

Natural and Urban Soundscapes: The need for multi-disciplined research

Robert Kull, Parsons

Brigitte Schulte-Fortkamp, TU-Berlin

Tim Lavalley, LPES, Inc.

Soundscapes

- Acoustic environments are much more complicated than descriptions of the sound level or audibility of intrusive sounds
- Soundscapes are multi-dimensional and require a more robust examination of the influences and affects of the acoustic environment
- Soundscapes can be thought of as a continuum from completely natural environments to entirely urban

Approach

- Started with the basic sources of sound
- Built a simple model based on an undefined receiver (human or animal)
- Made some assumptions and generalizations of the contribution of anthropogenic and non-anthropogenic sources
- Determined what aspects of soundscapes are measurable

Natural Soundscapes

- Non-Anthropogenic elements:
 - Weather
 - Animals
 - Vegetation
 - Physical/mechanical

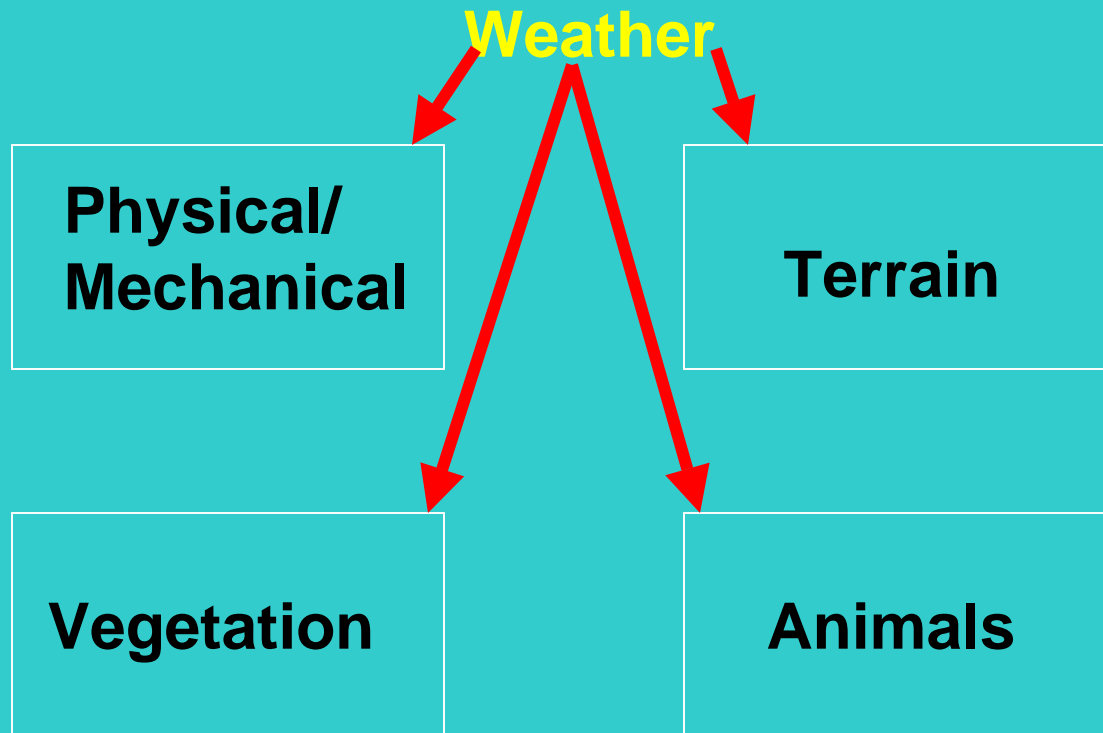
Natural Soundscapes

- Non-Anthropogenic elements:
 - **Weather:** wind, rain, thunder, earthquakes
 - **Animals:** mammals, birds, amphibians, insects
 - **Vegetation:** leaves rustling, branches
 - **Physical/mechanical:** rivers, streams, waves hitting the beach, air interactions with terrain, vegetation, ice breaking

Weather

- **Direct acoustical effects**
 - Sound generation; sound propagation (attenuation, reflection, refraction, diffusion, diffraction), masking
- **Indirect acoustical effects**
 - Seasonal cycles; diurnal cycles; hearing effectiveness
- **Non-acoustical effects (other senses)**
 - Visibility, smell, touch, taste
- **Interactions and effects on other natural soundscape elements**
 - Affects animals, mechanical, vegetation
- **Measurable parameters**
 - Sound metrics, duration, period, location, temperature, etc.

Natural (Non-Anthropogenic) Elements of Soundscapes

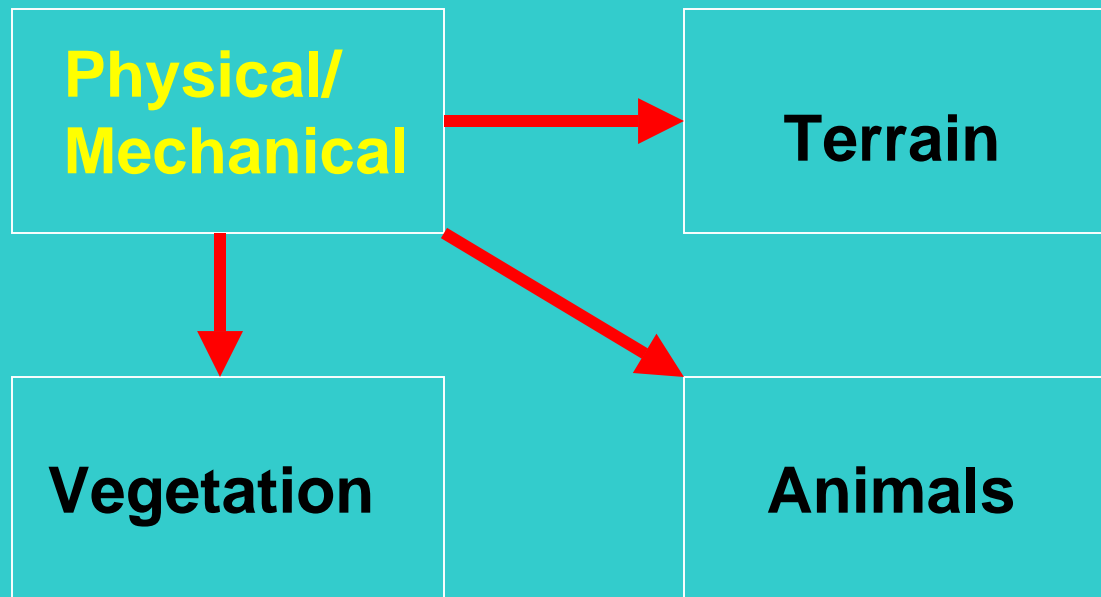


Physical/Mechanical

- **Direct acoustical effects**
 - Sound generation; masking
- **Indirect acoustical effects**
 - Seasonal cycles; diurnal cycles; hearing effectiveness
- **Non-acoustical effects (other senses)**
 - Visibility, smell, touch, taste
- **Interactions and effects on other natural soundscape elements**
 - None
- **Measurable parameters**
 - Sound metrics, duration, period, quantity, flow, speed, direction, temperature

Natural (Non-Anthropogenic) Elements of Soundscapes

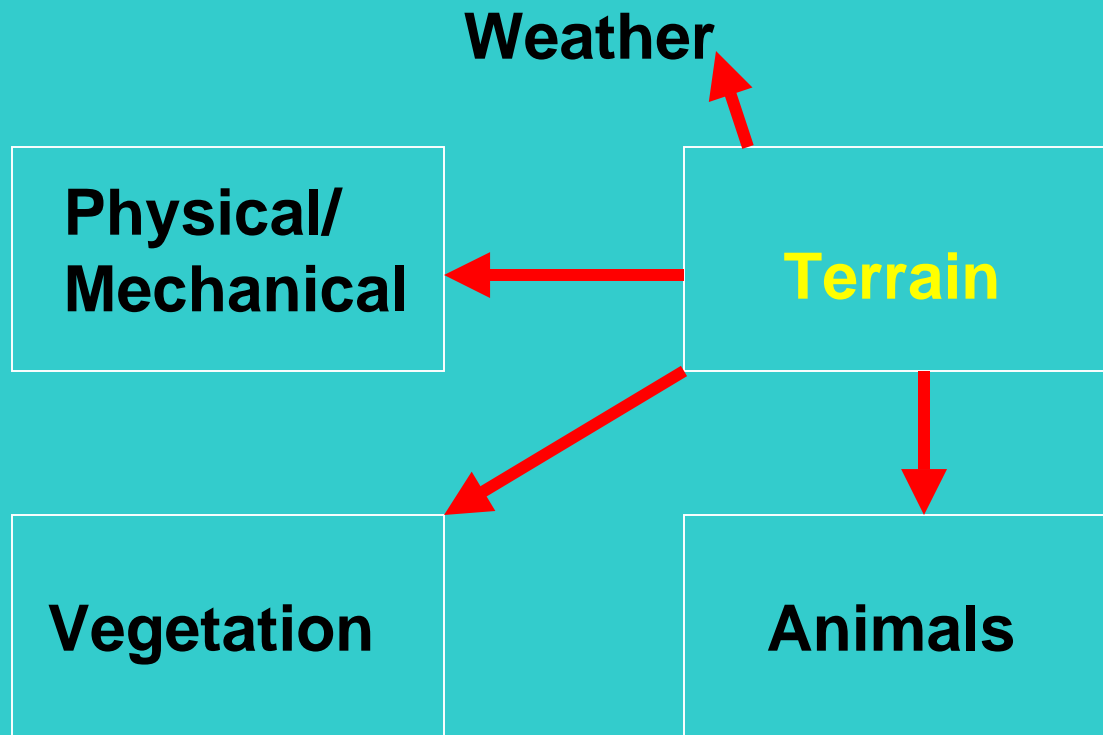
Weather



Terrain

- **Direct acoustical effects**
 - Sound propagation (attenuation, reflection, refraction, diffusion, diffraction)
- **Indirect acoustical effects**
 - None
- **Non-acoustical effects (other senses)**
 - Visibility
- **Interactions and effects on other natural soundscape elements**
 - Affects animals, mechanical, vegetation, weather
- **Measurable parameters**
 - Topography, surface type, soil type

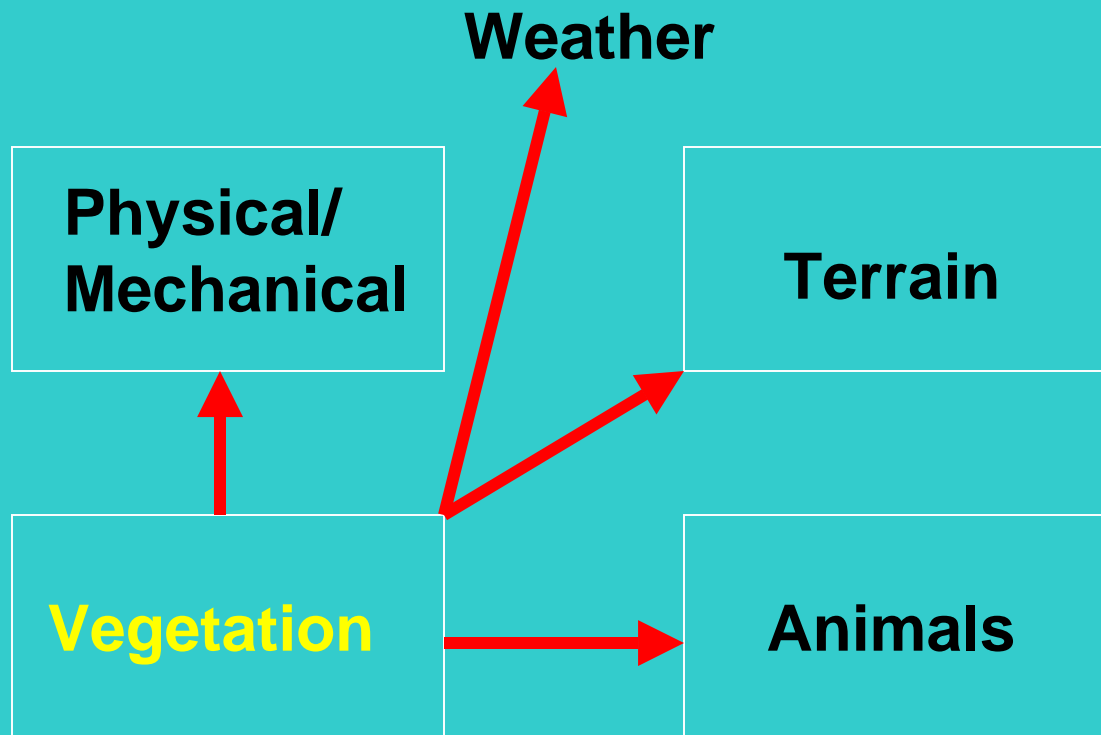
Natural (Non-Anthropogenic) Elements of Soundscapes



Vegetation

- **Direct acoustical effects**
 - Sound generation; sound propagation (attenuation, refraction, diffusion, diffraction), masking
- **Indirect acoustical effects**
 - Seasonal cycles; diurnal cycles; hearing effectiveness
- **Non-acoustical effects (other senses)**
 - Visibility, smell, touch, taste
- **Interactions and effects on other natural soundscape elements**
 - Affects animals, mechanical, and weather
- **Measurable parameters**
 - Sound metrics, duration, period, location, species, habitat

Natural (Non-Anthropogenic) Elements of Soundscapes

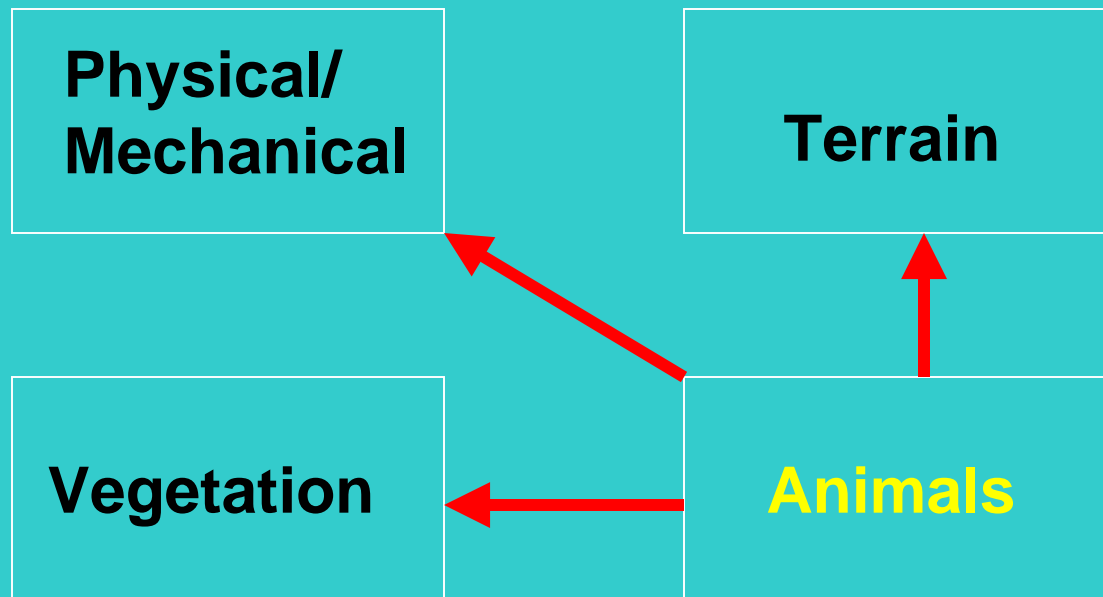


Animals

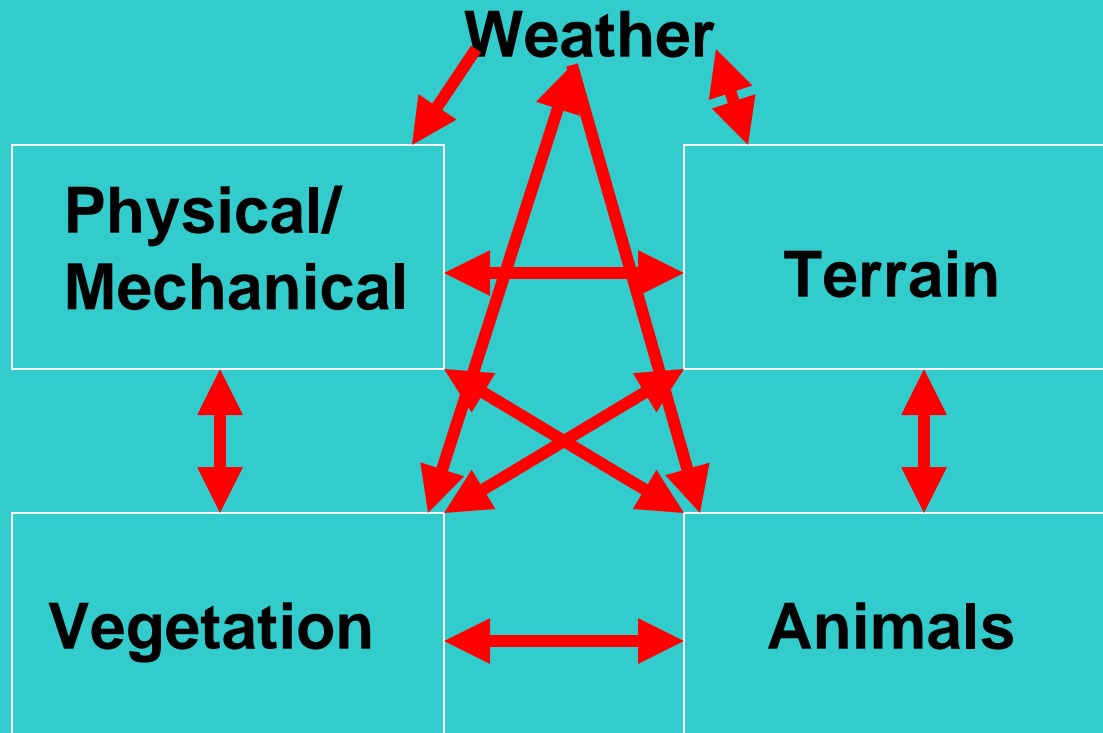
- **Direct acoustical effects**
 - Sound generation; masking
- **Indirect acoustical effects**
 - Seasonal cycles; diurnal cycles; behavioral effects on members of same species or other species
- **Non-acoustical effects (other senses)**
 - Visibility, smell, touch, taste
- **Interactions and effects on other natural soundscape elements**
 - none
- **Measurable parameters**
 - Sound metrics, duration, period, location, species, number of individuals, territorial occupancy, reproductive success, behavioral state

Natural (Non-Anthropogenic) Elements of Soundscapes

Weather



Natural (Non-Anthropogenic) Elements of Soundscapes



Anthropogenic Soundscapes

- Mobile sources
- Stationary sources
- Structures/materials
- Noise control devices

Anthropogenic Elements of Soundscapes

**Mobile
Sources**

**Stationary
Sources**

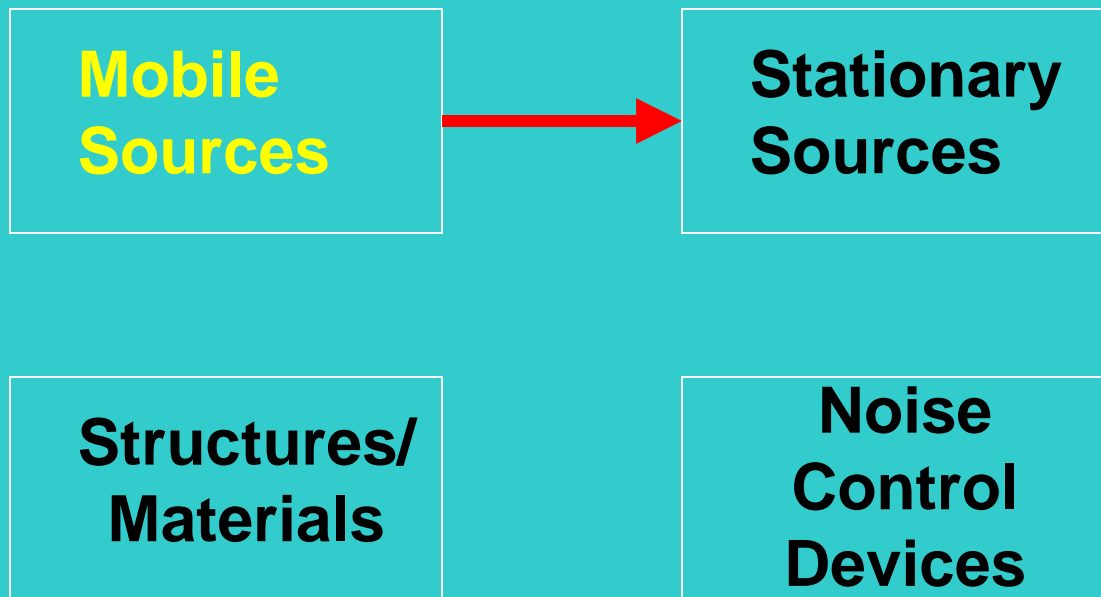
**Structures/
Materials**

**Noise
Control
Devices**

Mobile Sources

- **Sound sources**
 - Humans, transportation, recreational, industrial, construction, material handling
- **Direct acoustical effects**
 - Sound generation; masking
- **Indirect acoustical effects**
 - Seasonal cycles; diurnal cycles
- **Non-acoustical effects (other senses)**
 - All senses
- **Measurable parameters**
 - Sound metrics, size, shape, frequency, duration, speed, location, hours of operation

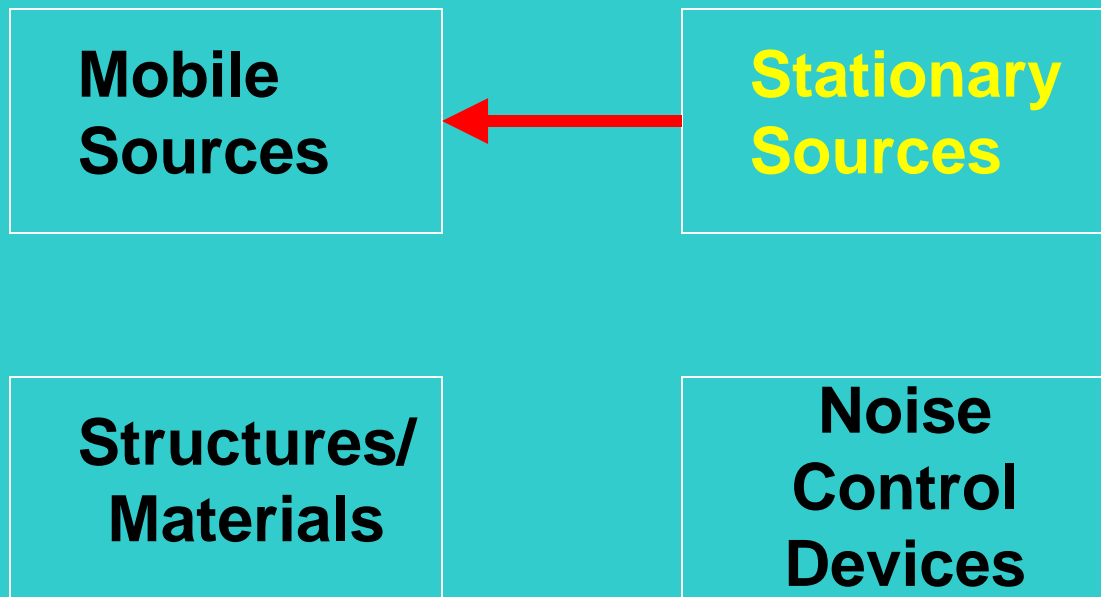
Anthropogenic Elements of Soundscapes



Stationary Sources

- **Sound sources**
 - Domestic sources, workplace sources, construction equipment, agricultural equipment, industrial equipment
- **Direct acoustical effects**
 - Sound generation; masking
- **Indirect acoustical effects**
 - Seasonal cycles; diurnal cycles
- **Non-acoustical effects (other senses)**
 - All senses
- **Measurable parameters**
 - Sound metrics, size, shape, frequency, duration, location, hours of operation

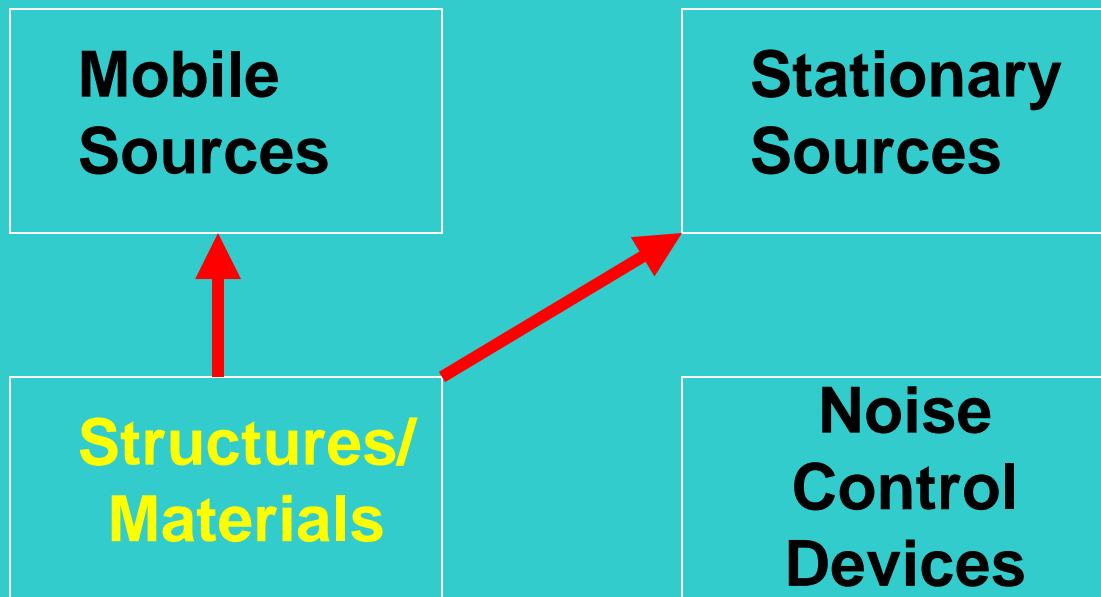
Anthropogenic Elements of Soundscapes



Structures/Materials

- **Acoustical component**
 - Buildings, walls, roads surfaces
- **Direct acoustical effects**
 - Attenuation, reflection, refraction, diffusion, diffraction
- **Indirect acoustical effects**
 - None
- **Non-acoustical effects (other senses)**
 - All senses
- **Measurable parameters**
 - Sound metrics, frequency, location, transmission loss

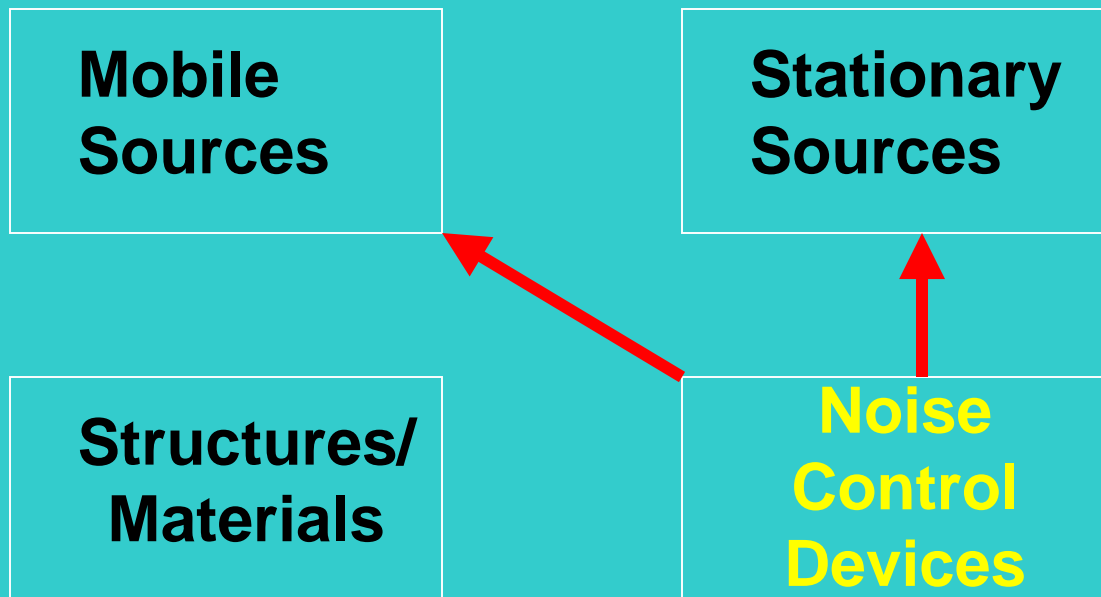
Anthropogenic Elements of Soundscapes



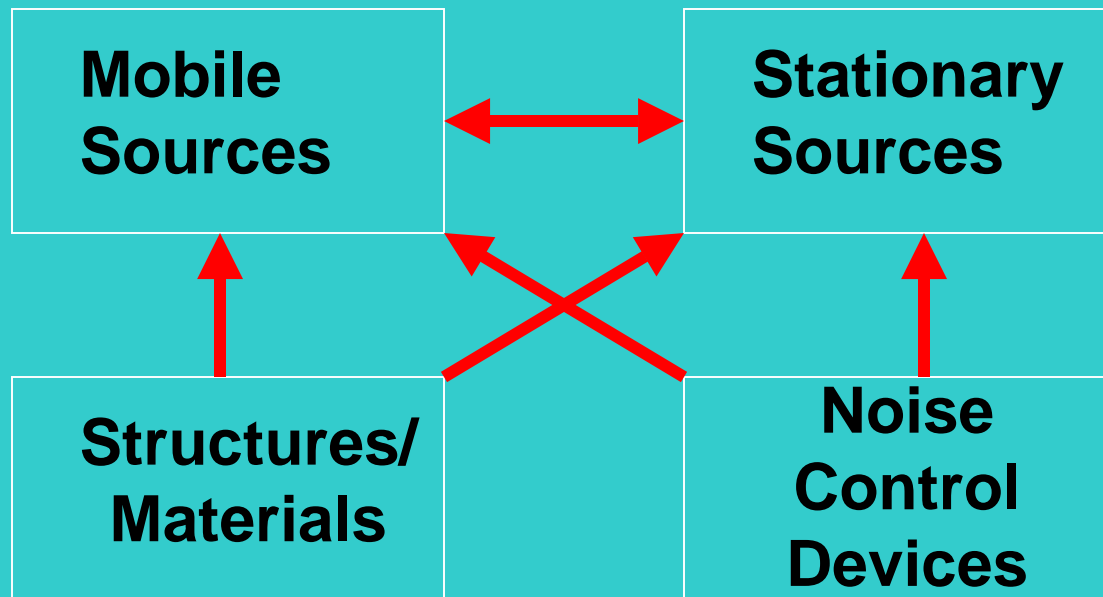
Noise Control Devices

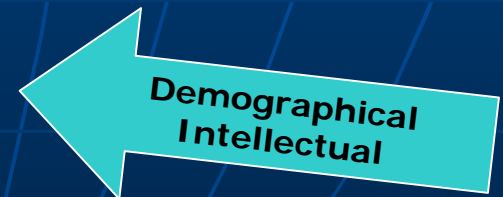
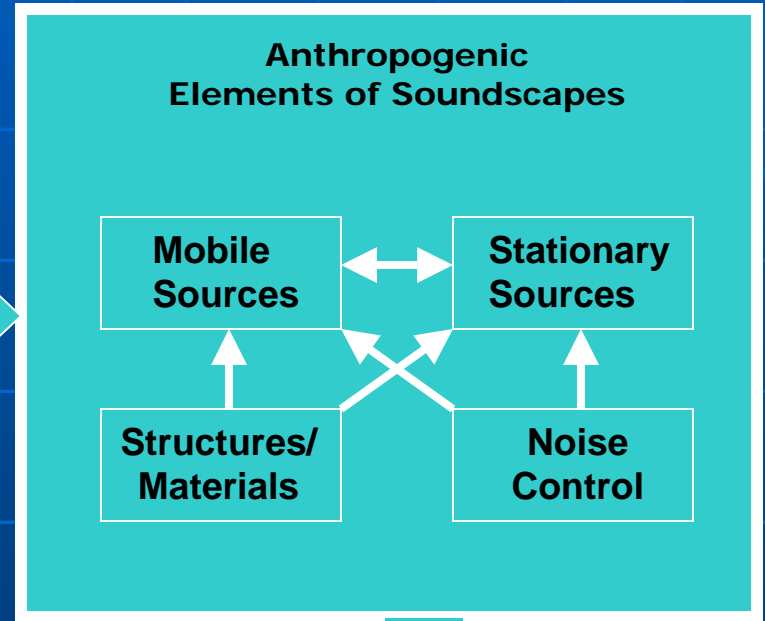
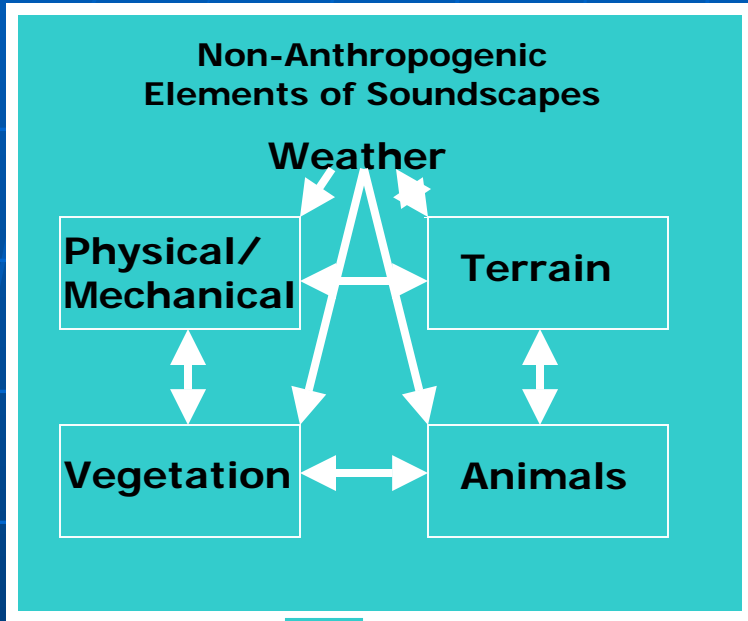
- **Acoustical component**
 - Engineered controls (mufflers, masking devices, active noise, sound reduction devices), personal protective devices (ear plugs, headphones), scheduling
- **Direct acoustical effects**
 - Sound generation, sound propagation (attenuation, reflection, refraction, diffusion, diffraction), masking
- **Indirect acoustical effects**
 - None
- **Non-acoustical effects (other senses)**
 - All senses
- **Measurable parameters**
 - Sound metrics, purpose, frequency, attenuation

Anthropogenic Elements of Soundscapes



Anthropogenic Elements of Soundscapes



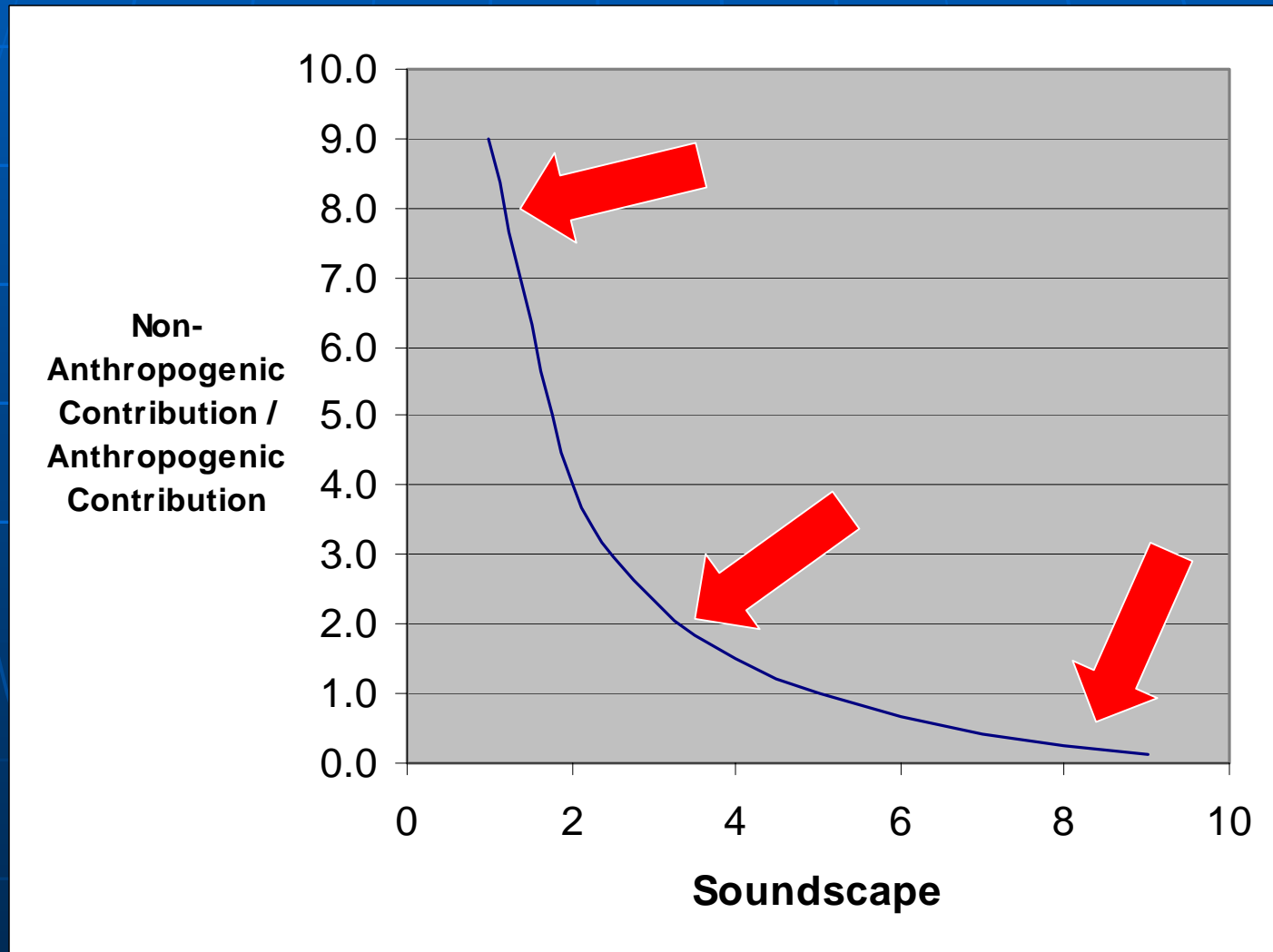


Ratio of Non-Anthropogenic to Anthropogenic to Soundscapes

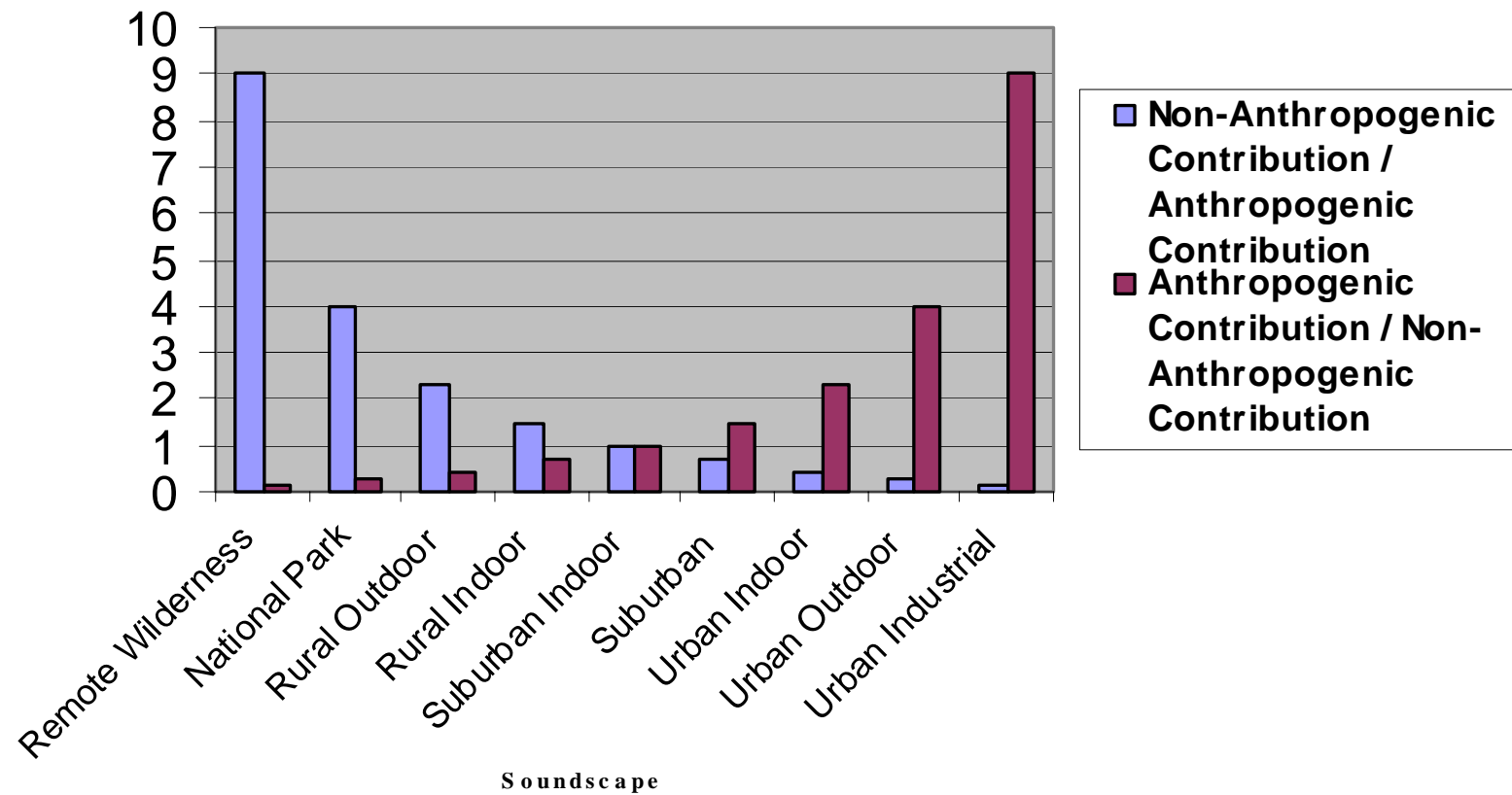
(not including intrusive sounds)

Anthropogenic Leq	Non-Anthropogenic Leq	Soundscape	Non-Anthropogenic Contribution / Anthropogenic Contribution	Anthropogenic Contribution / Non-Anthropogenic Contribution
10	90	Remote Wilderness	9.0	0.1
20	80	National Park	4.0	0.3
30	70	Rural Outdoor	2.3	0.4
40	60	Rural Indoor	1.5	0.7
50	50	Suburban Indoor	1.0	1.0
60	40	Suburban	0.7	1.5
70	30	Urban Indoor	0.4	2.3
80	20	Urban Outdoor	0.3	4.0
90	10	Urban Industrial	0.1	9.0

Ratio of Non-Anthropogenic to Anthropogenic Contribution to Soundscapes



Comparison of Non-Anthropogenic Contribution and Anthropogenic Contribution for Different Soundscapes



Soundscape studies require multi-disciplines:

- Physical acoustics
- Architectural acoustics
- Structural acoustics
- Underwater acoustics
- Psychoacoustics
- Physiological acoustics
- Animal bioacoustics
- Engineering
- Computer programming
- Urban planning
- Meteorology
- Biology
- Geology
- Geography
- Botany
- Geographical Information systems
- Cartography

Summary

- There is a full spectrum of soundscapes, from completely natural to entirely urban sounds
- A multi-disciplined approach should be used to better describe soundscapes
- A methodology is needed to fully utilize the multi-dimensional aspects of soundscapes