Guy H. Means
State Geologist and Director

REPORT OF INVESTIGATION #123, Plate 3
SURFACE GEOMORPHOLOGY OF THE TRAIL RIDGE PLACERS, FLORIDA FOCUS AREA

2026

BY

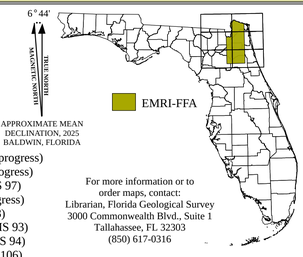
MARY E. LUPO, (P.G. # 3134), BENJAMIN L. DAVIS, ERICKA L. MCMAHAN, AND GUY H. MEANS

ADJOINING MAPS

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1. Okefenokee Swamp (In progress)
2. Fernandina Beach (In progress)
3. Lake City - West (OFMS 97)
4. Lake City - East (In progress)
5. Jacksonville (OFMS 108)
6. Gainesville - West (OFMS 93)
7. Gainesville - East (OFMS 94)
8. Saint Augustine (OFMS 106)

Statewide - Florida Geomorphology Atlas (SP 59)



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Qualification: This map was created using Florida Department of Environmental Protection (DEP) databases and data obtained by the Florida Geological Survey (FGS). Lidar used for the completion of this basemap was delivered by the county area and mosaiced to cover the entire study area. A hillshade with an adjusted scale and Z Factor of 50 is displayed. The map entered review in August of 2023 and was completed in 2025. This document is prepared for the presentation of the geologic information shown and is not intended to replace site-specific or use-specific investigations. Cooperatively funded by the DEP/FGS and the U.S. Geological Survey (USGS) Earth Mapping Resource Initiative under USGS assistance award number G20AC00169. The views and conclusions in this document are those of the authors and should not be interpreted as necessarily representing the opinions or official policies, either expressed or implied, of the DEP, FGS, the State, or the U.S. Geological Survey or U.S. government.

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EMRI-FFA Geomorphology

Text from Williams et al. (2022)

Barrier Island Sequence District - The Barrier Island Sequence District (Clark and Zisa, 1976) continues from Florida into Georgia and, based on regional lidar data, likely continues northward into Virginia, where similar coastal geomorphology extends up the Atlantic Coast. The Barrier Island Sequence District defines roughly 1,900 square miles of the surficial geomorphology in the EMRI-FFA. This district is characterized by north-south trending Pliocene-Holocene beach ridge systems, barrier island complexes, lagoons, embayments, and shallow water terraces. The modern topographic surface represents the periodicity of sea-level stands from the Pliocene to modern day and the subsequent development and evolution of strand plains, tidal marshes, and barrier islands. Additionally, major rivers throughout the region have affected surface landforms helping to guide deposition and erosion and provide transport mechanism for the mineralogic framework observed in Florida's placer deposits. The Barrier Island Sequence District is composed of 11 distinct provinces, six of which occur in the EMRI-FFA.

Atlantic Coastal Complex Province - The Atlantic Coastal Complex Province extends from the St. Johns River in Duval County to northeastern Palm Beach County. The Atlantic Coastal Complex Province consists of Quaternary barrier islands, beach ridges, dunes, and estuaries. Water bodies and wetlands landward of the barrier islands include lagoons, small embayments, and tidal marshes in the north that transition to mangrove swamps to the south. Within the EMRI-FFA study area, the surficial stratigraphic units that affect the landforms in the Atlantic Coastal Complex Province include Tertiary-Quaternary undifferentiated shelly sediments, Quaternary undifferentiated sediments, and Quaternary beach ridge and dune sediments. Holocene undifferentiated sediments occur on many of the barrier islands and in the tidal marsh/mangrove estuaries.

Duval Upland Province - The Duval Upland Province extends from the Georgia-Florida border, along the St. Marys River in Nassau County, southward to Putnam County. The Duval Upland Province is a broad, marine terrace located between the St. Marys Plain and Lower St. Johns River Valley provinces to the east and Trail Ridge Province to the west. Low ridges and swales are better developed on the terrace in the northern and southern parts of the province than in the central part of the province. The Miocene Charlton Member of the Coosawhatchie Formation (Hawthorn Group) is the oldest unit affecting the landforms at the surface in the northernmost part of the Duval Upland Province. Much of the province is underlain by sediments of the Pliocene-Pleistocene Cypresshead Formation, which is at or near the land surface throughout most of the province. Quaternary undifferentiated sediments have been mapped in the central part of the province.

Lower St. Johns River Valley Province - The Lower St. Johns River Valley Province extends from central Duval County to northernmost Volusia County. The Lower St. Johns River Valley Province occupies an ancient marine embayment and river valley system that continued to develop through erosional and depositional processes during both low and high sea-level stands. The St. Johns River is estuarine as far south as Doctors Lake within the EMRI-FFA, just south of Orange Park, and it is normally tidal as far upstream as Lake George in the St. Johns River Offset Province of the Lakes District (University of North Florida and Jacksonville University, 2014). Fluvial- and embayment-related processes shaped the Lower St. Johns River Valley Province. There are few distinct coastal landform remnants visible within the province because of the relatively low-energy environments of an embayment. Most of the undeveloped areas of the province are generally flat with abundant wetlands. In the northernmost Lower St. Johns River Valley Province, the Miocene Charlton Member of the Coosawhatchie Formation (Hawthorn Group) is the oldest unit that may affect the land surface. Quaternary undifferentiated sediments are mapped at the surface throughout most of the Lower St. Johns River Valley Province within the EMRI-FFA study area. The other surficial stratigraphic units that affect the landforms in this province include Tertiary-Quaternary undifferentiated shelly sediments , as well as Holocene undifferentiated sediments which have been mapped along the St. Johns River floodplain (Scott, 2001; Green et al., 2013; Green et al., 2014).

Sea Islands Province - The Sea Islands Province includes coastal parts of Nassau and Duval counties in northeastern Florida. The Sea Islands Province is the southern portion of a larger, interstate geomorphic region known as the Sea Islands that stretches from eastern South Carolina to northeastern Florida. The Sea Islands Province is characterized by tidally dominated streams and tidal marshes that are bordered by barrier islands to the east and broad, coast-parallel ridges and wetlands that have been dissected by drainage to the major rivers that border and cross the province from west to east. The rivers include the St. Marys, which forms the northern boundary of the province; the Nassau, which flows to the Atlantic Ocean through the middle of the province; and the St. Johns, which forms part of the southern province boundary. The Sea Islands Province includes the barrier islands of the Atlantic coastline and similar north- and south-trending ridges inland. The inland ridges are separated by low wetland areas and tidal marshes are extensive. Quaternary beach ridge and dune and Quaternary undifferentiated sediments are the oldest geologic units affecting the landforms in this province (Scott et al., 2001; Green et al., 2016). Recent deposition in tidal marshes and parts of the barrier islands of the Sea Islands Province are identified as Holocene undifferentiated sediments .

St. Marys Plain Province - The St. Marys Plain Province occurs in parts of Nassau and Duval counties. The St. Marys Plain Province is dominated by fluvial landforms, rather than coastal landforms which are common to many surrounding provinces. Much of the province is characterized by low hills and wetlands within a well-developed, dendritic drainage network. The St. Marys Plain Province lacks significant landforms indicative of coastal processes. The land surface is a former marine terrace where sculpting of the landscape by fluvial processes has essentially erased any coastal landforms that may once have been present. The oldest stratum in the St. Marys Plain Province that is involved in landform development is the Miocene Charlton Member of the Coosawhatchie Formation (Hawthorn Group) which crops out along the St. Marys River in the northwestern part of the St. Marys Plain Province. Most surficial sediments of the province are Quaternary undifferentiated sediments or Quaternary beach ridge and dune sediments, with some Holocene undifferentiated sediments in the Nassau River valley (Scott, 2001).

Trail Ridge Province - Trail Ridge Province occurs from the Georgia-Florida state line in Baker County, southward to northern Putnam County. Trail Ridge Province is a 130-mile-long sand ridge that extends southward from the Altamaha River in southern Georgia into northern Florida. It is the highest of the Atlantic Coast ridges in northeastern Florida. In northeastern Florida, the Trail Ridge Province creates a drainage divide between most of the water flowing toward the Gulf of Mexico to the southwest, and the Atlantic Ocean to the east. Only the St. Marys River flows east to the Atlantic Ocean from west of the province. The St. Marys River divides the province into northern and southern segments. Sediments in the province include a suite of important heavy minerals which are actively mined, mainly for their titanium content. Trail Ridge was formed by coastal processes, developing as a barrier island or offshore bar during higher sea level stands. Based on recent mapping within the EMRI-FFA study area, the oldest unit at the land surface of the Trail Ridge Province is the Pliocene-Pleistocene Cypresshead Formation.

Okefenokee Basin District - The Okefenokee Basin District encompasses a geographic area in north-central Florida that extends into Georgia and includes the Okefenokee Swamp. The Okefenokee Basin District defines roughly 250 square miles of the surficial geomorphology in the EMRI-FFA. Prominent geomorphic features include low lying wetlands in the northern part of the district near the Okefenokee Swamp and in swales between coastal features with higher relief (e.g. Lake City Ridge and Raiford Ridges). The topographic surface is a reflection of these remnant features and modern-day drainage. The wetlands and ridges drain via the St. Marys, Suwannee, Alapaha, and Santa Fe rivers. The Okefenokee Basin District is composed of three provinces, all of which occur within the EMRI-FFA.

Lake City Ridge Province - The Lake City Ridge Province occurs in limited parts of Baker and Columbia counties. The Lake City Ridge Province is a distinct, arcuate ridge that was either a coastal spit or bar. It has the highest elevations found within the Okefenokee Basin District. It once extended further west, but the western end of the Lake City Ridge Province has been extensively eroded by coastal, fluvial, and karst processes in the Suwannee River valley and Cody Escarpment within the Alachua Karst Hills Province (Ocala Karst District). Ancient coastal processes created the Lake City Ridge Province. The province consists of several closely spaced, coastal ridges. Within the EMRI-FFA, the surficial stratigraphic unit that affects the landforms of this province are those of the Pliocene-Pleistocene Cypresshead Formation. These sediments are underlain by the Miocene Hawthorn Group and the Eocene Ocala Limestone in the Lake City Ridge Province. Where the Oligocene Suwannee Limestone sporadically occurs, it overlies the Ocala Limestone near the westernmost end of the province. Dissolution of the Ocala Limestone and Suwannee Limestone are important in the formation of the few karst features in the western part of the province.

Ocean Pond Plain Province - The Ocean Pond Plain Province covers the eastern two-thirds of Hamilton County and northern Columbia and Baker counties. The Ocean Pond Plain Province includes the southern extent of the Okefenokee Swamp. It is a relatively flat plain with extensive wetlands. There are no obvious coastal or marine landforms in the Ocean Pond Plain Province. However, the low ridges, which are crudely aligned between wetlands in the province, are possibly associated with depositional patterns in the Pliocene-Pleistocene marine terrace or in the ancestral Okefenokee Swamp. Except for Ocean Pond, karst landforms are uncommon throughout most of the Ocean Pond Plain Province. Within the EMRI-FFA, the Pliocene-Pleistocene Cypresshead Formation is at the land surface in the Ocean Pond Plain Province. Thick siliciclastic sediments with minor carbonate sediments of the Hawthorn Group underlie the Cypresshead Formation. The Eocene Ocala Limestone underlies the Ocean Pond Plain Province. The Oligocene Suwannee Limestone occurs overlying the Ocala Limestone along the western boundary of the province with the Alachua Karst Hills and the Branford Karst Plain provinces (Ocala Karst District). The dissolution of these limestones in the shallow subsurface are important to the formation of the karst features in the western part of the province.

Raiford Ridges Province - The Raiford Ridges Province occurs in parts of Columbia, Baker, Bradford, Union, and Alachua counties. The Raiford Ridges Province consists of an ancient marine terrace that is crossed by a series of ridges with low to moderate relief. The ridges are roughly oriented from northeast to southwest. Streams and wetlands occupy swales between these ridges. The ridges are sub-parallel to the Lake City Ridge Province to the north. Coastal or shallow-marine ridges and swales are common in the Raiford Ridges Province. There are three major sets of ridges, each with multiple smaller ridges within the major ridge. They trend from north-northeast to southwest in gentle arcs that are concave to the northwest. Like the Lake City Ridge Province, these features are cut by, and are therefore older than, Trail Ridge (Pirkle and Pirkle, 1984). Broad, shallow depressions of probable karst origin occur infrequently over most of the Raiford Ridges Province. The oldest unit exposed at the land surface of the Raiford Ridges Province is the Miocene Coosawhatchie Formation of the Hawthorn Group (Scott, 2001; Green et al., 2006). Siliciclastic sediments of the Pliocene-Pleistocene Cypresshead Formation overlie the Coosawhatchie Formation. The Eocene Ocala Limestone underlies the Raiford Ridges Province. Dissolution of the Ocala Limestone is the source for the karst features in the western part of the Raiford Ridges Province and the larger sinkhole lakes in the province.

Lakes District - The Lakes District encompasses a geographic area in central peninsular Florida that extends from the southern portions of the EMRI-FFA to the southern tip of the Lake Wales Ridge. The Lakes District defines roughly 330 square miles of the surficial geomorphology in the EMRI-FFA. Prominent geomorphic features include north-south trending ridges, large lakes, and segments of the St. Johns River valley. In the EMRI-FFA, the northern part of the Lakes District is marked by extensive karstification of carbonates in the subsurface. Dissolution is pervasive enough throughout portions of the Lakes District that several large sinkholes are expressed at the surface and have developed through the overlying Cypresshead Formation. Trail Ridge at its southern extent approaches its highest elevations. This coincides with a thinning of the siliciclastic deposits. Authors have suggested karstification as a method of rejuvenation and later stages of uplift (Adams et al., 2010; Creveling et al., 2019). The Lakes District is composed of 13 provinces, three of which occur within the EMRI-FFA.

Hawthorne Lakes Province - The Hawthorne Lakes Province is located in eastern Alachua, southernmost Bradford, southwestern Clay, western Putnam, and northernmost Marion counties. This province includes many large karst lakes and "wet prairies" or wetlands. Some of the lakes in the region have developed outflow streams. Many of the lakes in the northern part of the province are associated with well-developed steephead ravines. Important karst features include Paynes Prairie, a large polje, and Orange Lake, a complex sinkhole lake that is filling with sediment to form a polje. Only remnants of coastal landforms are present in the northern part of the Hawthorne Lakes Province. These are faint remnants of the ridges that are well-developed in the Raiford Ridges Province to the north. Broad lakes and wetlands constitute the most visible landforms in the Hawthorne Lakes Province. Karst and fluvial landforms are important in much of the province. Within the EMRI-FFA, the near-surface geologic units, include the Miocene Coosawhatchie Formation (Hawthorn Group), and Pliocene-Pleistocene Cypresshead Formation. Dissolution in the Ocala Limestone is responsible for the development of karst features in the province.

Palatka Hill Province - The Palatka Hill Province is in east-central Putnam County. The Palatka Hill Province consists of a small, remnant hill that is largely within the St. Johns River Offset Province. It is an outlier related to the Crescent City Ridge and the other eastern ridges in the Lakes District. The faint ridges and swales on the Palatka Hill Province are the only apparent remnant landforms of coastal processes affecting the province. The margins of the province may be marine escarpments that have been heavily modified by fluvial and surficial erosion. Fluvial processes on the Palatka Hill Province are most notable in the steephead ravine streams of Ravine Gardens State Park. The steephead seeps at Ravine Gardens State Park are sourced from the surficial aquifer system. Headward erosion at the steephead seeps has created the two ravines. Sinkholes and sinkhole lakes are not common in the Palatka Hill Province. However, there are circular, closed-depression lakes and a few dry sinkholes in the central and western part of the province. The oldest unit at the land surface of the Palatka Hill Province is the Pliocene-Pleistocene Cypresshead Formation. Sinkholes are a result of dissolution of the Upper Eocene Ocala Limestone.

St. Johns River Offset Province - The St. Johns River Offset Province follows the valley of the St. Johns River between Sanford and Palatka. This parallel, westerly deviation of the St. Johns River valley was termed the St. Johns River Offset by White (1970). This segment of the St. Johns River valley is narrower and has higher elevations in the adjacent parts of the surrounding provinces than the Lower St. Johns River Valley and Upper St. Johns River Valley provinces (Barrier Island Sequence District). The valley of the St. Johns River dominates the fluvial landscape of the St. Johns River Offset Province. The valley of the St. Johns River Offset Province is at times up to 75 feet lower than the adjacent ridge provinces not on map. Fluvial valley landforms, including numerous meanders and oxbows, are present in the river and floodplain. The St. Johns River passes through numerous floodplain wetlands. Dissolution of underlying carbonate strata and resulting subsidence may explain the large, wide lakes and floodplain wetlands within the otherwise narrow river valley. Springs are the most prominent karst landforms within the province, particularly near the boundaries with adjacent provinces. Recent mapping within the EMRI-FFA suggests the oldest strata affecting the land surface in the St. Johns River Offset Province are Pliocene-Pleistocene Cypresshead Formation sediments and Quaternary undifferentiated sediments. Holocene undifferentiated sediments overlie the Quaternary undifferentiated sediments in parts of the province (Scott, 2001; Green et al., 2013; Green et al., 2014). Karst features occurring in the St. Johns River Offset Province primarily formed due to dissolution in the Eocene Ocala Limestone.

SELECTED FIELD PHOTOGRAPHS

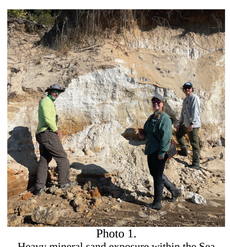


Photo 1.
Heavy mineral sand exposure within the Sea Islands Province, along the St. Marys River.



Photo 2.
An exposure of Quaternary beach ridge and dune sediment within the Sea Islands Province. Primary bedding and secondary mineralization common dunes and heavy mineral sands.

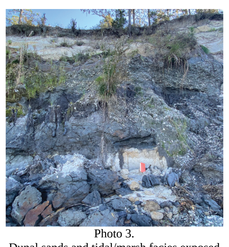


Photo 3.
Dunal sands and tidal/marsh facies exposed along Reids Bluff.

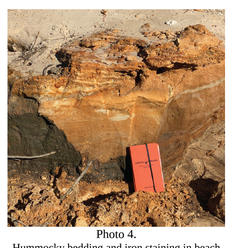


Photo 4.
Hummocky bedding and iron staining in beach ridge and dune sediments along the St. Marys River.

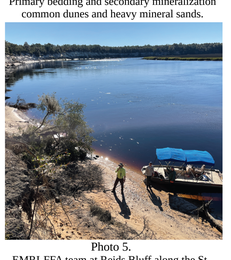


Photo 5.
EMRI-FFA team at Reids Bluff along the St. Marys River. The St. Marys exposes several N-S trending paleoshorelines.

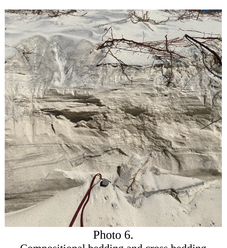


Photo 6.
Compositional bedding and cross bedding observed in heavy mineral sands proximal to the EMRI-FFA boundary.



Photo 7.
A zone of *Ophiomorpha nodosa* observed in beach ridge and dune sequence along the St. Marys River.



Photo 8.
Bluffs exposing the N-S trending paleoshorelines. These paleoshorelines often host heavy mineral placer deposits.

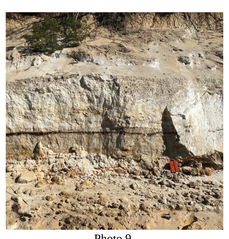


Photo 9.
Bedding structures and compositional bedding typical of coastal deposits observed within the study area with variable amounts of clay, organics, and other accessory minerals.

SCALE 1:100,000

1 CENTIMETER ON THE MAP REPRESENTS 1 KILOMETER ON THE GROUND

0 4 8 16 Miles

0 4 8 16 Kilometers

Projection: NAD 1983 HARN Florida GDL Albers (Meters)
Horizontal Datum: North American Datum 1983 HARN (NAD83 HARN)
Vertical Datum: North American Vertical Datum 1988 (NAVD88)
Basemap: Digital data compiled by the
Florida Department of Environmental Protection / Florida Geological Survey (2026)

Basemap Coordinate Explanation
10,000-meter grid, zone 17: Universal Transverse Mercator
25,000-foot grid ticks based on Florida coordinate system, north zone
4Q ∞ 4Q 0000mE
270000 FEET (NORTH)

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EARTH MAPPING RESOURCE INITIATIVE
FLORIDA FOCUS AREA
2020-2023