附录 1　本研究使用的声学指数及其定义和属性
Appendix 1　Definitions and properties of acoustic indices used in this study

声学指标 Acoustic index	定义 Definition	属性 Property	参考文献 Reference
声音复杂度指数 Acoustic complexity index (ACI)	每一小段时间间隔中声音振幅(强度)的平均相对变化, 指示声音强度的变异性。Mean relative change in sound intensity across consecutive time periods and frequency bins.	值越大, 则声景中强度不断变化的声音(如鸟类、昆虫鸣唱等多数动物发声)比重越大; 值越小, 则声景中持续不变的声音(如人为噪声)比重越大。High values: high levels of bird activity; low values: consistent insect noises or anthropogenic sounds.	Pieretti et al, 2011; Barbaro et al, 2022
声音多样性指数 Acoustic diversity index (ADI)	提取声音信号中声强超过一定阈值的频段并计算其Shannon指数, 指示声音频段的多样性。Computed by applying the Shannon diversity index to the relative proportion of signal occurring in each 1 kHz frequency band.	值越大, 表明整个频率范围内不同频段的声音种类越多、频率分布越均匀; 值越小, 表明声景被某个单一频段的声音所占据(例如单一频率的昆虫噪声或人为噪声)。High values: greater number of occupied frequency; low values: pure tones dominating single frequency band.	Villanueva-Rivera et al, 2011; Bradfer-Lawrence et al, 2019; 赵莹等, 2020; Barbaro et al, 2022
声音均匀度指数 Acoustic evenness index (AEI)	提取声音信号中声强超过一定阈值的频段并计算其Gini指数, 指示声音频段的不均匀性。Measures the evenness of the acoustic activity distribution estimating the Gini coefficient on the signal proportion in each 1 kHz band.	取值范围是0–1, 与ADI相反, 值越大, 则声景中声音频率的分布越不均匀。High values: high sound intensity in a restricted range of frequencies; low values: either high or no acoustic activity across all frequency bins.	Villanueva-Rivera et al, 2011; Bradfer-Lawrence et al, 2019; 赵莹等, 2020; Barbaro et al, 2022
生物声学指数 Bioacoustic index (BIO)	计算2–11 kHz频段(生物声)中, 超过最小分贝数的声压(dB)~频率(Hz)曲线下面积, 评估生物发声的强度。Estimates the area under curve of the mean spectrum above a specific dB threshold within 2–11 kHz.	值越大, 表明声景中鸟类的多度越大, 占据2–11 kHz (生物声)的频段数越多, 或者声景被强烈的蝉鸣声主导; 值越小, 表明2 kHz以上的生物声强度越低。High values: higher avian abundance and occupancy of frequency bands or blanker cicada noise; low values: low biophony.	Boelman et al, 2007; Eldridge et al, 2018; Sánchez-Giraldo et al, 2021; Barbaro et al, 2022
标准化声景差异指数 Normalized difference soundscape index (NDSI)	计算声音信号中生物声(2–11 kHz)与人为声(1–2 kHz)能量(功率)的比率, 评估声景中人为干扰的强度, 衡量声景的健康程度。Calculates the ration of signal power in the frequency bands between 1–2 kHz (anthrophony) and 2–8 kHz (biophony).	取值范围是–1–1, 值越接近1表明生物声所占比重越大; 值越接近–1则表明人为声所占比重越大。High values: higher levels of biophonic activity; low values: higher levels of anthrophonic activity.	Kasten et al, 2012; Bradfer-Lawrence et al, 2019; 赵莹等, 2020
声学熵指数 Acoustic entropy index (H)	计算时间熵H_t与频率熵H_f的乘积, 衡量声音信号在时频域上的均匀度和复杂度。Results from multiplying a temporal diversity index and a frequency diversity index, which are generated by applying Shannon diversity index to the amplitude envelope.	取值范围是0–1, 含义与ADI相似, 值越接近1则表明声音频率的分布越均匀(声景中包含更多发声物种)或完全静默的声景或随机噪声; 值越接近0则表明只占据单一频率的单调纯音。High values: soundscape containing many vocalizing species; low values: pure tones dominating single frequency	Sueur et al, 2008; Bradfer-Lawrence et al, 2019; 赵莹等, 2020; Sánchez-Giraldo et al, 2021

声学指标 Acoustic index	定义 Definition	属性 Property	参考文献 Reference
		band.	
功率谱密度 Power spectral density (PSD)	计算每一频段上的功率密度, 即每kHz所包含的能量, 用来评估声谱中某一频段包含的能量大小, 可以代表不同声景成分的发声强度。Calculating the power density of each frequency band to reflect the presence of species and the proportion of various soundscape components.	通常将值进行标准化, 取值范围0–1, 值越大表明这一频段的能量越大。High values: higher power of the frequency band.	Welch, 1967; Doser et al, 2020; Hao et al, 2021

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