Data Analysis
GRCA Summer 2005

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Goal:

To determine Natural Ambient Sound Levels for the primary vegetation types in GRCA for summer season.

To provide a baseline for use in modeling efforts to assess achievement of substantial restoration goal.

DRAFT RESULTS-NOT FINAL

How do we determine natural ambient sound levels?

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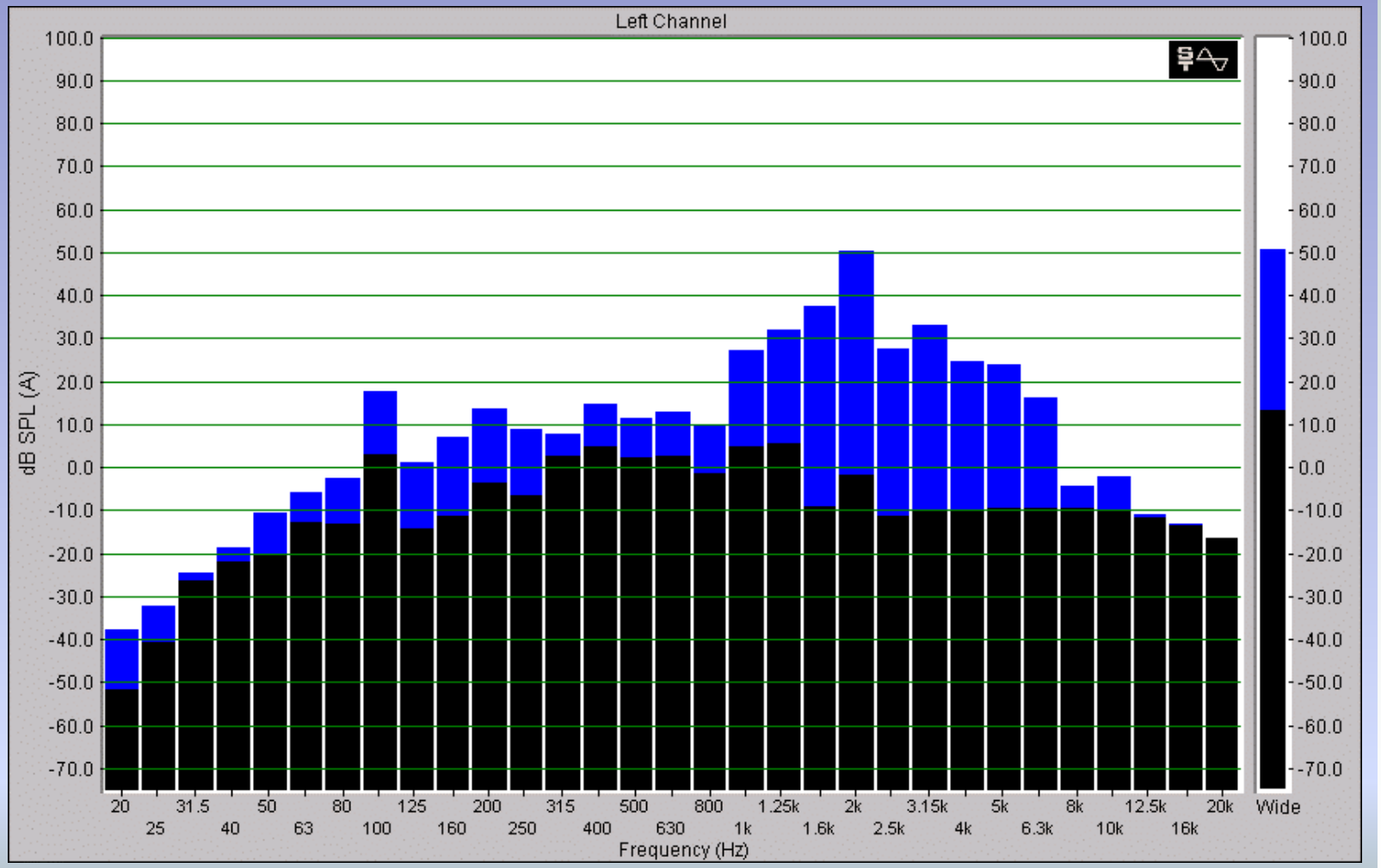
- Review park vegetation types (acoustic zones);
- Select representative measurement sites;
- Deploy monitors for adequate sample period;
- Check monitors and download data weekly;
- Analyze decibel data, observer logs, and digital recordings.

Before beginning, some basic acoustics….

Basics of Acoustics



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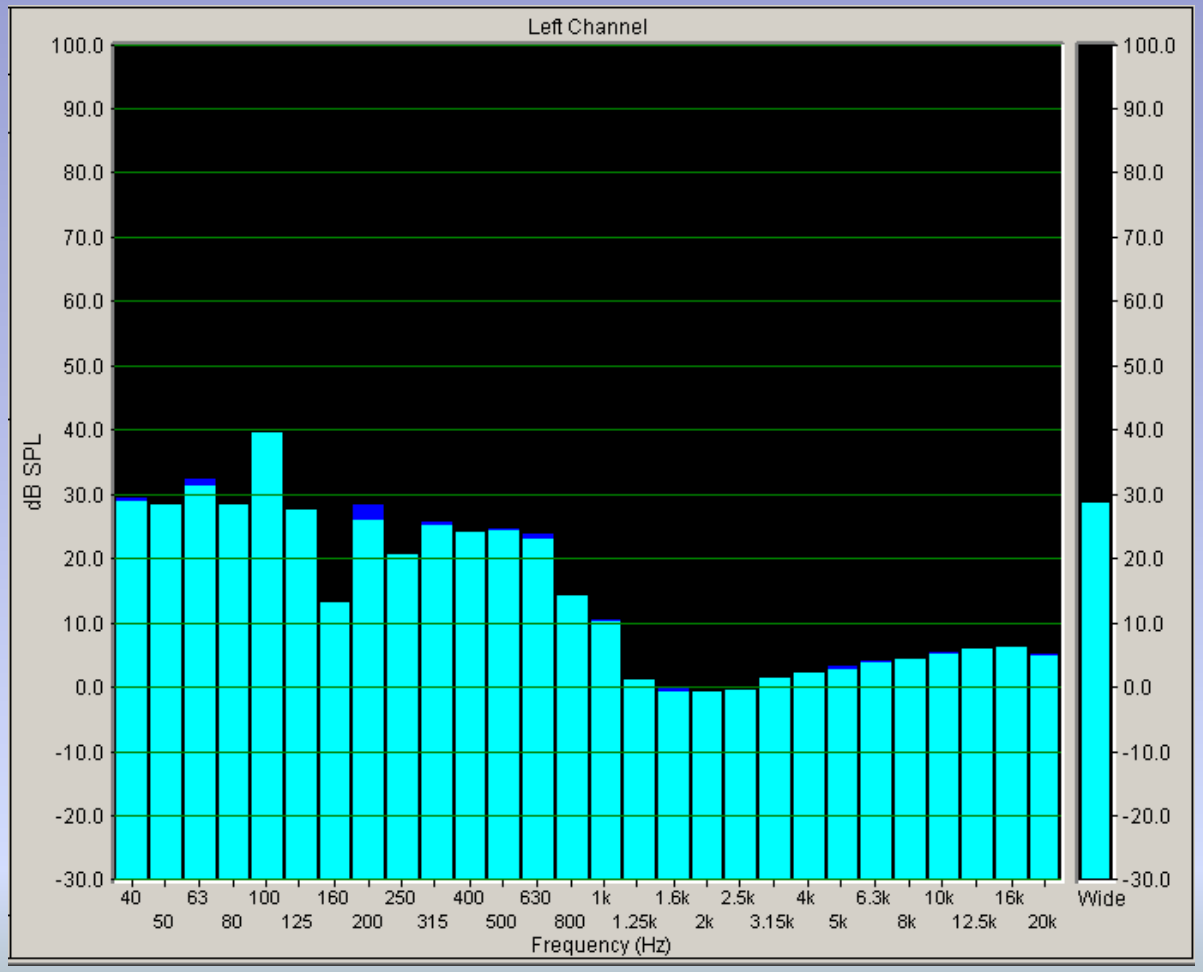
Why is frequency content important? Elk and airplane.



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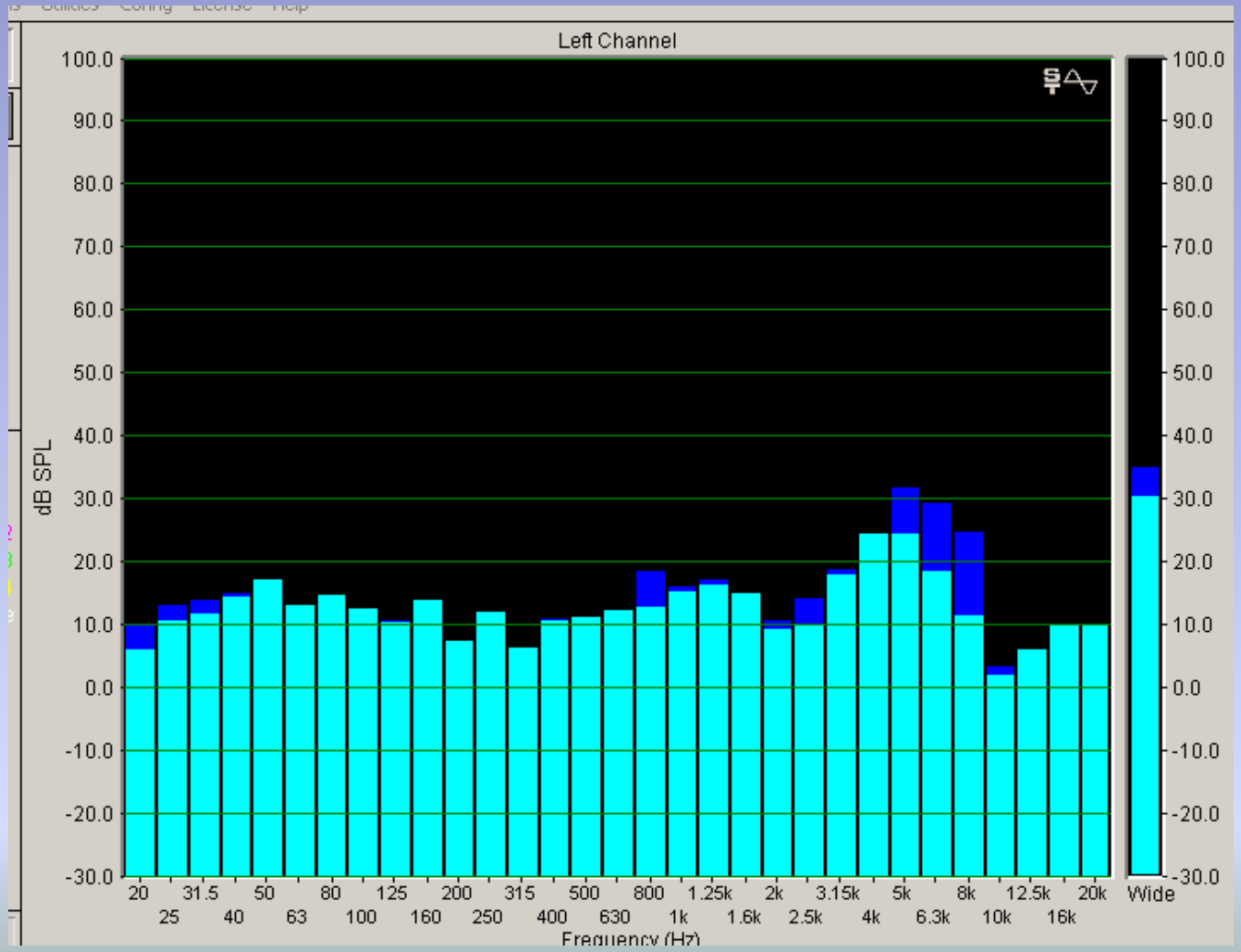
Birds (about 43 dBA) and helicopter (about 36 dBA)



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Definitions

- *Leq (Equivalent Sound Level)*

  The logarithmic average (i.e., on an energy basis) of sound pressure levels over a specific time period.

  Not an arithmetic average, but a logarithmic average.

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Definitions

- *Existing Ambient Sound Level (L50)*

  All sounds in a given area, including all natural sounds as well as all mechanical, electrical and other human-caused sounds.

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Definitions

- *Natural Ambient Sound Level (Lnat)*

  All natural sounds in a given area, excluding all mechanical, electrical and other human-caused sounds).

  "Natural ambient" is considered synonymous with the term "natural quiet," although natural ambient is more appropriate because nature is often not quiet.

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Definitions

- *Audibility*

  Audibility is the ability of animals with normal hearing, including humans, to hear a given sound. Audibility is affected by the hearing ability of the animal, other simultaneous interfering sounds or stimuli, and by the frequency content and amplitude of the sound.

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Definitions

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- *Detectability*: An increase of 1 dB to an existing sound level is considered detectable by a person (with normal hearing) who is listening attentively.
- *Noticeability*: An increase of ?? dB (3 or 5 or 10 dB) to an existing sound level is considered noticeable by a person engaged in an activity other than listening attentively.

"Noticeability" is very difficult to quantify; references are available that state 3 dB, 5 dB, and 10 dBA are "noticeable" differences in sound levels.

Examples of sound levels (dBA) in National Parks.

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	dBA
❖ Threshold of human hearing	0
❖ Haleakala, Volcano crater	10
(probably occurs in many parks, need sensitive mics)	
❖ Canyonlands, Leaves rustling	20
❖ Zion, Crickets (5 m)	40
❖ Whitman Mission, Speech (3 m)	60
❖ Yellowstone, Snowcoach (30 m)	80
❖ Arches, Thunder	100
❖ Yukon-Charley Rivers, jet (100 m)	120

Site Selection and Data Collection

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Four primary vegetation types,

Four measurement sites.

Measurement Period:

Minimum of 25 days at each site.

(to achieve a margin of error of <3 dBA)

Acoustic Data Collected and Metrics Computed

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Data Collected:	Metric Computed:
Sound Pressure Level Data (1-second L_{eq} dBA and 31 1/3 octave bands, 20-20,000 Hz)	• L_{eq}, L_{10}, L_{50}, L_{90}, L_{nat}, L_{min}, L_{max} for each hour, day, month
Observer Logging and Digital Recordings • Loud events; • Regular samples.	• Percent Time Audible • Identification of sources of sound • Distribution of sources of sounds • Number/duration of events, by source • Noise-free interval

GRCA Summer 2005 Acoustic Monitors

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Equipment, GRCA Summer 2005

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Equipment, GRCA Summer 2005

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Results, GRCA Summer 2005

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- Sources and Percent time human-caused sounds audible;
- Computed Lx based on percent time audible;
- Sources and Percent time natural sounds audible;
- Noise Free Interval; and
- Sound Pressure Levels.

GRCA Summer 2005, 0700-1900 Percent Time Human-caused Sounds Audible DRAFT RESULTS-NOT FINAL

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Site	Percent Time Human-caused Audible	L_x Value
GRCA008	41%	L71
GRCA009	41%	L71
GRCA010	36%	L68
GRCA011	75%	L87
Mean:	48%	L74

Percent Time Jet, Propeller and Helicopter Aircraft Audible

DRAFT RESULTS-NOT FINAL

Site	Percent Time Jets Audible	Percent Time Prop/Helicopter Audible
GRCA008	29%	13%
GRCA009	26%	15%
GRCA010	29%	6%
GRCA011	44%	38%

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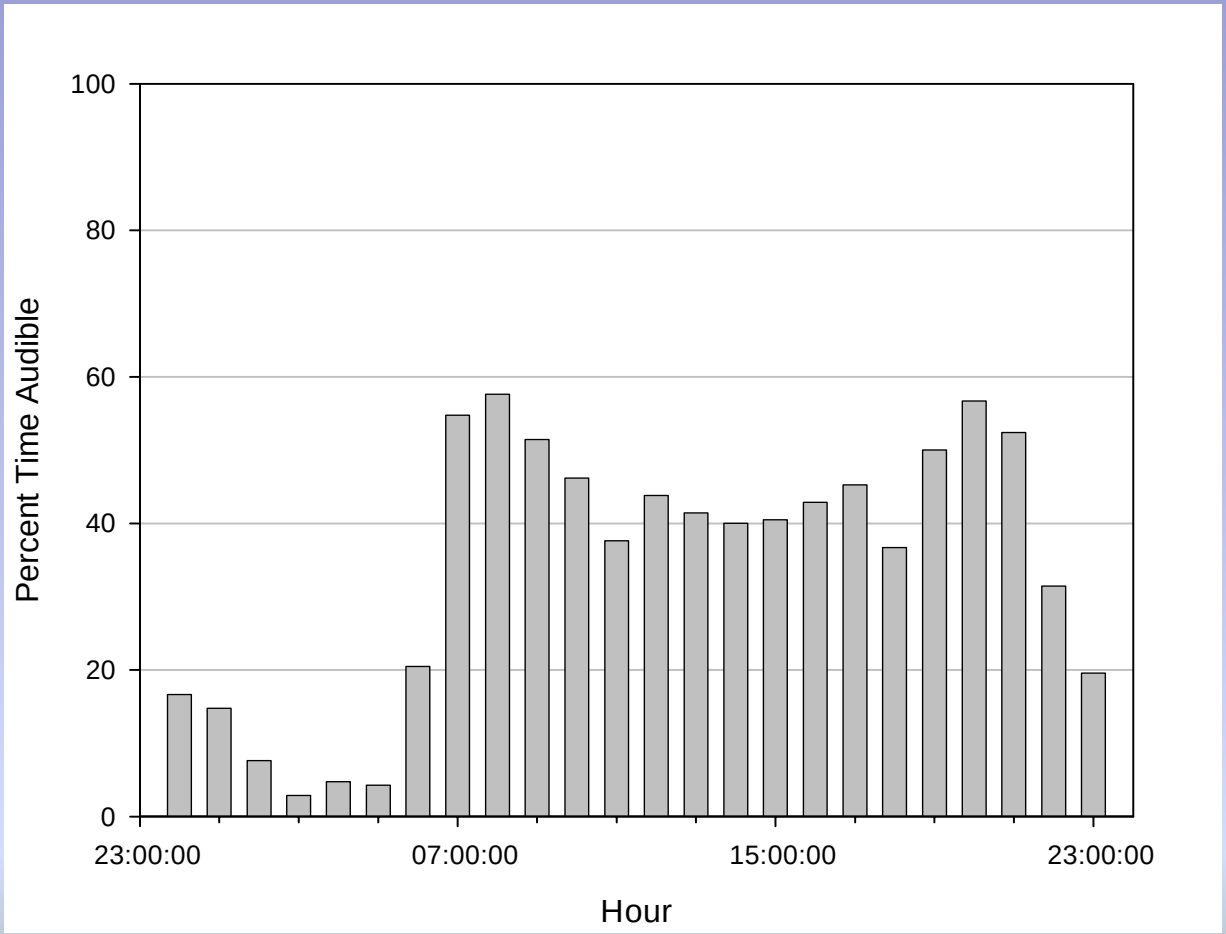
GRCA008 Summer 2005. Percent Time Human-caused sounds audible, by hour. DRAFT RESULTS-NOT FINAL



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GRCA011, July 1, 2005
Example of sample recording

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How is Natural Ambient calculated?

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- Determine percent time human-caused sounds audible.
- Remove that percentage from ranked data.
- Calculate the median of the remaining data (without human-caused sounds).

Example:

Human-caused sounds are audible 50% of hour;

L0 to L50 corresponds to the loudest sounds;

L50 to L100 corresponds to quietest sounds;

Median of L50 to L100 data is L75, “natural ambient.”

Concern: human-caused sounds not always the loudest, but if audible, then generally louder than natural sounds.

Result: greater than L50, less than L90.

How to address wind sounds

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- Wind sounds are a part of the natural soundscape, especially wind through vegetation.
- High wind speed can contaminate acoustic data, giving very high and inaccurate decibel data.
- But those periods of high winds and “loud” natural sounds are real and cannot be ignored.
- Best solution: site selection and good wind screen.
- If contaminated data are less than 50% of total, the median value will not be influenced.

  Same is true of very low decibel data, below the noise floor of the instrument. Inaccurate, but if less than 50%, the median is not influenced.

GRCA Summer 2005, 0000-2400
Source and Percent Time
Natural Sounds Audible

DRAFT RESULTS-NOT FINAL

Source:	Percent Time Audible:
Wind	63.6
Wind Distorted	4.3
Mammal	1.7
Bird	54.2
Amphibian	0.1
Insect	45.2
Animal sound	3.5
Unknown	4.3

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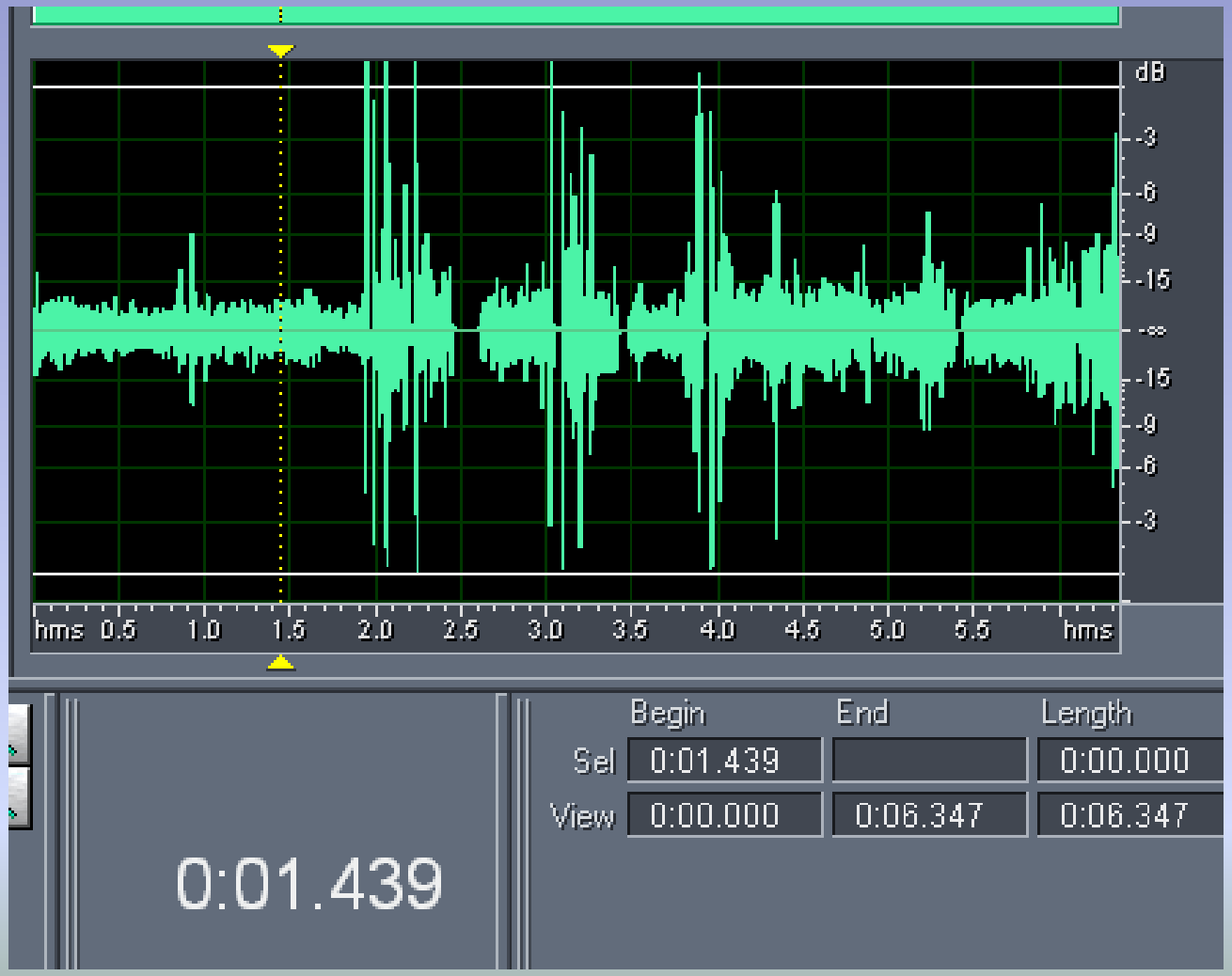
GRCA008, July 17, 2005
Example of Wind Distortion or Overload



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Examples of Sound Events

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Sound events that exceeded 55 dBA for 10 seconds.

- Coyotes
- Aircraft and Crickets
- Elk smelling/eating (?) foam windscreen

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Noise Free Interval, in Minutes

DRAFT RESULTS-NOT FINAL

Site	Ave. NFI	Max. NFI
GRCA008	4.6	45.7
GRCA009	3.0	18.2
GRCA010	4.1	34.0
GRCA011	0.9	4.2
Overall Mean:	3.1	

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GRCA Summer 2005 0700-1900 Natural Ambient Sound Levels, dBA

DRAFT RESULTS-NOT FINAL

Site:	Vegetation type:	L_{nat} dBA
GRCA008	Pinyon-Juniper	20.8 dBA
GRCA009	Warm Desert Scrub	17.9 dBA
GRCA010	Cold Desert Scrub	18.3 dBA
GRCA011	Ponderosa Pine	26.2 dBA

Pinyon-Juniper, ARCH, July 2001: 21.6 dBA

Ponderosa Pine, BRCA, July 2001: 24.8 dBA

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GRCA008 Summer 2005 0700-1900 Example of dBA & 1/3 Octave Band Data

DRAFT RESULTS-NOT FINAL

Freq/dBA	L_{eq}	L_{50}	L_{90}	L_{nat} *
dBA	29.8	23.2	19.2	20.8
20	36.9	31.2	26.8	29.2
25	35.4	30.5	25.5	28.3
31.5	34.3	29.7	24	27.1
40	33.3	28.7	22.4	25.9
Etc. For 31 1/3 octave bands, 20-20,000 Hz				
12500	6.8	6.7	6.5	6.6
16000	6.6	6.4	6.2	6.3
20000	5.7	5.5	5.4	5.5

* Note: The L_{nat} 1/3 octave band data are used in modeling.

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