Air Resources Division
Natural Sounds Program
Fort Collins, Colorado

More efficient and informative translation of acoustic data into estimates of noise impacts.

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40lbs 60lbs 40lbs Cumbersome

Solutions (Damon Joyce, CSU)

- Replace the notebook computer with a PDA: lower cost, lower power (2 watts)
- Develop new software
  - Lower power consumption
  - One user interface for all equipment settings
  - More complete data capture
- Improved battery packs (no solar required)
- Continuous audio

Easier Data Collection…
➔ The Data Avalanche

How can we visualize the acoustic environment?

Frequency = “pitch”

20,000 Hertz

.

.

.

34 one-third octave bands (3 of them span a doubling in frequency)

.

.

12.5 Hertz

Time = 24 Hours of the Day	
Midnight	1 am
2 am	3 am
4 am	5 am
6 am	7 am
8 am	9 am
10 am	11 am
Noon	1 pm
2 pm	3 pm
4 pm	5 pm
6 pm	7 pm
8 pm	9 pm
10 pm	11 pm

Amplitude in dB

90 dB

80 dB

70 dB

60 dB

50 dB

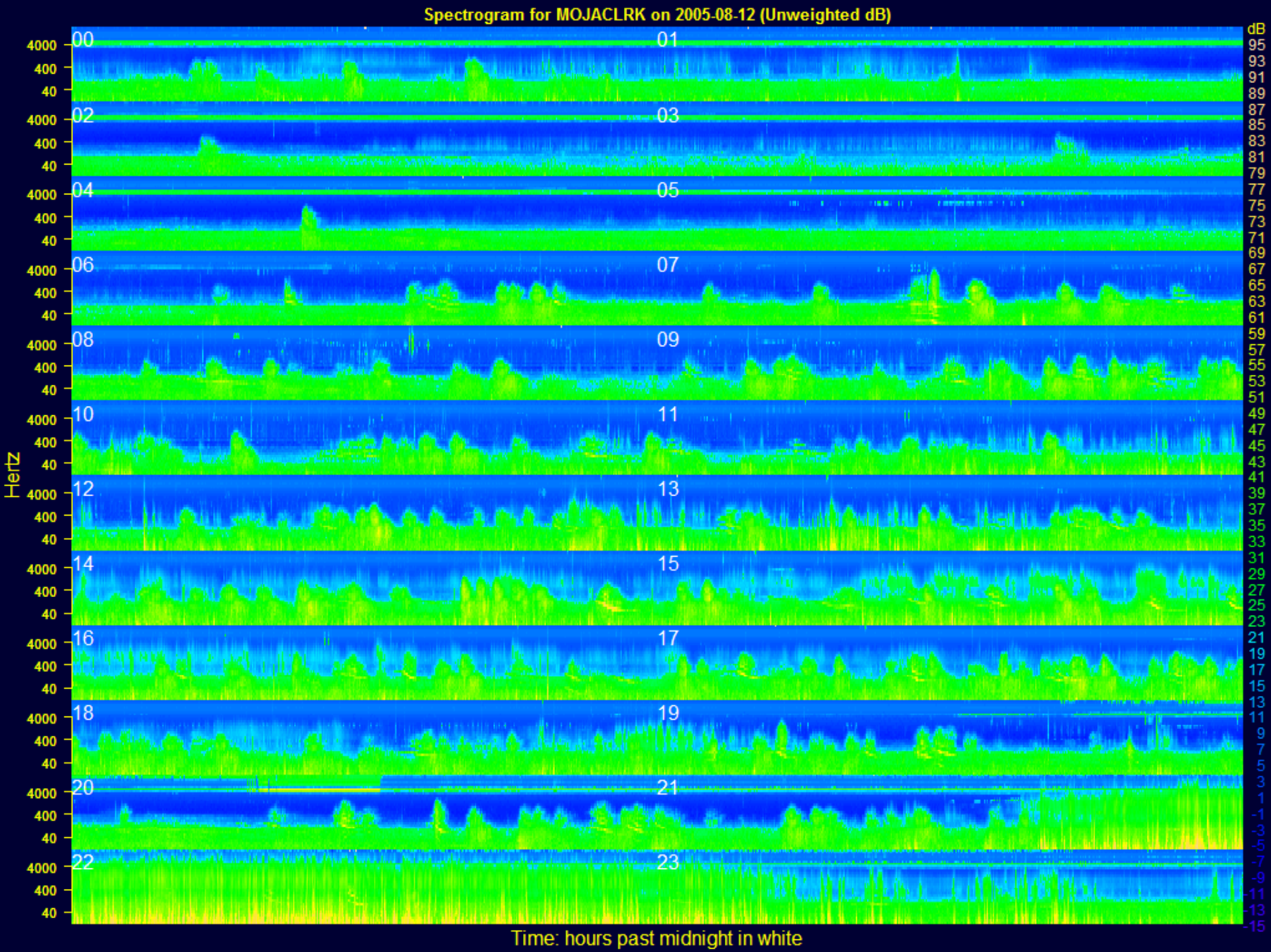
40 dB

30 dB

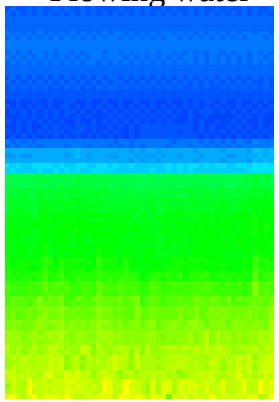
20 dB

10 dB

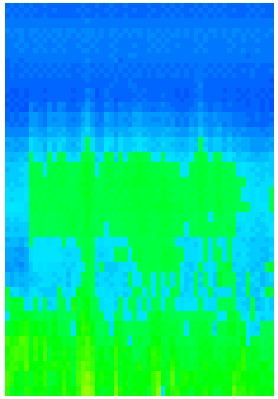
0 dB


Spectrogram for MOJACLRK on 2005-08-12 (Unweighted dB)
Hertz
4000
400
40
00
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
17
18
19
20
21
22
23
dB
95
93
91
89
87
85
83
81
79
77
75
73
71
69
67
65
63
61
59
57
55
53
51
49
47
45
43
41
39
37
35
33
31
29
27
25
23
21
19
17
15
13
11
9
7
5
3
1
-1
-3
-5
-7
-9
-11
-13
-15
Time: hours past midnight in white

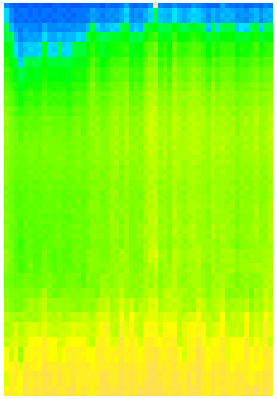
Flowing water



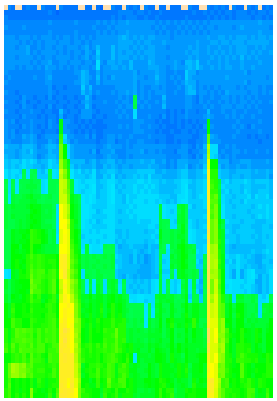
Wind



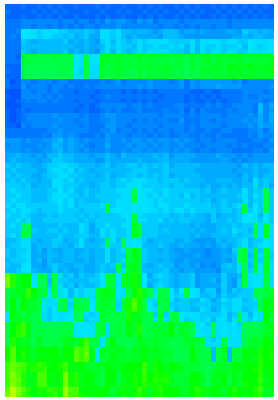
Rain



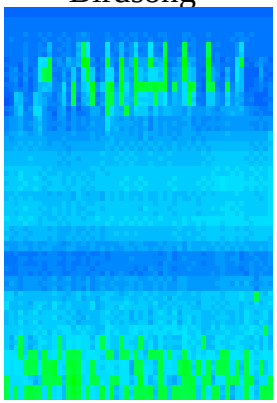
Thunder



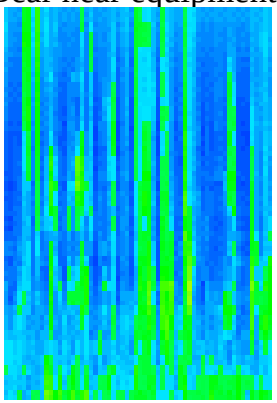
Insect



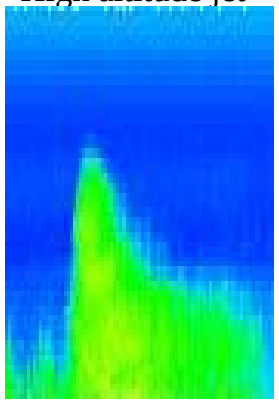
Birdsong



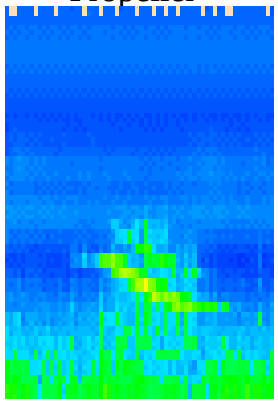
Bear near equipment



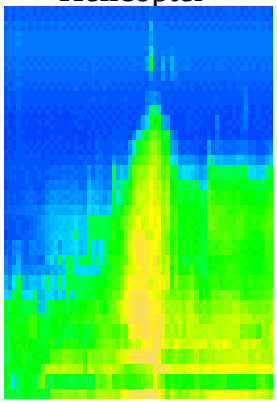
High altitude jet



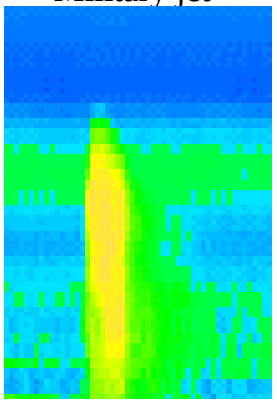
Propeller



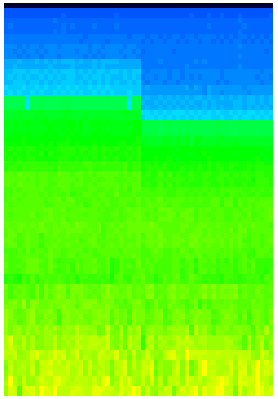
Helicopter



Military jet



Generator



Stages in more efficient data analysis

Human-only processing

No automation, human detects and classifies all signals

Machine-assisted human processing

Machine detects signals; human classifies

Human-verified machine processing

Machine detects and classifies signals; human verifies all classifications

Human-assisted machine processing

Machine detects and classifies reporting confidence; human verifies classifications falling below confidence threshold

Machine-only processing

Fully automated, machine detects and classifies all signals

Developing new analyses of noise impact in parks: *impairment need not be like pornography.*

- Organic Act and other NPS legal mandates present distinctive requirements.
- Audibility can inform us about loss of wilderness character; but determining impacts at the threshold of perception are problematic.
- All metrics that incorporate thresholds, can exhibit dramatic changes in value with small changes in conditions.
- Additional metrics will reinforce the value of audibility and other metrics.
- ***Metrics that are immediately intelligible to park managers foster more objective determinations of potential impact.***

Listening provides critical environmental awareness

- *All vertebrates* and most invertebrates perceive sounds.
- Best hearing thresholds coincide with the quietest ambient background conditions.
- Many animals and physical processes are more easily heard than seen.
- Each sound provides a wealth of ecological and behavioral information.
- Loss of this information dramatically alters ecological interactions and impoverishes visitor experience.
- Multiple social surveys of park visitors and the public at large document the high priority attached to preserving natural sounds.

Quantifying loss of listening opportunity

- When noise elevates ambient sound levels, incoming sounds must be that much louder to be heard.
- That increase in incoming sound level will require the sound source to be closer to the receiver, as in most cases the sender cannot increase its output.
- Sound propagation models for translating the required increase in received level to the reduction in maximum detection distance are established and in use.
- For many sounds, a very simple propagation model will provide an accurate approximation.

INM Noise Model

Aircraft sound source level

Transmission loss (spreading loss, absorption, scattering, ground interaction…

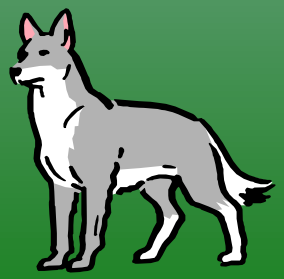
Predicted received level compared with ambient sound level

Natural listening opportunities

Unknown animal sound source level

Transmission loss (spreading loss, absorption, scattering, ground interaction…)

Minimum received level necessary for detection, given natural ambient sound level and hearing threshold



Natural detection range

Loss of listening area

Elevated ambient requires elevated received level for detection

Natural detection range

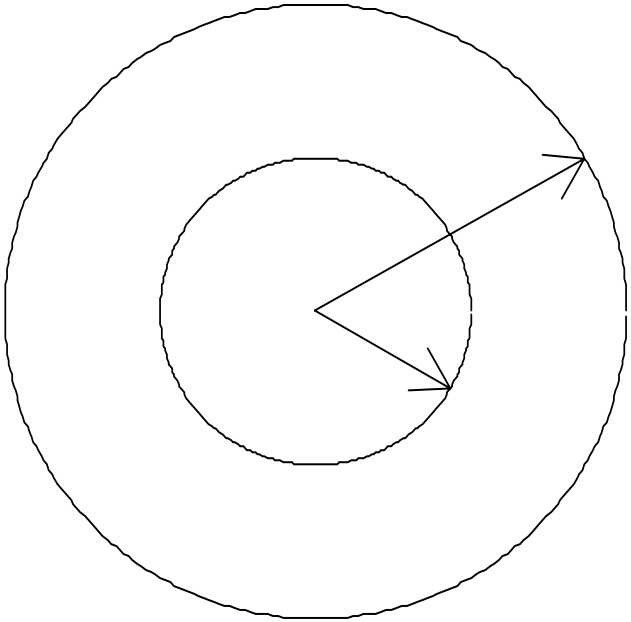
Same unknown animal sound source level

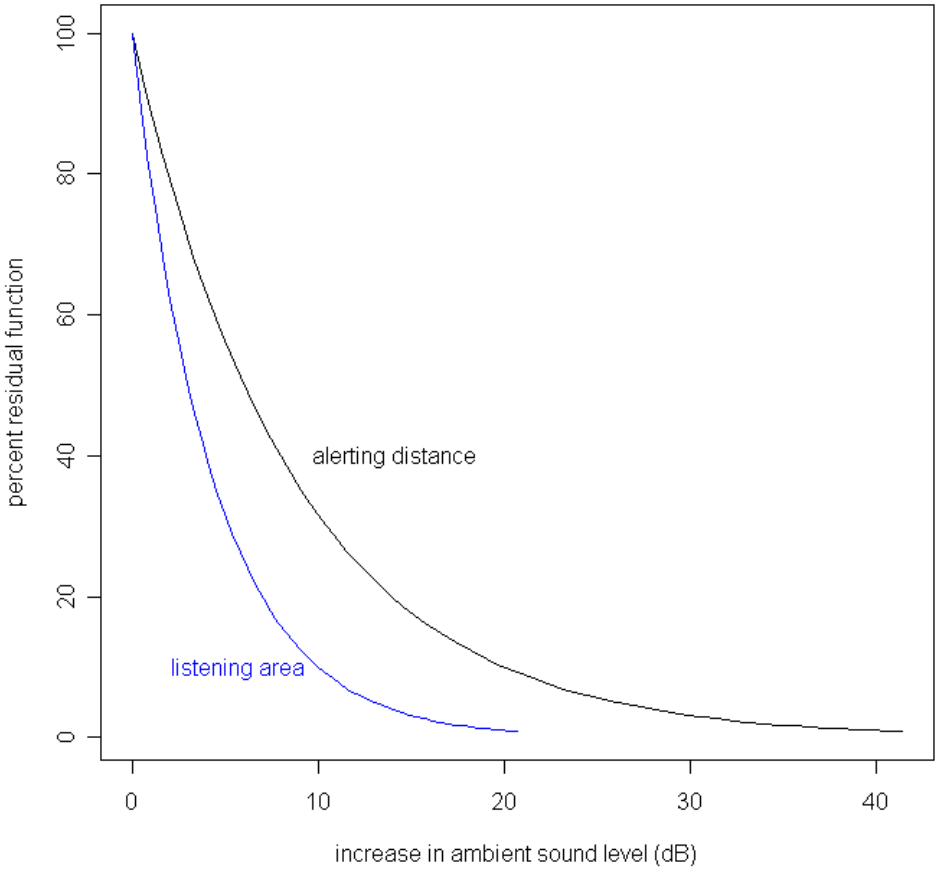
Reduced distance (spreading loss) to increase received level

Search functions are related to loss of area; alerting functions are related to loss of distance.

50% reduction in alerting distance…

→ 75% reduction in listening area





Getting maximal leverage from previous studies

- Extensive historical guidance relates to dBA.
- Most extrinsic noise sources have roughly similar spectral profiles, so a single measure of loudness is reasonable.
- However, the summation of environmental ambient sound energy must be limited to the same range of frequency as the noise sources. Bird songs and cricket chirps have no bearing on the impact of low frequency (<1000 Hz) noise!

National Park Service

Noise-Free Intervals measure respites between each kind of noise event. These quantify chances for recovery and resumption of normal behavior.

Noise Exposure Interferes with Speech:

- **Affects informal chats with park rangers**
- **Affects conversations among friends and family**
- **Affects tribal conversations**

Noise Exposure Interferes with Presentations:

- **Affects tribal ceremonies**
- **Affects park interpretive programs**
- **Affects rescue and law enforcement communication**

90% Loss of Listening Area, 68% Loss of Alerting Distance:

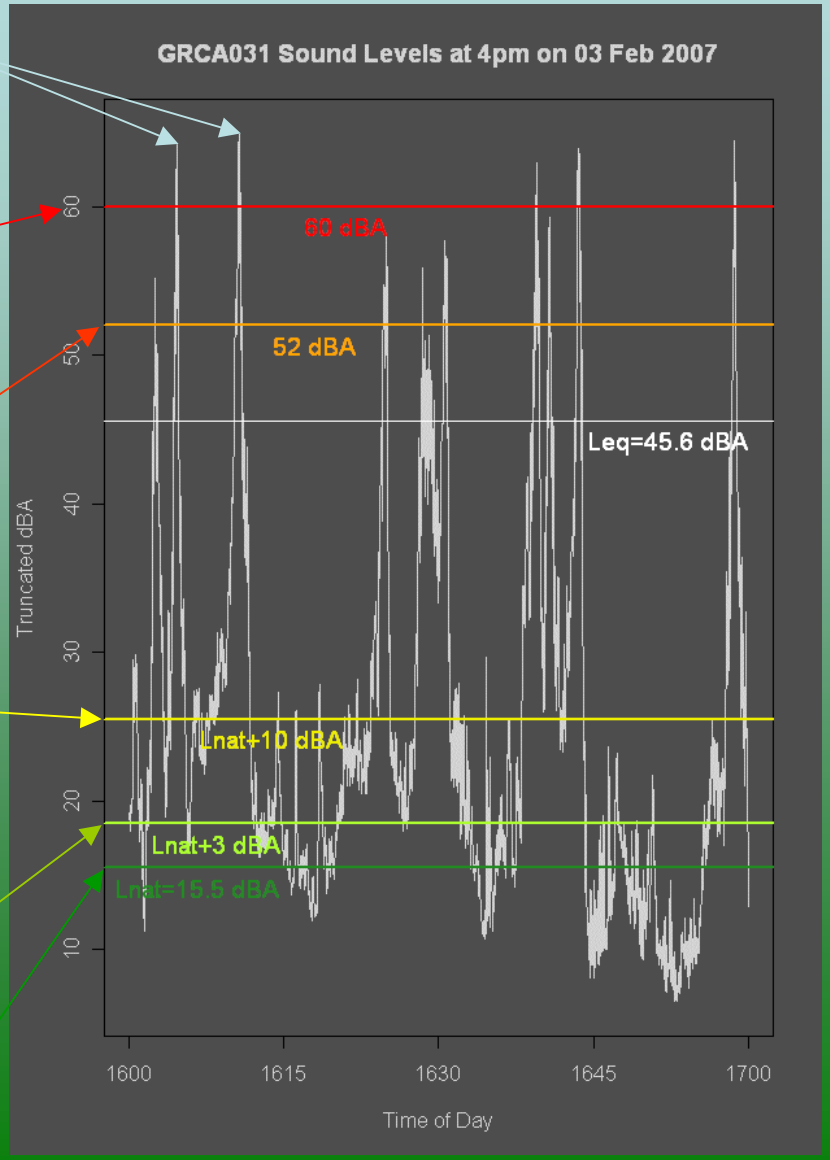
- **Acute loss of acoustic cues for animal foraging and mating**
- **Acute loss of visitor and tribal listening opportunities**
- **Visitors and wildlife miss sounds of approaching hazards**
- **Search and rescue are much less efficient**

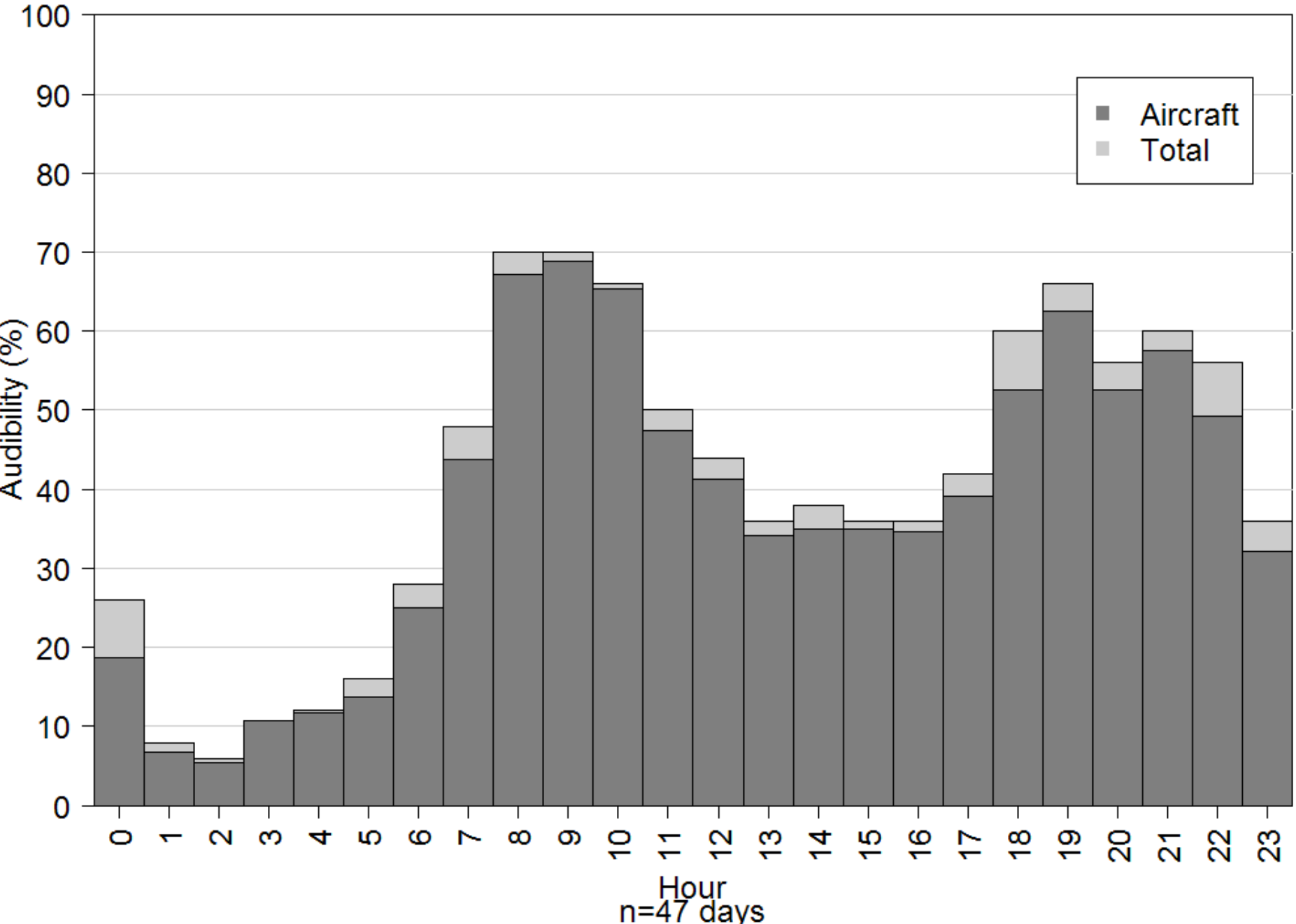
50% Loss of Listening Area:

- **Substantial loss of visitor and tribal listening opportunities**
- **Substantial loss of animal acoustic cues**
- **29% loss of Alerting Distance**

Natural Ambient Sound Level:

- **Sounds intrinsic to park units: animals, wind, flowing water**




Aircraft
Total
Audibility (%)
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
Hour
n=47 days