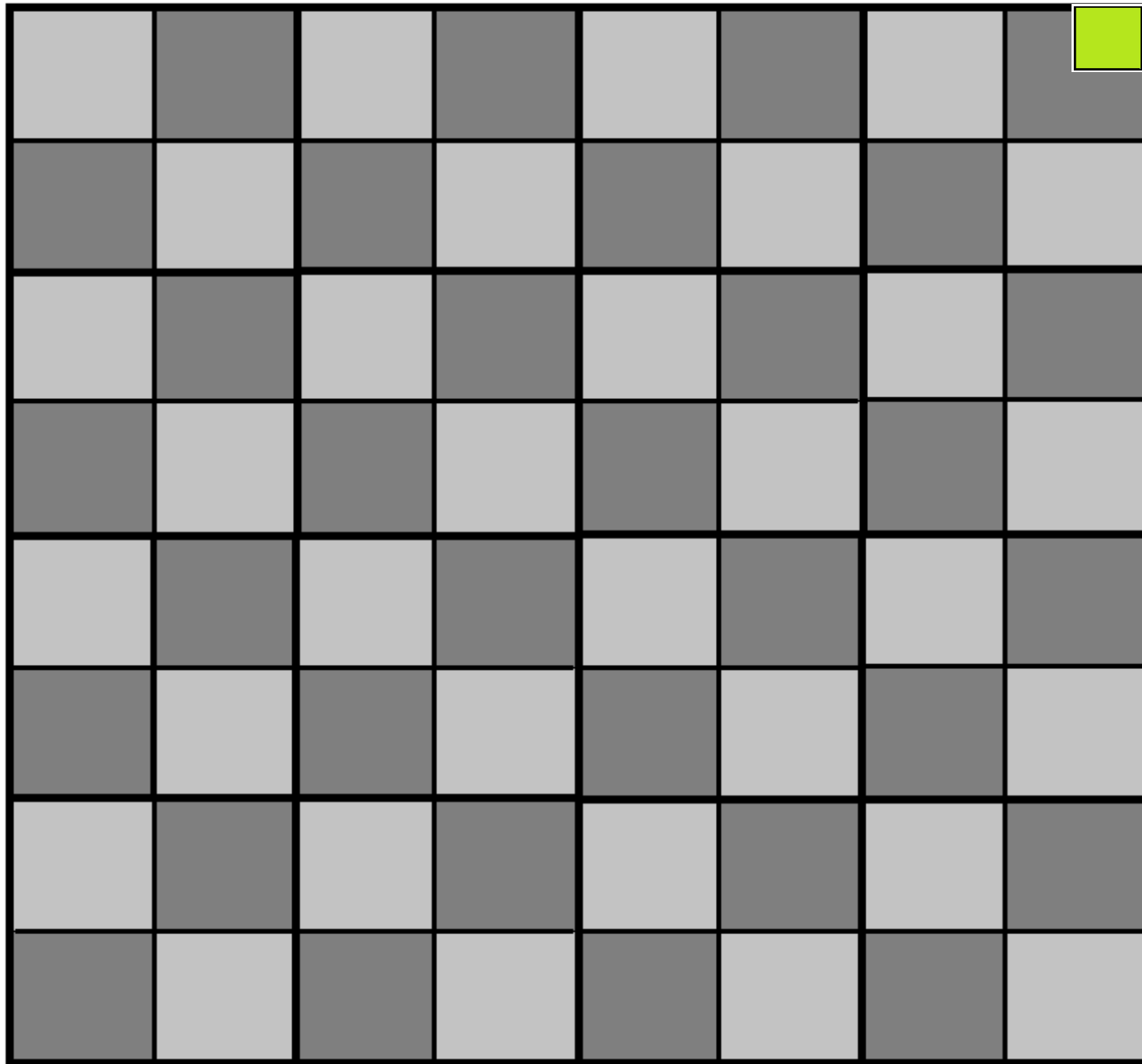
Acoustic Eco-Field

Physical Landscape





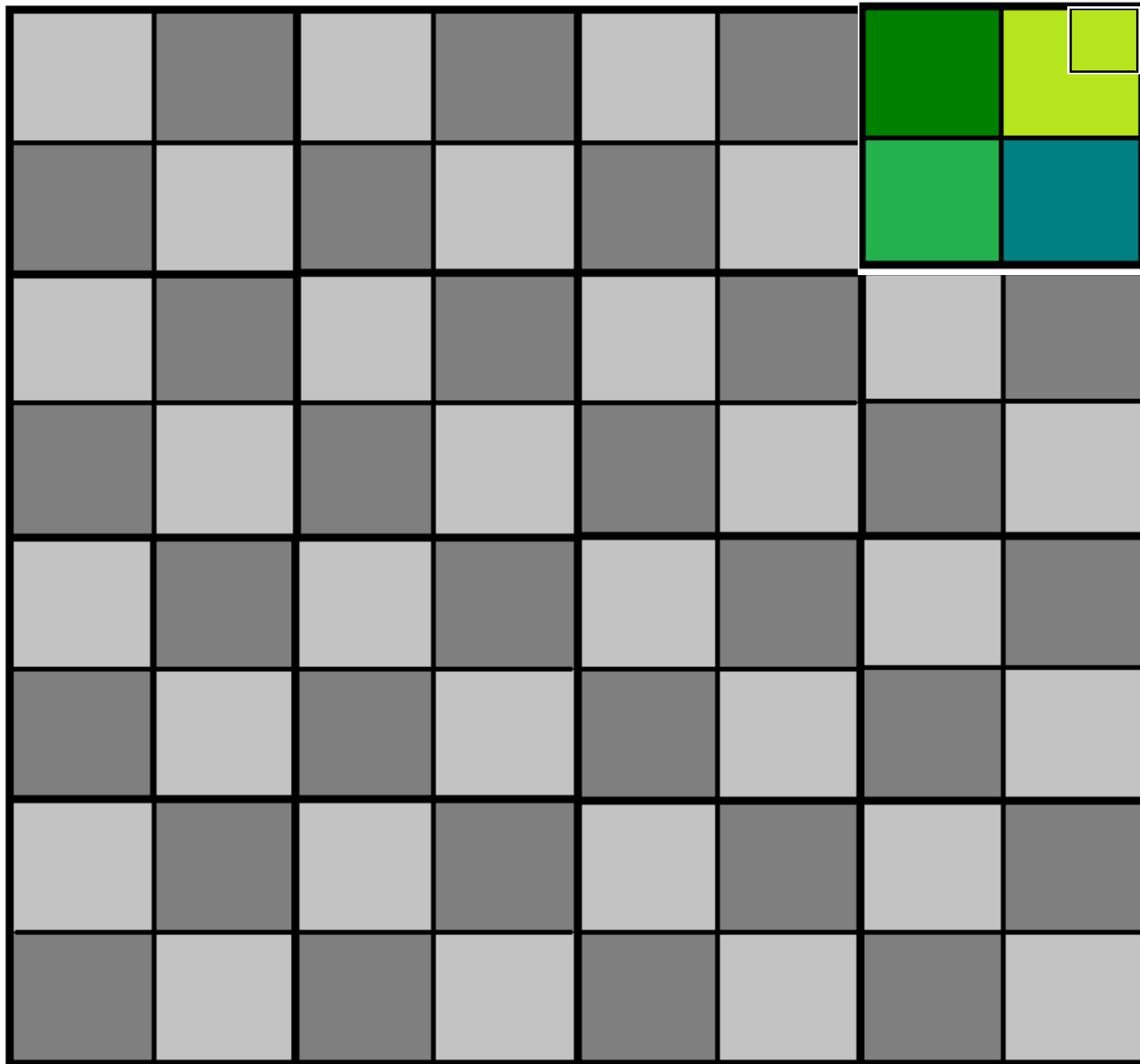
Empty Acoustic Space



} **Single species calling**

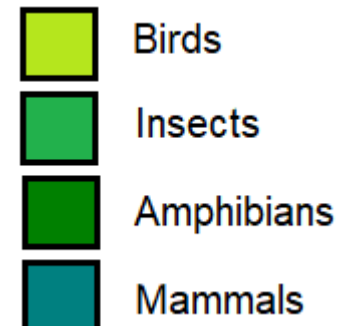
Biophony

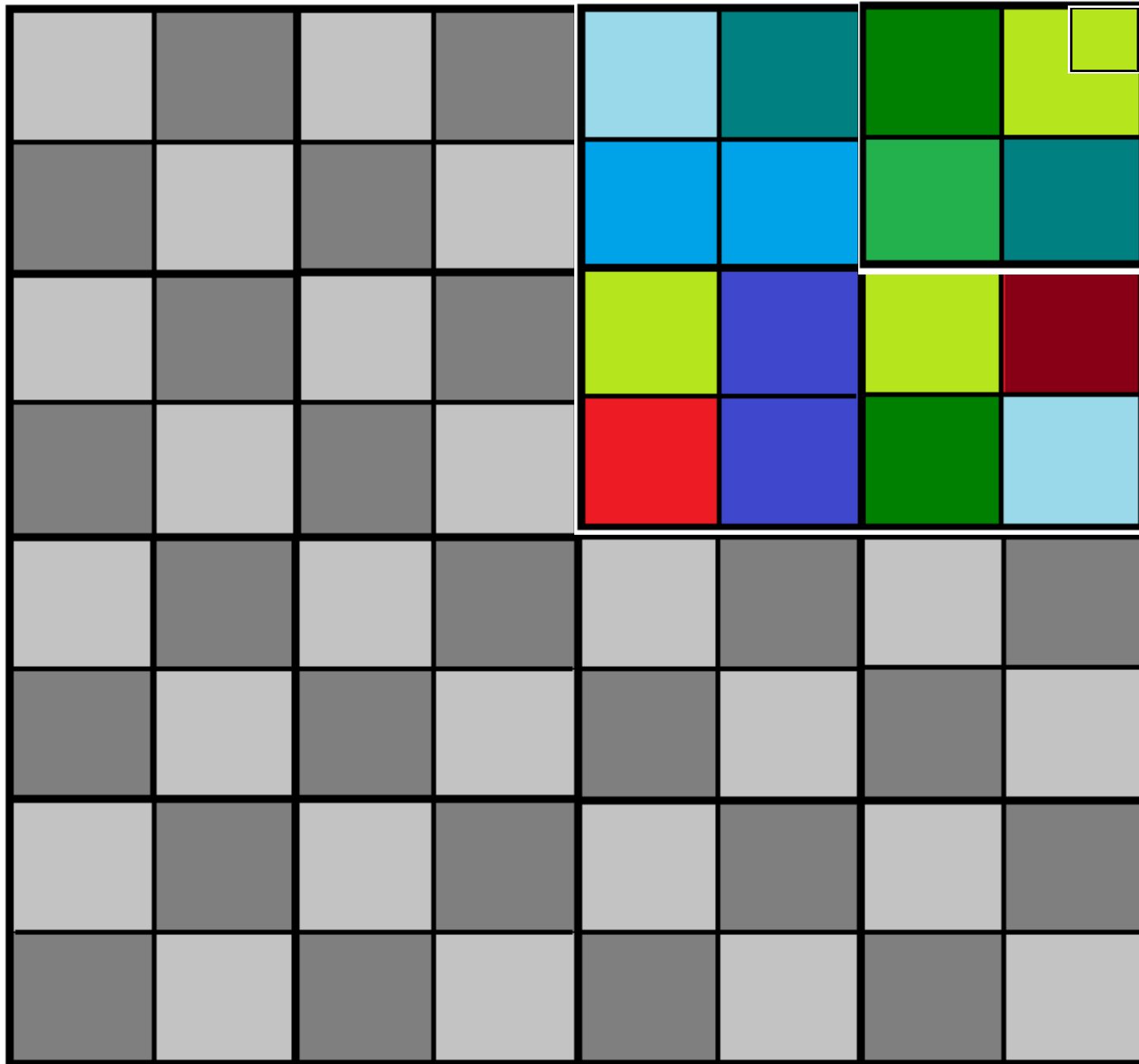
 Bird



Acoustic Community
of multiple animal
sounds

Biophony





Sonotope

A mix of
biophony,
geophony, &
technophony

Biophony

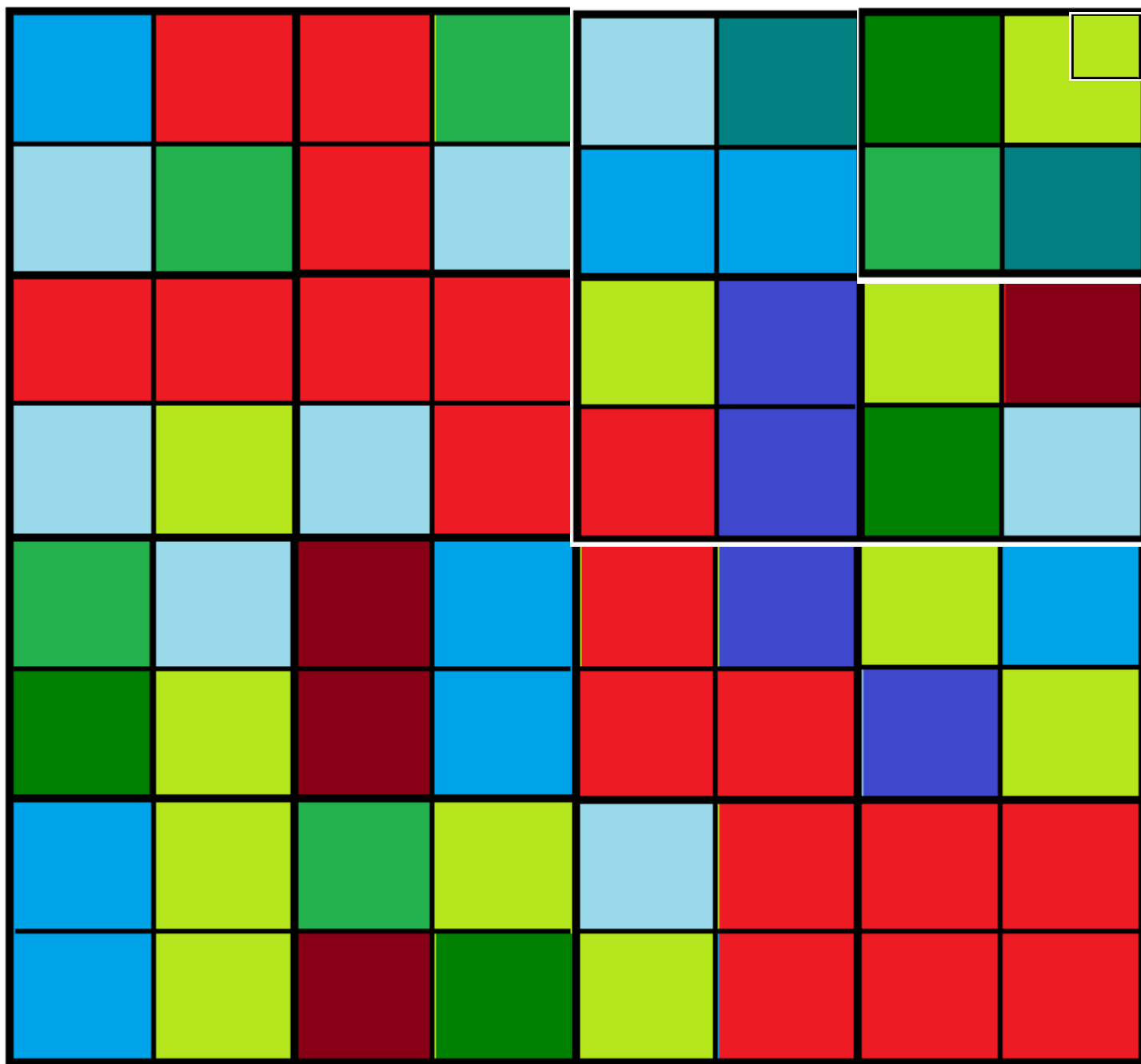
- Birds
- Insects
- Amphibians
- Mammals

Geophony

- Wind
- Rain
- River

Technophony

- Cars
- Planes



Soundscape

A landscape of
sound patterns
associated with
physical organisms,
geophysical events,
& human activity

Biophony

- Birds
- Insects
- Amphibians
- Mammals

Geophony

- Wind
- Rain
- River

Technophony

- Cars
- Planes

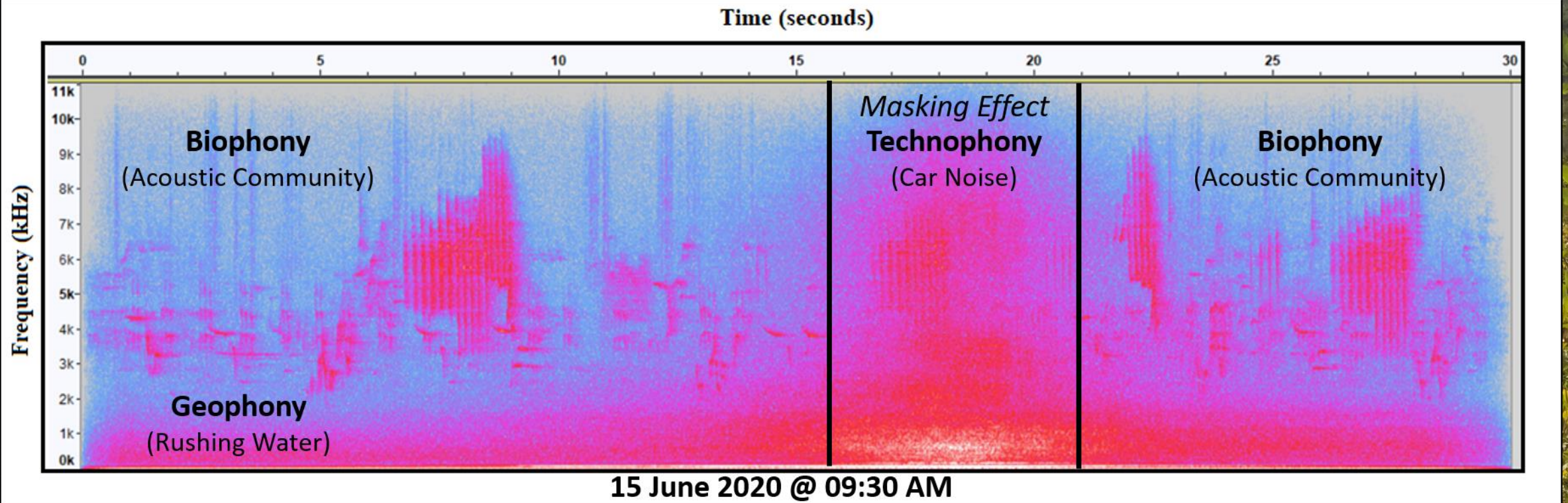
Theories of Sounds in Nature: Biophony

- Soniferous species use the acoustic space and acoustic eco-field in many ways
- **Acoustic Niche** – acoustic space must be available for animals to call and be heard
- **Soundscape Orientation** – sounds from others help animals locate resources
- **Acoustic Habitat** – animals require suitable acoustic conditions to be successful

Natural Sounds are Essential to Life

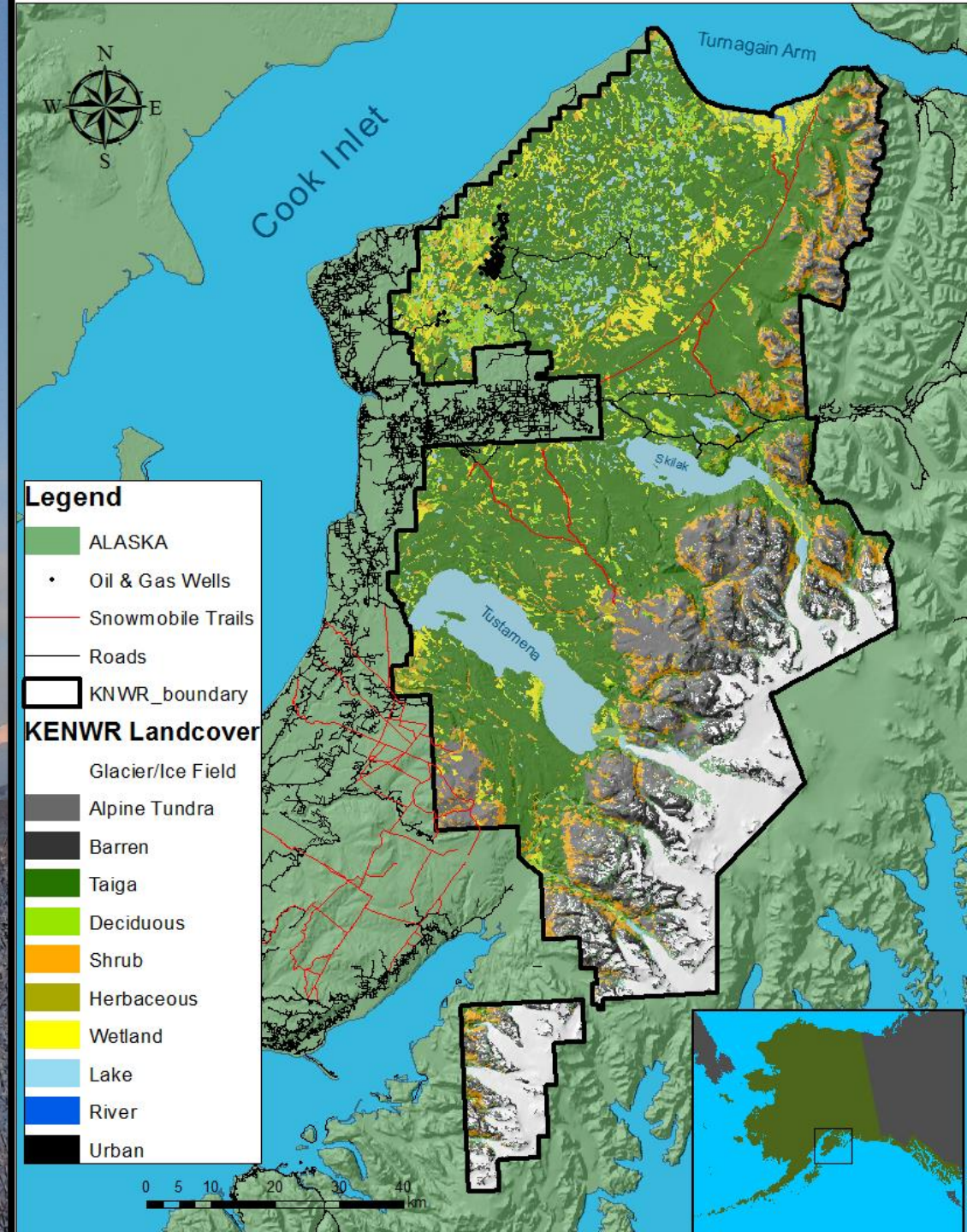


Acoustic Habitats & Noise








Kenai National Wildlife Refuge, Alaska

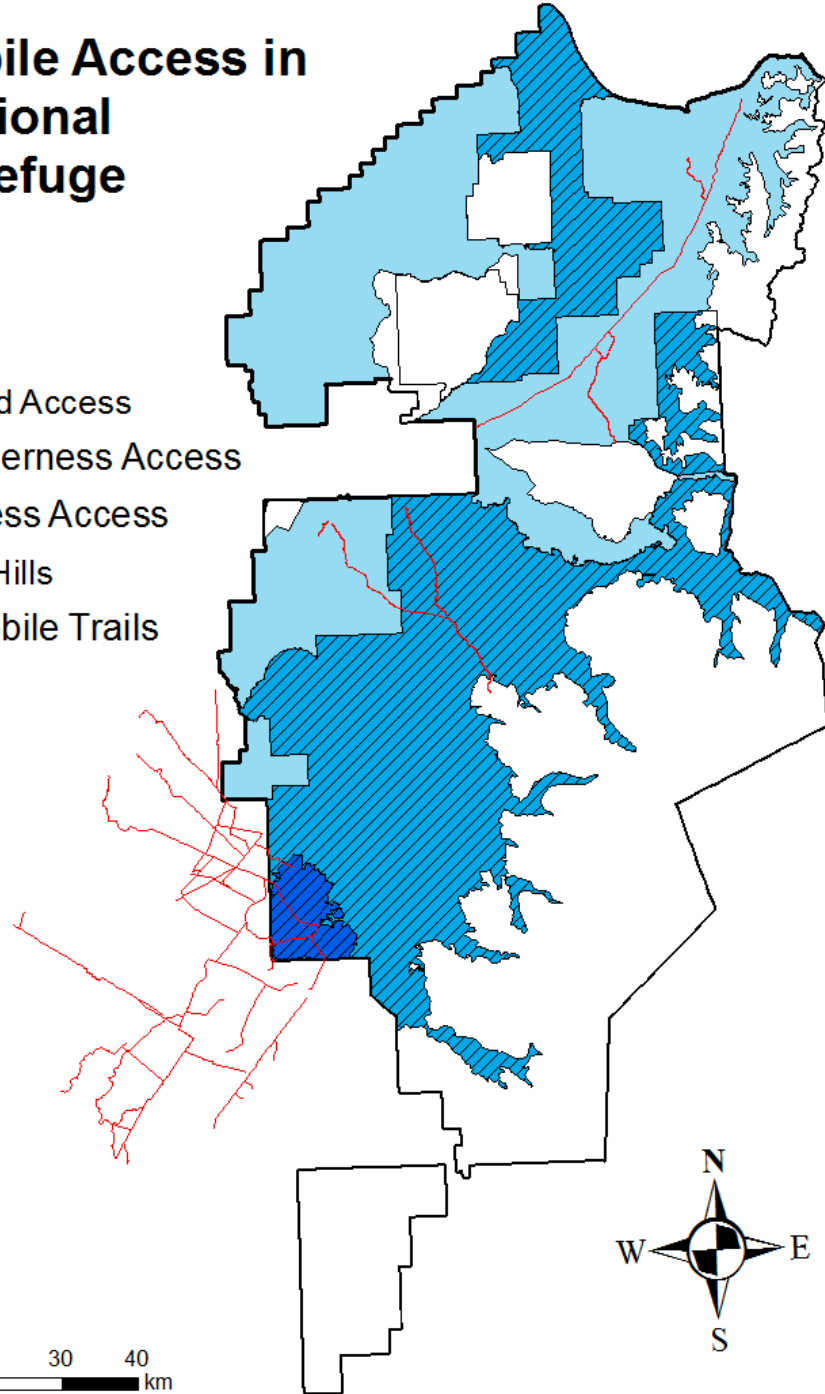
- 2 million acres
- Alaska in miniature



Snowmobile Access in Kenai National Wildlife Refuge

Legend

-  Restricted Access
-  Non-wilderness Access
-  Wilderness Access
-  Caribou Hills
-  Snowmobile Trails



Kenai National Wildlife Refuge: Wilderness

- 1.3 million acres of Wilderness
- Wilderness Act 1964
 - Required to preserve natural processes & opportunities for solitude
- ANILCA 1980
 - Established Wilderness
 - Allows snowmobiling in Wilderness for “traditional activities”

The Importance of Natural Quiet & Issue of Snowmobile Noise

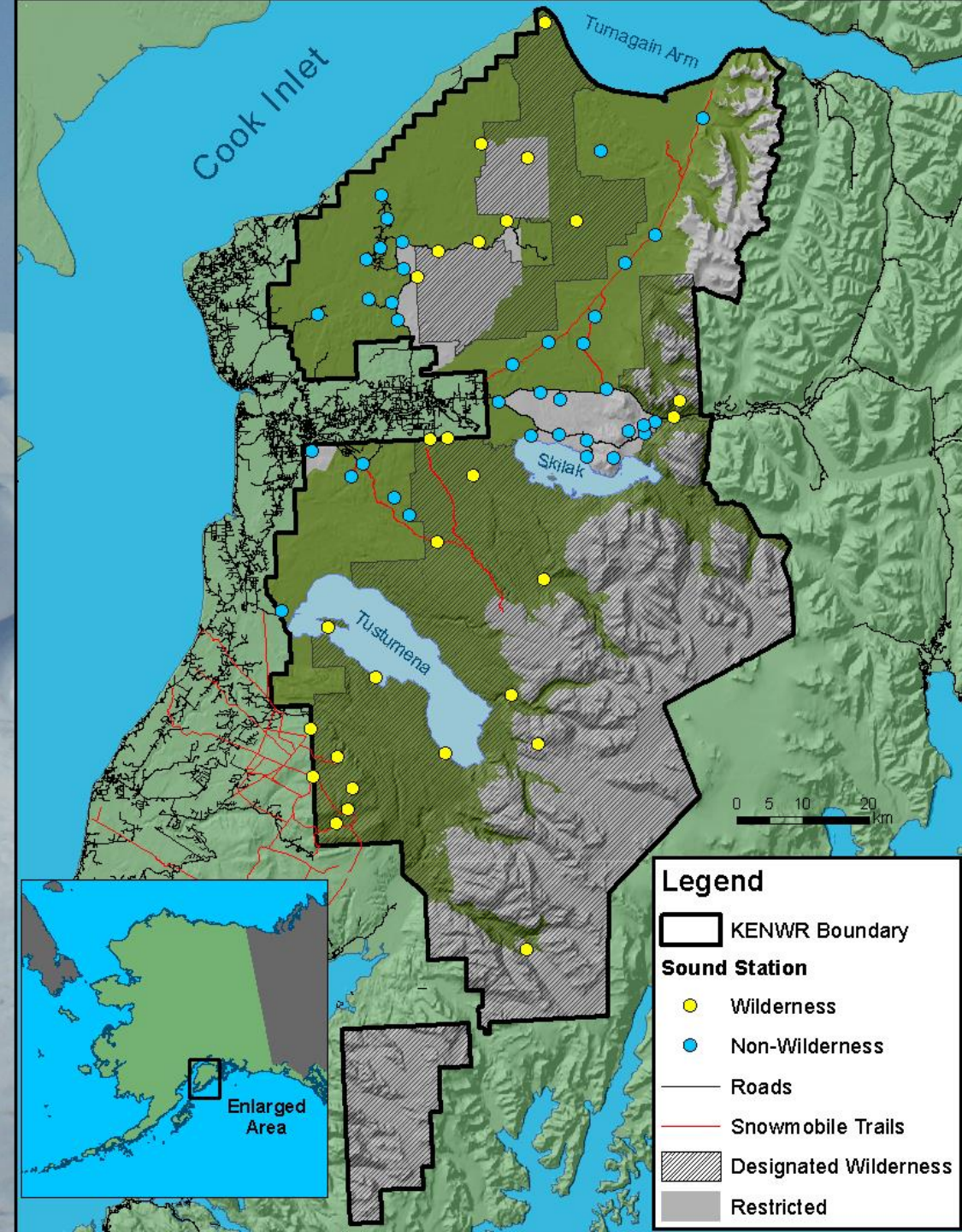
- Winter is quiet – reduced biophony & quieter geophony
- Natural Quiet is important to wildlife & naturalness
 - Perfect conditions for rest & hibernation
 - Reduces stress
 - Resources identified with acoustic information are more rare
- Natural Quiet is important to human solitude
 - Unique acoustic experience
 - Sense of true solitude of internal and external quiet
- Snowmobile Noise degrades these Wilderness qualities



Acoustic Footprint of Snowmobile Noise & Natural Quiet Refugia

Sound Sampling

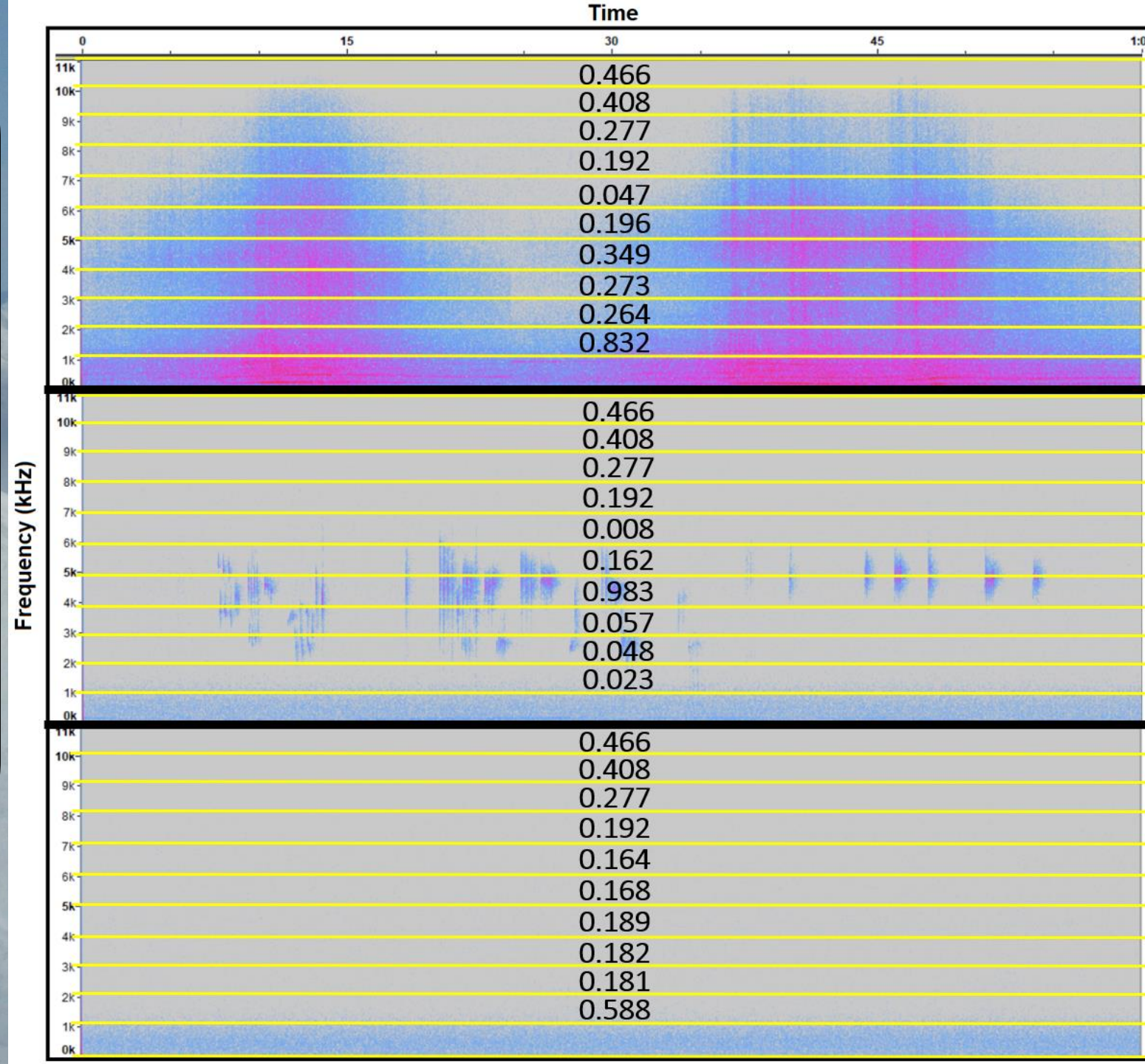
- Recorded sounds for 1 min every 30 min
- 27 sites in Wilderness areas
- 37 sites outside Wilderness areas



Acoustic Footprint of Snowmobile Noise & Natural Quiet Refugia

Sound Identification

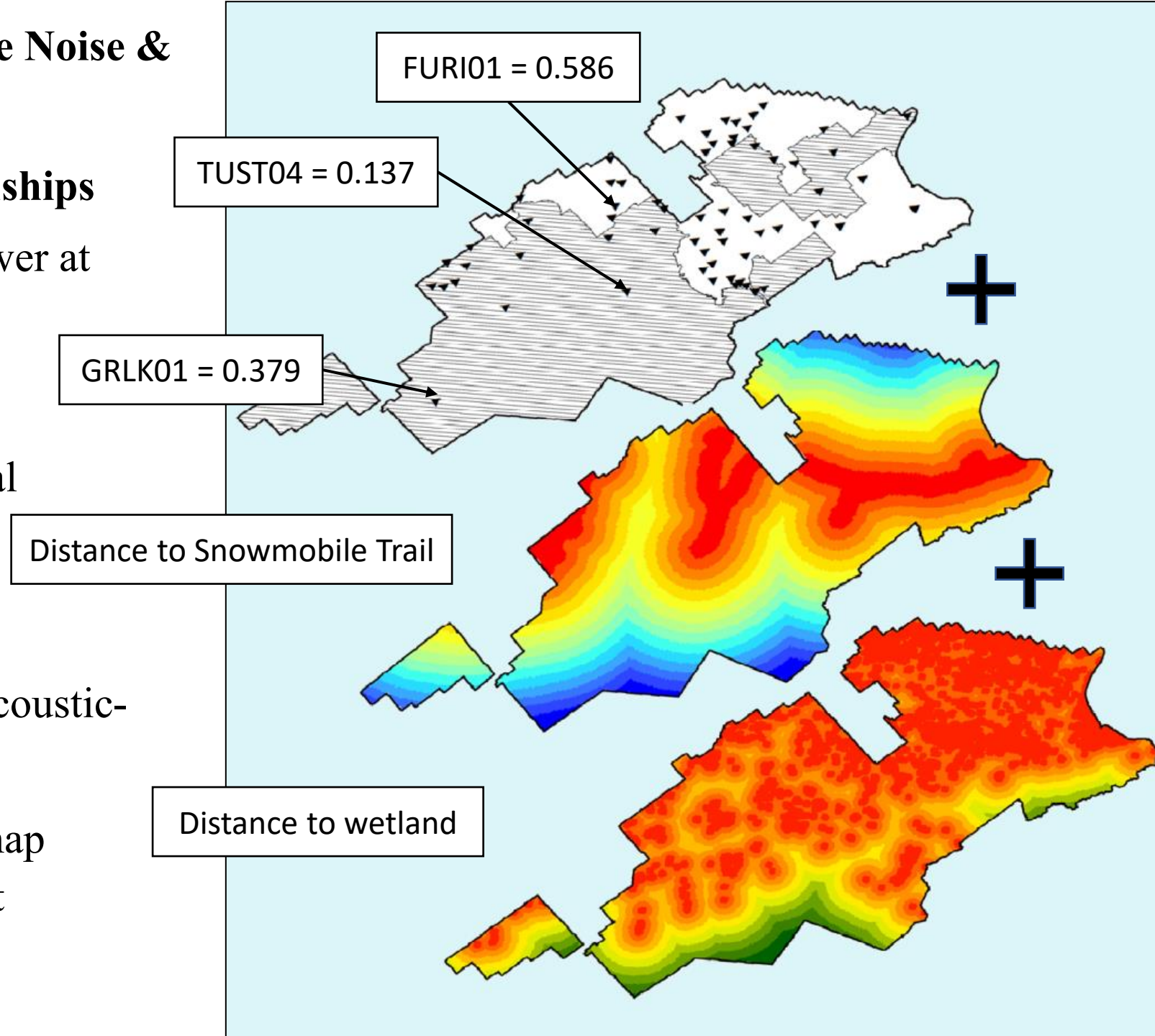
- Listened to 60,000 recordings
 - Natural Quiet = Biophony + Subtle Geophony
 - Snowmobile Noise
- Calculated sound energy
(*soundscape power*) @ 1-kHz intervals
- Summarized patterns of soundscape power over months and 24-h days

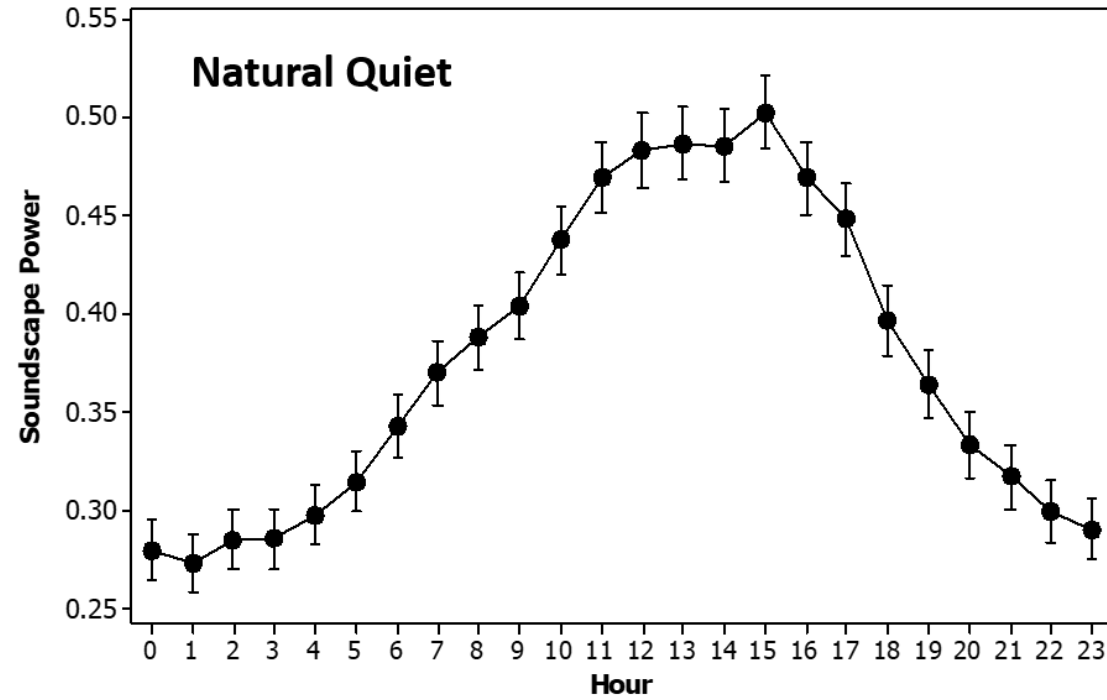
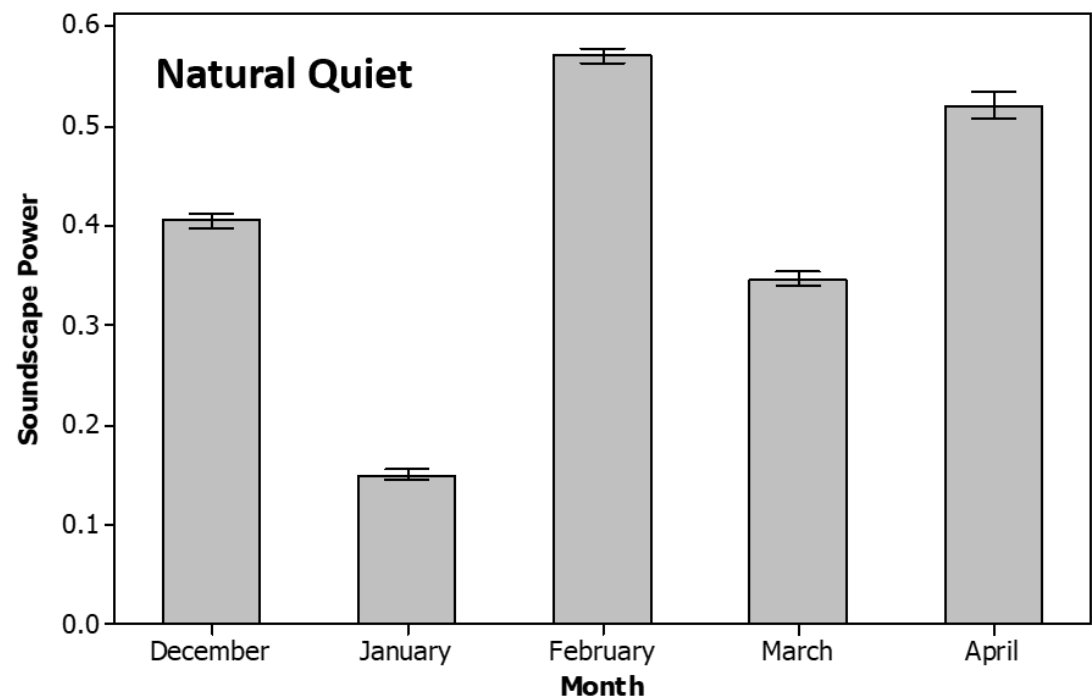
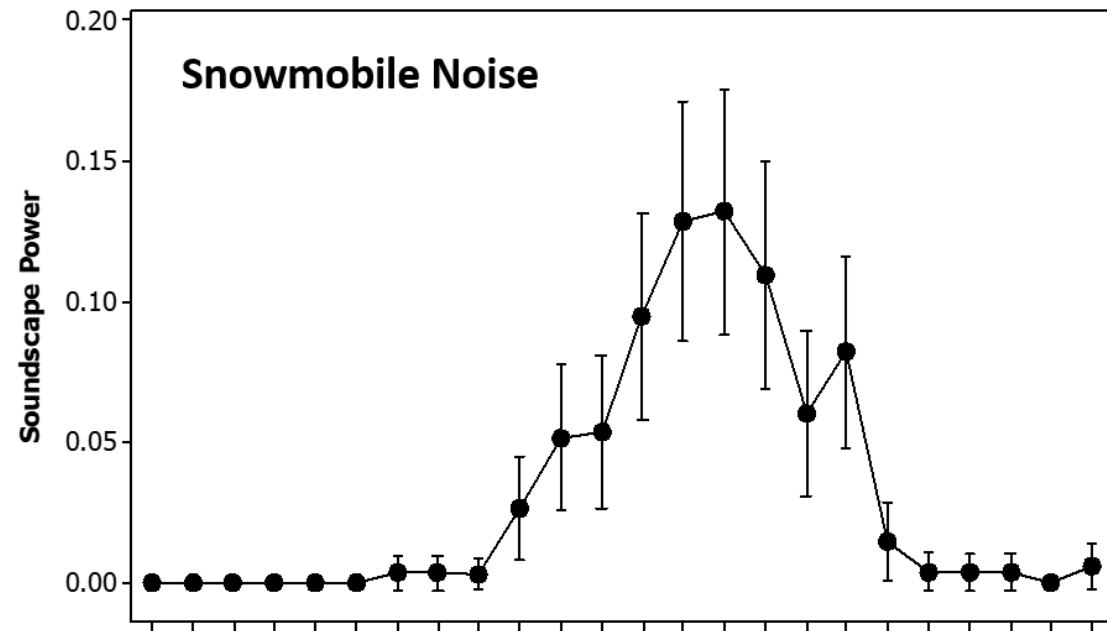
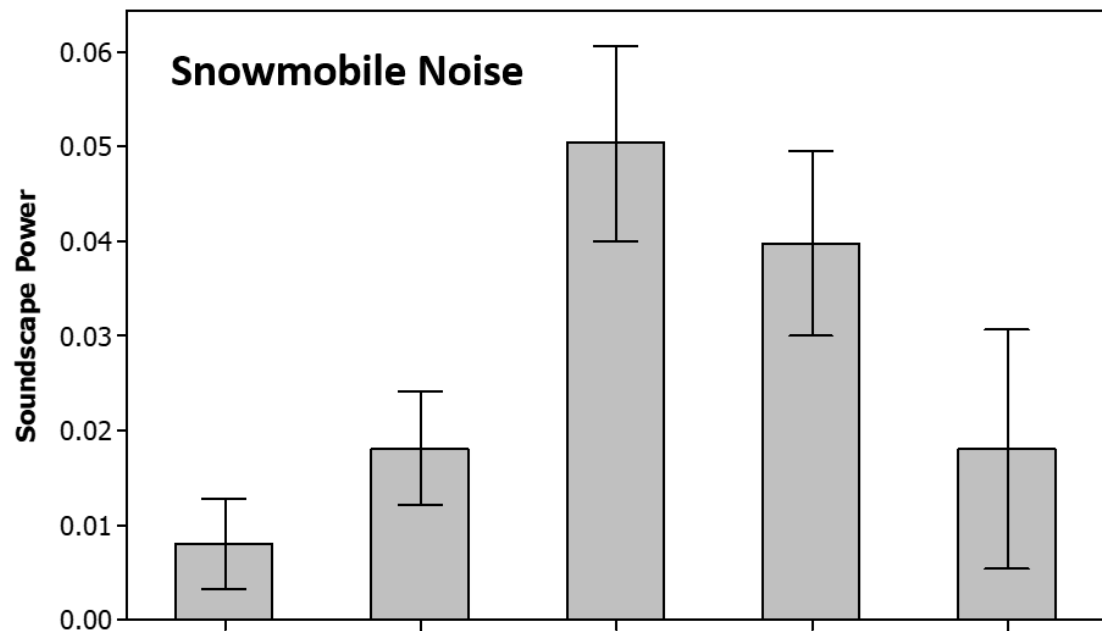


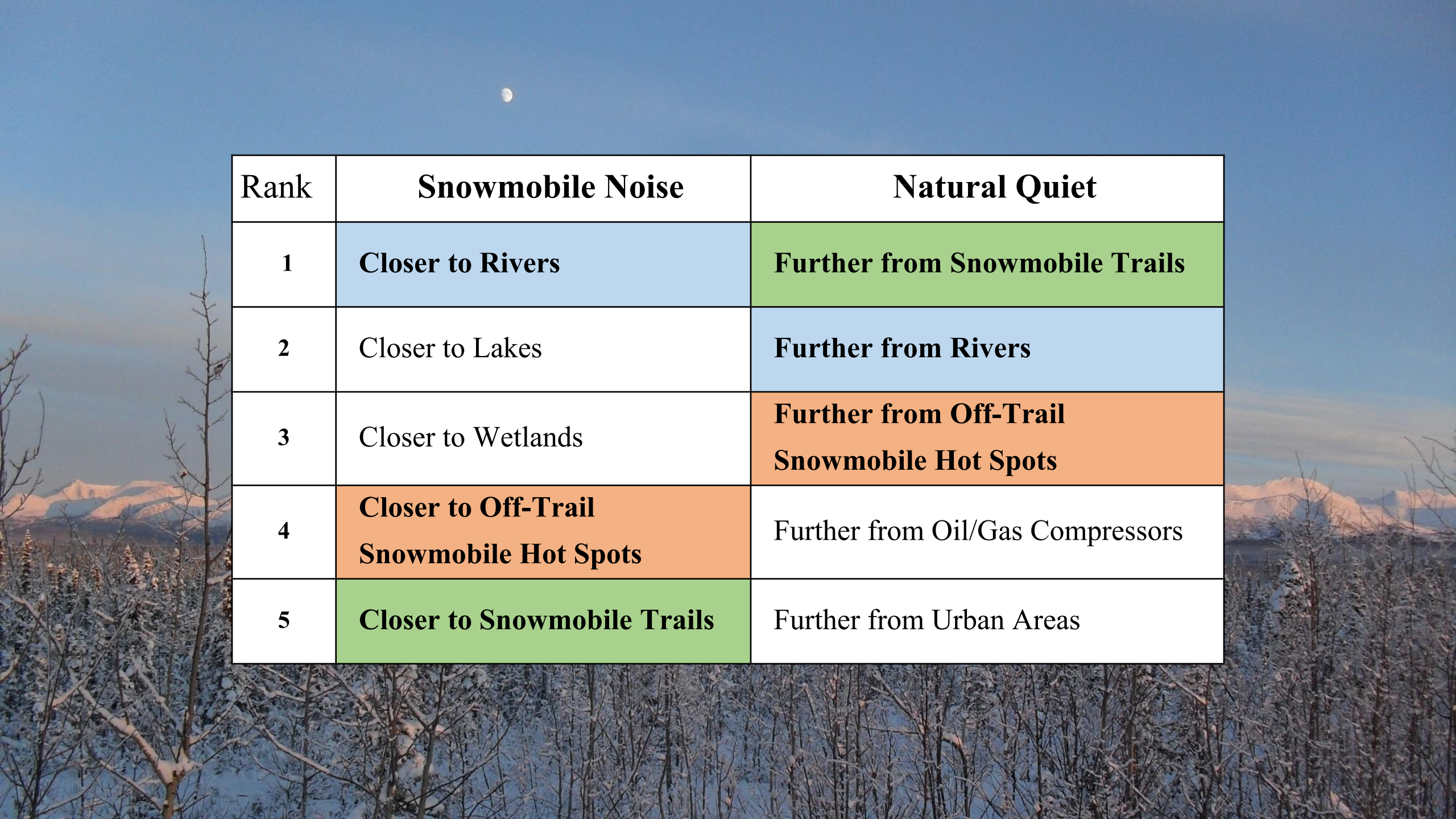
Acoustic Footprint of Snowmobile Noise & Natural Quiet Refugia

Acoustic-Environmental Relationships

- Took the average soundscape power at each site
- Overlaid with other environmental variables (16 variables)
- Used Machine Learning to find acoustic-environmental relationships
- Generated predictive models to map snowmobile noise & natural quiet

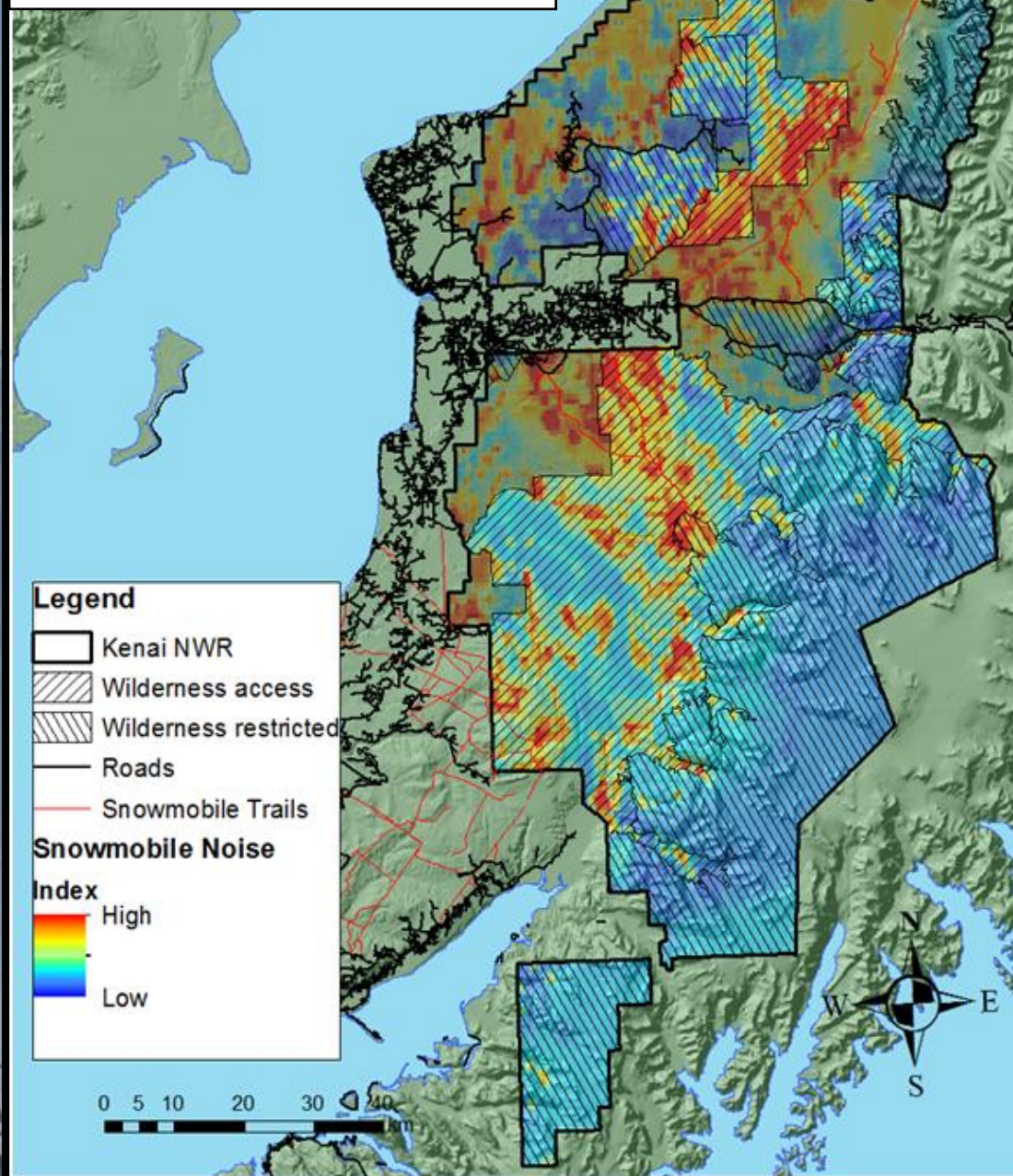




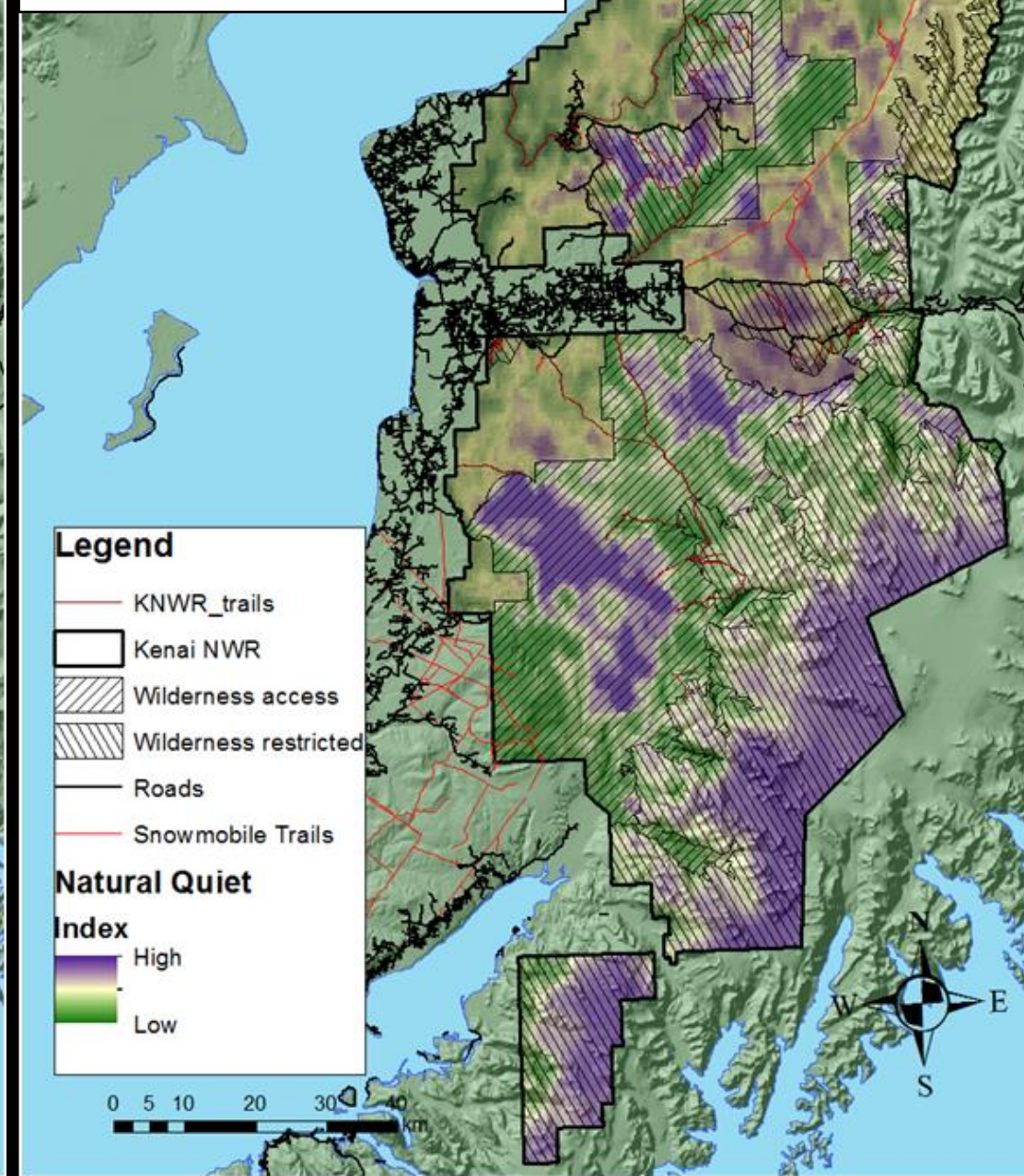


Rank	Snowmobile Noise	Natural Quiet
1	Closer to Rivers	Further from Snowmobile Trails
2	Closer to Lakes	Further from Rivers
3	Closer to Wetlands	Further from Off-Trail Snowmobile Hot Spots
4	Closer to Off-Trail Snowmobile Hot Spots	Further from Oil/Gas Compressors
5	Closer to Snowmobile Trails	Further from Urban Areas

**Predicted Distribution of
Snowmobile Noise**



**Predicted Distribution of
Natural Quiet**



Acoustic Footprint of Snowmobile Noise & Natural Quiet Refugia

Acoustic Footprint of Snowmobile Noise

Class	Total Area	Impact Area	% Impacted
Non-Wilderness	667,749	291,673	44
Wilderness Open to Snowmobiling	625,648	243,604	39
Wilderness Closed to Snowmobiling	694,755	29,176	4
All Wilderness	1,320,403	272,779	21
All KENWR	1,988,152	564,452	28

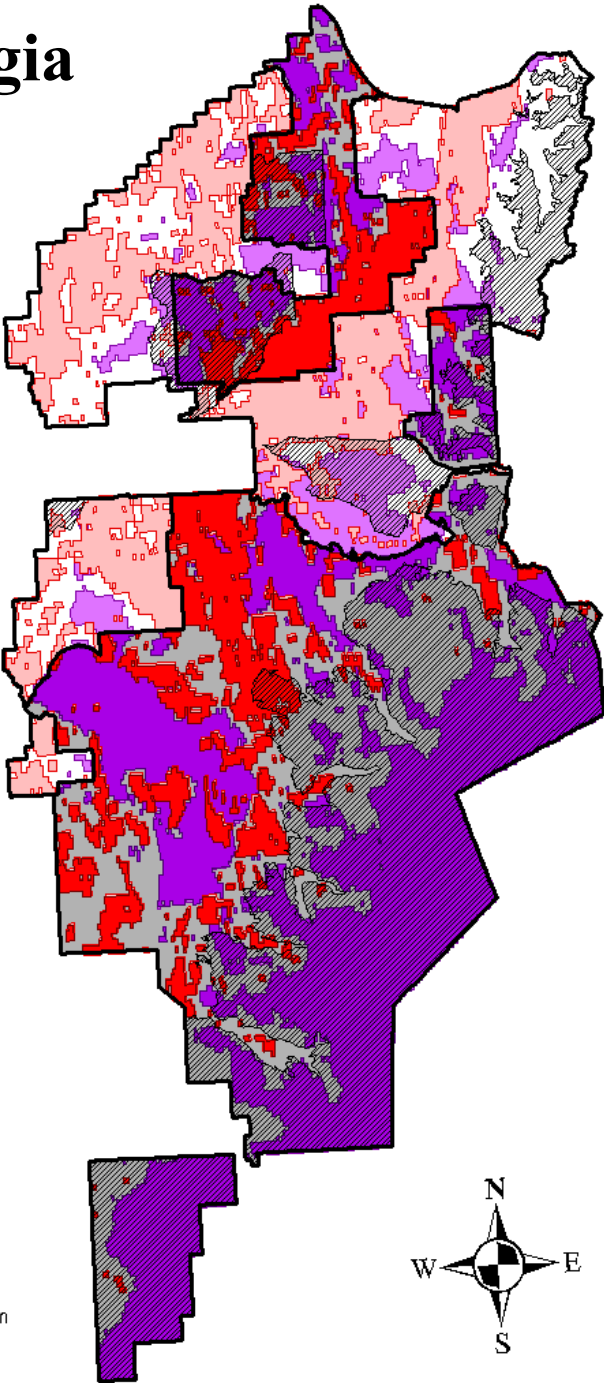
Natural Quiet Refugia

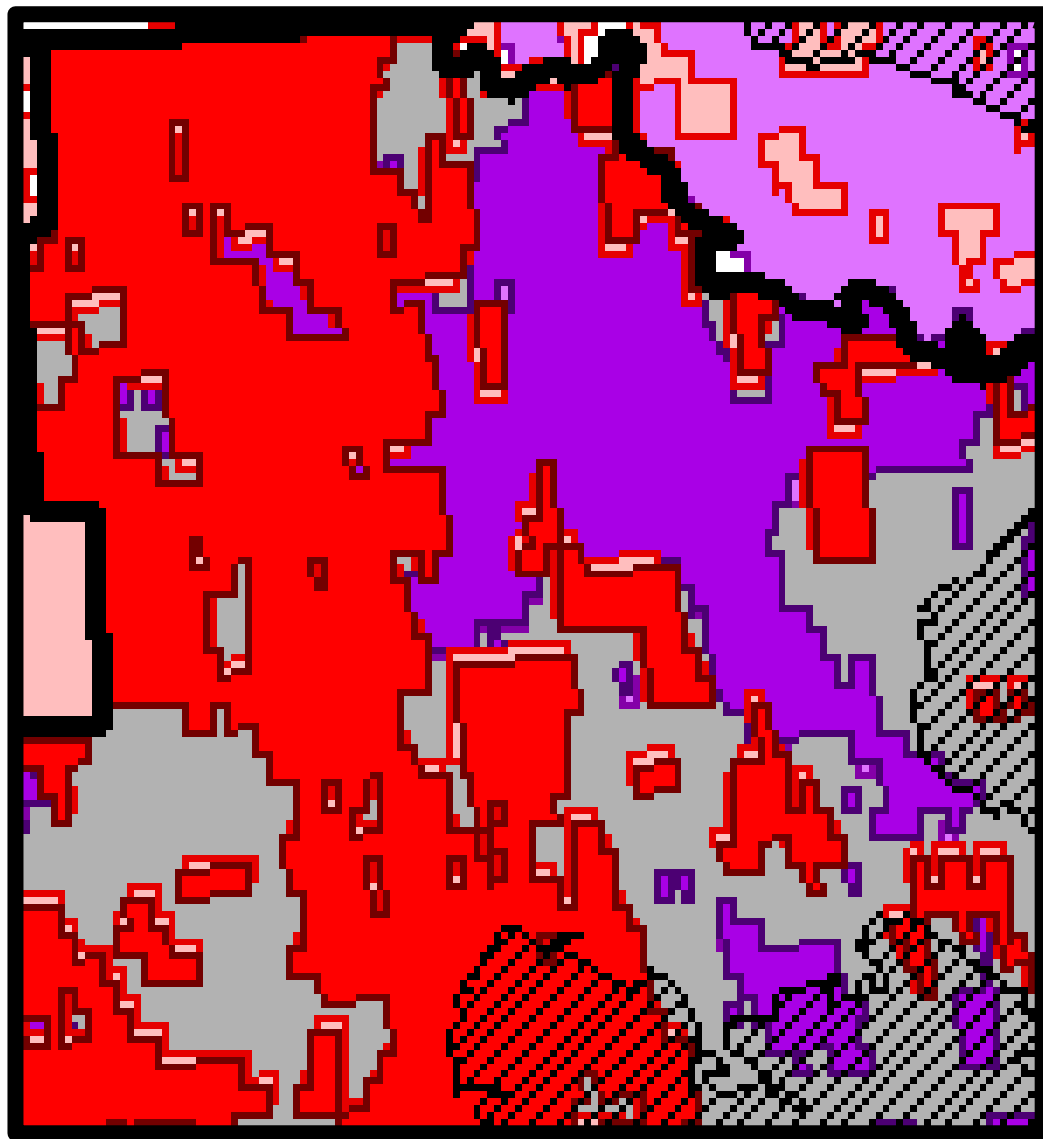
Class	Total Area	Quiet Area	% Quiet
Non-Wilderness	667,749	118,297	18
Wilderness Open to Snowmobiling	625,648	223,346	36
Wilderness Closed to Snowmobiling	694,755	443,810	64
All Wilderness	1,320,403	667,156	51
All KENWR	1,988,152	785,453	40

Natural quiet predominantly occurred in








- Restricted areas to snowmobiling (mainly Kenai Mountains)
- Areas inaccessible to snowmobiling (forests)

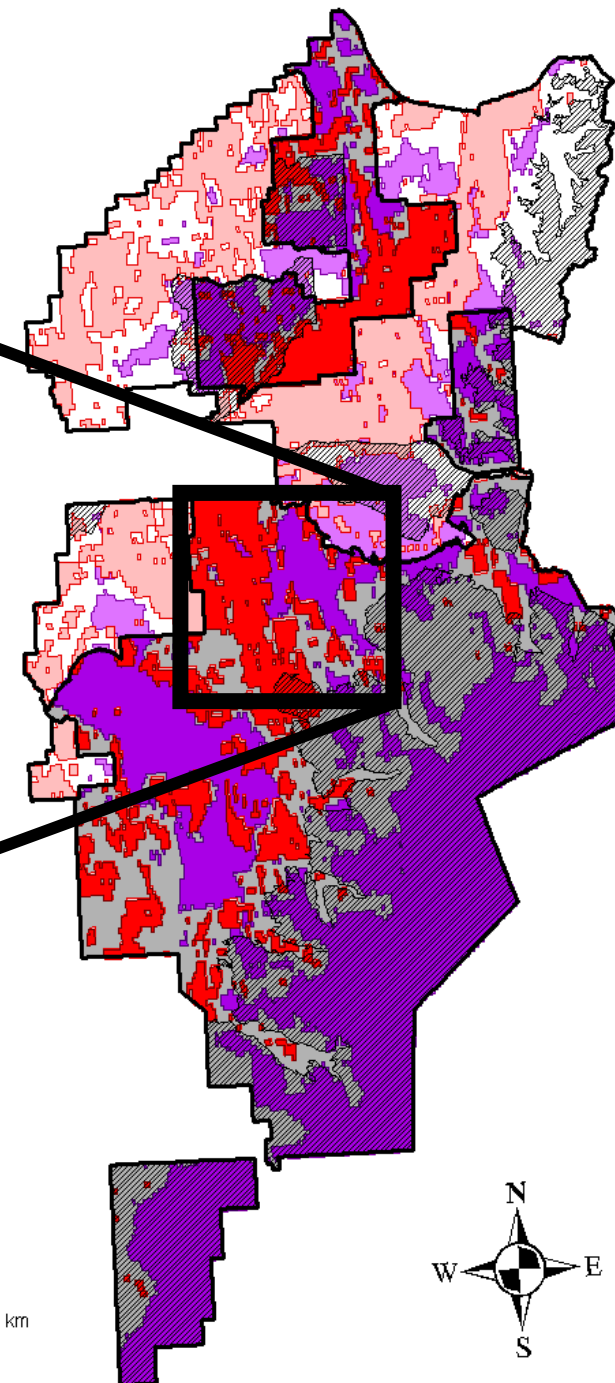
Legend





Legend

-  Kenai NWR
-  Restricted
-  Wilderness Areas
-  Snowmobile Noise (Wilderness)
-  Snowmobile Noise (Non-Wilderness)
-  Natural Quiet (Wilderness)
-  Natural Quiet (Non-Wilderness)



Noise & Natural Quiet-Fragmented Sonotope

The Alaska Conundrum: Accessing & Enjoying the Alaskan Wilderness

- Snowmobiling clearly degrades wilderness quality
- Snowmobilers are *not insidious* but also seek connection with nature
- Access to wilderness is difficult
- Machines have enabled access to many wilderness areas
- “*The Alaska Conundrum*” - *Using machines to enjoy wilderness while diminishing its wilderness qualities*
- There are now quieter alternatives to our machines of choice

Thank You for Listening

