Noninvasive Ground Penetrating Radar Investigation of *Fallicambarus fodiens* Subsurface Habitations

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Abstract

Ground penetrating radar (GPR) is a geophysical technique that uses electromagnetic energy to image and identify subsurface objects and structures. This methodology has been used in areas such as geology, archaeology and engineering; however, recent research has applied this geophysical method within the zoological community. Several studies have discussed the utility and benefit of using GPR to image wombat burrows, badger setts, gopher tortoise burrows, and pocket gopher tunnels. Our team sought to determine if subsurface structures constructed by burrowing crayfish could be imaged noninvasively, despite their comparatively smaller burrow sizes. In previous research, imaging crayfish burrows was a challenge when collecting data in clay derived soils. However, given the proper timing of rainfall and ground water infiltration, imaging of crayfish related structures in silt loam and clay soils is possible. Our studied species, the Digger Crayfish (*Fallicambarus fodiens*), was located and observed in southern Illinois, and 3D GPR scans were conducted and collected. The preliminary data show various subsurface anomalies where crayfish burrows (i.e. crayfish chimneys) were observed above ground. These anomalies were interpreted as subsurface structures created by crayfish activity.

Introduction & Background

GPR methods are commonly used to detect and analyze subsurface objects, such as gravesites, soil profiles, bedrock, and infrastructure. Recently the zoology community has used GPR to locate subsurface animal structures and to produce 3D rendered models of these zoological habitations. However, review of the literature suggests very limited applications of GPR to study crayfish. A research group in Georgia attempted to scan for crayfish burrows in both sandy soils and clay soils. As expected, they found that it was more difficult to obtain usable GPR data within the clay soil; however, crayfish actually preferred clay as sandy soil produced unstable burrows. Their study did not provide detailed images of individual burrows. However, we believe that depending on the timing of rain water infiltrating the soil, clay derived soils might produce usable GPR data and provide rendered 3D images of subsurface crayfish structures. In southern Illinois, burrowing crayfish are very common in and near streams, ponds and lakes, and in agricultural fields and ditches. Crayfish construct their subsurface structures usually in a "L" shaped burrow that extends down into the water table. Our team collected data from two sites: 1) near the lake at Ferne Clyffe State Park, Johnson County, IL and 2) in an agriculture field near Du Quoin, Perry County, IL (Figures 1-3). Site 1 has a Hosmer silt loam soil overlying clay, whereas Site 2 has a Cisne silt loam soil overlying clay. The Digger Crayfish (*Fallicambarus fodiens*) species of crayfish (Figure 4) was identified at Site 1 and photographed at Site 2 (Figure 5).

Methods

A 10m x 10m grid was established at each field site where apparent crayfish burrows (chimneys) where located on the surface. After field testing a GSSI SIR 4000 digital GPR system, data acquisition parameters were determined and GPR profiles were collected using a 400MHz antenna. Data collection parameters are listed in Table 1. A total of 202 GPR profiles (2km) were collected in a grid pattern every 10cm along the x and y axis at each site. Data were processed and interpolated using the GPR-Slice® software. The data was gained and dewowed, filtered to remove noise, gridded, velocity migrated, interpolated and rendered to produce horizontal depth slices and 3D subsurface models as displayed in the results section.

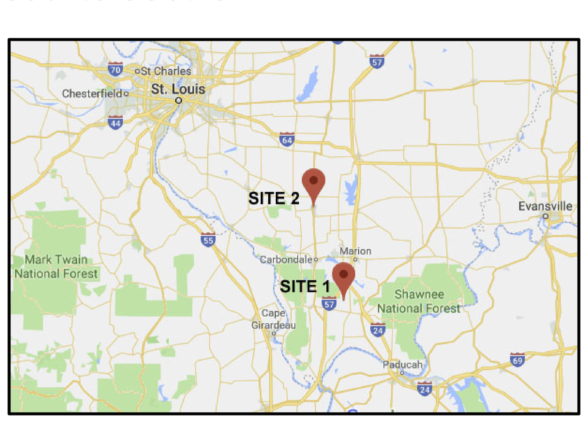

Figure 1. Index Map of study areas in southern IL.

Figure 2. Site 1 (yellow box) near the lake at Ferne Clyffe State Park in northwestern Johnson County, IL.

Figure 3. Collecting GPR data at Site 1 along Ferne Clyffe lake.

Table 1. Parameters

GPR System	GSSI SIR 4000
Antenna Frequency	400 MHz
Software	GPR-Slice
Samples/scan	512
Scans (Traces) per Profile	501
Distance Between Scans	2 cm
Profile Separation	10 cm

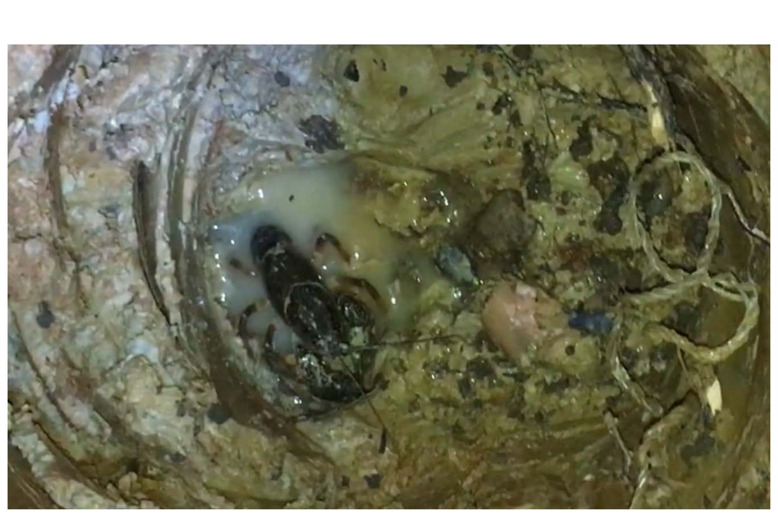

Figure 4. Crayfish (*Fallicambarus fodiens*), at Site 1.

Figure 5. Digger Crayfish (*Fallicambarus fodiens*), at Site 2.

Results

2D vertical profiles, horizontal depth slices and 3D isosurfaces for each site are displayed in Figures 6 and 7, respectively. Several GPR reflections were observed on the vertical profiles and interpreted as crayfish burrows (Figures 6a and 7a). The vertical profiles were interpolated into 3D blocks and horizontally sliced to produce depth slices (Figures 6b and 7b). Finally, the 3D data were rendered into isosurfaces to produce 3D models of the subsurface in an attempt to isolate crayfish burrows for both sites (Figures 6c and 7c).

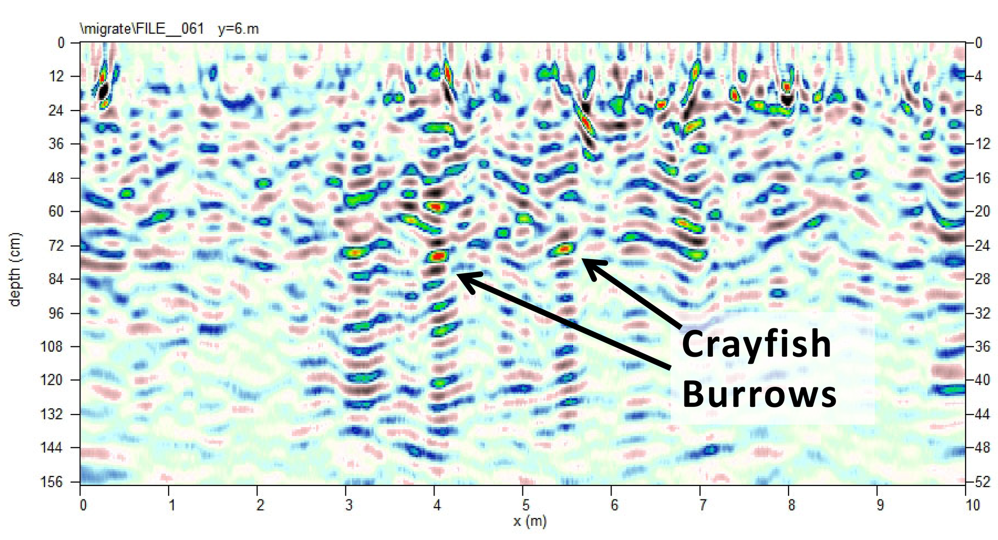

Figure 6a. 2D vertical GPR profile at Site 1 near along Ferne Clyffe lake.

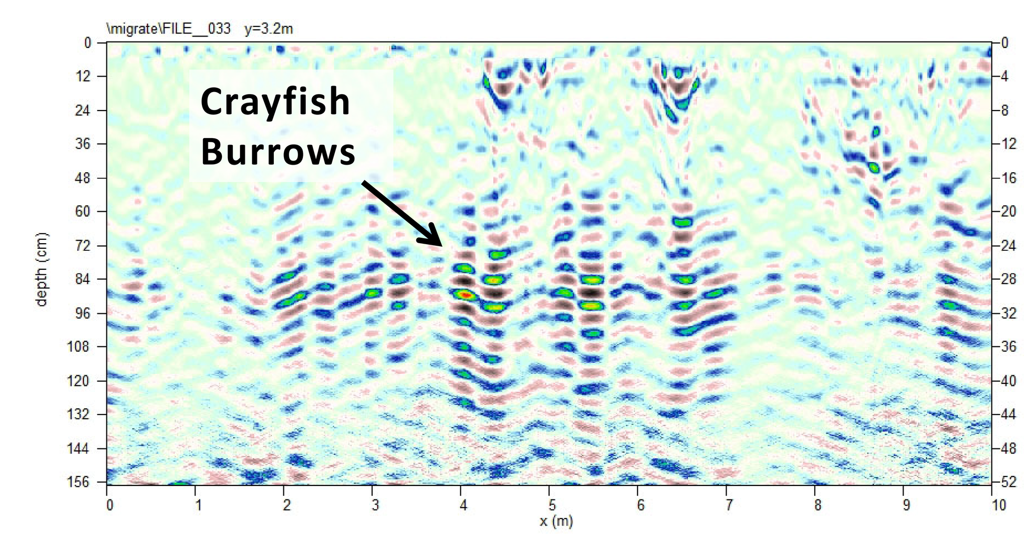

Figure 7a. 2D vertical GPR profile at Site 2 at Vancil Farm near Du Quoin, IL.

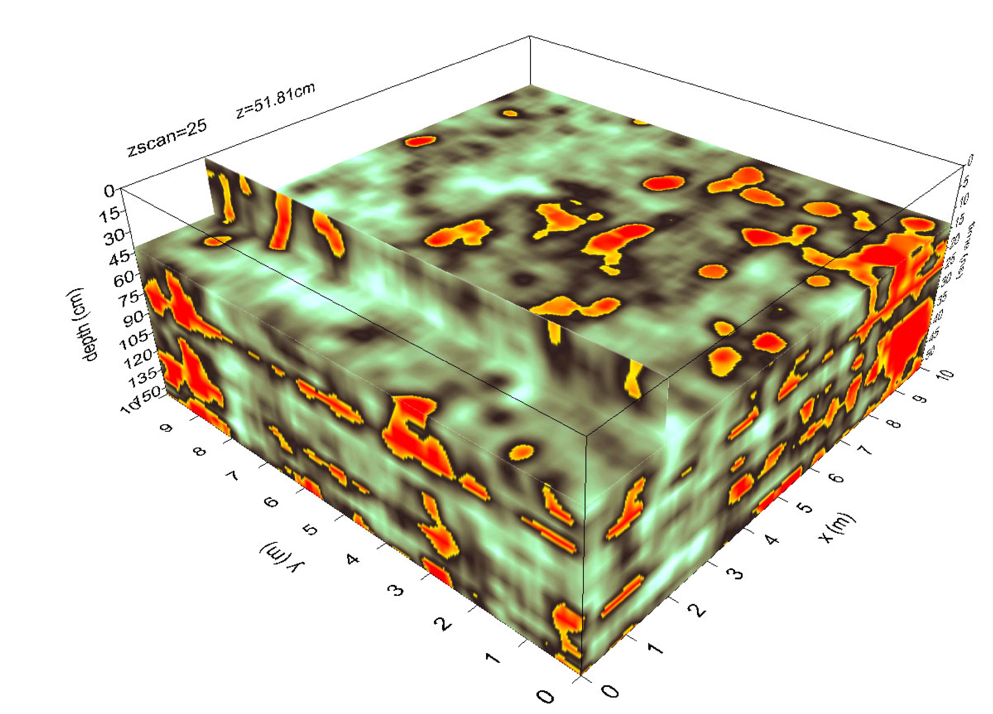

Figure 6b. Horizontal depth slices at Site 1 near Ferne Clyffe lake.

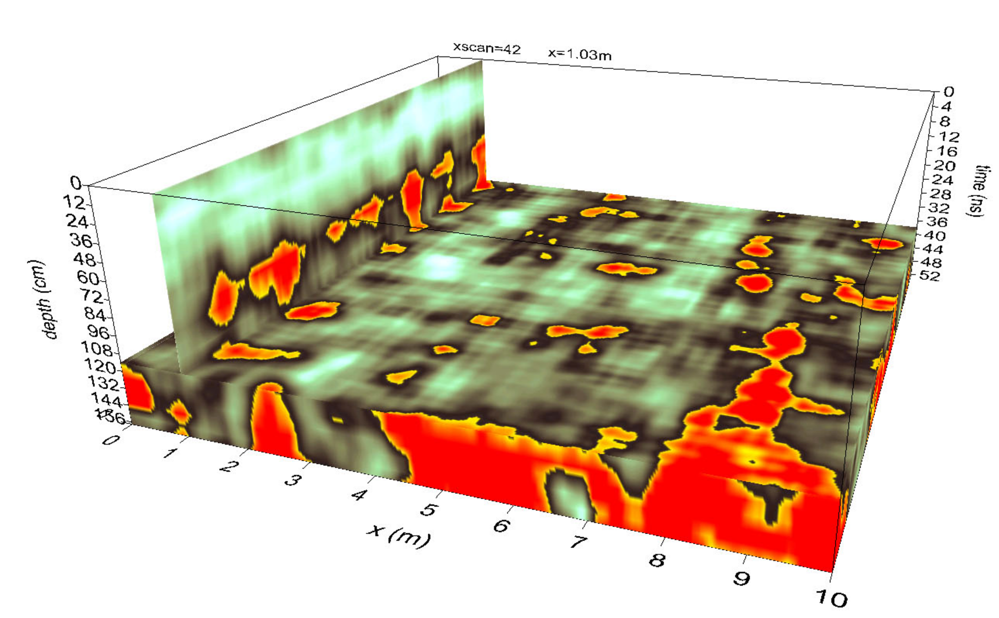

Figure 7b. Horizontal depth slice at Site 2 at Vancil Farm near Du Quoin, IL.

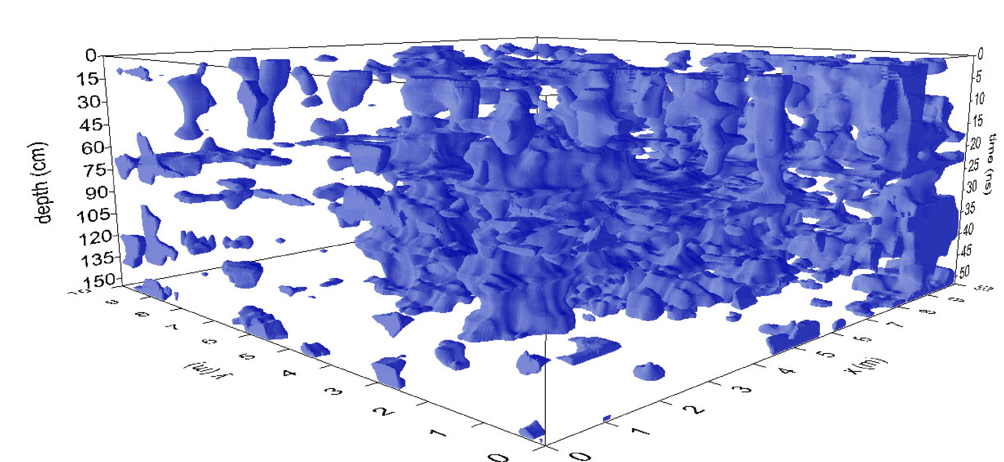

Figure 6c. Isosurface (3D model) of GPR data at Site 1 near Ferne Clyffe lake.

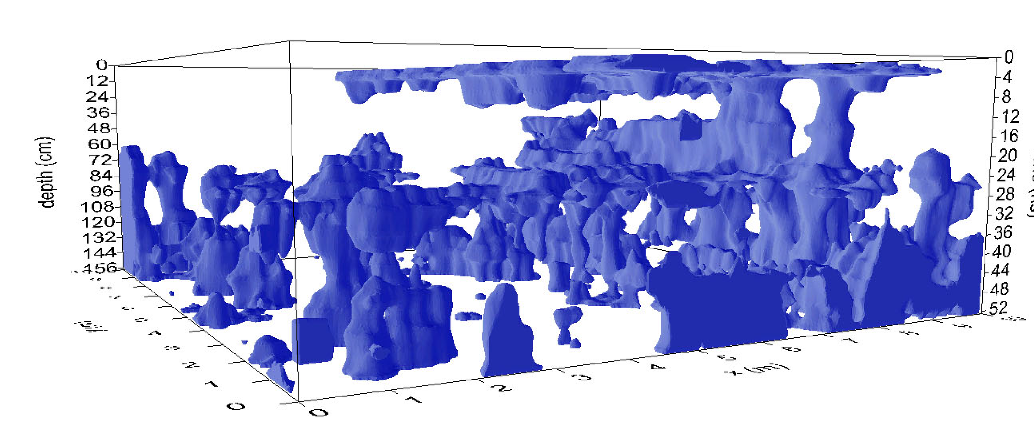

Figure 7c. Isosurface (3D model) of GPR data at Site 2 at Vancil Farm near Du Quoin, IL.

Discussion

Our goal was to test the suitability of using GPR to image subsurface crayfish structures. Results reveal that under the proper environmental conditions and using the appropriate acquisition equipment and parameters, crayfish burrows may be imaged and 3D isosurfaces of crayfish habitation may be produced from the GPR data. Although several crayfish burrows were imaged reasonably well, it appears that the relatively small diameter burrows might not have been adequately sampled with a profile spacing of 10cm and scan spacing of 2cm. We plan to repeat the experiment with a line spacing of 5cm in order to better image the smaller crayfish burrows.

Conclusion

Crayfish burrows were successfully imaged and modeled despite difficulties caused by conductive and saturated soils with a high clay content. The data resolution and fidelity of the GPR anomalies are less than desirable; therefore, some acquisition parameters must be tweaked during future studies. For example, higher GPR frequencies, such as 500, 800 or perhaps 1000 MHz might produce better results. Also, careful attention should be given to the weather conditions and the amount of runoff and groundwater in the soil. Additionally, the line spacing should be decreased to 5cm, and attention should be given to reduce line intersection and grid noise. As part of future work, GPR data will be collected during drought or low water infiltration periods to determine if data resolution and results may be improved.

Acknowledgements

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