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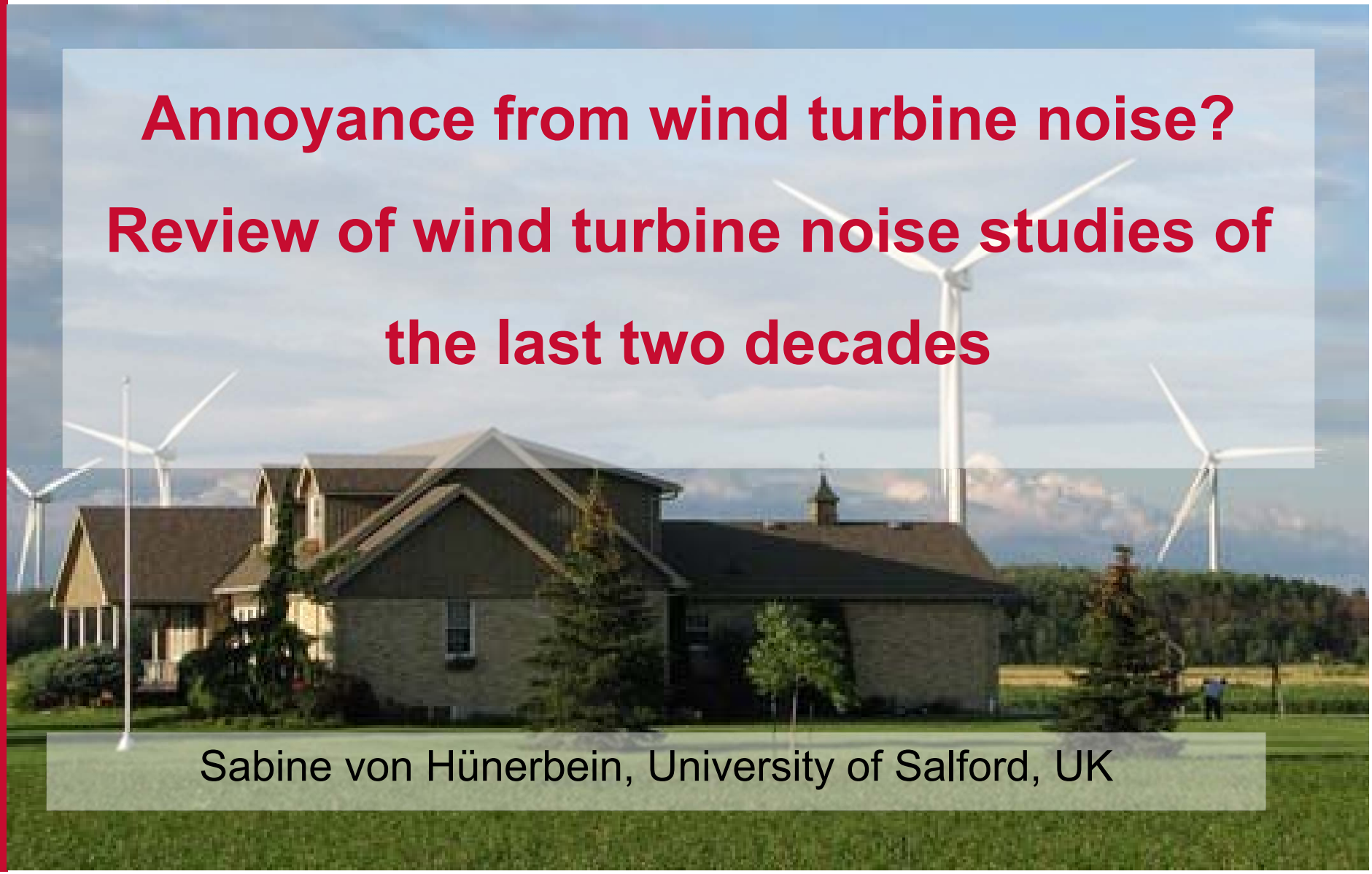

Annoyance from wind turbine noise? Review of wind turbine noise studies of the last two decades

Sabine von Hünerbein, University of Salford, UK

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Introduction

- Growing body of literature (> 200) on wind energy impact
- Majority of rejected planning applications due to noise concerns
- Major ‘health outcome’ annoyance
- Mostly related to wind turbine noise
- Dose-response relations derived
- Are they the best measures?

Annoyance definition

- Disturbance of activities (noise related)
- Emotional/attitudinal response
- Cognitive response

Guski, Schreckenberg, & Schuemer, 2017

https://www.sciencesquared.eu/news/traffic-noise-more-merely-annoying-it-cause-serious-ill-health

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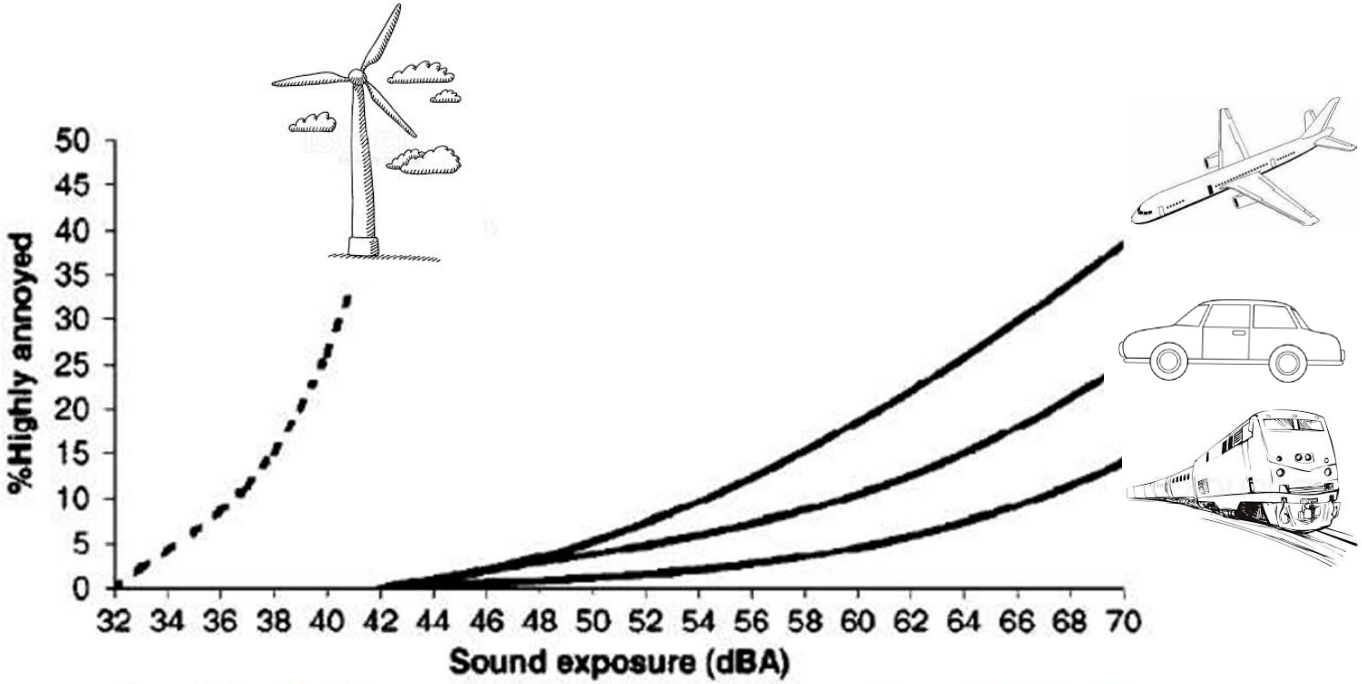
Dose-response for wind turbine noise?



Reprinted with permission from Pedersen, E. and K.P. Waye (2004). Perception and annoyance due to wind turbine noise—a dose-response relationship. The Journal of the Acoustical Society of America 116: 3460. Copyright 2004, Acoustical Society of America.

http://randacoustics.com/wind-turbine-sound/annoyance/

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Common exposure measures

- $L_{Aeq,\ 1h}$: equivalent A-weighted averaged sound level
- L_{den}: 24 h time weighted average L_{Aeq}
  +0 dB 7am-7pm, +5 dB 7-10pm, +10 dB 10pm-7am
- L_{dn}: 24 h time weighted average L_{Aeq}
  +0 dB +10 dB 22.00-7.00

Common outcome measures

% HA: Highly Annoyed

5 Very annoyed

4 Very
5 Extremely

% A: Annoyed

3 Slightly annoyed
4 Rather annoyed
5 Very annoyed

2 Slightly
3 Moderately
4 Very
5 Extremely

Or any combination of sub-ratings
% SA, MA, VA, EA:

Verbal scales

1 Do not notice
2 Notice, but not annoyed
3 Slightly annoyed
4 Rather annoyed
5 Very annoyed

1 Not at all
2 Slightly
3 Moderately
4 Very
5 Extremely
9 Inaudible

1 Not at all
2 Slightly
3 Moderately
4 Very
5 Extremely
98 Refusal
99 Don't know

Dose-response studies

Pedersen 2004
Sweden,
N = 351

Pedersen 2007
Sweden,
N = 751

Pedersen *et al.* 2009
NL, N = 725

Kuwano 2014
Japan, N = 651 (332)

Michaud *et al.*, 2016
Canada, N = 1238

China,
N = 227
Song, 2016

N & pane size = participant no, colour code dominant terrain type

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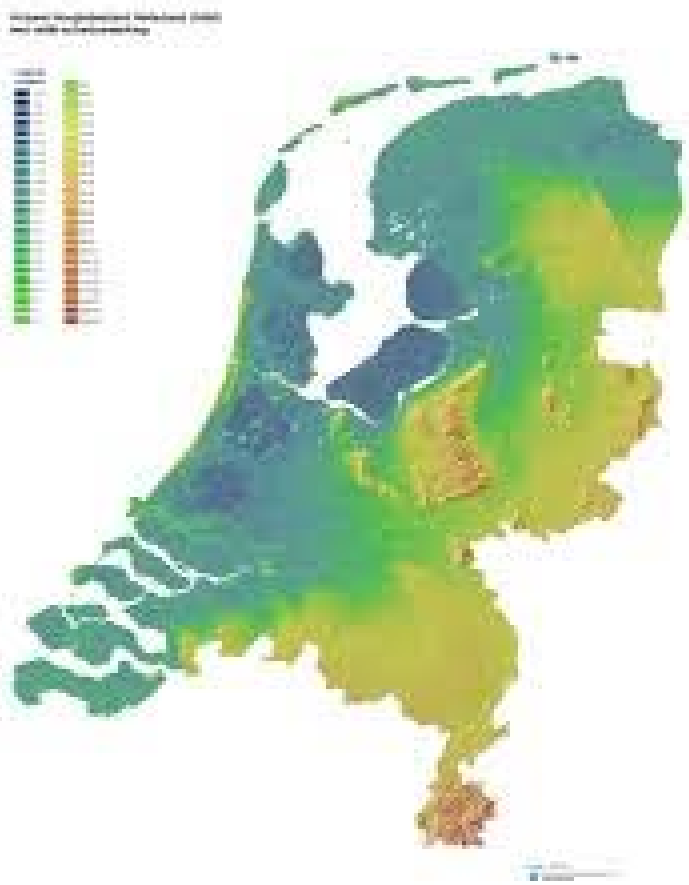
Sweden 2000/2005, NL



Annoyance question:
"State for each nuisance below if you notice or are annoyed when you spend time *outdoors/indoors* at your dwelling: odour from industries, odour from manure, flies, noise from hay fans, noise from wind turbines, railway noise, road traffic noise, lawn mowers.

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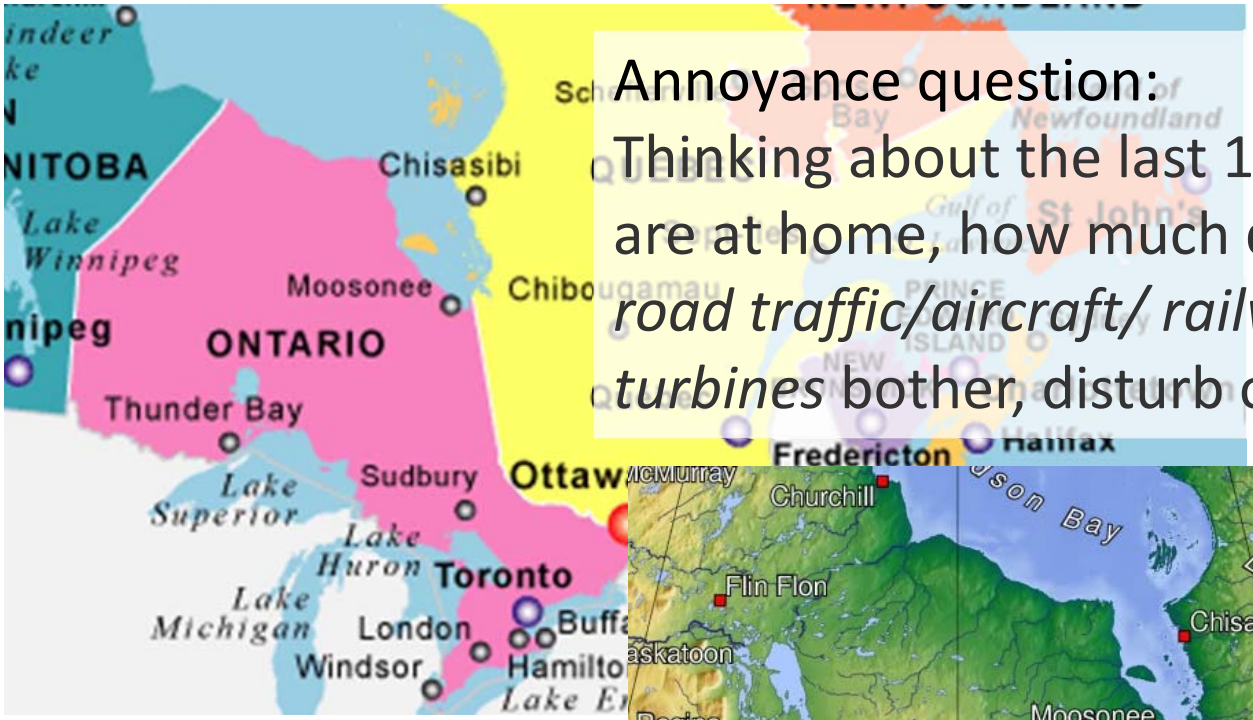
Canada



Annoyance question:

Thinking about the last 12 months, when you are at home, how much does noise from *road traffic/aircraft/ railways or trains/wind turbines* bother, disturb or annoy you?

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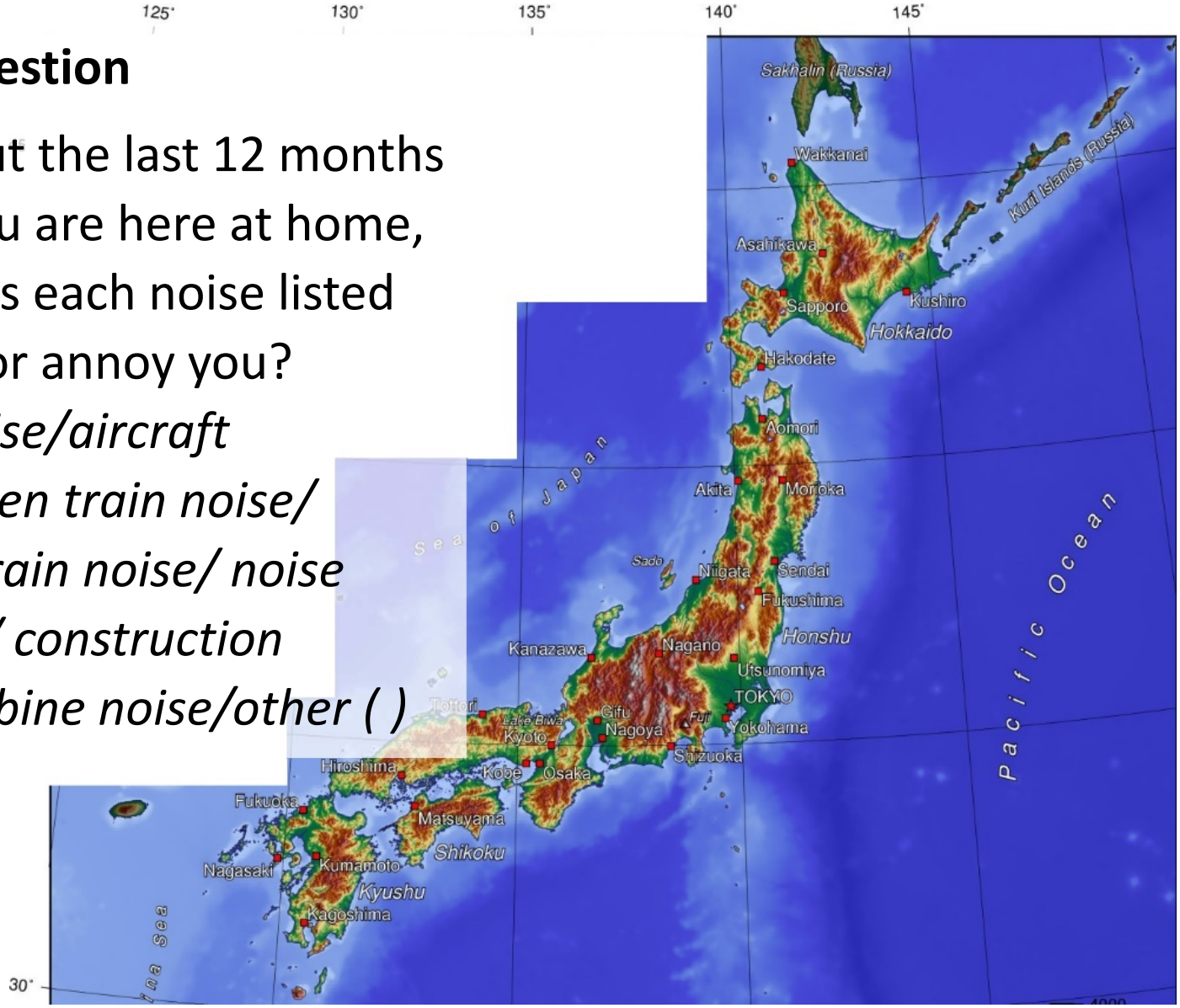
Japan

Annoyance question

"Thinking about the last 12 months or so, when you are here at home, how much does each noise listed below bother or annoy you?
road traffic noise/aircraft noise/shinkansen train noise/ conventional train noise/ noise from factories/ construction noise/wind turbine noise/other ( )



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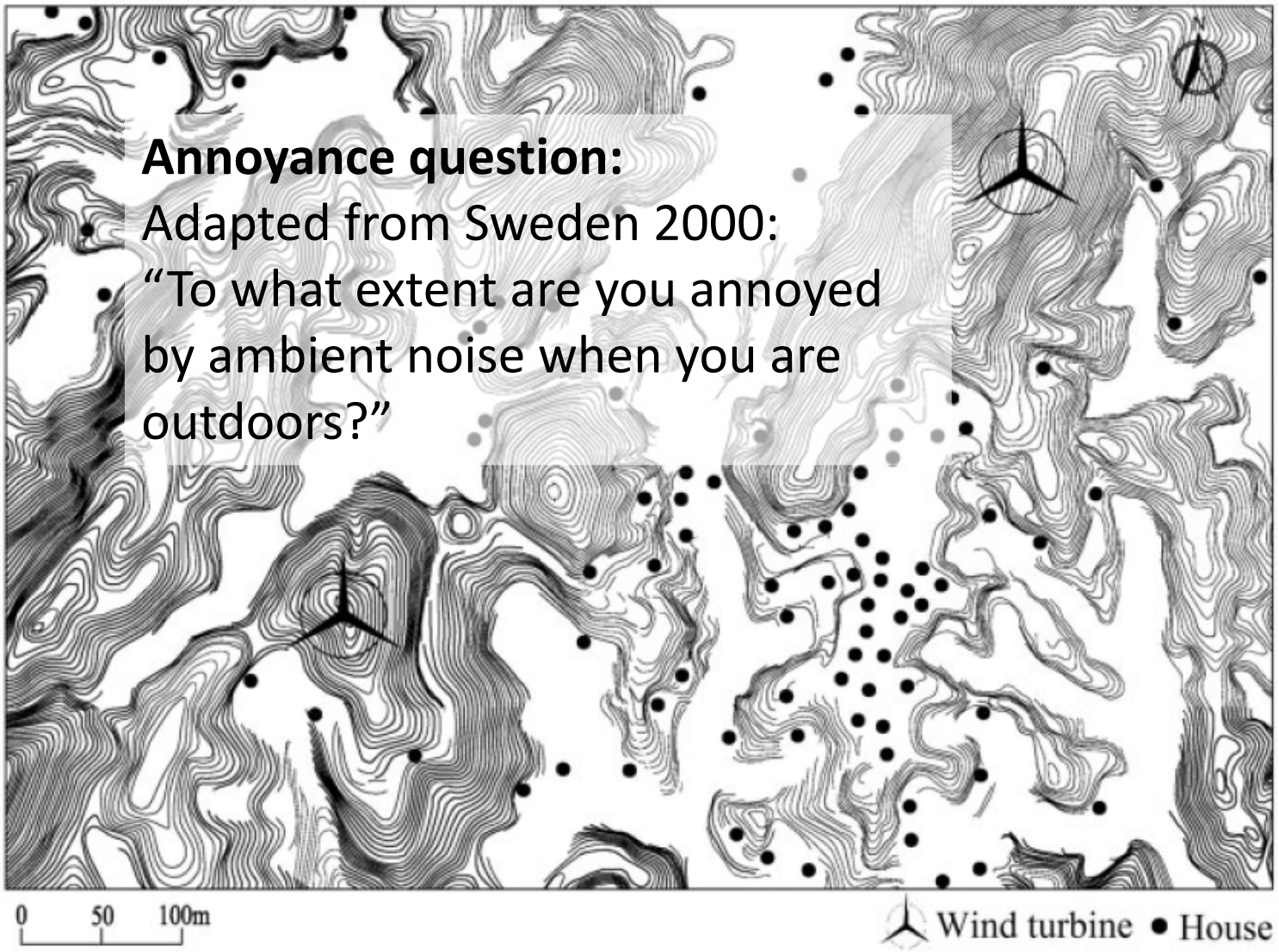
China, 2015



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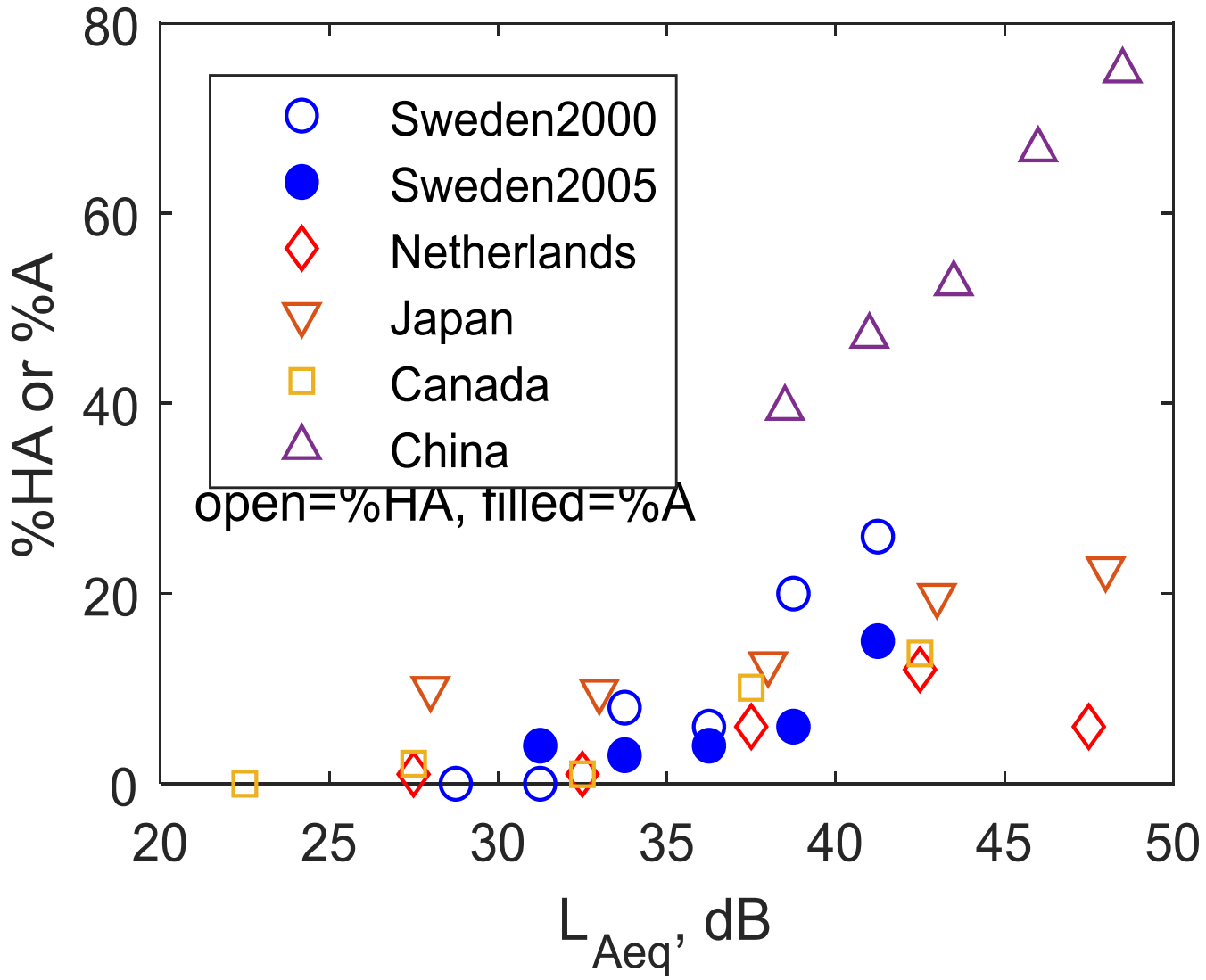
Study comparison



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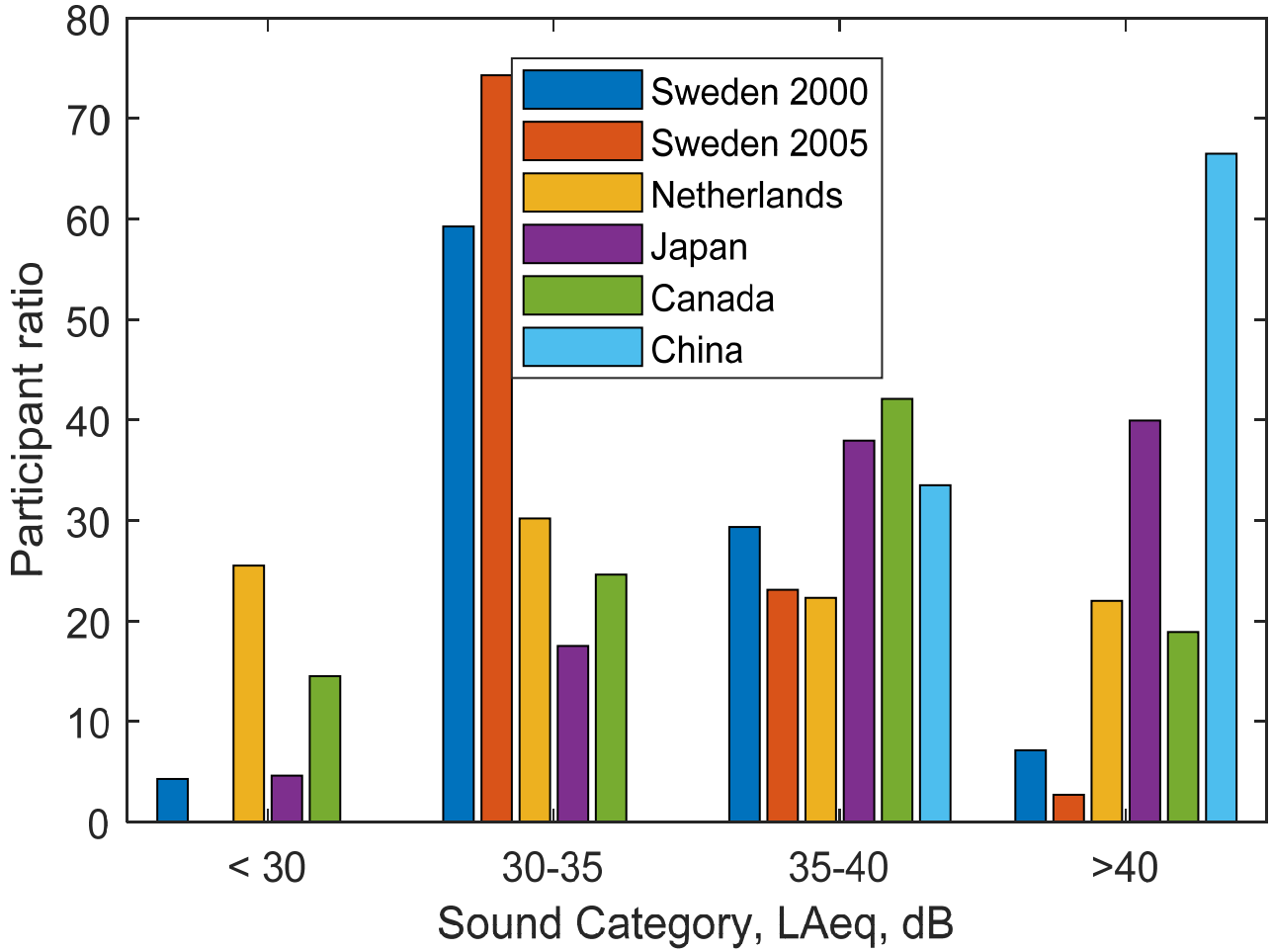
Percentage of participants in exposure categories



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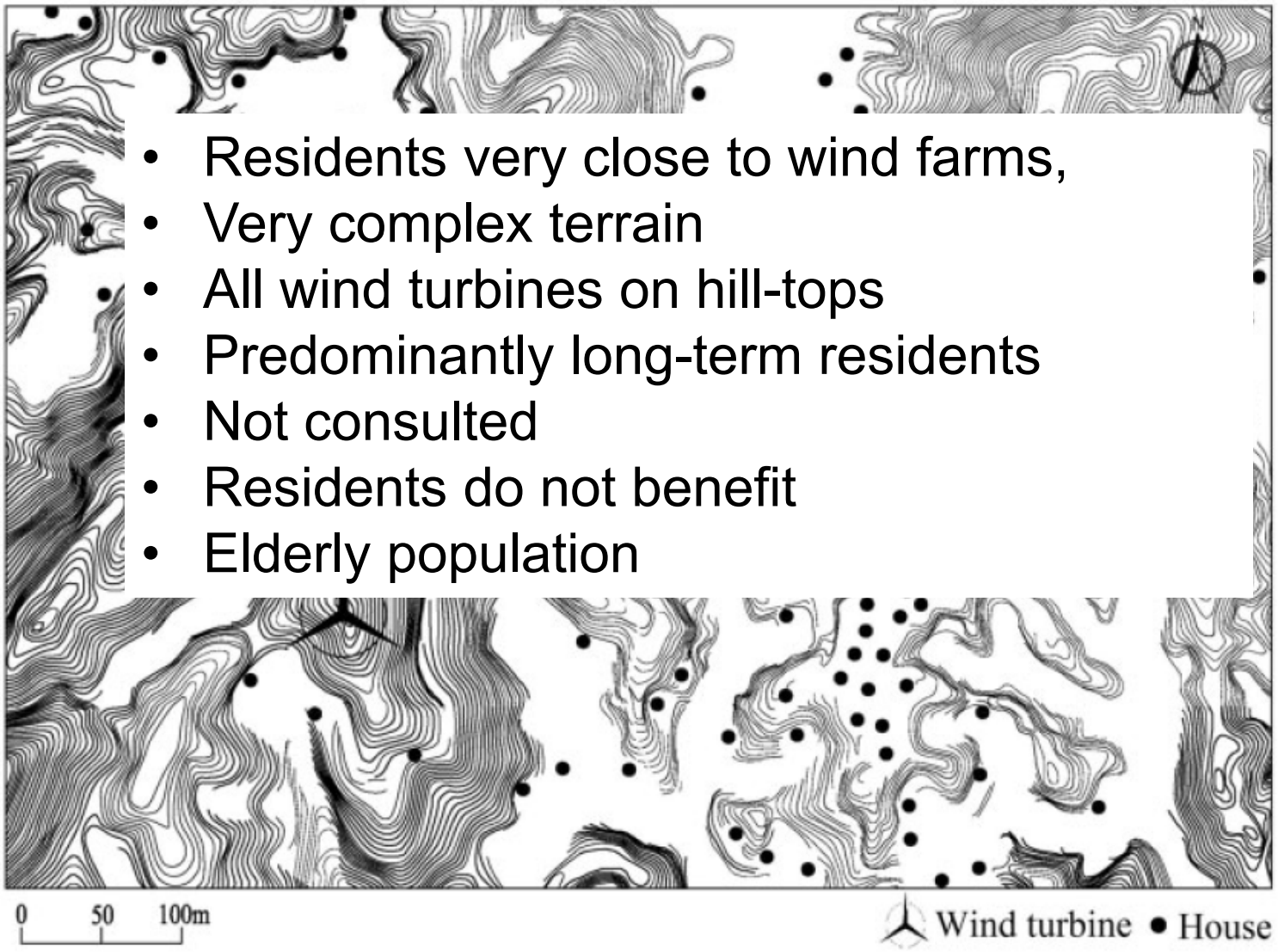
China, 2015



- Residents very close to wind farms,
- Very complex terrain
- All wind turbines on hill-tops
- Predominantly long-term residents
- Not consulted
- Residents do not benefit
- Elderly population

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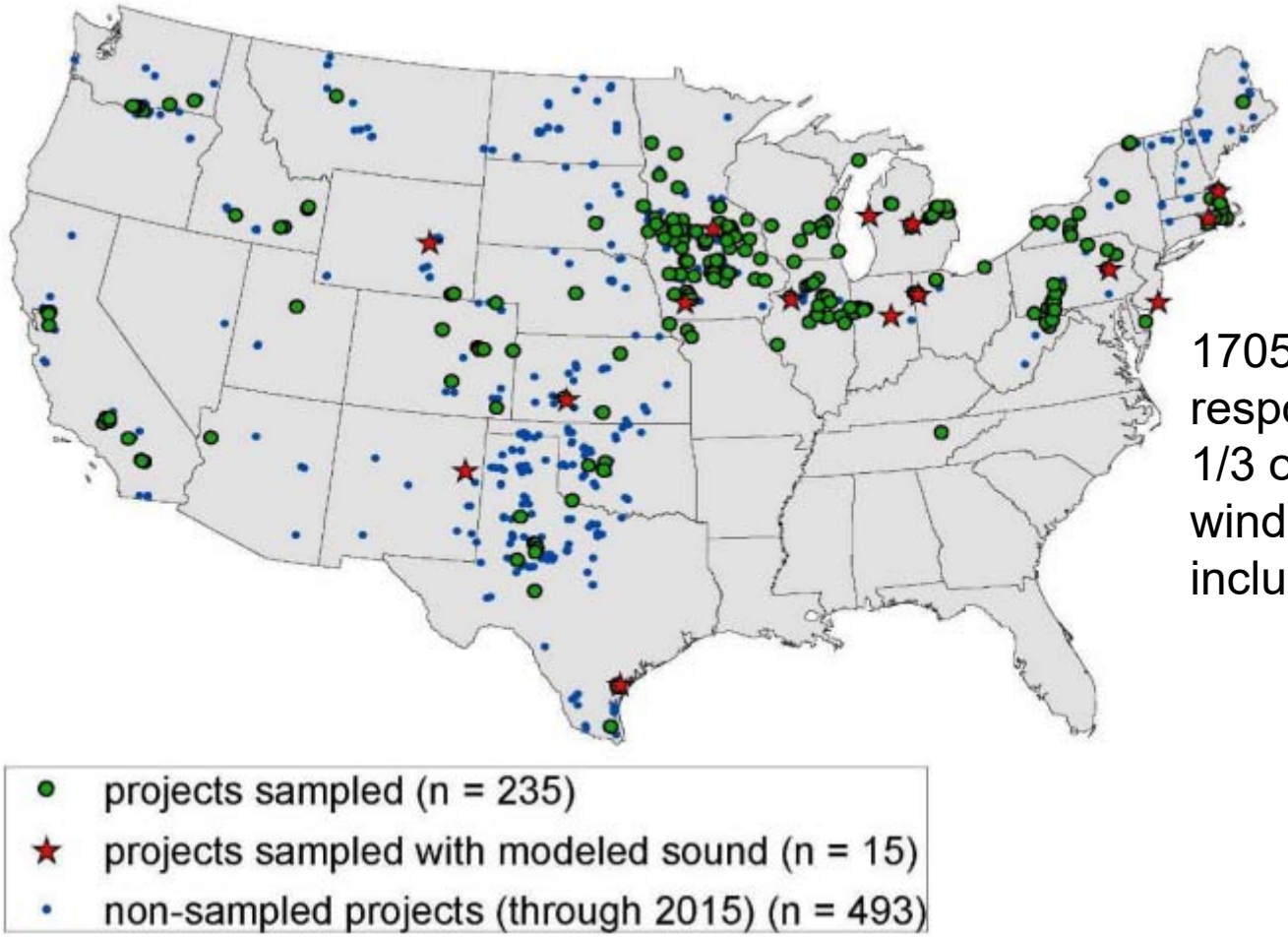
Attitude towards local wind project, US, 2016



1705 respondents
1/3 of large US wind projects included

Hoen, B., J. Firestone, J. Rand, D. Elliott, G. Hübner, J. Pohl, R. Wiser, E. Lantz (2018) Overall Analysis of Attitudes of 1,705 Wind Power Project Neighbors. Lawrence Berkeley National Laboratory. Preliminary Results Webinar. January 30, 2018.

US study focus

Central research question:

- What is your attitude toward the local wind project now?
- Independent variables in 5 groups
  1. Planning process/arrival into area
  2. Related attitudes
  3. Sensory perceptions
  4. Project characteristics, compensation
  5. Demographics

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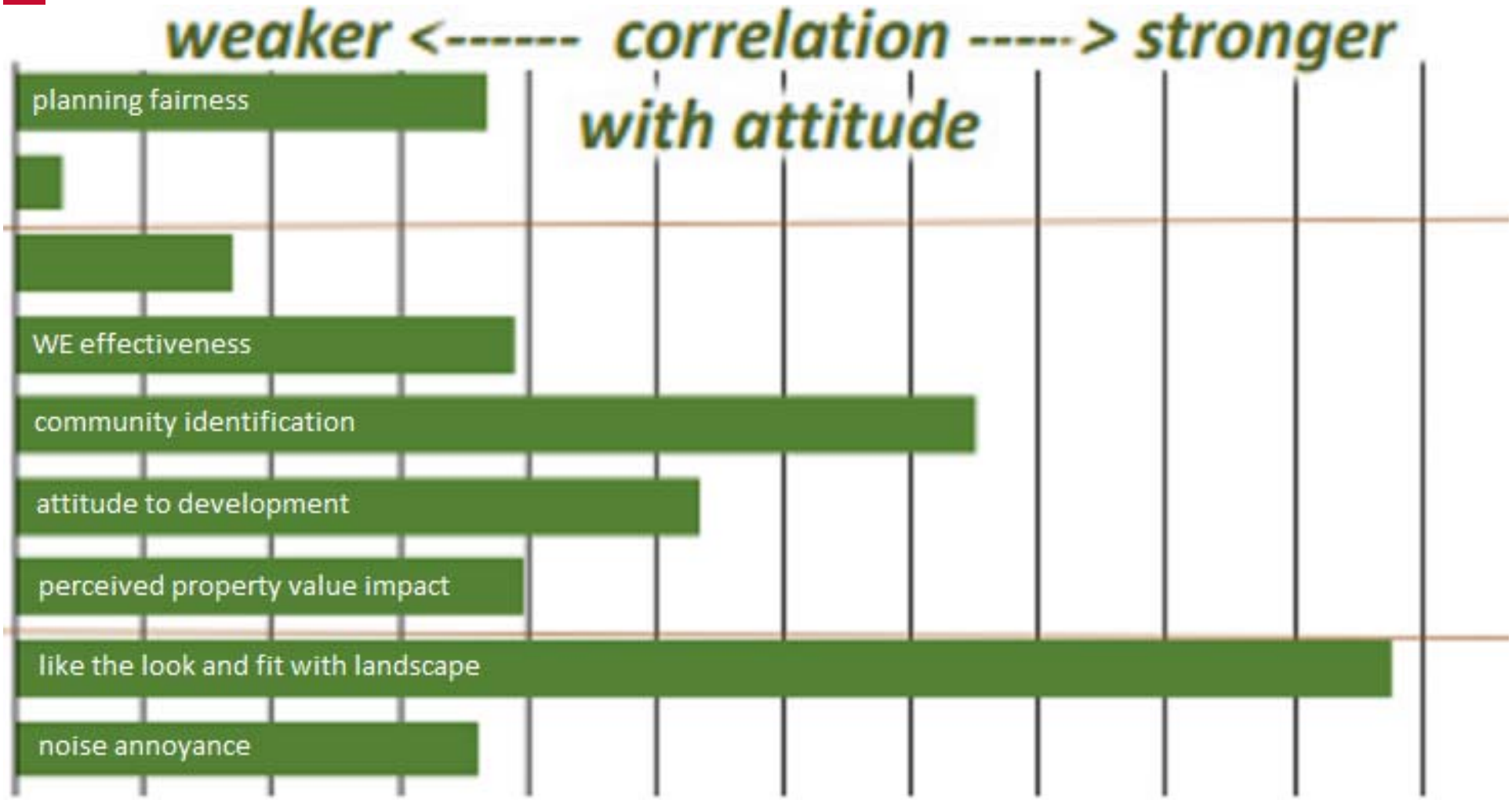
Attitude towards local wind project, multivariate regression



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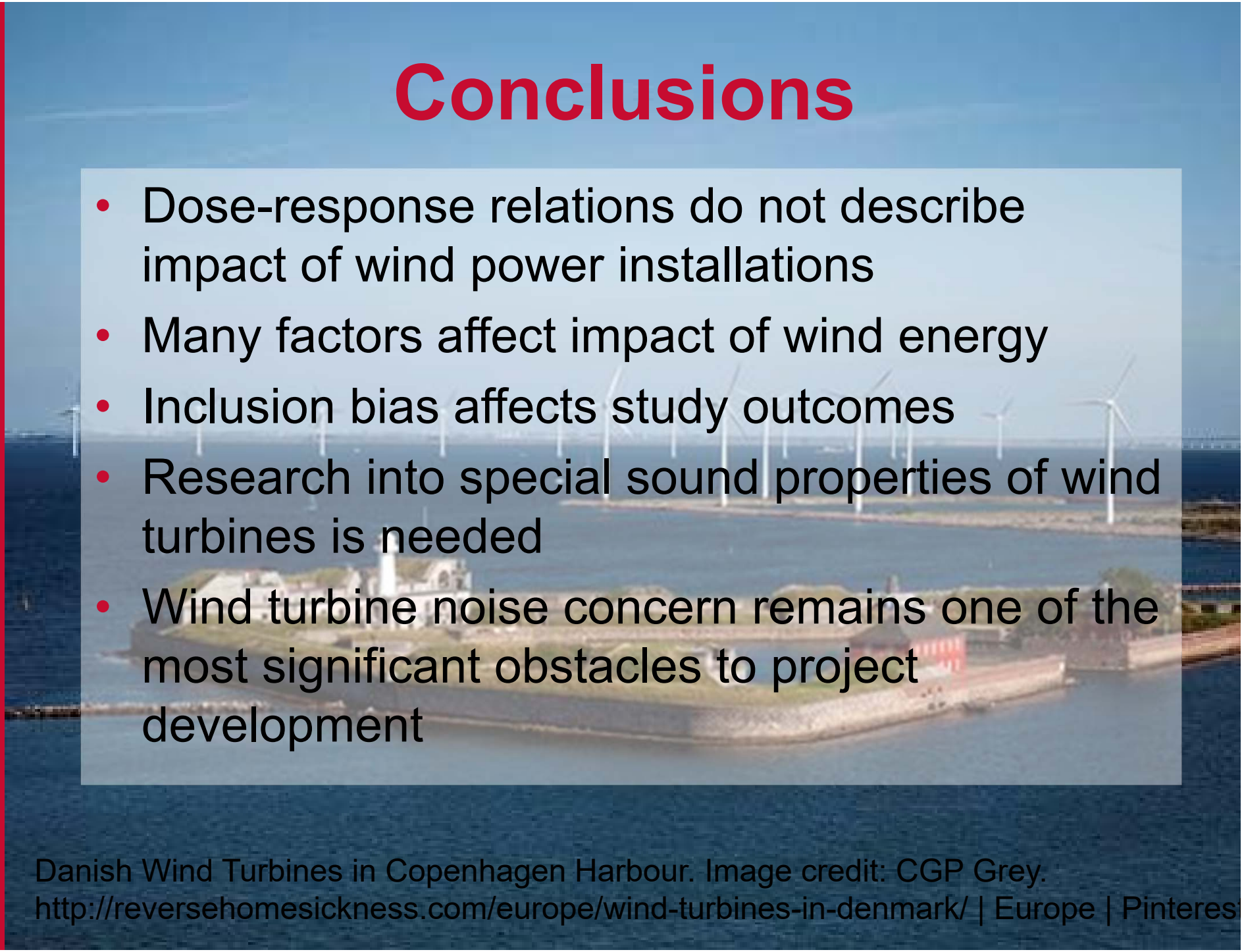
Conclusions

- Dose-response relations do not describe impact of wind power installations
- Many factors affect impact of wind energy
- Inclusion bias affects study outcomes
- Research into special sound properties of wind turbines is needed
- Wind turbine noise concern remains one of the most significant obstacles to project development



Danish Wind Turbines in Copenhagen Harbour. Image credit: CGP Grey.
http://reversehomesickness.com/europe/wind-turbines-in-denmark/ | Europe | Pinterest

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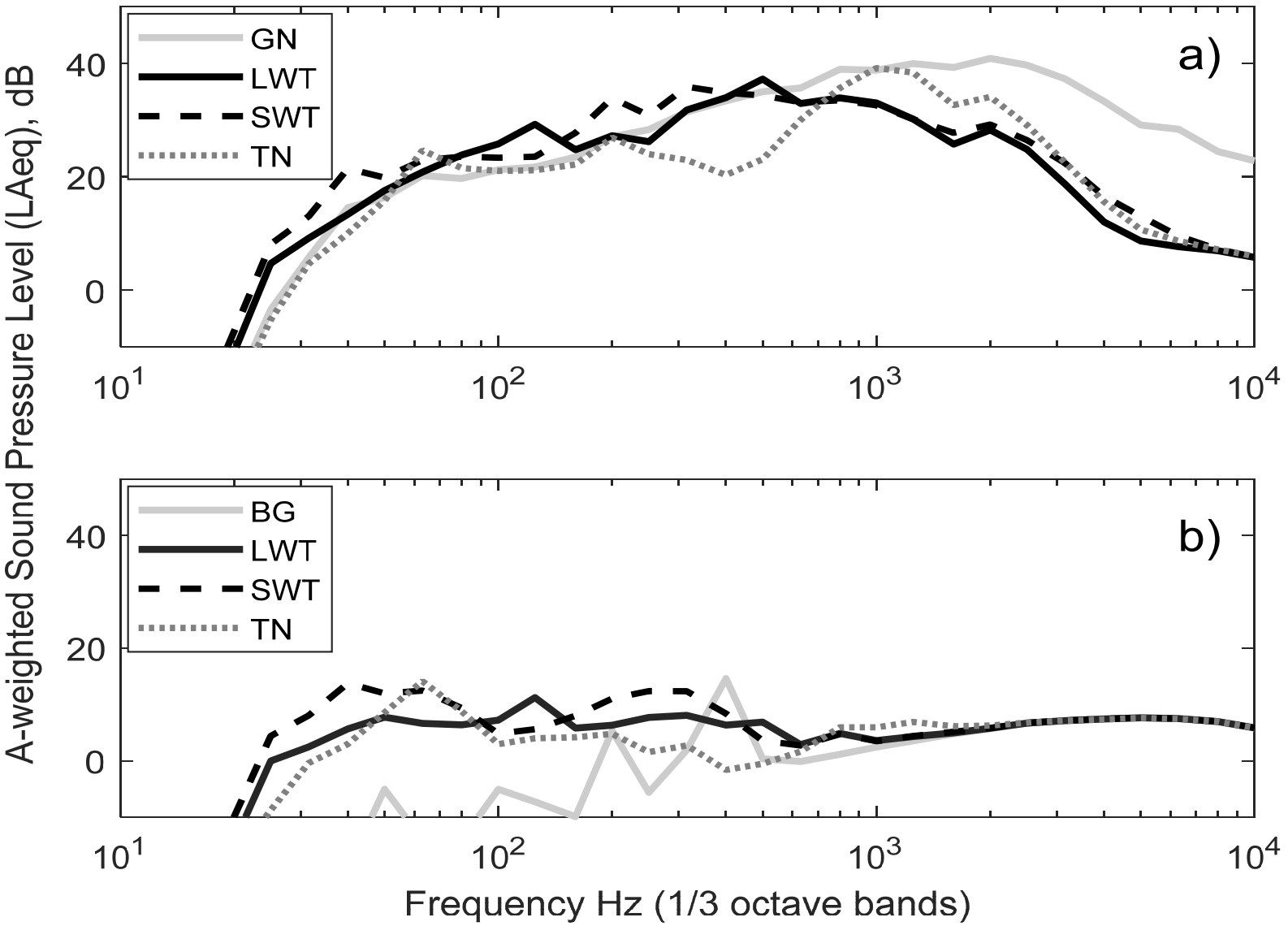
Comparative Spectra



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Equal loudness contours