

Title:

“The Acoustic and Ecological Interrelationship Between Singing Dunes and Juniperus Forests: A Scientific Exploration through Soundscape Composition”

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Abstract:

This paper bridges the gap between acoustic ecology and environmental science through a combined artistic and scientific investigation. Using the *Dytikos* soundscape piece - a composition based on field recordings from the island of Gavdos in Greece - the paper explores potential connections between the acoustic phenomena of singing dunes and the ecological health of Juniperus forests found in the island. These natural elements, though seemingly unrelated, share a common environmental framework within the unique ecosystem of the Kedres forest, home to rare species of Juniperus trees. This interdisciplinary study hypothesizes that the sounds produced by singing dunes could serve as indicators of the forest's ecological state, thus offering innovative perspectives for environmental monitoring.

Introduction:

The exploration of sound in nature can reveal complex relationships that are not immediately apparent. The *Dytikos* soundscape piece is an artistic endeavor rooted in the natural environment of Gavdos where the interplay of sound and landscape forms the foundation of an intriguing scientific hypothesis. The Kedres forest on Gavdos, home to two rare species of Juniperus trees (*Juniperus Macrocarpa* and *Juniperus Phoenicea*), serves as both the subject of this soundscape and a focal point for examining the relationship between singing dunes and forest health.

Singing dunes are a rare natural phenomenon where the movement of sand creates sounds ranging from faint whistles to loud booms. Juniperus forests, especially those growing in sandy environments, are sensitive to changes in their surroundings. This study proposes that the acoustic properties of singing dunes could reflect the ecological conditions of Juniperus forests, thereby providing a novel method for assessing the health of these important ecosystems.

Wind blows from the West: Dytikos

The track *Dytikos* is inspired by the unique auditory environment of Gavdos, particularly the western region of Stravolimni, where the island's powerful west winds shape the soundscape, the landscape and the way of living. The title *Dytikos* reflects the influence of these winds, as “dytikos” is Greek for “western.” This piece tries to capture the essence of the island's natural soundscape, incorporating field recordings of the wind, water, the forest's ambient sounds as well as the human activities especially in the summertime where the area is a temporary home of many nature lovers.

Initially, the creation of *Dytikos* was a purely an artistic endeavor, aimed at immersing listeners in the rich auditory experience of Gavdos. However, as the composition evolved, it became apparent that some of the documented sounds held a deeper significance and potentially linked to the island's environmental health. A constant, almost drone-like sound frequency varying between 300 and 500 Hz, led to the positive hypothesis that this could be the sound of the dunes themselves - an idea that would later spark a scientific inquiry.

Singing Dunes: Natural Phenomena as Acoustic Indicators

Singing dunes, also known by other names such as whistling, barking, or booming dunes, are a unique natural phenomenon where sound is produced by the movement of sand. These sounds arise when sand grains, typically between 0.1 and 0.5 millimeters in diameter and rich in silica, move under specific conditions, including humidity and wind. A common frequency of these sounds is around 450Hz and in some cases they can be as loud as 105 decibels lasting for several minutes (Branney, 2015).

For the exact process that causes it different theories exist. Some researchers believe that the frequency of the sound is controlled by the rate at which the sand grains move (Nori et al., 2010). Others suggest that the sound is amplified by the resonance between the dry top layer of sand and a moist layer beneath it which creates a sound wave that echoes and increases in volume (Douady et al., 2006). These sounds, though they may seem mysterious, are indicative of specific environmental conditions, such as the moisture content and movement of the sand, both essential elements for the preservation of a sand based Juniperus forest.

Juniperus Forests: Ecological Sentinels in Fragile Ecosystems

Juniperus forests play a crucial role in various ecosystems, especially in arid and semi-arid regions. These forests thrive in areas with dry, rocky soils or sand and are able to survive in very harsh conditions, making them important indicators of environmental health (Adams, 2014). A healthy Juniperus forest contributes to the stability of its ecosystem by preventing soil erosion, maintaining the balance of local water systems and providing a habitat for a wide range of wildlife. In Gavdos in particular, they provide a natural habitat for many species of migratory birds.

However, Juniperus forests can also be vulnerable to environmental stressors such as prolonged drought, soil erosion and competition from invasive species (Pine trees in Gavdos). When Juniperus trees are stressed, it often signals broader ecological problems, such as desertification or climate change. The health of Juniperus forests is closely connected to the same environmental factors that affect the formation and the activity of singing dunes.

Interdisciplinary Hypothesis: Linking Sound and Science

The *Dytikos* piece serves as both an artistic representation and a scientific inquiry into the relationship between singing dunes and Juniperus forests. The persistent frequencies observed in the initial recordings led to the hypothesis that these sounds could be an acoustic reflection of environmental conditions affecting the forest. These frequencies are present almost every time the wind blows more than 3 Beaufort (approximately) from the

West. The soundscape thus becomes a tool for exploring whether changes in the acoustic properties of the soundscape might indicate changes in the health of the forest.

Environmental Interconnections: Soil, Erosion, and Climate

The potential link between singing dunes and Juniperus forests is rooted in the environmental context they share. Both are influenced by similar factors, such as soil conditions, moisture levels and climate. This section explores how these factors might create an indirect relationship between the presence of singing dunes and the health of Juniperus forests.

1. **Soil and Erosion:** Singing dunes usually form in areas with loose soil and little vegetation. This type of environment is also prone to soil erosion, which can threaten the stability of Juniperus trees by disrupting their roots and reducing soil fertility (Parker, 2012). If a Juniperus forest is very active by singing dunes, it could be a sign that soil erosion is occurring, potentially affecting the forest's health.
2. **Climate Conditions:** Singing dunes are more likely to form in dry, arid climates where the sand is loose and easily moved by wind. Similarly, Juniperus forests in these climates might suffer from water scarcity, leading to decreased tree health (Chambers et al., 1999). An increase in dune activity could indicate worsening dry conditions that might also harm nearby Juniperus trees.
3. **Vegetation Cover:** A healthy Juniperus forest helps to stabilize soil, making it less likely that dunes will form or move. Conversely, a forest in decline might have less vegetation, leading to more unstable soil and increased dune activity (Pérez, 2010). The large presence of active dunes in a Juniperus forest might suggest that the forest's health is declining due to reduced vegetation cover and less stable soil.

Without extensive field research, directly determining the health of a Juniperus forest solely by analyzing the frequency or intensity of singing dunes is not yet proven and the author of this paper was not able to find information connecting these phenomena. However, we can infer certain environmental conditions that may correlate with the health of the forest by examining the acoustic characteristics of the dunes. Here's how different aspects of the dunes' sounds might relate to forest health:

1. Frequency Content of Singing Dunes

- **High Frequency:** If the singing dunes produce higher frequency sounds (around 450 Hz or more), this could indicate that the sand grains are small and highly mobile. This situation might suggest that the surrounding area is experiencing significant dryness or erosion, potentially negatively impacting the Juniperus forest. Dry conditions reduce soil moisture, which is crucial for the health of Juniperus trees.
- **Low Frequency:** Lower frequency sounds might indicate larger, coarser sand grains, which could suggest that the dunes are more stable and less prone to movement. This stability could be a sign that the surrounding soil is more cohesive and possibly better vegetated, which would be beneficial for the health of the Juniperus forest.

2. Intensity of the Sound

- **High Intensity:** If the singing dunes produce very loud sounds (up to 105 decibels), it may suggest that the dunes are highly active, with significant sand movement. This could indicate environmental conditions such as strong winds and low vegetation cover, which could be harmful to the forest. High-intensity sounds might reflect an ecosystem under stress, with increased erosion and less protection for the soil, potentially leading to forest decline.
- **Low Intensity:** Softer dune sounds might indicate less movement of sand, which could correlate with a more stable environment, possibly with better soil moisture and vegetation. In such cases, the *Juniperus* forest might be healthier, as the reduced sand movement suggests a more stable and supportive environment for tree growth.

Field Work & Measurements

To test this hypothesis, comprehensive scientific measurements need to be conducted probably for several years. The growth rate of this *Juniperus* species is very slow. (approximately 1 cm per year). These measurements should integrate sound analysis (frequency, duration and intensity) with the physical measurements and subjective health of the trees. This approach will enable us to examine whether there is a precise or loose correlation between these two different fields. Our focus should be on a specific portion of the forest, likely in an area with large sand dunes. Given the difficulty of accessing the island of Gavdos, especially during winter, it would be ideal to deploy permanent mobile acoustic monitoring at strategic locations. This setup would allow us to collect a substantial amount of sound data throughout the year.

Limitations and Future Directions:

While the *Dytikos* soundscape and subsequent analysis provide a compelling basis for hypothesis formation, there are limitations to this approach:

- **Indirect Correlation:** The relationship between dune acoustics and forest health is likely indirect, influenced by multiple environmental factors. As such, dune sounds alone cannot definitively diagnose the health of *Juniperus* forests. However, they can offer valuable context for broader ecological assessments.
- **Data Complexity:** The complexity of ecological interactions means that multiple years of data collection and analysis are required to draw meaningful conclusions. Short-term studies may not capture the full range of environmental variables affecting the dunes and the forest.

Conclusion:

Dytikos, born from an artistic engagement with the natural environment of Gavdos, has evolved into a scientific exploration of the relationship between acoustic phenomena and ecological health. This interdisciplinary approach suggests that the sounds of singing dunes could serve as environmental indicators, potentially reflecting the health of nearby *Juniperus* forests. While further research is necessary to confirm these connections, this study highlights the potential of soundscape ecology as a tool for understanding and preserving fragile ecosystems.

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