Understanding the relationship between soundscape and landscape features in a Tropical Andean environment, Colombia

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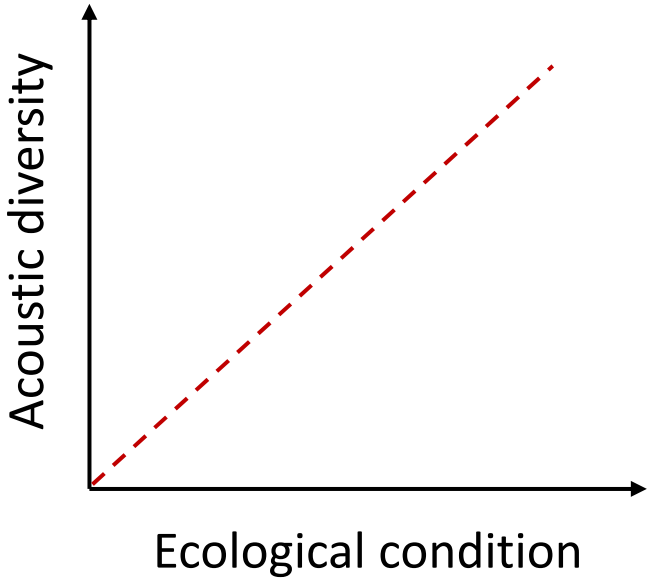
Soundscape: acoustic dimension of the landscape

Soundscape as indicator of landscape conditions

Soundscape

Acoustic indices
Soundscape indices
Power espectral density

Landscape features



Tucker et al. 2014, Fuller et al. 2015, Mullet et al. 2016

Soundscape: acoustic dimension of the landscape

Soundscape as indicator of landscape conditions

Soundscape

Acoustic indices
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Power espectral density

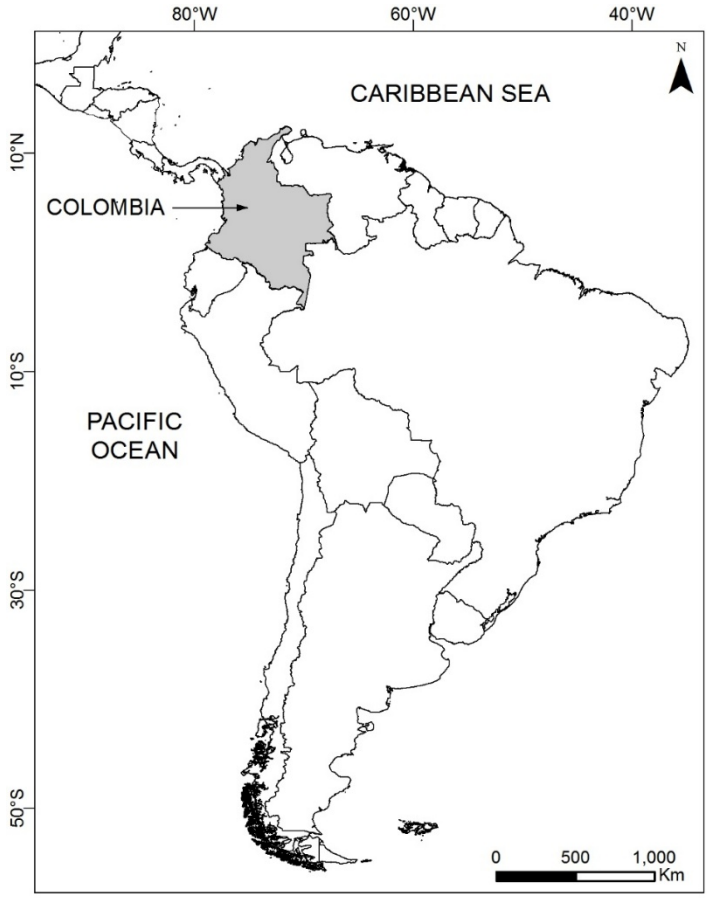
Landscape features

- Vegetation cover
- Forest structure
- Land use types
- Human disturbance
- Patch size
- Fragmentation

Tucker et al. 2014, Fuller et al. 2015, Mullet et al. 2016

Soundscape monitoring on the Northen Andes

Northern Andes



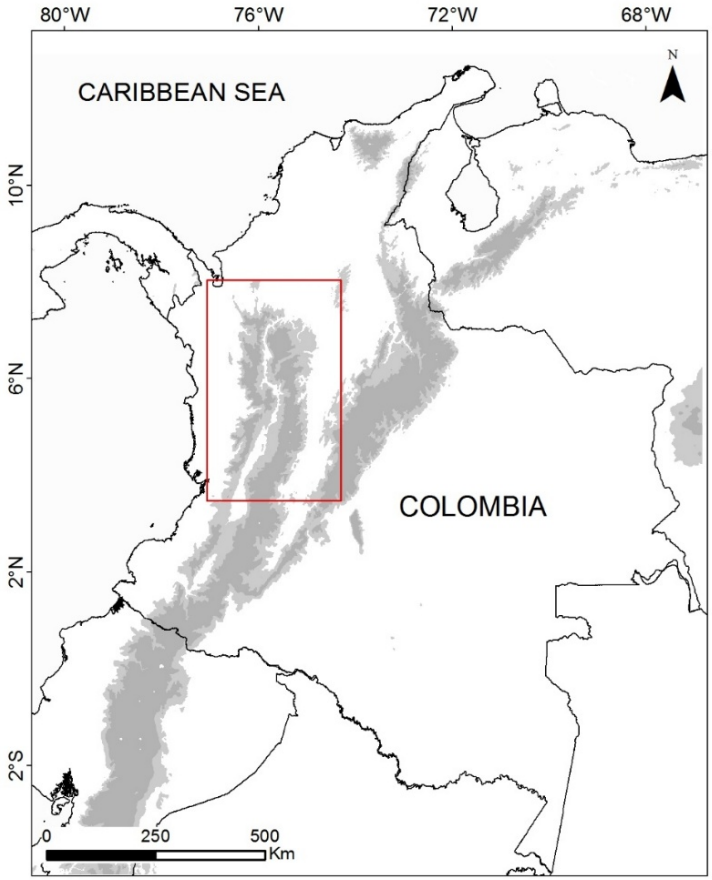
- High levels of species richness and endemism

Threats

- Agroecosystem and human density
- Energy-mining and infrastructure projects

Soundscape monitoring on the Northen Andes

Northern Andes



- High levels of species richness and endemism

Threats

- Agroecosystem and human density
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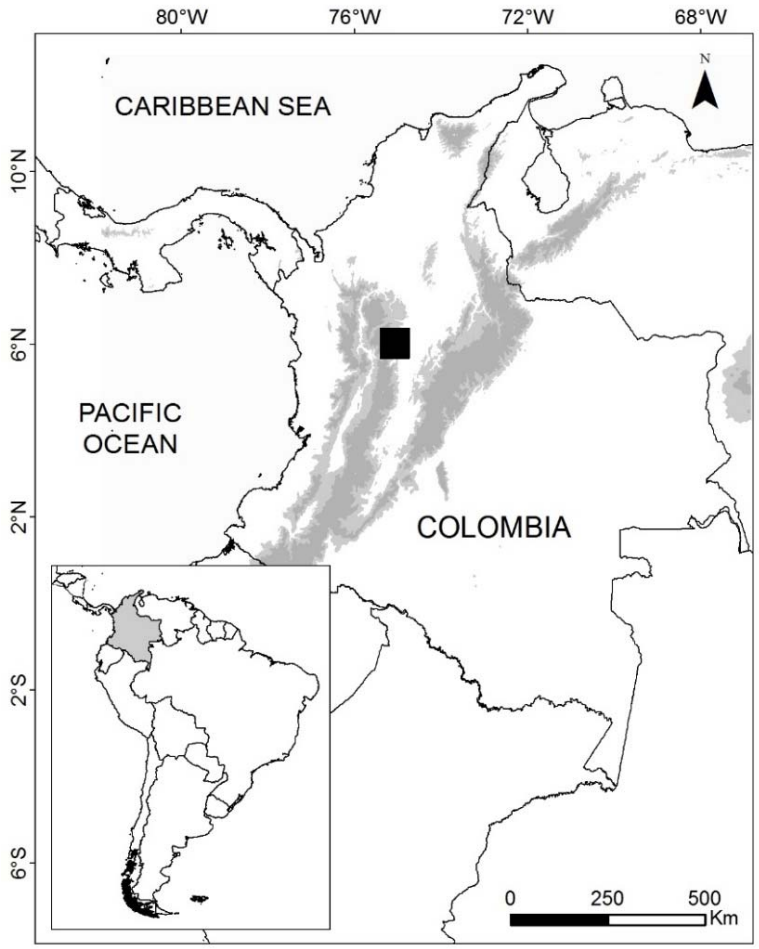
Questions

What is the relationship between acoustic indices as soundscape complexity measurements and landscape and habitat features in tropical Andean environments?.

Are there specific associations between acoustic indices and vegetation, fragmentation, water availability, terrain and soil conditions in tropical Andean environments?

Study area

Northern Andes

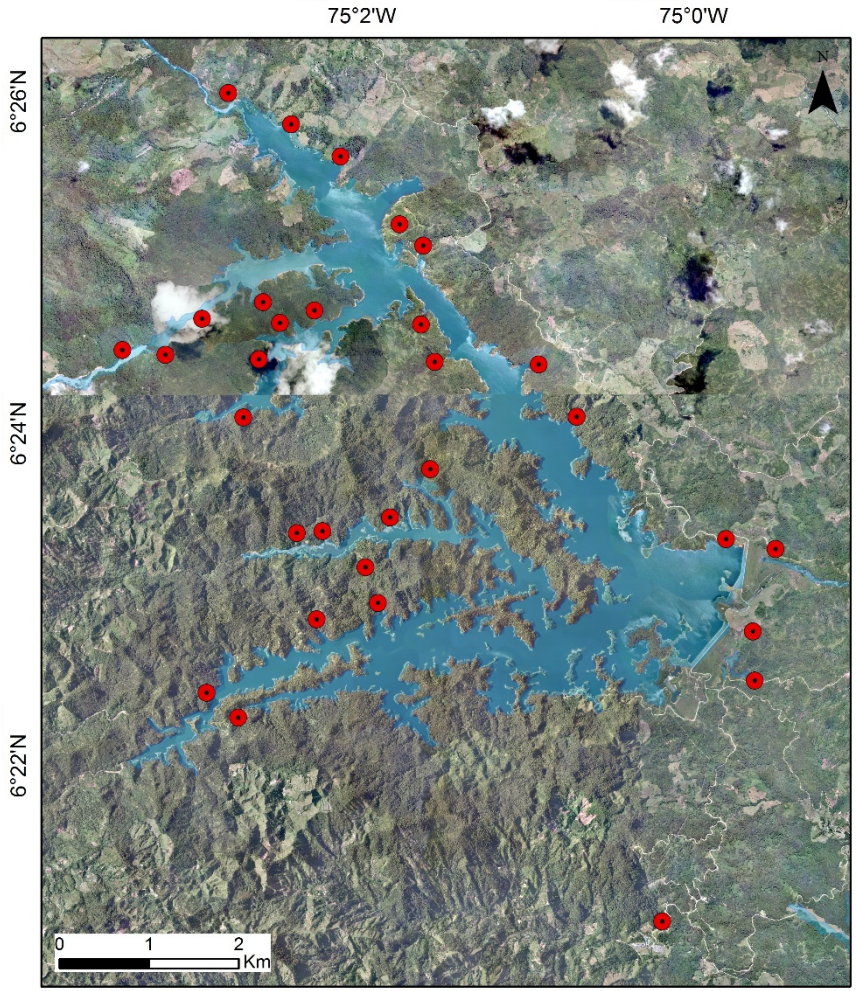


- Jaguas Hydroelectric Plant
- Protected area: 50 Km^2
- 800-1400 masl
- Magdalena Valley montane forest

Study area

Sampling Design

31 Sites



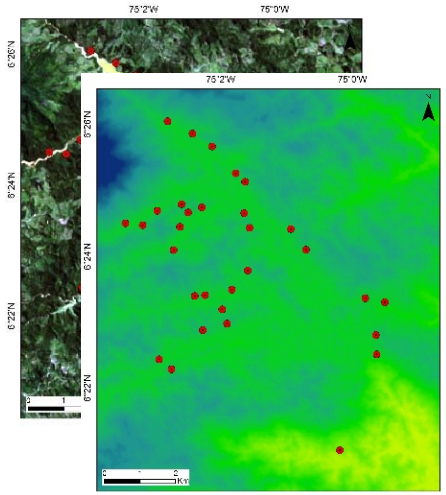
- 6 days per site / 24 h
- 1-min recording / 15 min
- Rate: 22.05 KHz
- April – June 2017

↓

432 min per site
13392 min

Landscape and habitat variables

Scenes 2016
LANDSAT-8
ALOS (PRIMS)



31 sites
100 m buffer
12 variables

Fragmentation	Soil	Terrain	Vegetation	Water
-Spatial heterogeneity	-Bare ground -Temperature	-Roughness -Slope -Elevation	-Active Vegetation -Forest cover -Leaf coverage -NDVI	-Watersheds -Distance to water

Acoustic analysis

Acoustic indices → 1 min → Max value / hour → 24 values/day

ACI - Acoustic Complexity Index
ADI - Acoustic Diversity Index
AEI - Acoustic Evenness Index
AR - Acoustic Richness
Hm - Entropy of Spectral Maxima
ESV - Entropy of Spectral Variance
M - Median of Amplitude Envelope
NP - Number of Peaks
Hs - Spectral Entropy
TE - Temporal Entropy
BI - Bioacoustic Index

By day

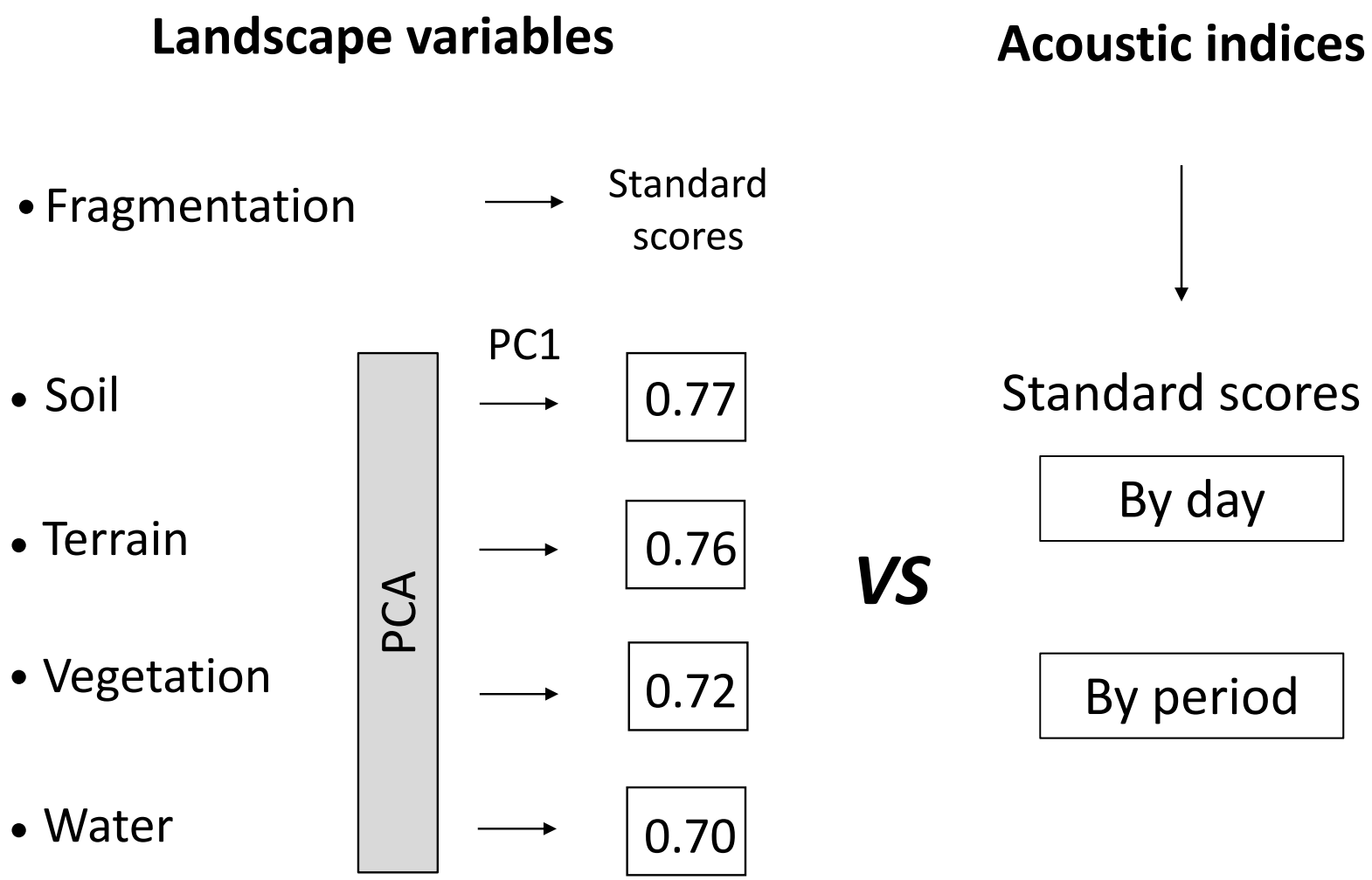
Site	Mean AI
1	
2	
3	
…	
…	
…	
…	
31	

By period

Hour	Period	Sites			
		1	2	…	31
5-8	Dawn				
8-11	Diurnal				
11-14	Diurnal				
14-17	Diurnal				
17-20	Dusk				
20-23	Nocturnal				
23-02	Nocturnal				
02-05	Nocturnal				

Gómez et al. 2018

Correlation analyses



Results and Discussion

Correlation analyses by day

Correlation coefficients for acoustic indices and landscape

	ADI	ACI	BI	TE	M	NP	ESV	AR
Vegetation	-0.06	0.00	-0.12	-0.38	-0.12	-0.11	0.03	-0.31
Terrain	0.29	-0.24	-0.04	0.12	0.14	-0.20	-0.11	0.11
Soil	0.03	0.03	0.06	0.30	0.28	-0.04	-0.06	0.31
Water	0.11	-0.06	0.26	-0.18	-0.03	0.26	0.10	-0.28
Fragmentation	-0.40	0.00	-0.10	0.11	-0.31	-0.20	-0.27	0.12

p<0.05

- Inverse relationship between fragmentation and acoustic diversity is consistent with the expected behavior.
- Vegetation-acoustic diversity relationship can be associated to the increase in the cover heterogeneity

Bormpoudakis et al. 2013, Tucker et al. 2014, Fuller et al. 2015

Correlation analyses by period

Correlation coefficients for acoustic indices and landscape

	ADI	ACI	BI	TE	M	NP	ESV	AR
Vegetation				-0.38				-0.31
Terrain	0.29							
Soil								
Water			0.26			0.26		
Fragmentation	-0.40				-0.31			

p<0.05

- Inverse relationship between fragmentation and acoustic diversity is consistent with the expected behavior.
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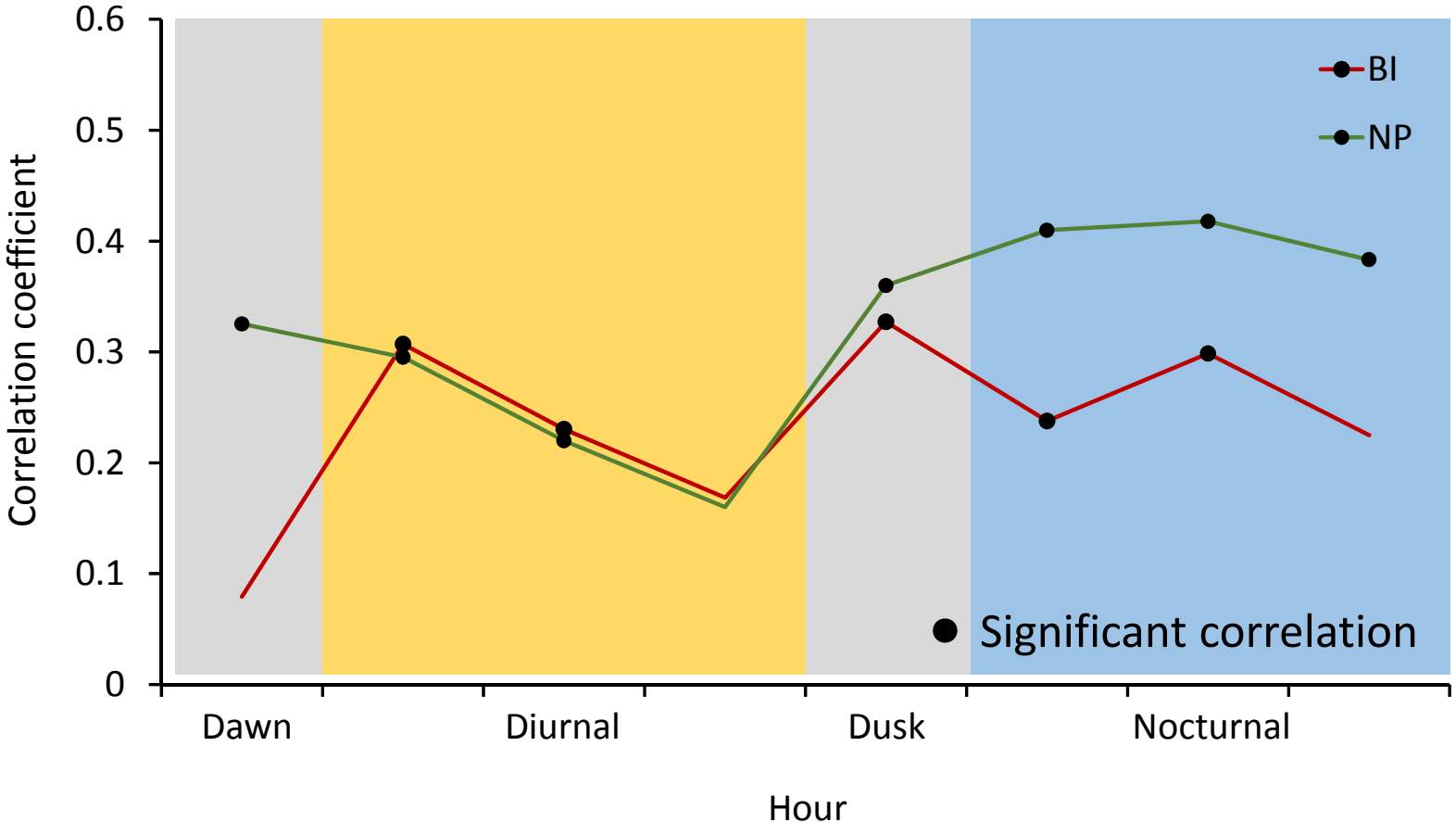
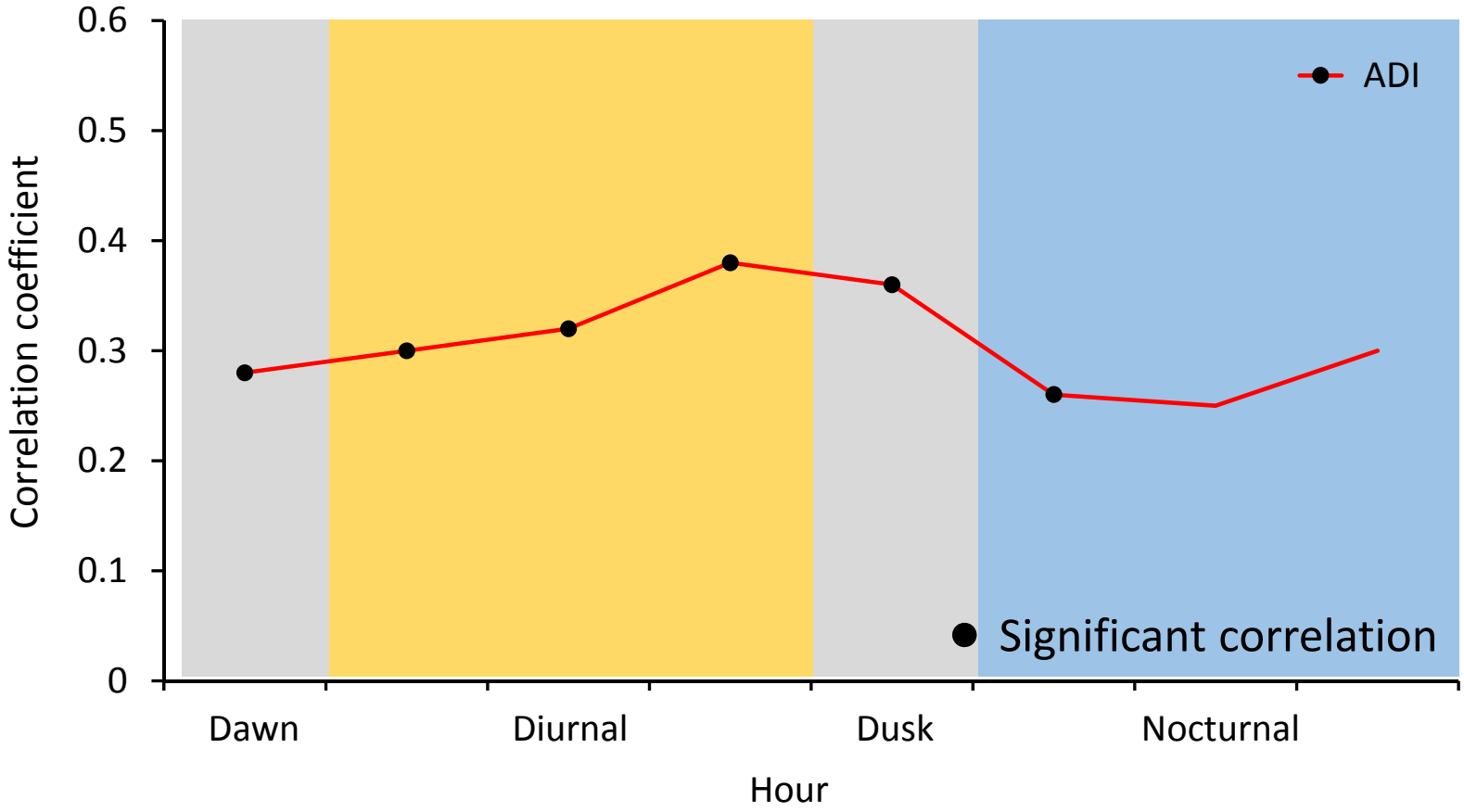
Water resources

- Frog species highly dependent of water conditions
- Water → Frog richness → Acoustic diversity



Terrain conditions

- Higher coefficients in diurnal (14-17) and dusk periods.
- Increasing in terrain complexity and water → Acoustic diversity



Castaño-Villa 2014, Casas et al. 2016

Conclusions and future work

Proposed acoustic indices as indicadors of the landscape conditions

Index	Variable	Day	Period
ACI		✗	✗
ESV		✗	✗
ADI	Fragmentation	✓	
	Terrain		✓ Diurnal-Dusk
M	Fragmentation	✓	
AR	Vegetation	✓	
TE	Vegetation	✓	
NP	Water		✓ Nocturnal
BI	Water		✓ Dusk

Conclusions and future work

- Specific acoustic indices can be linked to particular attributes of landscape in Andean environments
- The acoustic monitoring of dusk – nocturnal time provides the most relevant information about landscape conditions.
- ADI (Acoustic Diversity Index) can be used as specific monitoring tool of fragmentation conditions in Andean environments.
- Integration of additional landscape and soundscape metrics in the analysis and assessing trends of the relationships in a larger time lapse.

Acknowledgements