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Sustainability in Seismic Acquisition

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Summary

Accurately imaging the subsurface with seismic, whether for traditional energy projects or in emerging cleantech areas such as geothermal, critical mineral exploration, carbon capture and storage, or nuclear waste management, requires the acquisition of a seismic survey. Generally, this involves deploying seismic sources and sensors in various patterns optimized to avoid surface exclusions and ensure operational efficiency. However, for more sustainable seismic solutions, these surveys can also be optimized for reduced environmental impact and lower greenhouse gas emissions. This can be accomplished by incorporating ecological data into the seismic planning and utilizing new innovations such as alternative sampling methods and equipment miniaturization. When combined with advances in seismic processing algorithms, the same subsurface data quality can be achieved, but with a significantly reduced environmental footprint (Crook, 2024; Crook et al., 2025). Through extensive collaboration between multiple disciplines (ecology, biology, geoscience, and engineering), the EcoSeis project has developed sustainable seismic solutions which can reduce both the surface land footprint and emissions associated with seismic acquisition by up to 50%. This case study will highlight lessons learned throughout the development, including best practices for acquiring and analyzing unbiased seismic experiments and applications of the technology in CCS monitoring.

Method

For large-scale resource projects, seismic data acquisition can be one of the most efficient methods, but in remote areas, seismic cut lines can result in substantive surface impact. For a more sustainable seismic solution, the seismic survey pattern can be optimized for reduced environmental impact by incorporating ecological data into the seismic planning and utilizing new innovations such as alternative sampling methods and equipment miniaturization to achieve a lower surface footprint. When combined with advances in seismic processing algorithms, the same subsurface data quality can be achieved as with traditional seismic survey methods, but with a significantly reduced environmental footprint.

To achieve perfect sampling of the subsurface, a 3D seismic surveys would need to be acquired with a continuous grid of source and receiver stations (full grid geometry) where receiver station interval = source station interval = receiver line interval = source line interval. Although ideal, this method is often cost-prohibitive or impossible due to surface constraints. The resulting interconnected, orthogonal seismic cutlines increase anthropogenic footprint, which can negatively affect sensitive species and habitats (Larson et al., 2020). Additionally, in areas with limited access and various environmental constraints such as sensitive habitats and mountainous terrain sparse orthogonal geometries with large station-to-line ratios have traditionally been used, and although a decent structural image is often attained, advanced geophysical analyses that rely on accurate seismic attributes become less reliable due to the sparse offset and azimuth sampling and low trace density at the near offsets (Crook et al., 2025).

Recent advances in equipment miniaturization (Crook et al., 2021) and acquisition methods (Crook, 2018, 2019) are enabling new 3D survey geometries such as alternative linear geometries to overcome these challenges. For example, parallel geometries have the potential to significantly reduce the land footprint associated with seismic acquisition with some methods, such as EcoSeis™ achieving up to a 50% reduction in seismic cut lines while maintaining subsurface data quality and enabling safe and efficient field operations (Crook, 2022; Naghizadeh et al., 2023, Goodway et al., 2025).

Results

This case study will present results from the EcoSeis™ project, a collaborative investigation between multiple disciplines (ecology, biology, geoscience, and engineering) into methods for reducing the environmental footprint of seismic exploration while maintaining data quality and enabling safe and efficient field operations. Learnings and best practices from recent field trials will be shared. This will include both technical results for improved subsurface imaging as well as results from the first full-scale operational test acquired in winter 2024/25, highlighting the efficiency of the technology and the surface land footprint reduction benefits.

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