Florida Institute of Technology

Scholarship Repository @ Florida Tech

Ocean Engineering and Marine Sciences Student Publications

Department of Ocean Engineering and Marine Sciences

4-2019

A GIS-Based Synthesis Of Relict Shorelines In Pennsular Florida

Justin O. Hardin
Florida Institute of Technology

Follow this and additional works at: https://repository.fit.edu/oems_student

Recommended Citation

Hardin, Justin O., "A GIS-Based Synthesis Of Relict Shorelines In Pennsular Florida" (2019). *Ocean Engineering and Marine Sciences Student Publications*. 2.
https://repository.fit.edu/oems_student/2

This Article is brought to you for free and open access by the Department of Ocean Engineering and Marine Sciences at Scholarship Repository @ Florida Tech. It has been accepted for inclusion in Ocean Engineering and Marine Sciences Student Publications by an authorized administrator of Scholarship Repository @ Florida Tech. For more information, please contact kheifner@fit.edu.

A GIS-BASED SYNTHESIS OF RELICT SHORELINES IN PENINSULAR FLORIDA

By

JUSTIN O. HARDIN

APRIL 2019

ABSTRACT

A literature review as well as a consultation with a geomorphologist, Dr. Christopher P. Williams, at the Florida Geological Survey (FGS) were both performed in order to understand the state of knowledge on relict shorelines in peninsular Florida. This knowledge was compiled into a map, Figure 1, that shows the locations and relative ages of geologically confirmed relict shorelines in the Florida peninsula. A number of additional required areas of research in order to "complete" the map are then discussed. The project highlights both the rapidity of Florida's Pliocene-Pleistocene coastal evolution and the relatively high amount of incompleteness still present in the current state of knowledge on Florida relict shorelines.

INTRODUCTION

THE RELICT SHORELINE CONCEPT

It is important to first define the meaning of the term "relict shoreline" for the purpose of this research. "Relict shoreline" is herein defined as geological evidence that the interface between the terrestrial environment and the marine environment existed at a particular location in the past. This definition is crafted in such a way because the geological evidence is not enough to make conclusions as specific as where the water line existed at a particular time, *etc.*, but instead is treated as a general indicator of the existence of a shoreline in the past. Additionally, automatically conflating the elevation of a relict shoreline with past sea level should be avoided, since geologic processes such as uplift can cause a relict shoreline to be preserved at an elevation different from the original elevation where it was formed. Such effects have been found to have occurred even in Florida (Opdyke, Spangler, Smith, Jones, & Lindquist, 1984). Synonyms for "relict shoreline" often found in the literature include "paleo-shoreline," "ancient shoreline," and "relict shoreface." Where older literature may use some of these terms to refer to certain geological evidence, herein the term "relict shoreline" will always be used.

The emphasis of geological evidence in this definition of "relict shoreline" is necessary. This is because archaeological evidence has also been used in the demarcation of relict shorelines, to a point (Johnson & Stright, 1992). Archaeological evidence, whereas not invalid, falls outside of the scope of this paper.

PURPOSE

The primary purpose of this project is to create a visualization (Figure 1) of Florida's Plio-Pleistocene coastal evolution using the evidence derived from geomorphic features and showing the approximate ages (as best as can be established, usually relative ages) of these relict shorelines. Although these ridges are sometimes still the focus of research, much of the information used to build the GIS product comes from a Florida Geological Survey bulletin from 1970 on Florida's geomorphology (White, 1970). A landmark update to White (1970) is currently in progress at the time of this writing, being authored by Williams, Scott, Upchurch, Hannon, & Paul (in preparation) at the Florida Geological Survey. There is still other interest in these geomorphic features, sometimes for commercial purposes (see Practical Significance subheading below) and to limnologists (Canfield & Hoyer, 1988), but there have not been any recent efforts to utilize GIS to create a visualization specifically focusing on the ancient Florida shorelines that they represent until now.

This GIS-based visualization, the product of this research, will be useful both as a resource for those who may be interested in Florida's coastal evolution in the future, as well as a tool for education that could be useful for any county, *etc.* that may want to highlight the fact that these significant landscape features are in fact windows into the geologic history of the Florida coast. This paper also serves to highlight the fact that further research is still required on this topic. As will be seen in the Results and Discussion sections, the body of evidence needed to fully correlate and lay out these relict shorelines in a complete picture of coastal evolution is not yet present. The Discussion section will elaborate on which specific details are not yet clear and require additional research in the future.

BEACH RIDGES

At the core of geological determination of relict shorelines are beach ridges. As discussed by Tamura (2012), there are multiple types of beach ridges, including storm-built, eolian, and berm ridges, as well as contention over the exact definition of a beach ridge. Because this paper is focused on relict shorelines in general, the differences between beach ridge types and any contention will be inconsequential, including whether or not there is a large eolian component, *i.e.* any geologic evidence for a relict shoreline will be used. It should also be noted that many of the physiographic features included in this research are not single beach ridges, but are actually a feature made up of a succession of ridges; that is to say, Lake Wales Ridge, for example, consists of more than one parallel sand ridge (C.P. Williams, personal communication, March 15, 2019).

RELATIONSHIP TO PALEOCLIMATOLOGY

Although it is tempting to associate central Florida's high-elevation sand ridges (up to approximately 300 feet) with a high stand of sea level, investigations have found that this is not the case. Adams (2010) noted that paleoclimatological research from other locales had found no evidence for a high stand of sea level close to those elevations within the past 1.5 million years. Karst-associated uplift has instead been proposed as an avenue by which central and northern Florida sand ridges have reached these high elevations (Adams, Opdyke, & Jaeger, 2010). Further confounding the problem is the fact that it is not known how much of the elevation of any given ridge is due to some mode of uplift, so even attempting to reckon the original elevations is an unreliable method. Therefore, relict shorelines of Pliocene and Pleistocene ages in Florida have little usefulness or meaning in the determination of past sea level.

The same is true for relict shorelines of very recent age. According to Tamura (2012), variations in height which are not associated with differences in sea level are so statistically great that they are of little use in describing changes of sea level which are not significant enough to fall outside of this range of variation. More modern ridge features that exist very close to the present shoreline may preserve evidence of storm patterns, *etc.* in the recent past (Tamura 2012) but these are not relevant in illustrating any great changes in Florida's shorelines over time.

Thus, relict shorelines in Florida should not be considered paleoclimatological markers for sea level. The map of relict shorelines and their ages herein should be thought of in terms of an illustration of the evolution of Florida's coastline and not associated with a significant (~300 foot) regression in sea level.

PRACTICAL SIGNIFICANCE

Although not yet of particular use in paleoclimatological study of ancient sea level, Florida's relict shorelines and associated sand ridges are of some interest in the realm of economic geology. The sand from these beach ridge deposits is mined, both as an alternative to the use of offshore sand in civil engineering projects, and for a number of industrial uses (Lewis, 2010). In addition to this, heavy minerals are often found in association with beach ridge deposits; there has been interest in and exploitation of these heavy minerals, especially titanium derived from ilmenite (Pirkle, Pirkle, & Rich, 2013).

METHODS

LITERATURE REVIEW

The primary reference for this project are the physiographic maps of Florida and accompanying report prepared by White (1970) in FGS Bulletin 51, entitled *The Geomorphology of the Florida Peninsula*. A review of the literature was performed when additional information about specific physiographic features, such as ages and correlations, was required. In many cases, available literature was sparse. Because of this, assistance was required from the Florida Geological Survey, in particular Dr. Christopher P. Williams, who at the time of this writing is preparing a lengthy publication on the geomorphology of Florida (Williams *et al.*, in preparation). In cases where such as-of-yet unpublished information or wisdom from experience was utilized, an in-text personal interview citation accompanies it. FGS also provided a DEM (digital elevation model) dataset which is used *e.g.* in the Discussion section below to help identify areas of needed future research.

MAP CREATION

The map of relict shorelines shown in Results (Figure 1) was created with the use of the relevant polygons from White (1970) (ESRI, 2016). Because White (1970) included Florida county borders in his physiographic map of the state, they are used to appropriately position the polygons. The county borders are lined up with those of White (1970) plates 1-B (north peninsular Florida) and 1-C (south peninsular Florida) by way of overlaying, since White (1970) does not provide any specific coordinates for more accurate georeferencing. In the Discussion section, a few changes and updates to White (1970) are noted. Most importantly, only relict shorelines with confirmed geological evidence are displayed on the map. In addition, very geologically recent features that are directly adjacent to the present-day shoreline are not mapped herein.

RESULTS

MAP

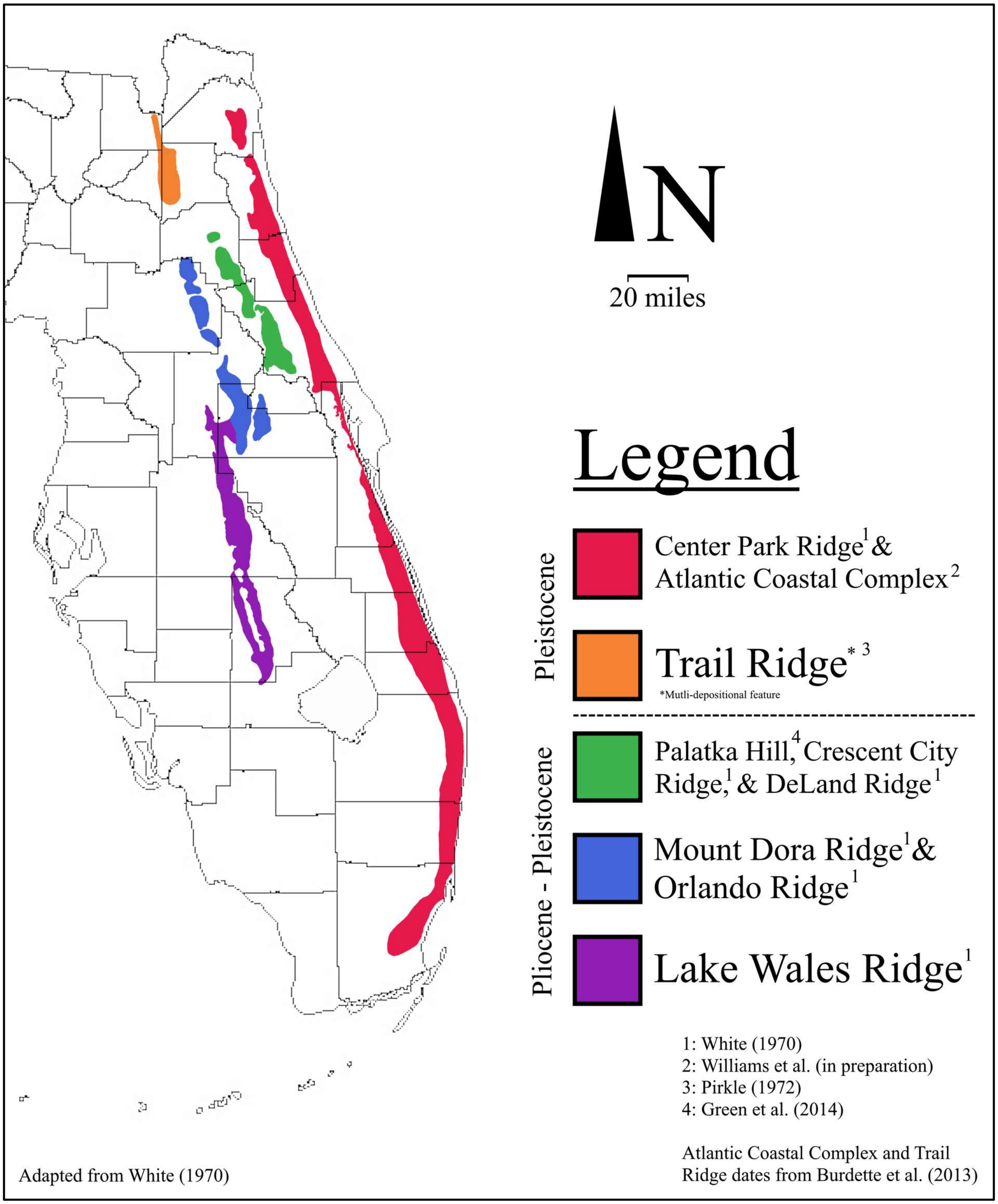

Figure 1: Map of relict shoreline features expressed on the Florida peninsula. Note that the listed ages represent the age of the material that is derived from relict shorelines.

DISCUSSION

CYPRESSHEAD FORMATION

The Cypresshead Formation and reworked Cypresshead Formation as seen on surficial geological maps (Scott et al., 2001) are indicative of sand bodies that may represent relict coastal features. However, because there were multiple depositional stages for this formation (Fountain, 2010), the fact that something may be mapped as Cypresshead Formation or reworked Cypresshead Formation cannot help narrow down an age further than Plio-Pleistocene. This is relevant in the case of Palatka Hill, which is now mapped as Cypresshead Formation (Green *et al.*, 2014) and therefore, is considered in Figure 1 to be a northern existing edge of Crescent City Ridge. This is also relevant to the way in which most of the ridge dates are displayed in the map (Figure 1) because all of the displayed ridges that are mapped as Cypresshead Formation are reliant on relative dating. The general rule is that ridges further east are younger than those to the west of them, with Lake Wales Ridge as the oldest, as is the logical succession.

CHANGES AND UPDATES

Some of physiographic features mapped by White (1970) are planned to change names or become grouped with other features under new names in the currently in-progress update by Williams *et al.* (in preparation); most prominently, the feature referred to as the Atlantic Coastal Complex in the map (Figure 1) includes ridges that White (1970) mapped as the Atlantic Coastal Ridge (north section), Espanola Hill, Ten Mile Ridge, Fellsmere Ridge (mapped as part of Ten Mile Ridge), and Green Ridge. Its western extent in Volusia and Flagler counties is increased in the update by Williams *et al.* (in preparation). It is extended all the way south to border with the southerly feature that White (1970) also mapped as the Atlantic Coastal Ridge. This southerly feature will retain its name, being a carbonate-dominated analogue to the new Atlantic Coastal Complex (Williams *et al.*, in preparation).

The feature mapped as Palatka Hill by White (1970) will be considered a northerly extent of Crescent City Ridge which has been separated from the main body by erosion. This is justified by the relatively recent remapping of Palatka Hill as Cypresshead Formation in Green *et al.* (2014).

OMISSIONS

Some physiographic features that White (1970) mapped as ridges are not included in this paper. Physiographic features that do not appear either in the previous map (Figure 1) or in the following discussion cannot be clearly defined as relict shorelines (C.P. Williams, personal communication, March 15, 2019) or in a few cases are very geologically recent features adjacent to the modern shoreline. Table 1 below lists the reasons why specific features were not included.

Table 1: Explanations for why certain physiographic features mapped by White (1970) are omitted in the map (Figure 1).

Feature	Reason
Bell Ridge	The origin of Bell Ridge sand has several hypotheses [1] [2].
Brooksville Ridge	Relevance to relict shorelines is unclear, excepting for erosional escarpments on its western flank [1].
Cotton Plant Ridge	Relevance to relict shorelines is unclear [1].
Bombing Range Ridge	Presently being mapped by the Florida Geological Survey [1].
Welaka Hill	Not a separate feature from Crescent City Ridge [3].
Geneva Hill	Feature most recently mapped as undifferentiated Quaternary sediments [4].
Silver Bluff Scarp	A shoreline of Pamlico age visible in the Miami area that runs along the southeast edge of the Atlantic Coastal Ridge in Figure 1; the feature is too small scale to be shown on the map [2].
Caloosahatchee Incline	Nature of formation is submarine [2].

1: C.P. Williams, personal communication (March 15, 2019)
2: White (1970)
3: Williams *et al.* (in preparation)
4: Green *et al.* (2015)

ORLANDO RIDGE

White (1970) correlates the Mount Dora Ridge and Orlando Ridge, expressing that Orlando Ridge represents a cape feature similar to what we see today at Cape Canaveral. Adams (2018) suggests that Cape Canaveral may be a paleodelta feature, which casts some doubt on

Orlando Ridge being an ancient analogue of the present features. It is possible that Orlando Ridge is contemporaneous with Mount Dora Ridge, but is submarine in its nature of formation (as it exists at a lower elevation); however, it could also be subaerial and younger than Mount Dora Ridge (C.P. Williams, personal communication, March 15, 2019). The interpretation of White (1970) is used herein pending further research.

TRAIL RIDGE

Trail Ridge represents a special case amongst the mapped ridges because absolute age dating data is available for it in Burdette, Rink, Mallinson, Means, & Parham (2013). Burdette *et al.* (2013) found ages at two sites along the main body of Trail Ridge as mapped by White (1970) that dated from 0.72 – 2.21 Ma (millions of years ago) (another sample was dated at 3.43 Ma but had an error of 1.65 Ma plus or minus). Thus, Trail Ridge is denoted as a multi-depositional feature with a range of ages. Burdette *et al.* (2013) also provides some controls on ages within the Atlantic Coastal Complex.

FURTHER POSSIBILITIES

There are several cases in which the available DEM (digital elevation model) data (Florida Geological Survey, 2016) reveal the location of other sand bodies and/or ridges that should be investigated, such as:

- A feature unmapped by White (1970) south of Yulee Hill. Yulee Hill and Roses Bluff, roughly geometrically in a line, should also be investigated, as there is documentation of heavy mineral sands near Yulee (Pirkle, Pirkle, Pirkle, & Stayert, 1984). Evergreen Hill to the west should also be investigated.
- An insufficiently investigated sand ridge noted by White (1970) running along the western side of Brooksville Ridge.
- A feature mapped as beach ridge and dune (Scott *et al.*, 2001) very roughly parallel with the modern coastline in western Taylor County.
- A physiographic feature that will be known as Lake City Ridge running approximately east to west in the area White (1970) mapped as the Northern Highlands, plus additional features south of that ridge which are parallel to it; these will be referred to as the Raiford Ridges (Williams *et al.*, in preparation).

- Much of what White (1970) mapped as the Duval Upland, a large portion of which is mapped as Cypresshead Formation (Scott *et al.*, 2001).
- A southeastern portion of what White (1970) mapped as the Sumter Upland, which is mapped as Cypresshead Formation (Scott *et al.*, 2001).
- Lakeland Ridge, Winter Haven Ridge, Gordonville Ridge, and Lake Henry Ridge, which will be grouped with Lake Wales Ridge in a feature called the Lake Wales Ridge Complex (Williams *et al.*, in preparation). The timing and nature of these ridges remain unclear (C.P. Williams, personal communication, March 15, 2019).

CONCLUSION

The map (Figure 1) displays the current extent of ancient relict shorelines for which geological evidence is present in peninsular Florida. It is hoped that additional geological investigation will result in another product of a similar type sometime in the future with improved information regarding the extent and number of features as well as improved information about the relative and absolute ages of the features. The two main overarching themes that need to be further studied are: 1) the rapidity of Florida's coastal evolution in the Plio-Pleistocene geologic epochs, noting that some locations currently directly on the coast such as Amelia Island and Big Talbot Island have Pleistocene cores (Pirkle, Pirkle, & Rich, 2013) and 2) the overall incompleteness of the evidence required for many features to be confirmed as relict shorelines. The Discussion section of this review indicates many of the locations, which require further research, although it does not represent a comprehensive list.

ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. Gary Zarillo, for introducing me to this topic and for providing general wisdom, access to software, and revision expertise. I thank my other committee members, Dr. Charles Bostater and Dr. Gordon Patterson. I would also like to thank Dr. Christopher P. Williams at the Florida Geological Survey for taking the time to provide insights on the current state of relict shoreline research in Florida, as well as providing references that I would not have otherwise located. I'd like to thank Dan Phelps at FGS for getting me in contact with Dr. Williams; I thank my colleague Sara Ramos for software technical assistance, and I thank William Pross for hardware technical assistance.

REFERENCES

Adams, P. N. (2010). A plausible explanation for raised coastal ridges and terraces along the axis of peninsular Florida. In M. V. Hurst (Ed.), *Central Florida's Sand Mining District* (Field Trip Guidebook No. 50, pp. 36-40). Tallahassee, FL: Southeastern Geological Society.

Adams, P. N. (2018). Geomorphic origin of Merritt Island-Cape Canaveral, Florida, USA: A paleodelta of the reversed St. Johns River? *Geomorphology, 306*, 102-107.

Adams, P. N., Opdyke, N. D., & Jaeger, J. M. (2010). Isostatic uplift driven by karstification and sea-level oscillation: Modeling landscape evolution in north Florida. *Geology, 38*(6), 531-534.

Burdette, K. E., Rink, W. J., Mallinson, D. J., Means, G. H., & Parham, P. R. (2013). Electron spin resonance optical dating of marine, estuarine, and aeolian sediments in Florida, USA. *Quaternary Research, 79*(01), 66-74.

Canfield, D. E., & Hoyer, M. V. (1988). Regional Geology and the Chemical and Trophic State Characteristics of Florida Lakes. *Lake and Reservoir Management, 4*(1), 21-31.

ESRI (2016). ArcGIS (Version 10.5) [Computer software].

Florida Geological Survey (2016). *Florida Digital Elevation Model.* Tallahassee, FL: Florida Department of Environmental Protection.

Fountain, K.B. (2010). Depositional and facies characteristics of the Cypresshead Formation in north-central Florida. In M. V. Hurst (Ed.), *Central Florida's Sand Mining District* (Field Trip Guidebook No. 50, pp. 14-27). Tallahassee, FL: Southeastern Geological Society.

Green, R.C., Williams, C.P., Bambach, P.W., Hannon, L.M., Apolinar, B., Campbell, K.M., & Dyer, S.B. (2015). *Geologic map of the USGS Orlando 30x60 minute quadrangle, central Florida,* Florida Geological Survey Open-File Map (Ser. 107) [3 plates].

Green, R.C., Williams, C.P., Campbell, K.M., Bambach, P.W., Hannon, L.M., Bassett, S.W., Evans III, W.L., Paul, D.T., & Apolinar, B. (2014). *Geologic map of the USGS Saint Augustine 30x60 minute quadrangle, northeast Florida,* Florida Geological Survey Open-File Map (Ser. 106) [3 plates].

Johnson, L. L., & Stright, M. (1992). *Paleoshorelines and prehistory: An investigation of method*. Boca Raton: CRC Press.

Lewis, M. (2010). Commercial sand production at the CEMEX Davenport sand mine, Polk County, Florida. In M. V. Hurst (Ed.), *Central Florida's Sand Mining District* (Field Trip Guidebook No. 50, pp. 54-58). Tallahassee, FL: Southeastern Geological Society.

Opdyke, N. D., Spangler, D. P., Smith, D. L., Jones, D. S., & Lindquist, R. C. (1984). Origin of the epeirogenic uplift of Pliocene-Pleistocene beach ridges in Florida and development of the Florida karst. *Geology, 12*(4), 226.

Pirkle, E. C., Pirkle, F. L., Pirkle, W. A., & Stayert, P. R. (1984). The Yulee heavy mineral sand deposits of northeastern Florida. *Economic Geology, 79*(4), 725-737.

Pirkle, F. L., Pirkle, W. A., & Rich, F. J. (2013). Heavy-Mineral Mining in the Atlantic Coastal Plain and What Deposit Locations Tell Us about Ancient Shorelines. *Journal of Coastal Research, 69*, 154-175.

Pirkle, W.A. (1972). Trail Ridge, a relict shoreline feature of Florida and Georgia [Ph.D. thesis]: Chapel Hill, University of North Carolina.

Scott, T. M., Campbell, K. M., Rupert, F. R., Arthur, J. D., Green, R. C., Means, G. H., Missimer, T.M., Lloyd, J.M., Yon, J.W., & Duncan, J.G. (2001). Geologic Map of the State of Florida [Map]. (Ser. 146). Tallahassee, FL: Florida Geological Survey.

Tamura, T. (2012). Beach ridges and prograded beach deposits as palaeoenvironment records. *Earth-Science Reviews, 114*(3-4), 279-297.

White, W. A. (1970). *The geomorphology of the Florida Peninsula*, Florida Geological Survey Bulletin 51. Tallahassee, FL: Bureau of Geology, Division of Interior Resources, Florida Dept. of Natural Resources.

Williams, C.P., Scott, T.M., Upchurch, S.B., Hannon, L.M., and Paul, D.T., in preparation, *Florida Geomorphology*, Florida Geological Survey Bulletin 72.