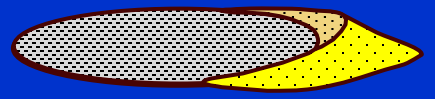
THE BARCHAN DUNE CAROLINA BAY MODEL



2024 SOUTHEASTERN SECTION MEETING OF GSA – ASHEVILLE, NC

CAROLINA BAYS: BORN IN THE LEE OF PLEISTOCENE EOLIAN BARCHAN SAND DUNES; A NEW MODEL FROM SCOTLAND COUNTY, NORTH CAROLINA

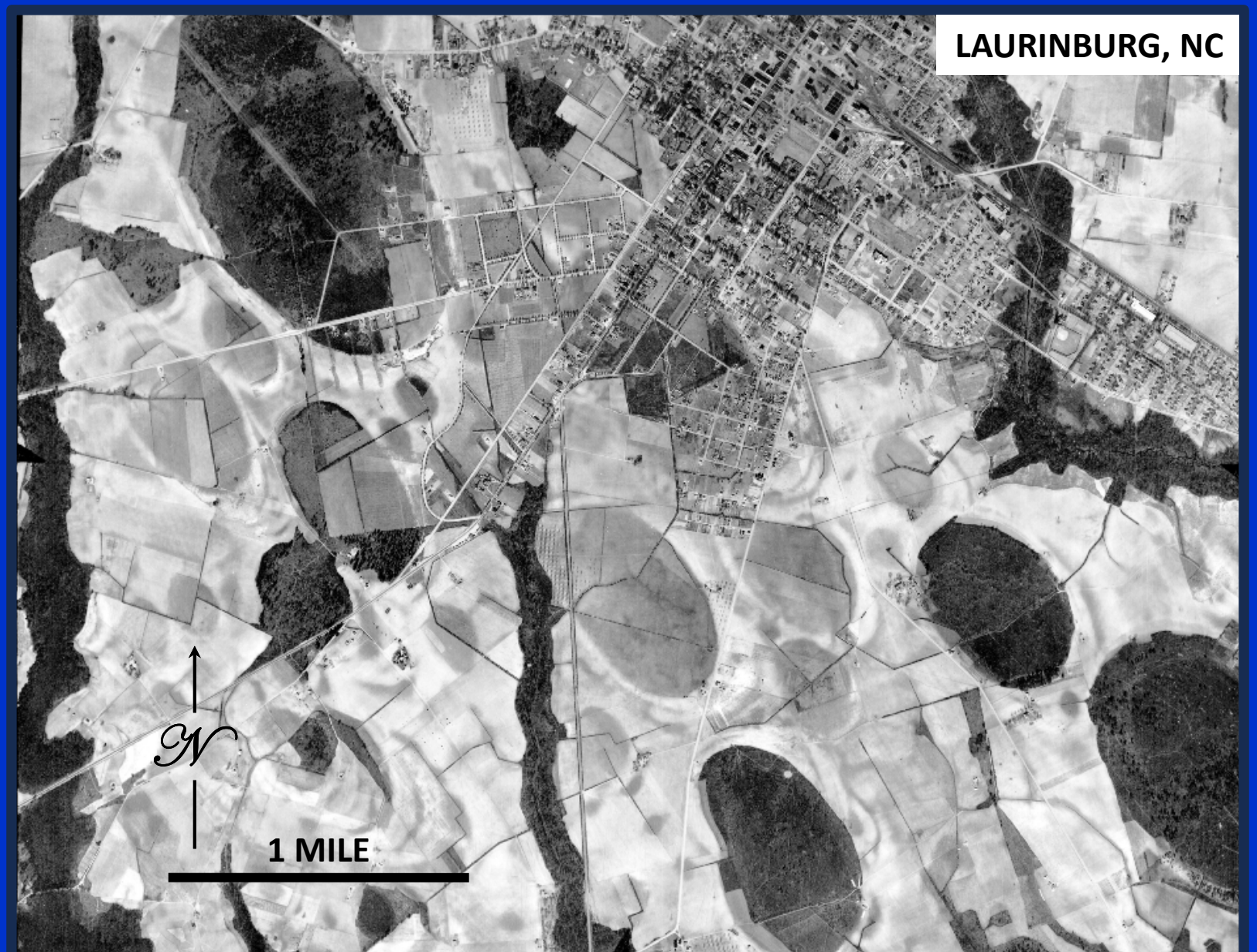
Douglas B Watkins

Consulting Petroleum Geologist

THE BARCHAN DUNE CAROLINA BAY MODEL

TYPICAL BAYS IN SCOTLAND CO, NC - 1938

USDA PHOTO SERIES 1938

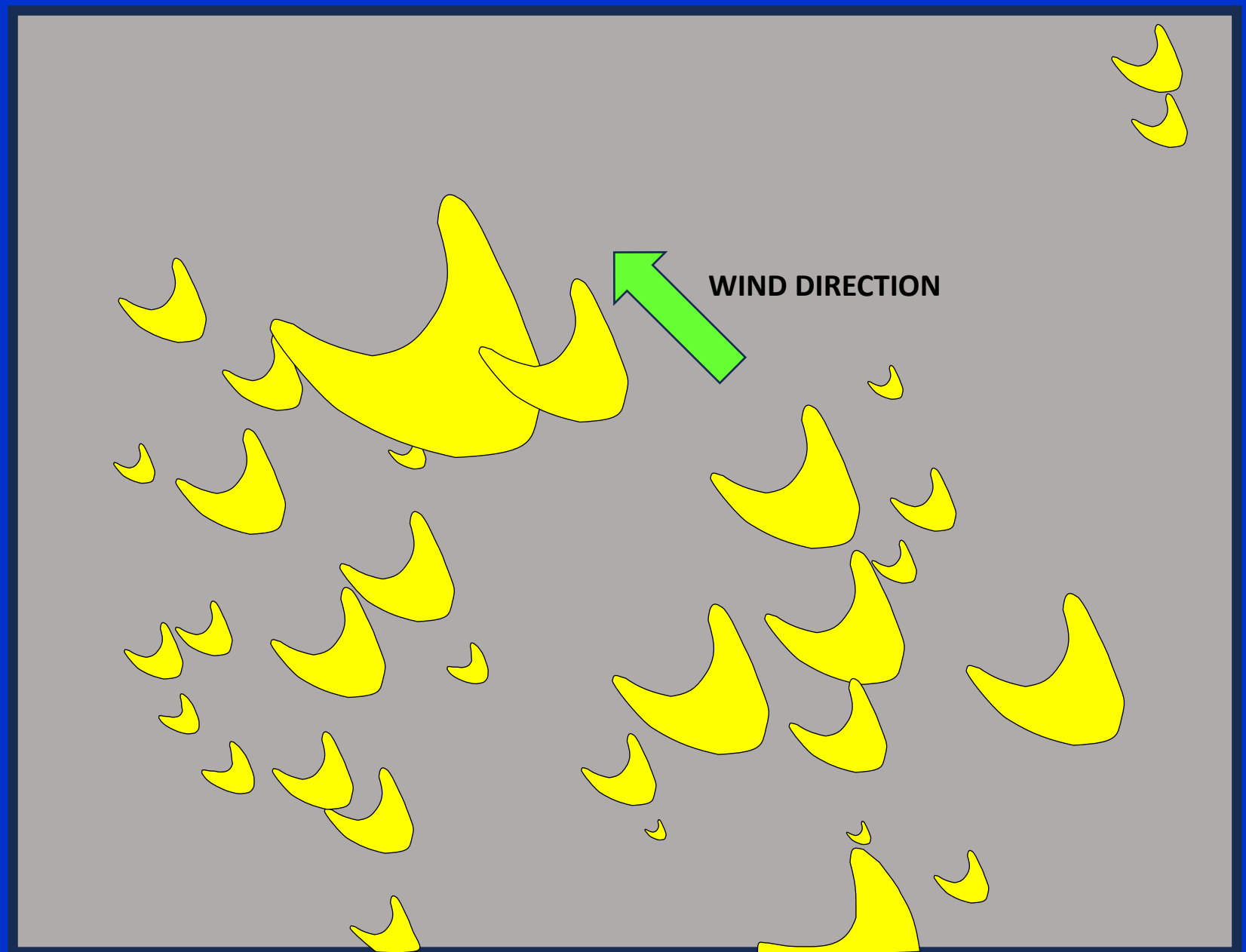


THE BARCHAN DUNE CAROLINA BAY MODEL

150,000 YBP – A DESERT DEVELOPS ON THE PLEISTOCENE COASTAL PLAIN

THE BARCHAN DUNE CAROLINA BAY MODEL

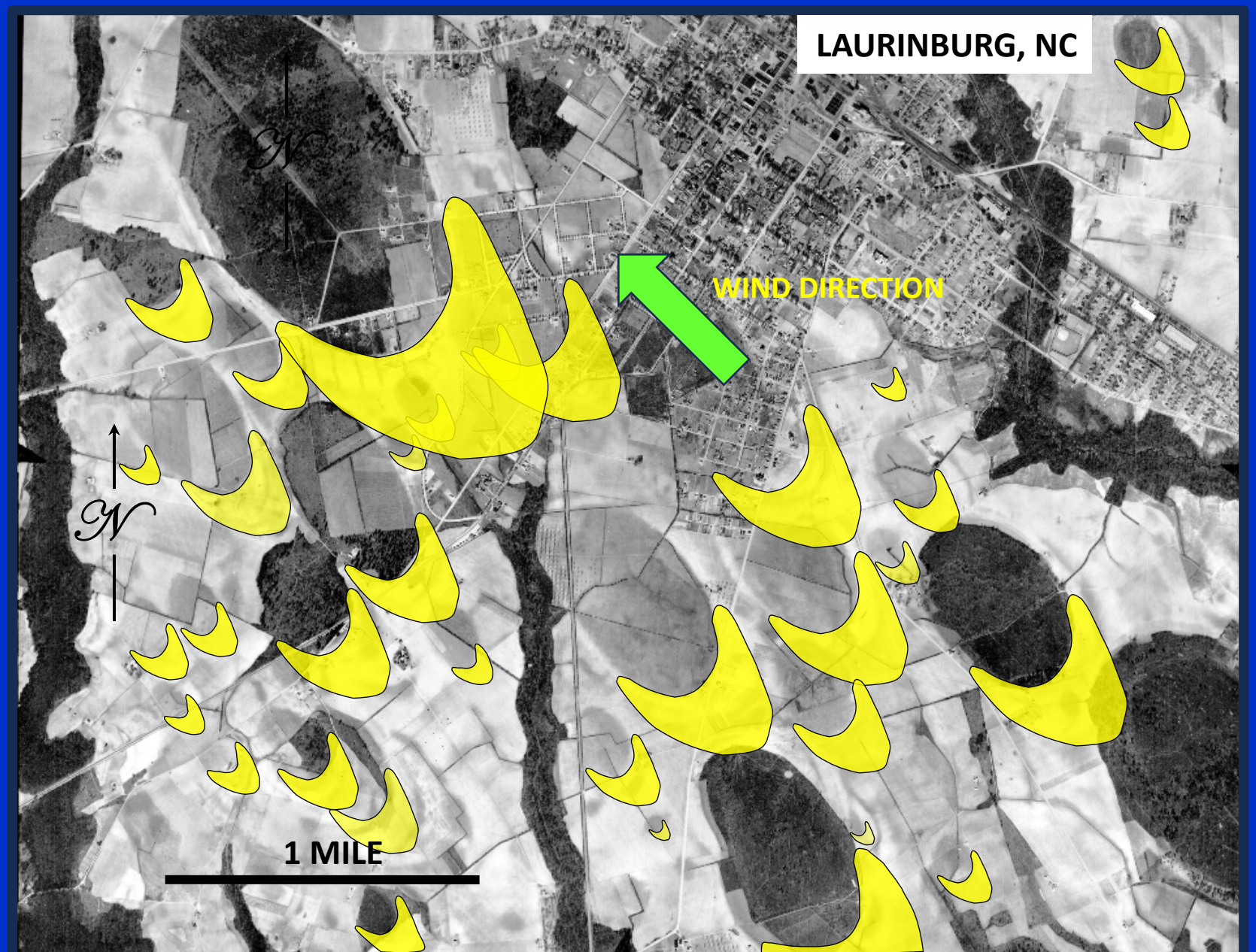
150,000 YBP – BARCHAN DUNES DEVELOP ON THE DESERT (ERG) PENEPLAIN



THE BARCHAN DUNE CAROLINA BAY MODEL

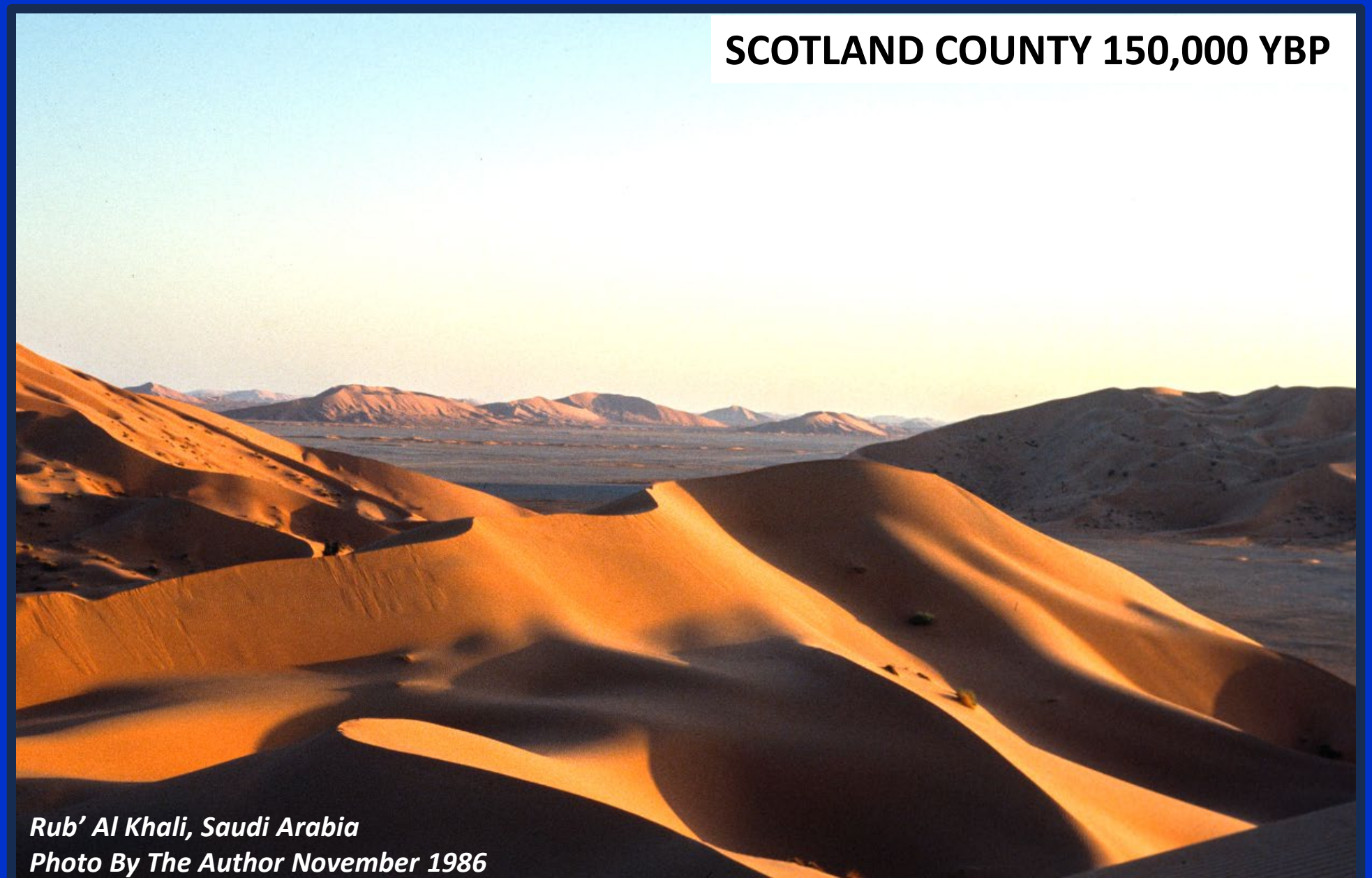
CAROLINA BAYS WITH BARCHAN DUNE OVERLAY

USDA PHOTO SERIES 1938



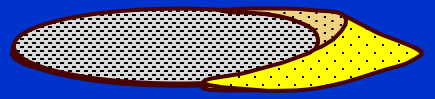
THE BARCHAN DUNE CAROLINA BAY MODEL

CAROLINA BAYS – ORIGINAL DESERT DEPOSITIONAL ENVIRONMENT – AN ERG



Rub' Al Khali, Saudi Arabia
Photo By The Author November 1986

THE BARCHAN DUNE CAROLINA BAY MODEL



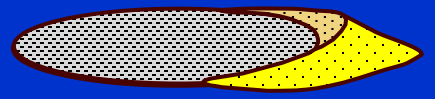
UNIFORMITARIANISM vs CATASTROPHISM

PRESENTING A NON-KINETIC

BARCHAN DUNE MODEL

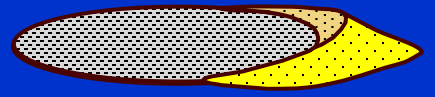
FOR THE ORIGIN OF CAROLINA BAYS

THE BARCHAN DUNE CAROLINA BAY MODEL



TOPICS TO BE PRESENTED

- A BARCHAN DUNE AND ITS INTEGRAL ADJACENT CAROLINA BAY
- A CAROLINA BAY PEAT-RICH SEDIMENTARY SEQUENCE EXPOSURE
- A BARCHAN/BAY DEPOSITIONAL MODEL THAT EXPLAINS CAROLINA BAY ORIGIN, SEDIMENTATION AND SUBSIDENCE
- EXAMPLES OF BARCHAN DUNE PRESERVATION, EROSION AND SAND REDISTRIBUTION
- PINEHURST FORMATION REVISITED



LOCATION AND GEOLOGICAL SETTING

THE BARCHAN DUNE CAROLINA BAY MODEL

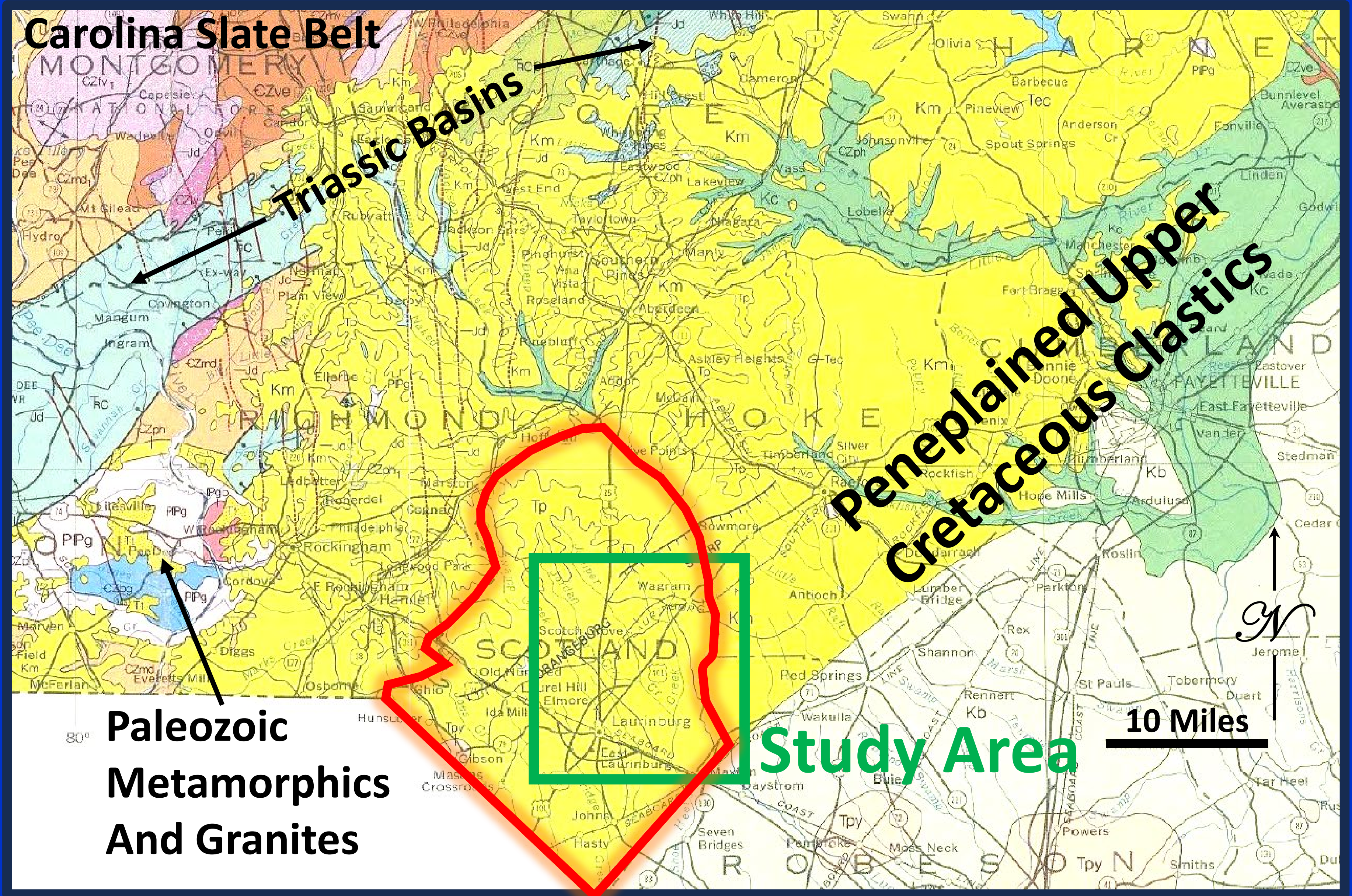
SCOTLAND COUNTY LOCATION MAP

NC TOPOGRAPHIC MAP 1972

THE BARCHAN DUNE CAROLINA BAY MODEL

STUDY AREA LOCATION

NC GEOLOGIC MAP 1985



THE BARCHAN DUNE CAROLINA BAY MODEL

STUDY AREA OUTCROP: MIDDENDORF FORMATION

NC GEOLOGIC MAP 1985

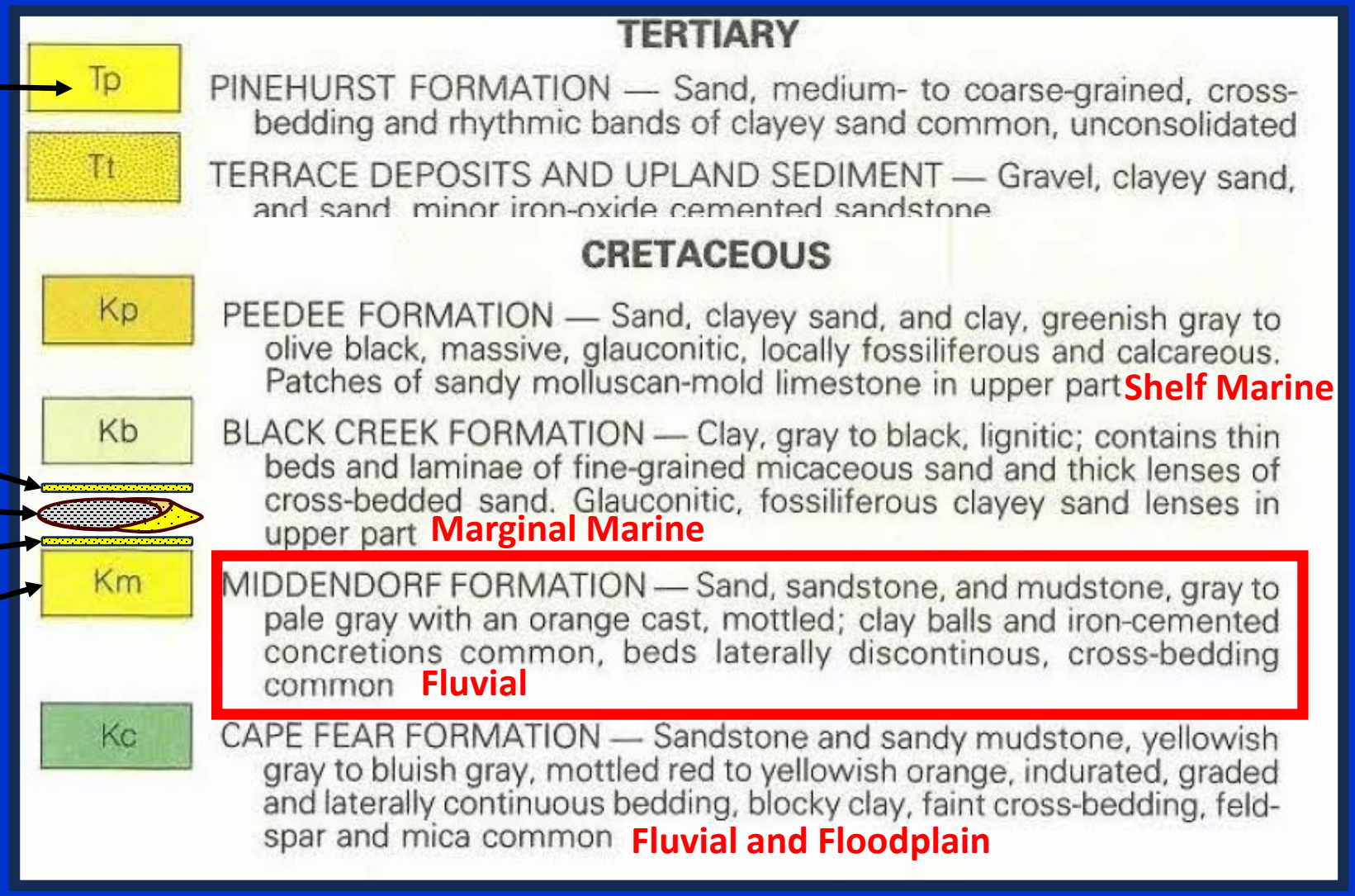
RELATED STRATIGRAPHIC UNIT

SHEET SANDS

BARCHAN/BAY

SHEET SANDS

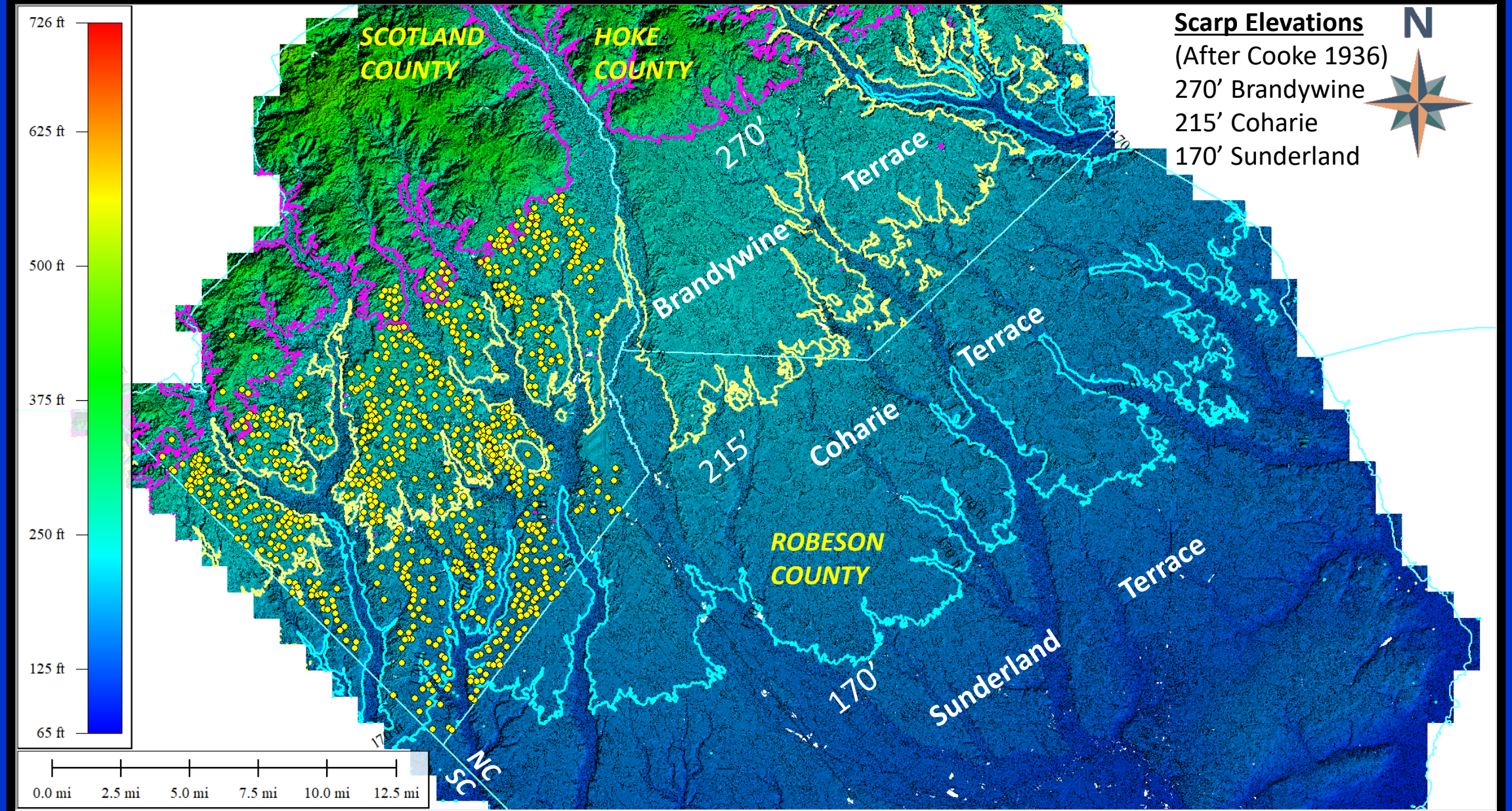
SUBSTRATE



THE BARCHAN DUNE CAROLINA BAY MODEL

SCOTLAND COUNTY CAROLINA BAY LOCATIONS (841, LAST COUNT)

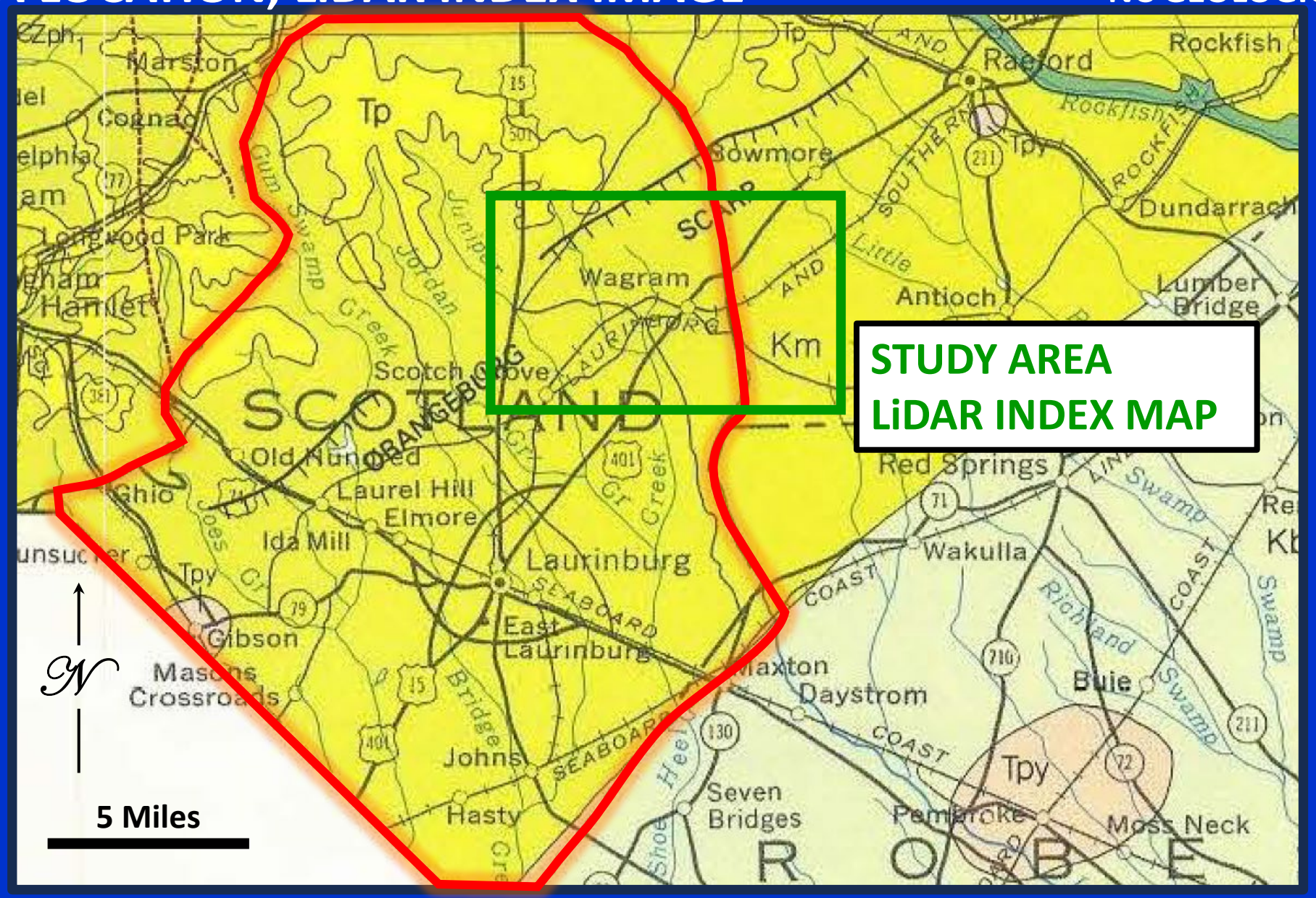
GRIDDED 2014 LIDAR ELEVATION DATA



THE BARCHAN DUNE CAROLINA BAY MODEL

STUDY AREA LOCATION, LiDAR INDEX IMAGE

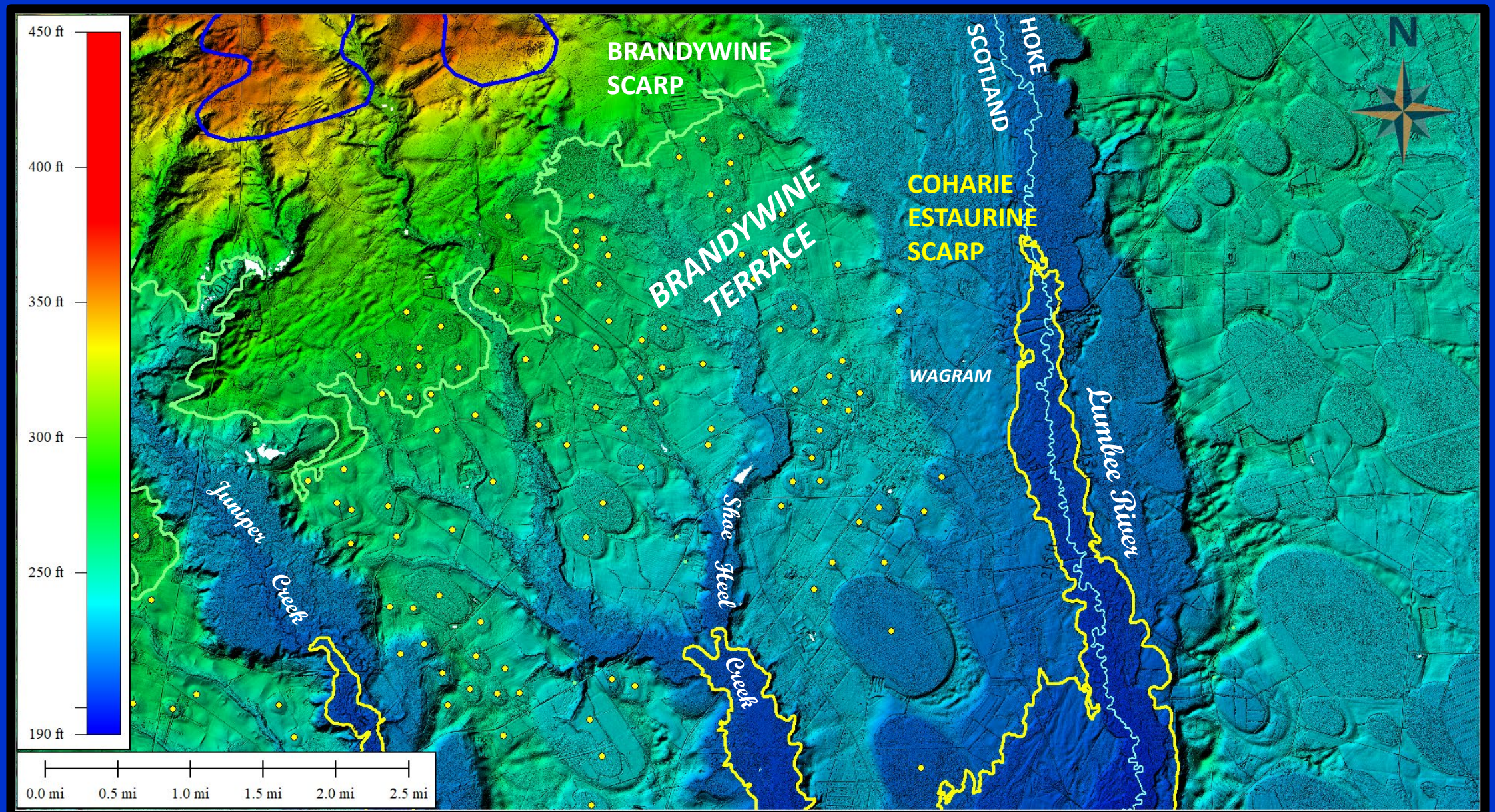
NC GEOLOGIC MAP 1985



THE BARCHAN DUNE CAROLINA BAY MODEL

STUDY AREA LiDAR INDEX MAP

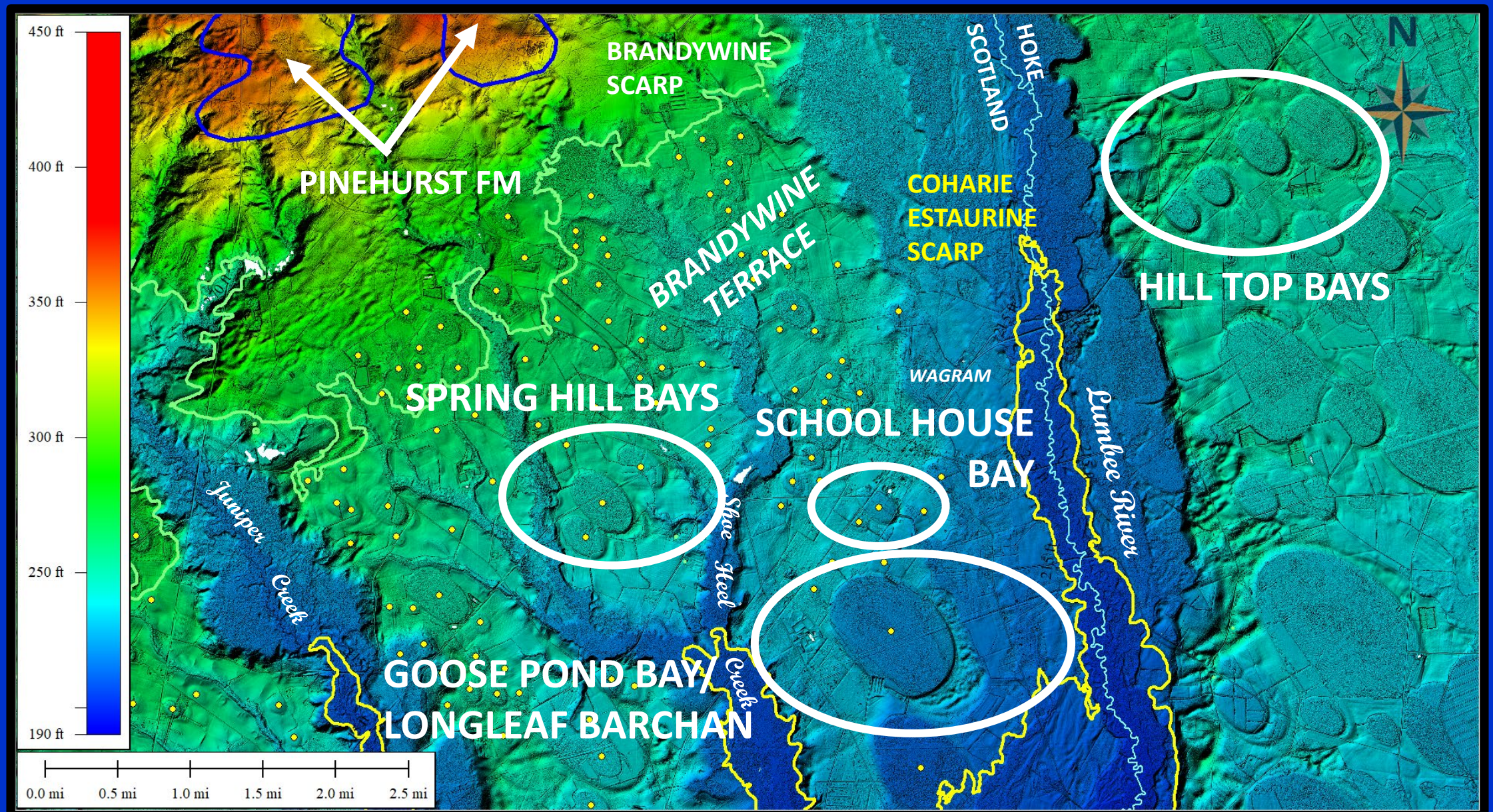
GRIDDED 2014 LiDAR ELEVATION DATA



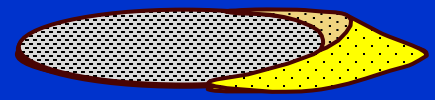
THE BARCHAN DUNE CAROLINA BAY MODEL

STUDY AREA LiDAR INDEX MAP

GRIDDED 2014 LiDAR ELEVATION DATA



THE BARCHAN DUNE CAROLINA BAY MODEL



THE HYPOTHESIS

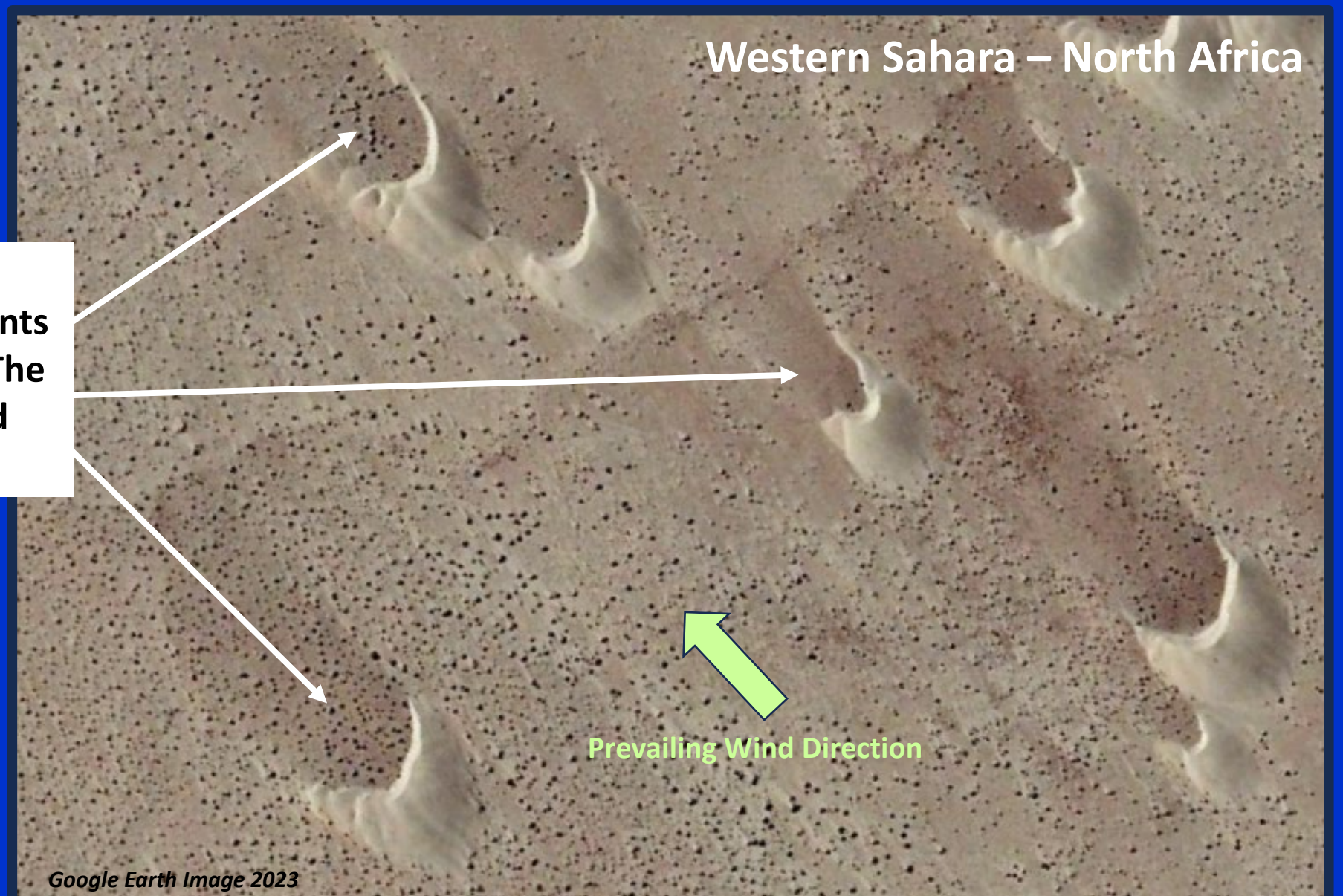
- Carolina Bays Are Consequent Landforms Created In The Lee (Wind Shadow) Of Pleistocene Eolian Barchan Sand Dunes, Where Suspended Fine-Grained Sediments Settled, Accumulated, Formed A Basal Aquiclude And Differentially Compacted, Thereby Allowing Vegetation Growth To Anchor The Bay Sediments

- The Barchans Formed During Glacial Sea-Level Low Stands, Part Of A Desert (An Erg) On The Peneplained Upper Cretaceous Coastal Plain Substrate

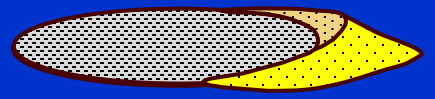
- The Barchan Dunes Were Formed By An Onshore Southeast Wind Field, Thus Orienting The Bays Southeast - Northwest

THE BARCHAN DUNE CAROLINA BAY MODEL

THE HYPOTHESIS



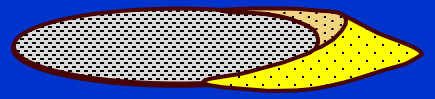
THE BARCHAN DUNE CAROLINA BAY MODEL



METHODOLOGY

- Geology Is An Observational Science
- Growing Up, I Was A Keen Observer “The Sandhills” And “The Goose Pond”, Literally Out My Back Door
- As A Young Geologist, I Observed Similar Barchans And Depressions Overflying The Empty Quarter Of Saudi Arabia; It Was A Moment Of Enlightenment

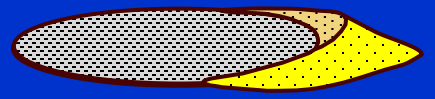
THE BARCHAN DUNE CAROLINA BAY MODEL



METHODOLOGY - DATASETS

- Vintage (1938) US Dept of Agriculture Air Photos
- USGS Quad Topos, NC State Geologic Map
- LiDAR, Global Mapper
- Google Earth
- A Vast Array Of Carolina Bay Literature

THE BARCHAN DUNE CAROLINA BAY MODEL

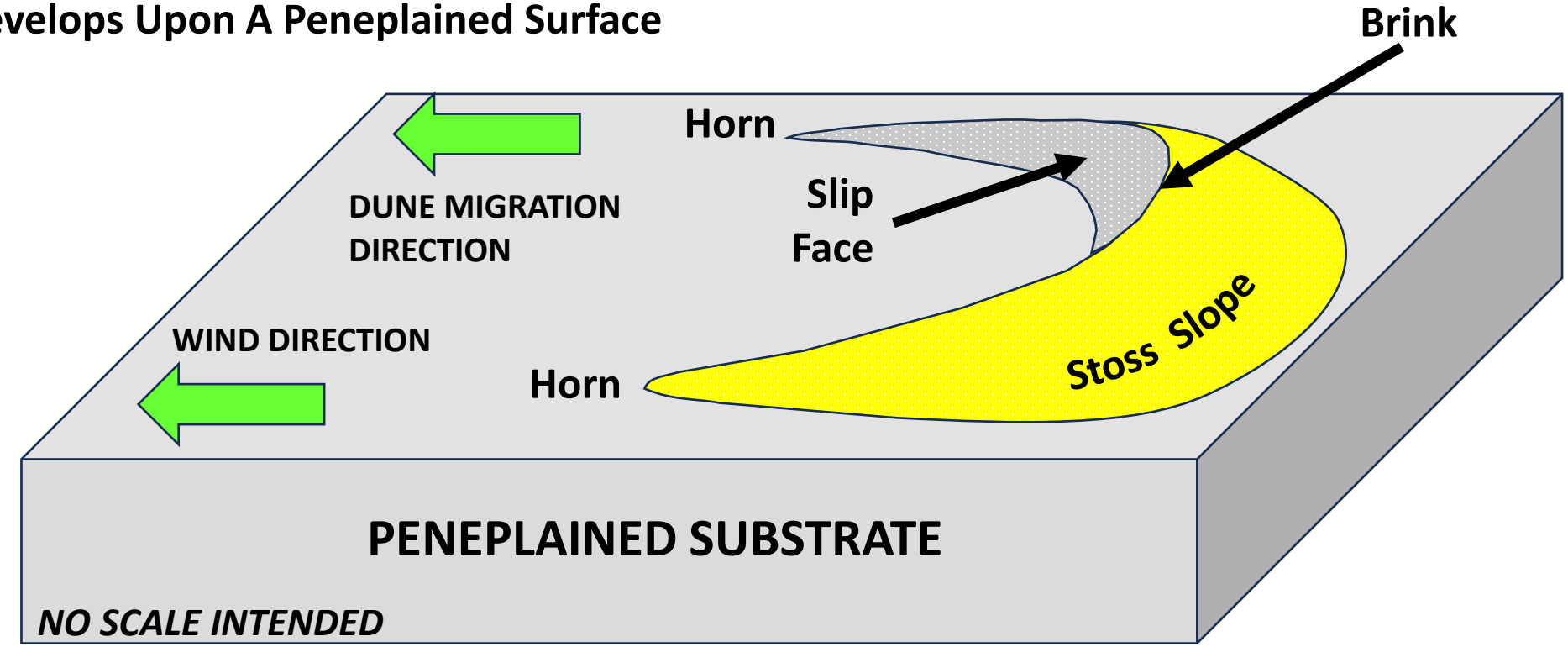


SANDHILLS, GOOSE POND AND THE DEVELOPMENT OF THE BARCHAN DUNE CONCEPT

THE BARCHAN DUNE CAROLINA BAY MODEL

BARCHAN DUNEOLOGY 101

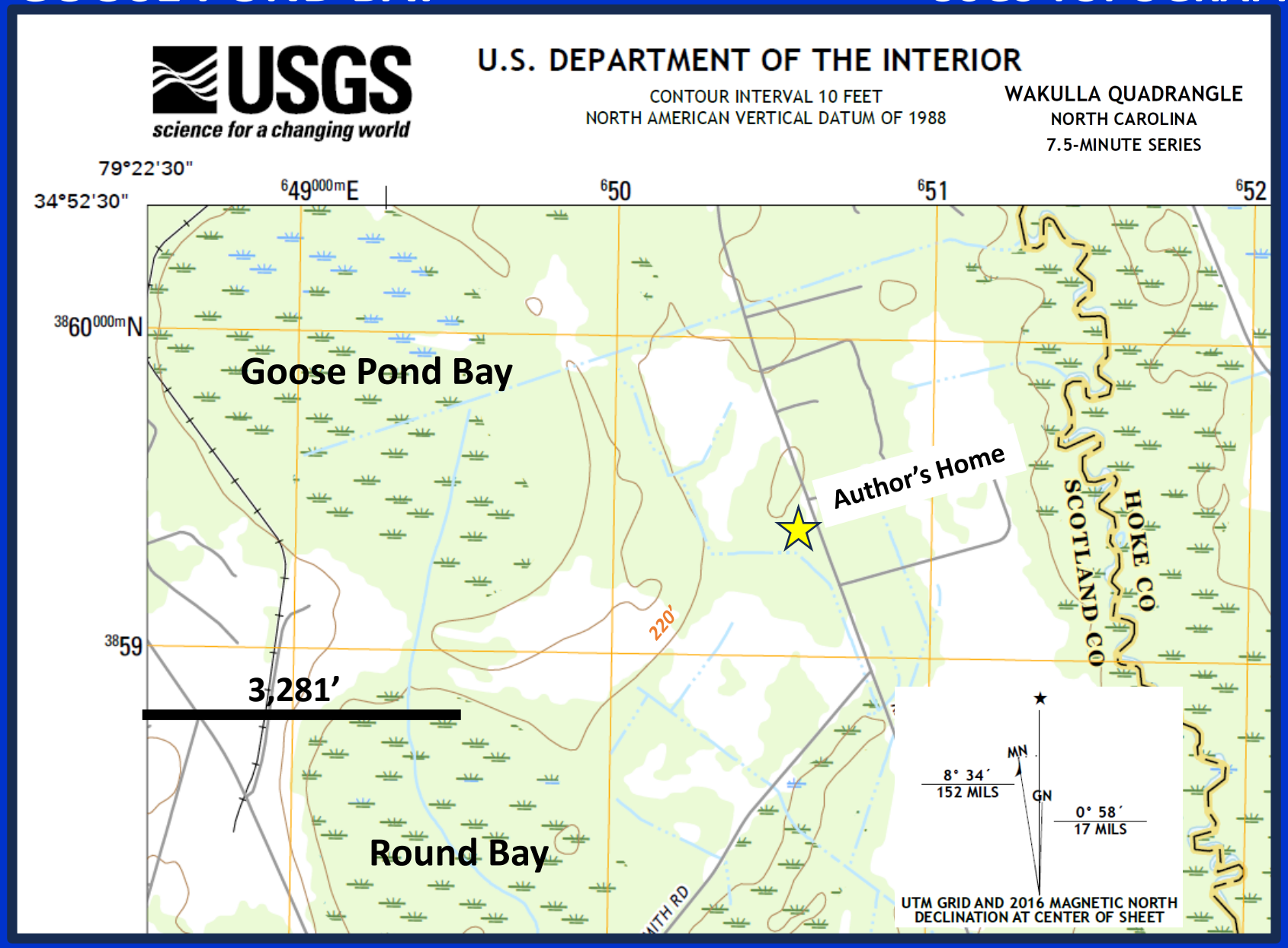
- Crescent Shaped Sand Dune
- Gentle Convex Stoss Slope Faces Wind; Steep Concave Leeward Slip Face
- Horns Point Downwind; Dune Migrates Via Slumping Of Slip Face @ Angle Of Repose
- Forms Under A Consistent Wind Field
- Develops Upon A Peneplained Surface



THE BARCHAN DUNE CAROLINA BAY MODEL

LOCATION OF GOOSE POND BAY

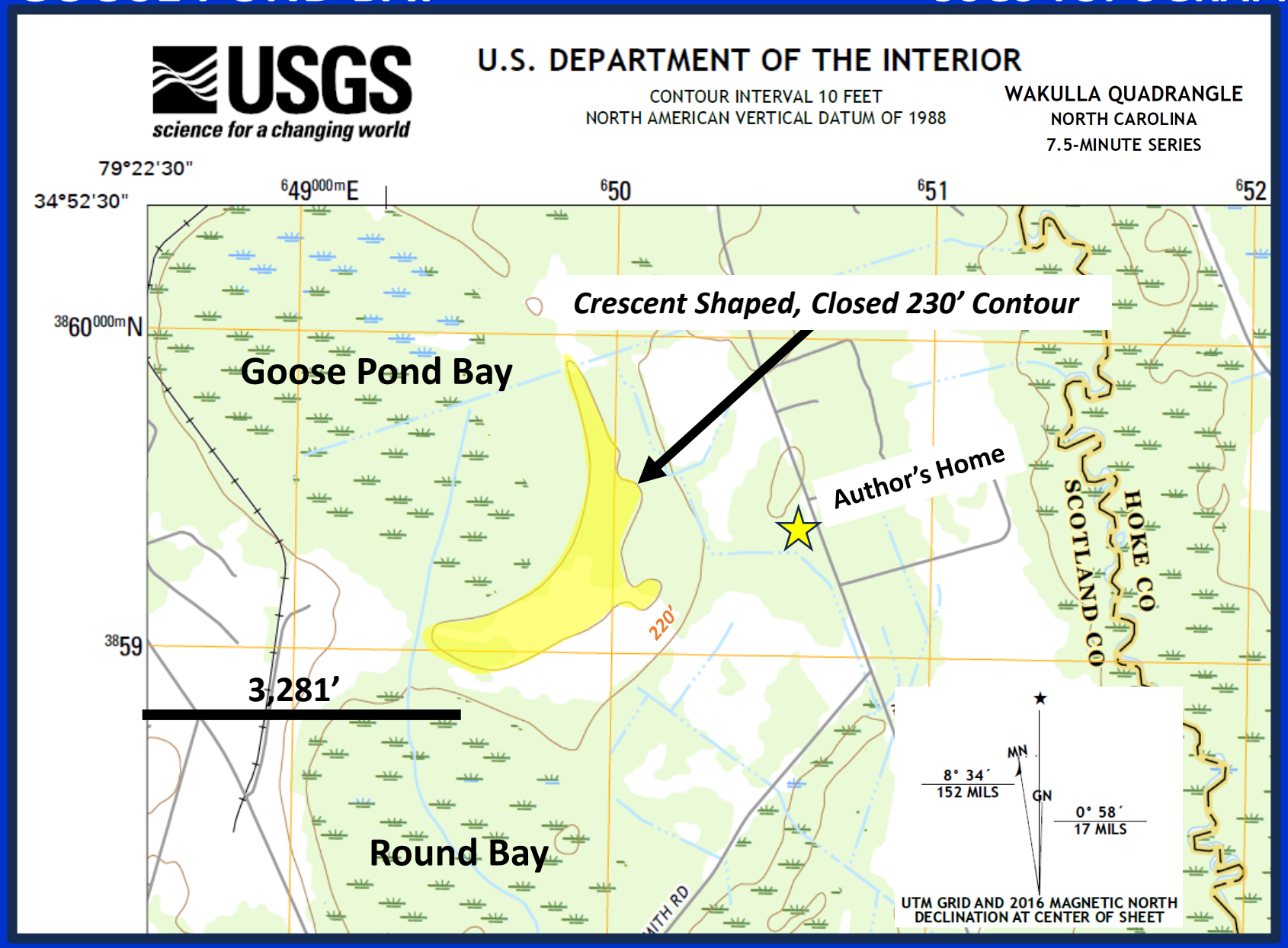
USGS TOPOGRAPHIC MAP 2016



THE BARCHAN DUNE CAROLINA BAY MODEL

LOCATION OF GOOSE POND BAY

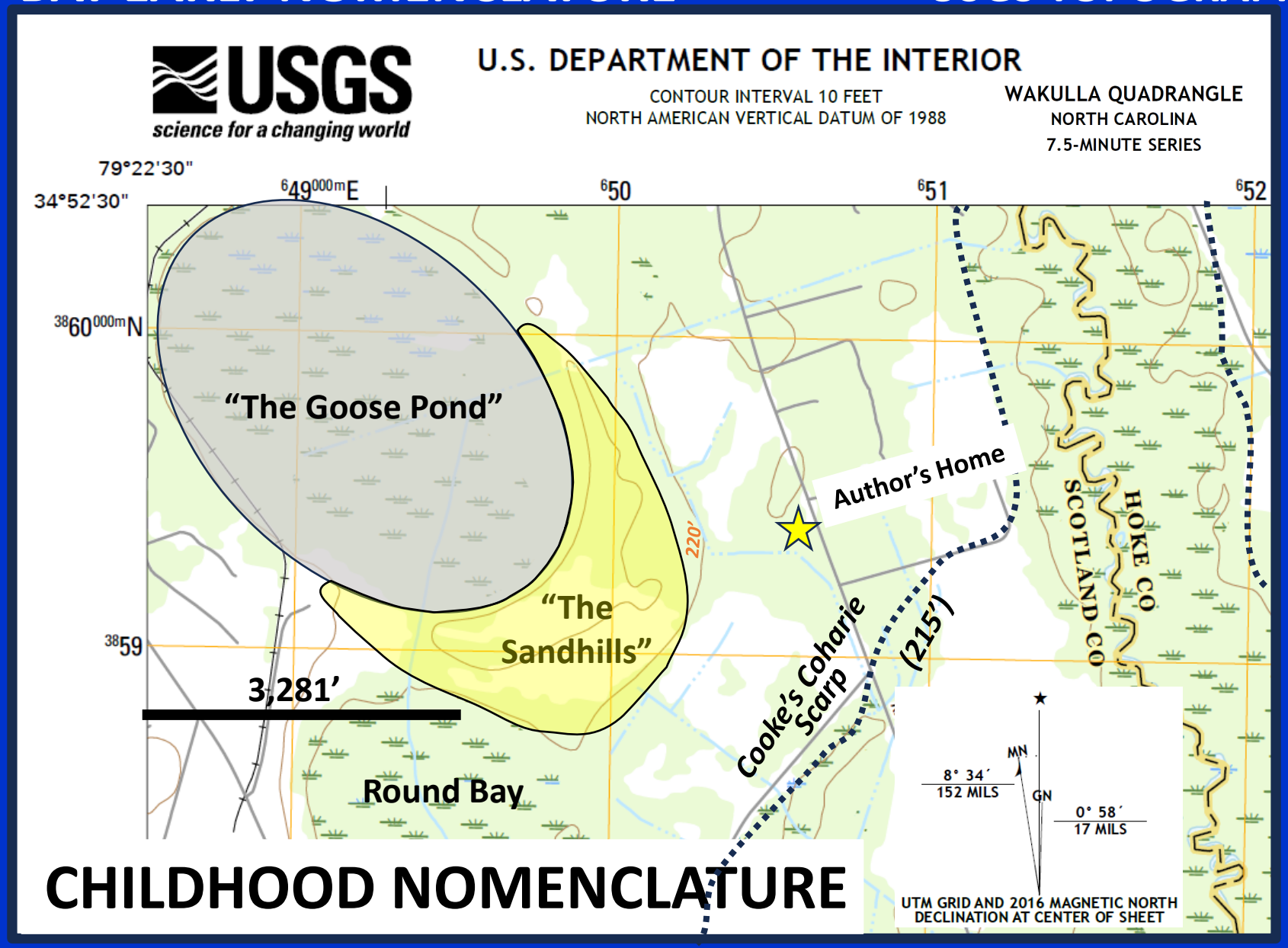
USGS TOPOGRAPHIC MAP 2016



THE BARCHAN DUNE CAROLINA BAY MODEL

GOOSE POND BAY EARLY NOMENCLATURE

USGS TOPOGRAPHIC MAP 2016

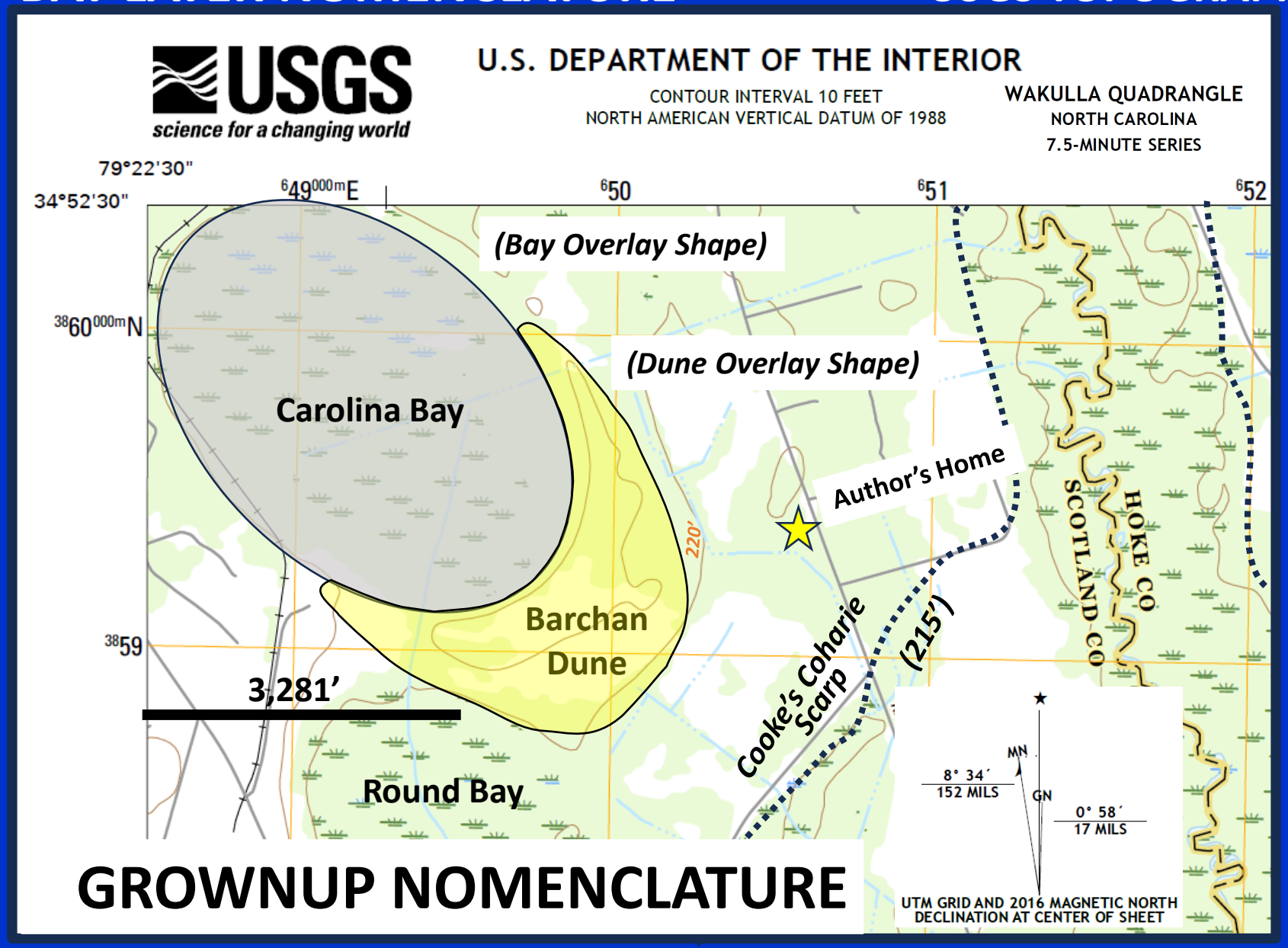


CHILDHOOD NOMENCLATURE

THE BARCHAN DUNE CAROLINA BAY MODEL

GOOSE POND BAY LATER NOMENCLATURE

USGS TOPOGRAPHIC MAP 2016

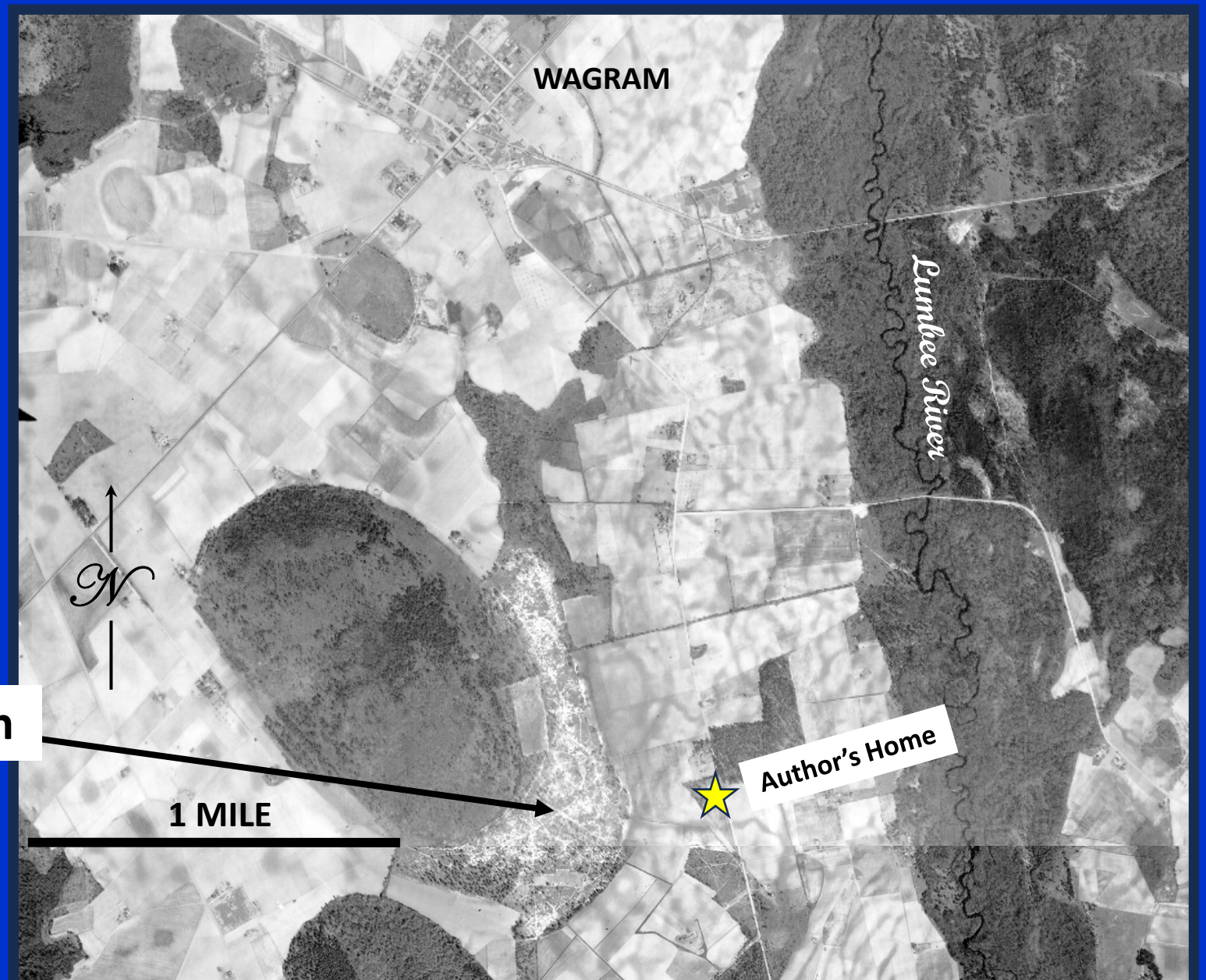


GROWNUP NOMENCLATURE

THE BARCHAN DUNE CAROLINA BAY MODEL

LONGLEAF BARCHAN ON OUTCROP

USDA AIR PHOTO SERIES 1938



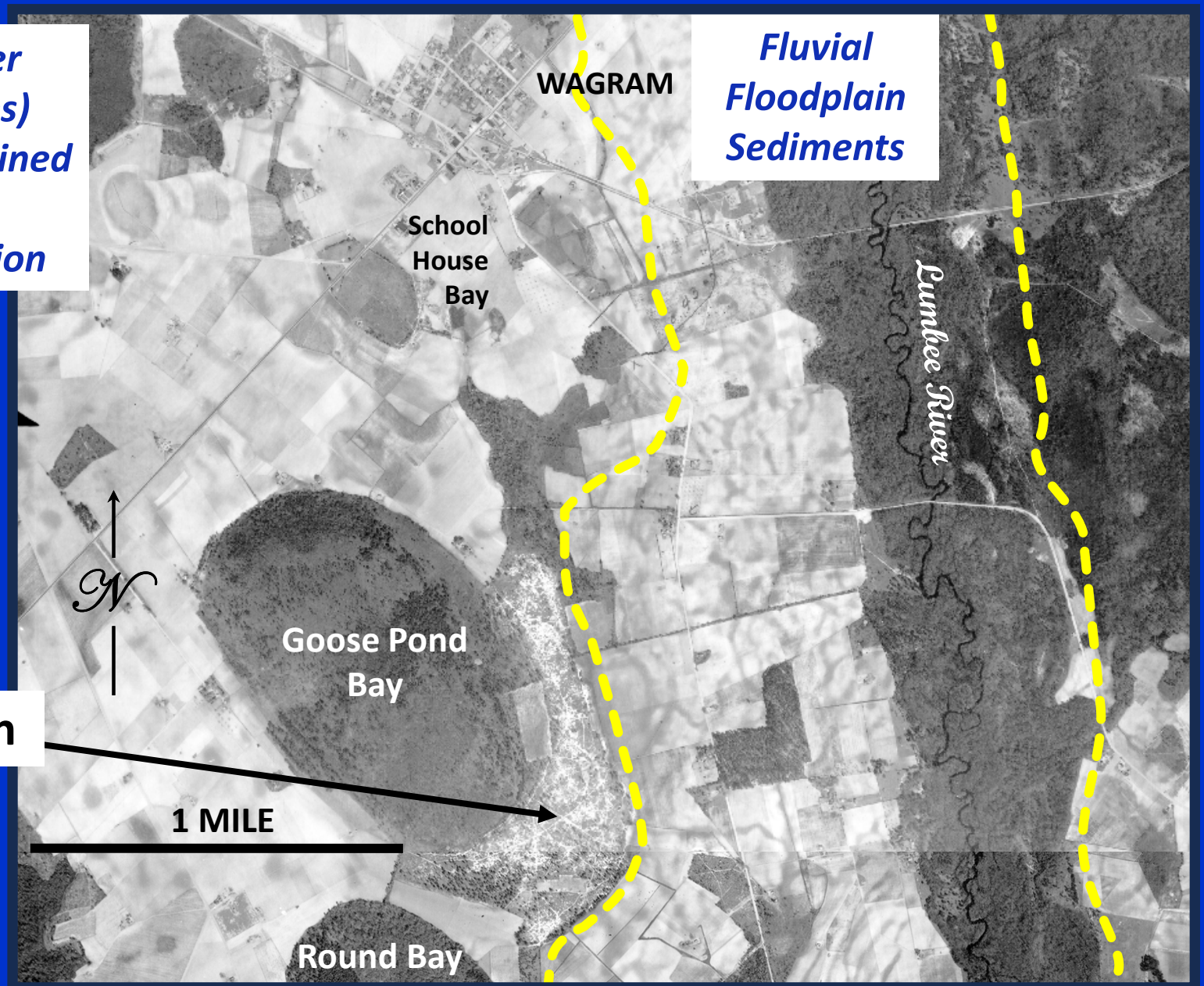
Longleaf Barchan

THE BARCHAN DUNE CAROLINA BAY MODEL

GOOSE POND BAY - LONGLEAF BARCHAN ON OUTCROP

USDA AIR PHOTO SERIES 1938

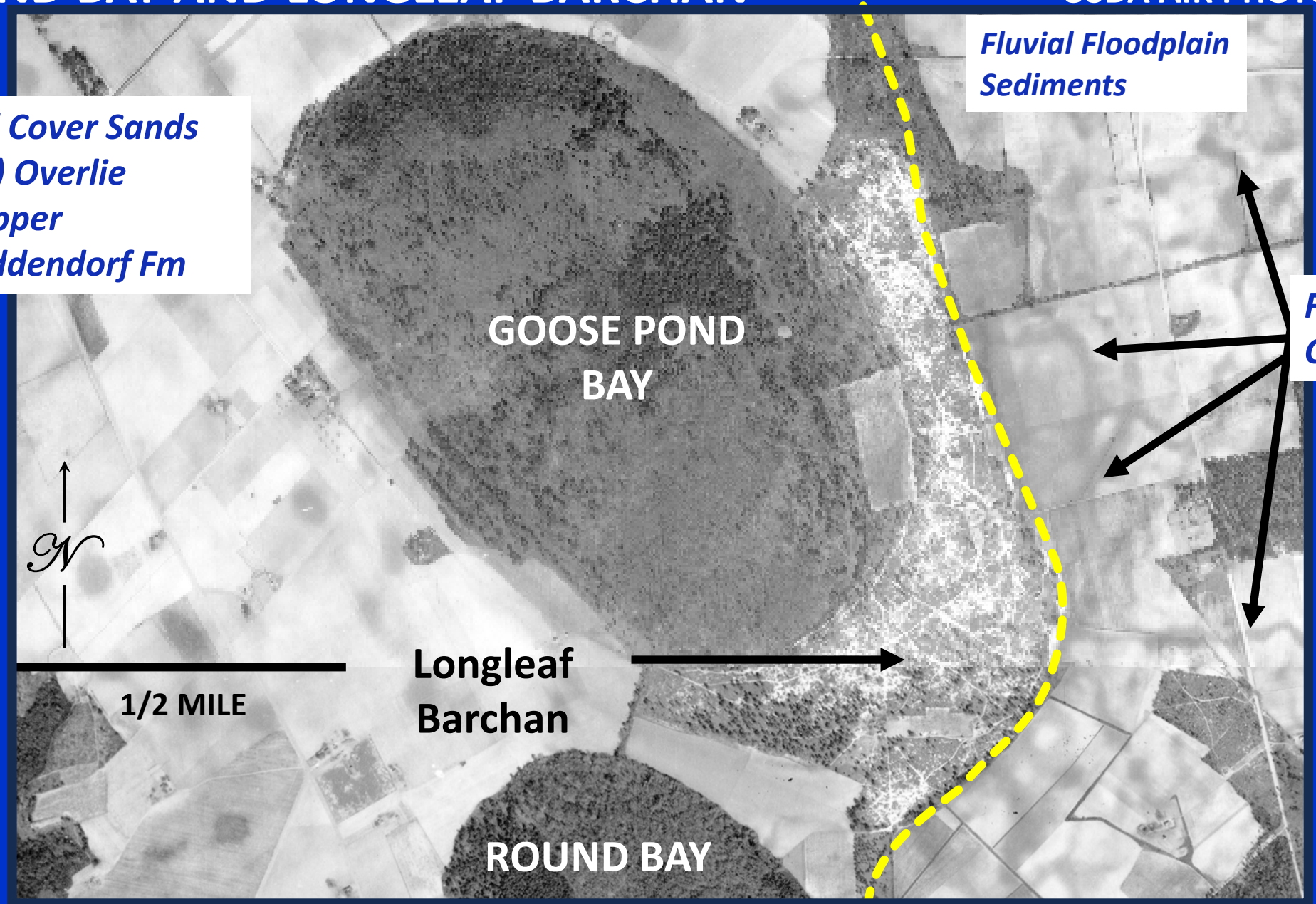
Bays, Rims and Cover Sands (Former Dunes) Overlie The Peneplained Upper Cretaceous Middendorf Formation



THE BARCHAN DUNE CAROLINA BAY MODEL

GOOSE POND BAY AND LONGLEAF BARCHAN

USDA AIR PHOTO SERIES 1938



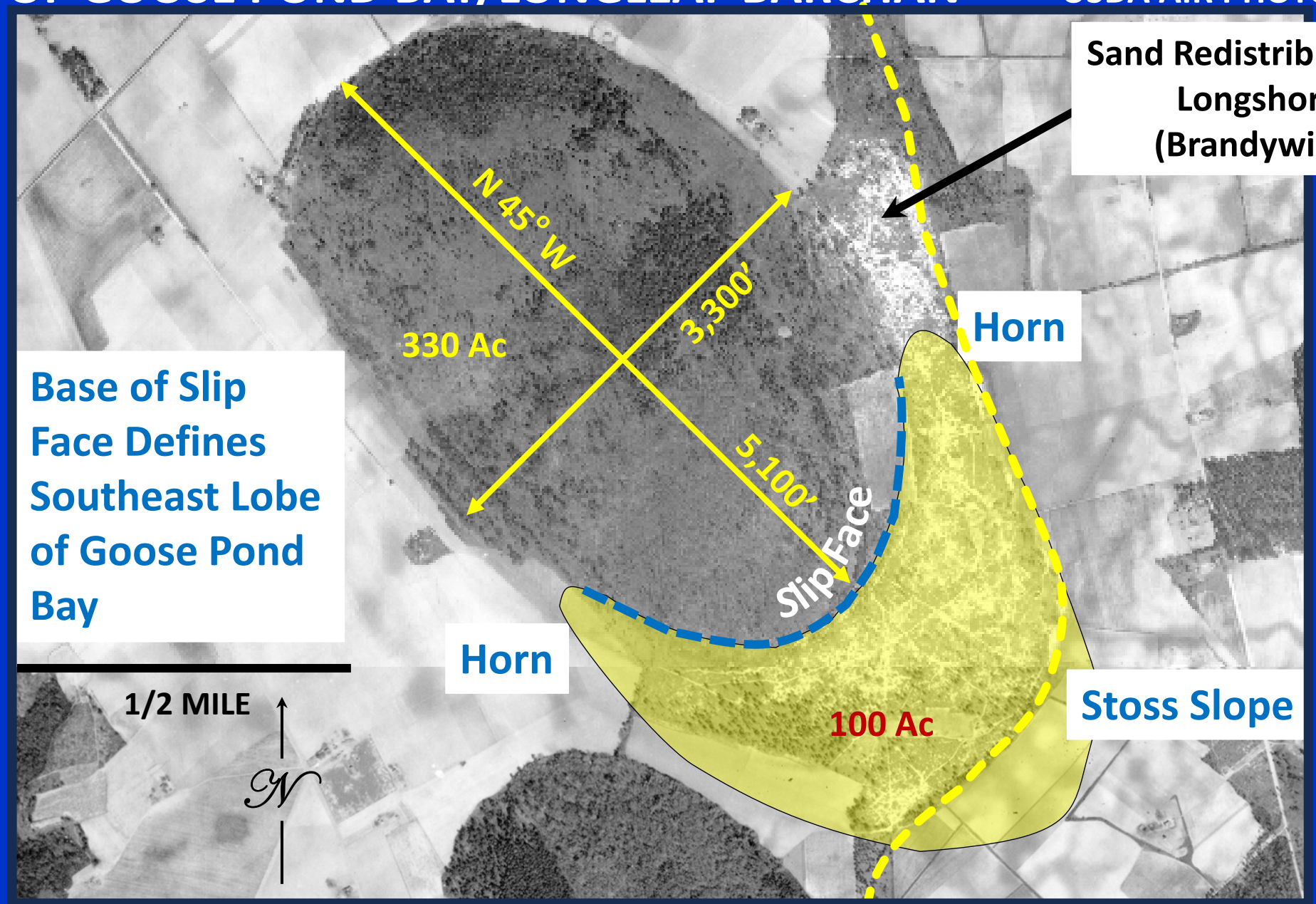
Bays, Rims and Cover Sands (Former Dunes) Overlie Peneplained Upper Cretaceous Middendorf Fm

Fluvial Channels

THE BARCHAN DUNE CAROLINA BAY MODEL

ELEMENTS OF GOOSE POND BAY/LONGLEAF BARCHAN

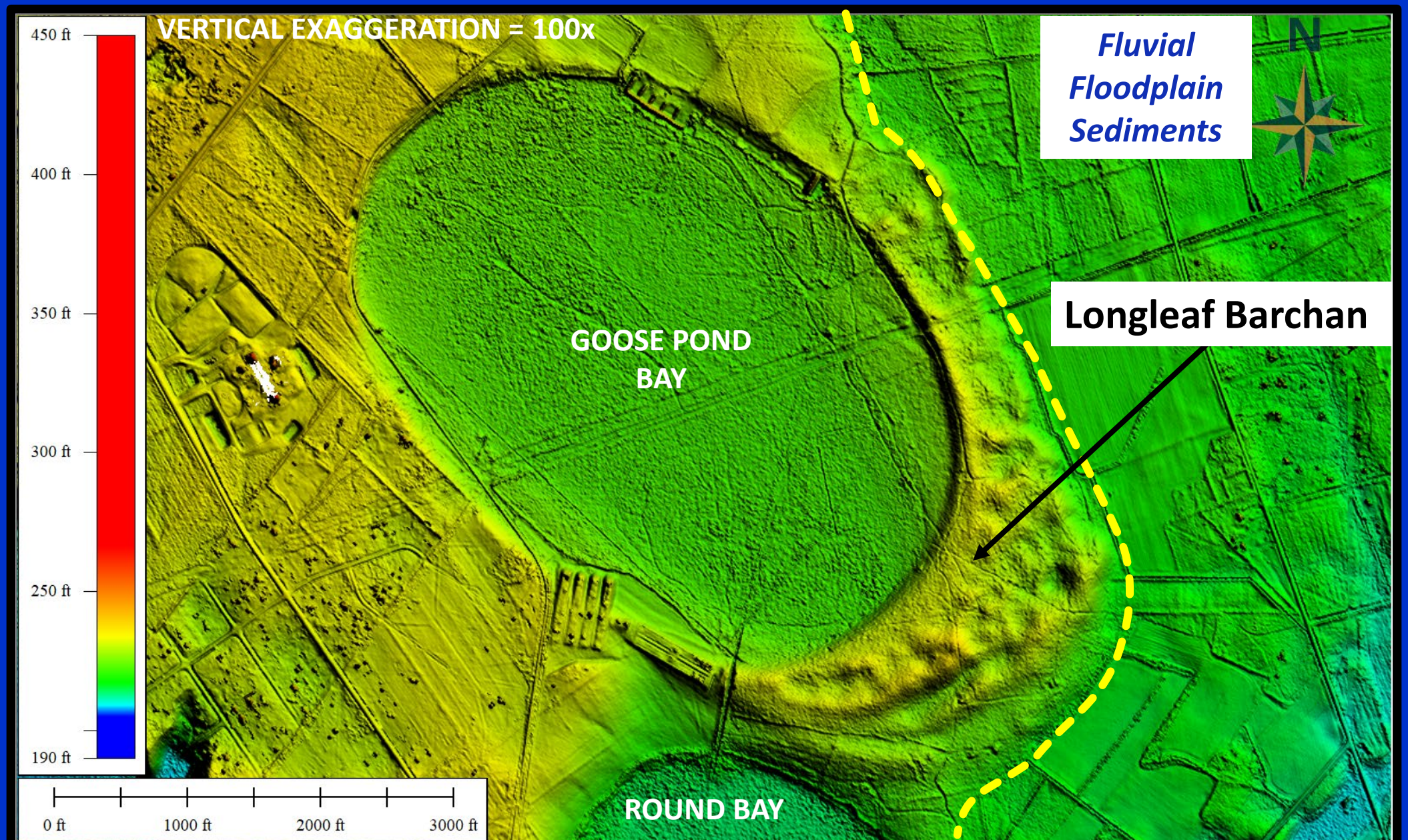
USDA AIR PHOTO SERIES 1938



THE BARCHAN DUNE CAROLINA BAY MODEL

GOOSE POND BAY AND LONGLEAF BARCHAN

GRIDDED 2014 LiDAR ELEVATION DATA



THE BARCHAN DUNE CAROLINA BAY MODEL

GOOSE POND BAY AND LONGLEAF BARCHAN

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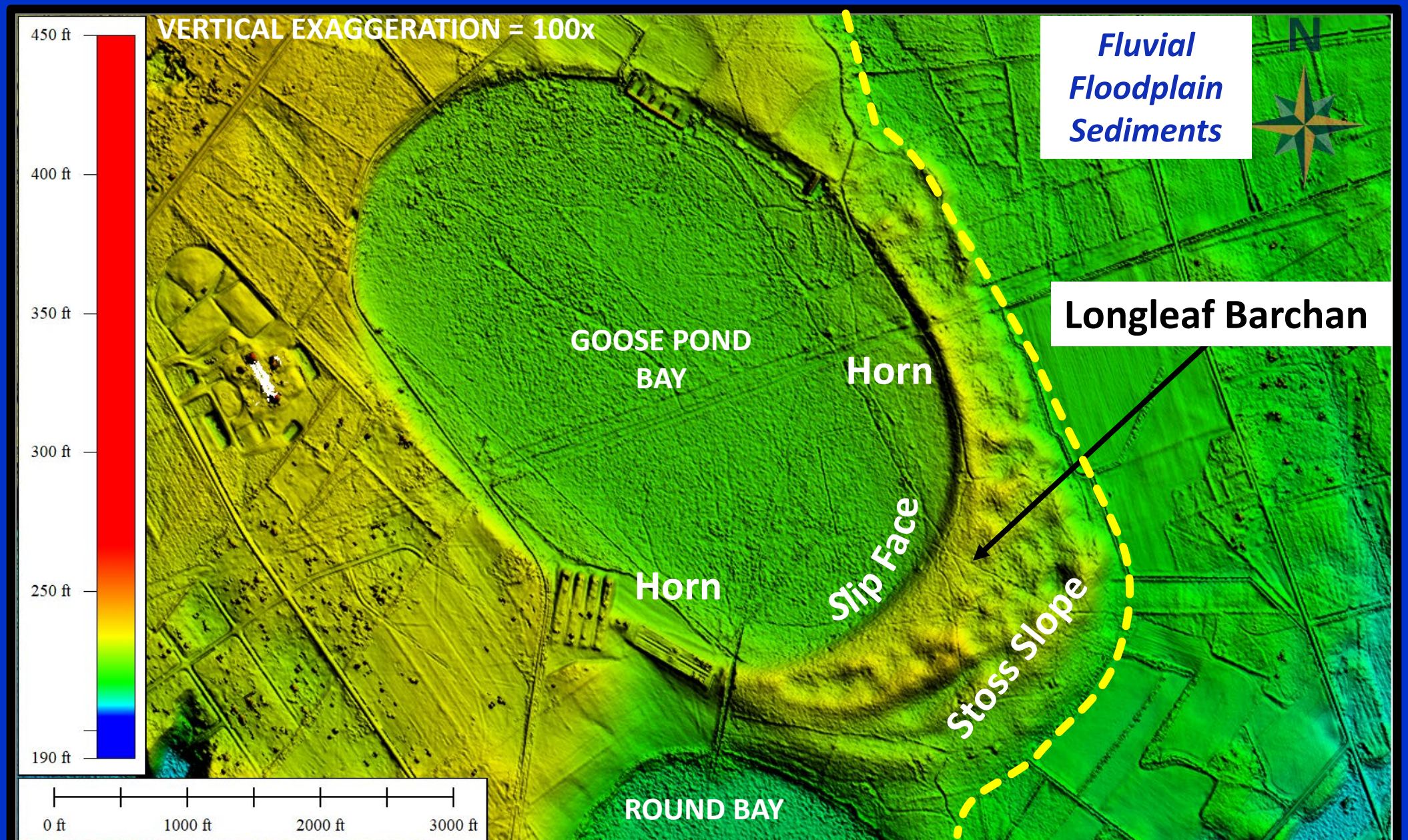
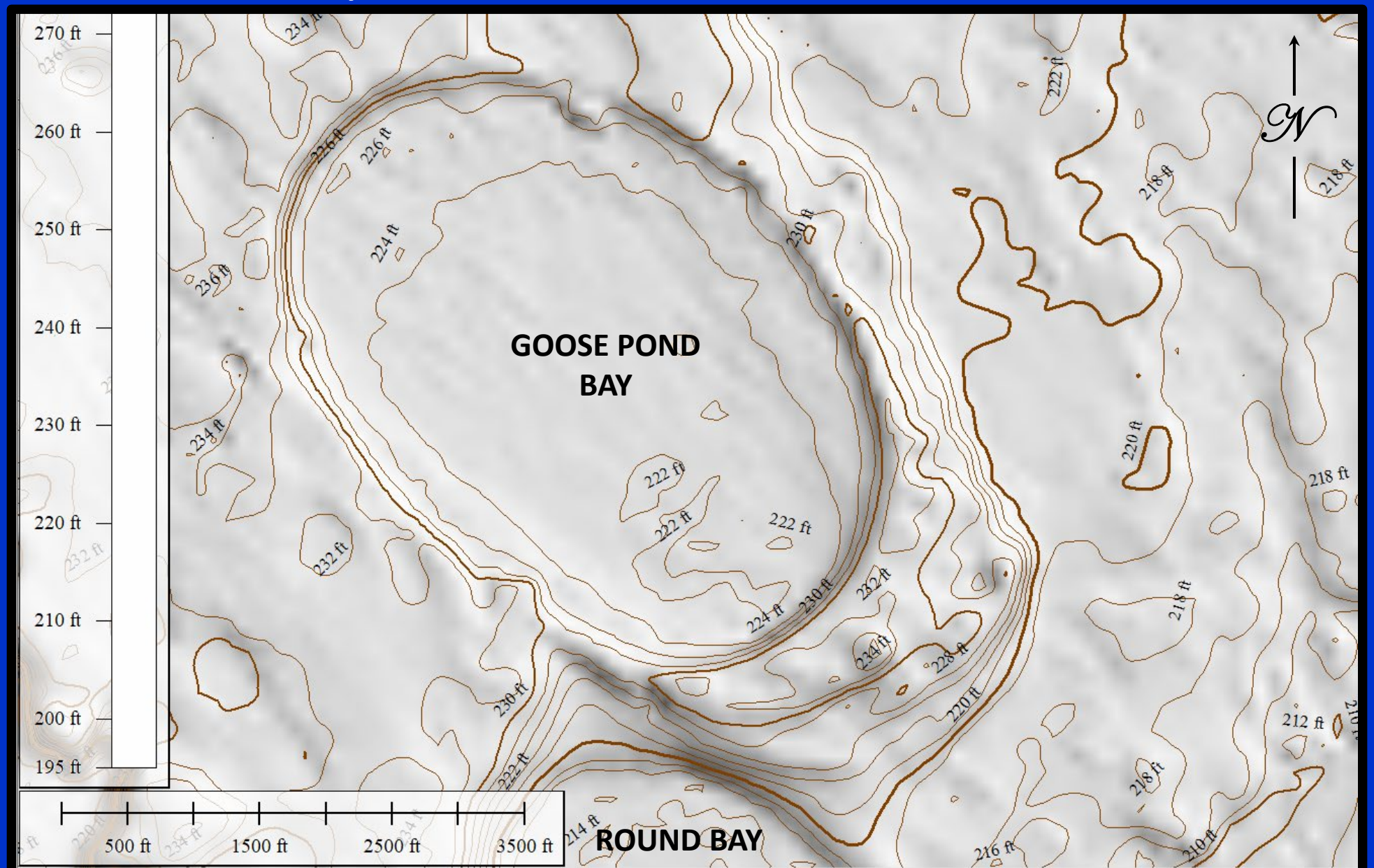


THE BARCHAN DUNE CAROLINA BAY MODEL

SURFACE CONTOUR MAP; C. I.= 2 FT

GRIDDED, CONTOURED 2008 LiDAR ELEVATION DATA



THE BARCHAN DUNE CAROLINA BAY MODEL

SURFACE CONTOUR MAP; C. I.= 2 FT

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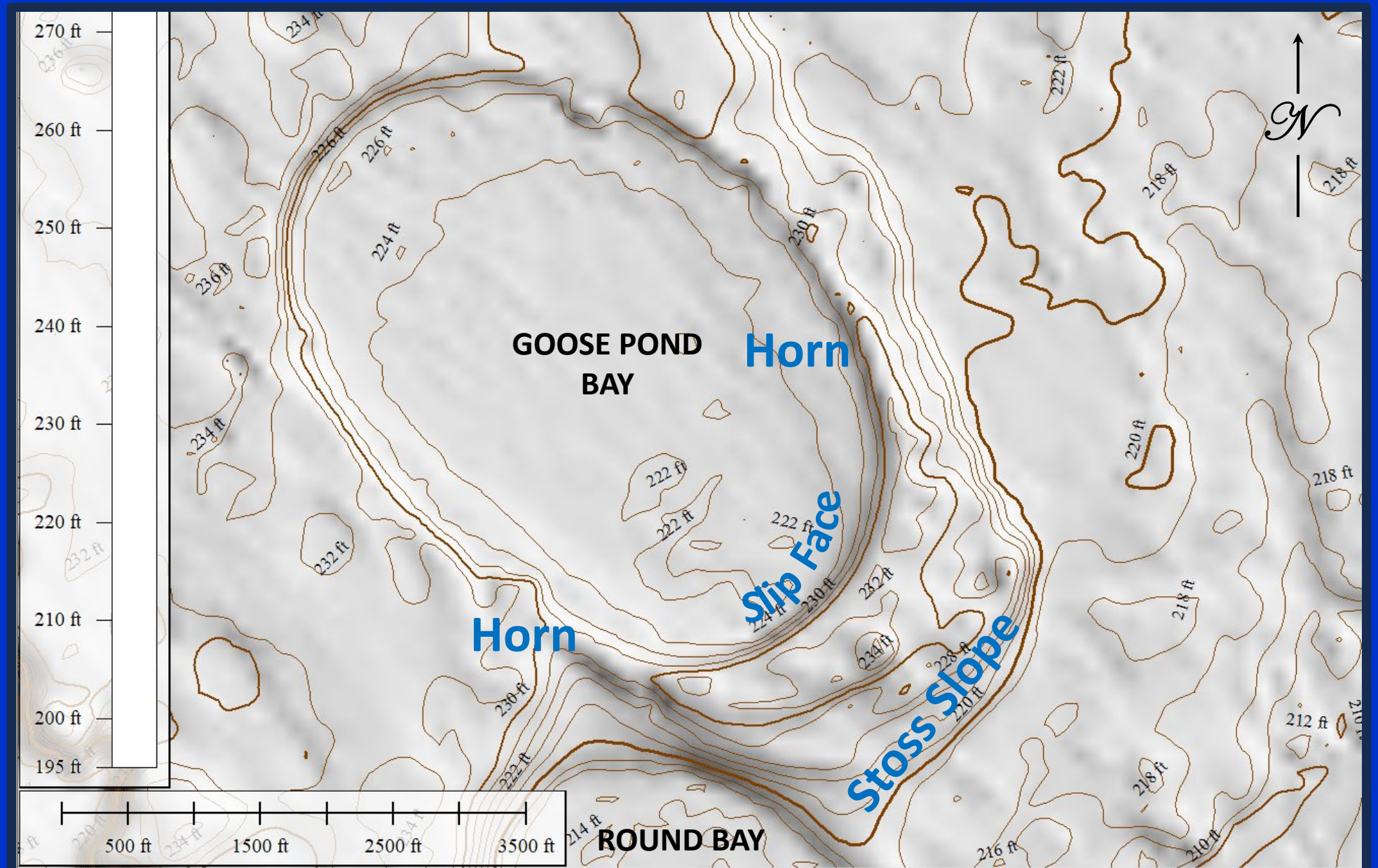
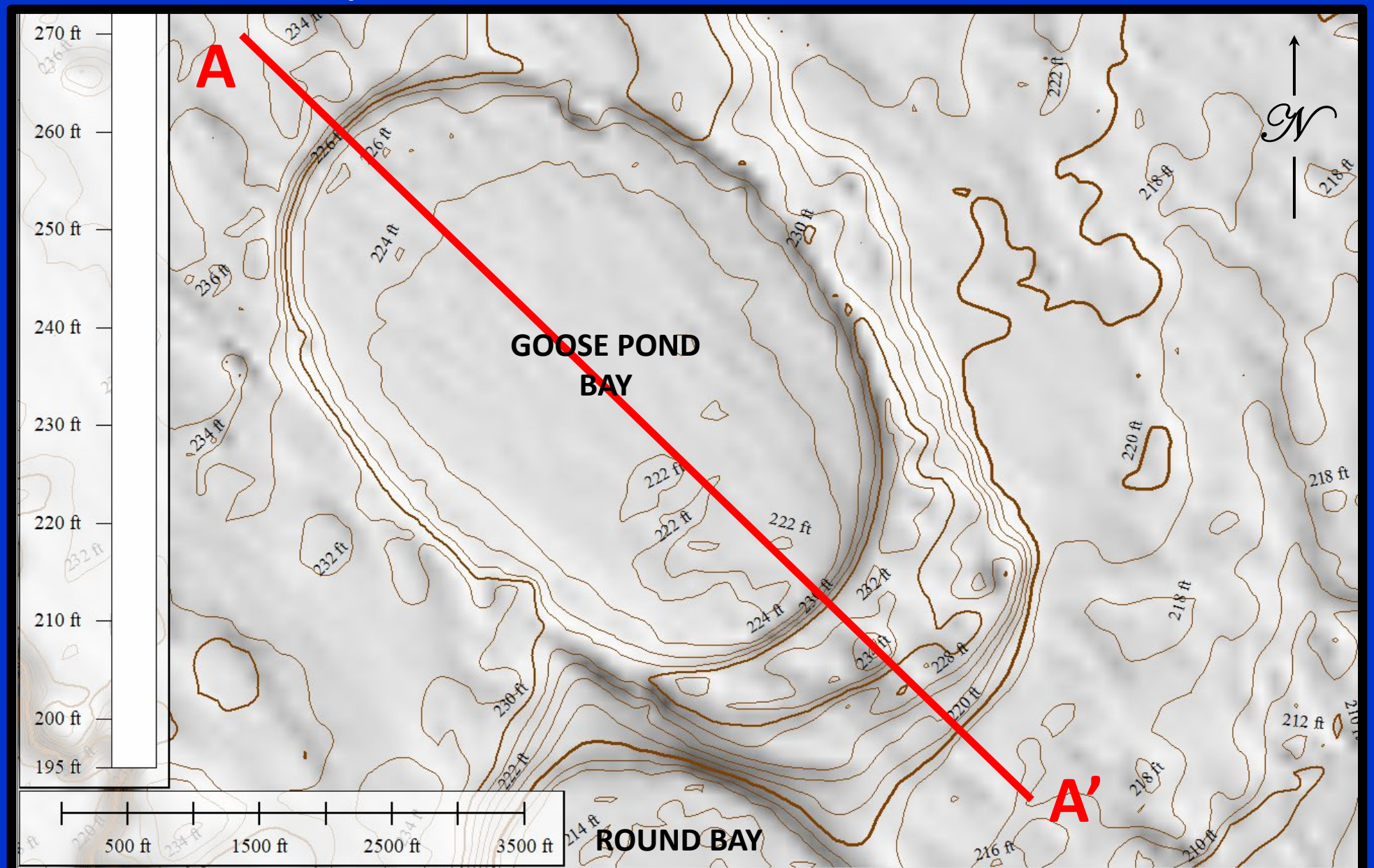


THE BARCHAN DUNE CAROLINA BAY MODEL

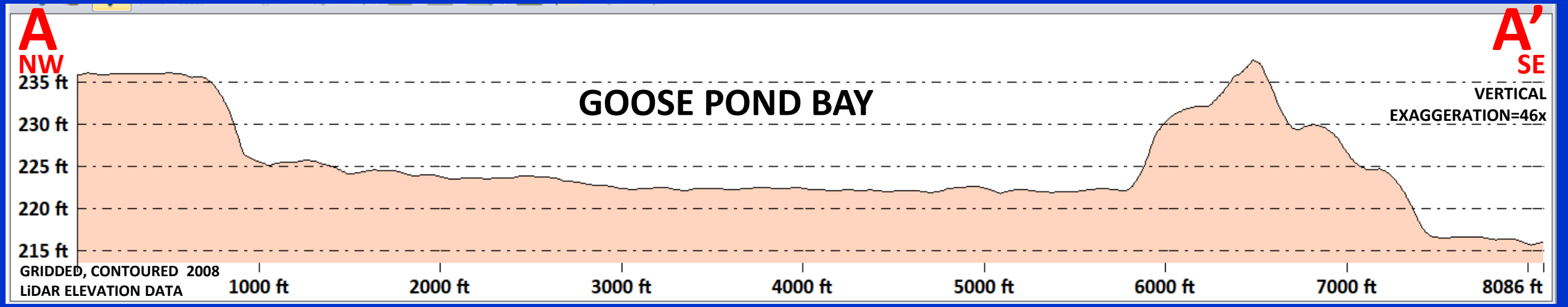
SURFACE CONTOUR MAP; C. I.= 2 FT

GRIDDED, CONTOURED 2008 LiDAR ELEVATION DATA



THE BARCHAN DUNE CAROLINA BAY MODEL

GOOSE POND BAY CROSS-SECTION A-A’ ELEVATION PROFILE



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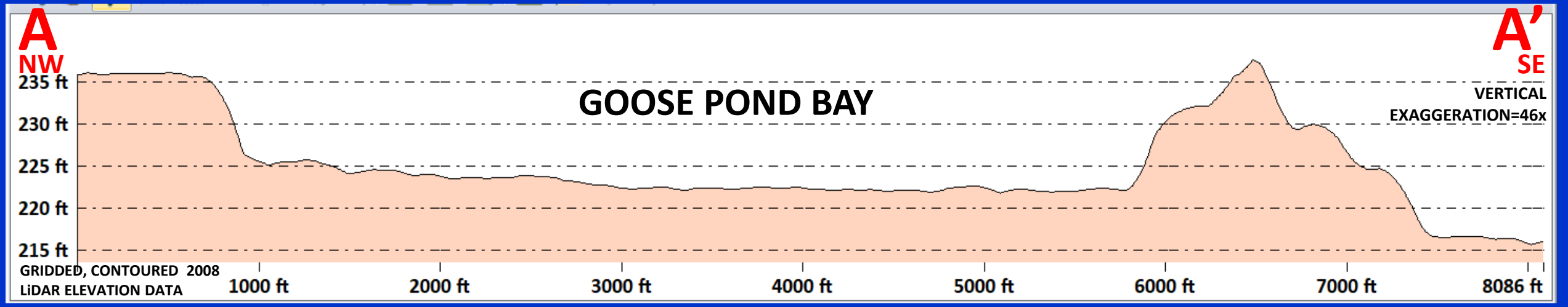
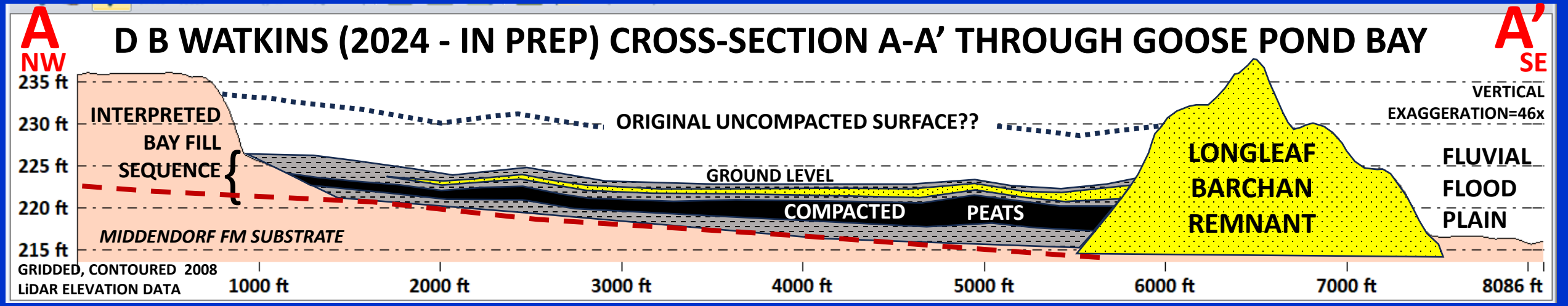
GOOSE POND BAY CROSS-SECTION A-A’ ELEVATION PROFILE



GOOSE POND BAY CROSS-SECTION A-A’ INTERPRETED STRATIGRAPHY



THE BARCHAN DUNE CAROLINA BAY MODEL

THE OLD AND THE NEW: A CROSS-SECTION COMPARISON

L C GLENN (1895) CROSS-SECTION A-B THROUGH A BAY NEAR DARLINGTON, SC

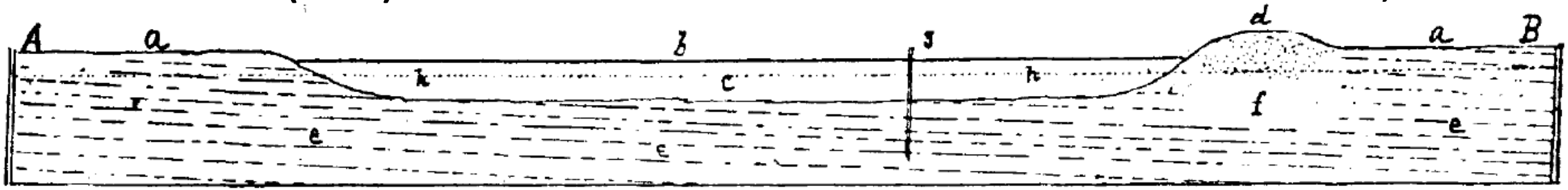
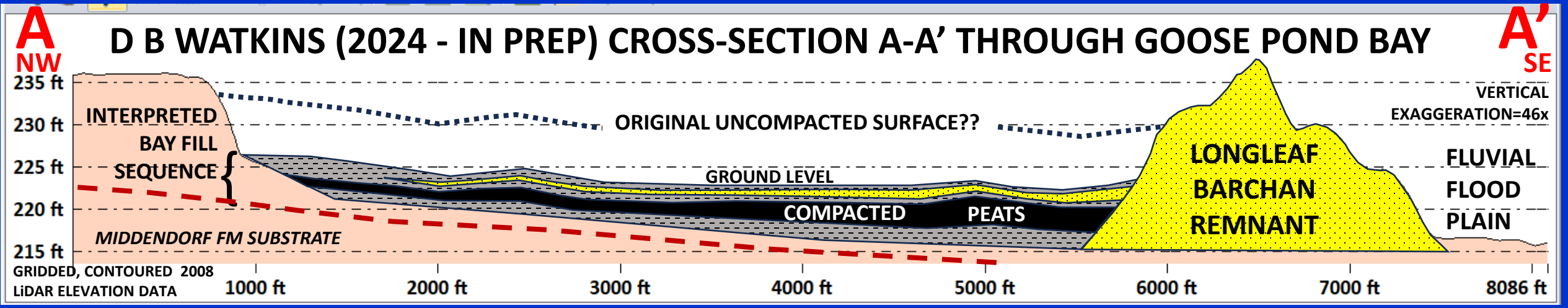
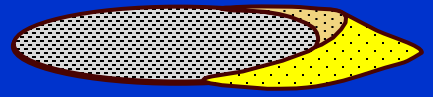


Fig. 3. *Section 'through a bay'* A B, general surface level; *b*, surface of 'bay'; *c*, clay filling basin of 'bay'; *d*, sand ridge; *e*, loose sands and clays dipping gently southeast; *f*, unknown part; *g*, pump; *h*, water level.

D B WATKINS (2024 - IN PREP) CROSS-SECTION A-A' THROUGH GOOSE POND BAY



THE BARCHAN DUNE CAROLINA BAY MODEL



A FIELD VISIT TO

LONGLEAF BARCHAN

THE BARCHAN DUNE CAROLINA BAY MODEL

LONGLEAF BARCHAN - ON STOSS SLOPE LOOKING UPDIP TOWARD CREST

THE BARCHAN DUNE CAROLINA BAY MODEL

LONGLEAF BARCHAN – CREST: WHITE, WELL-SORTED UNCONSOLIDATED QUARTZ SAND

THE BARCHAN DUNE CAROLINA BAY MODEL

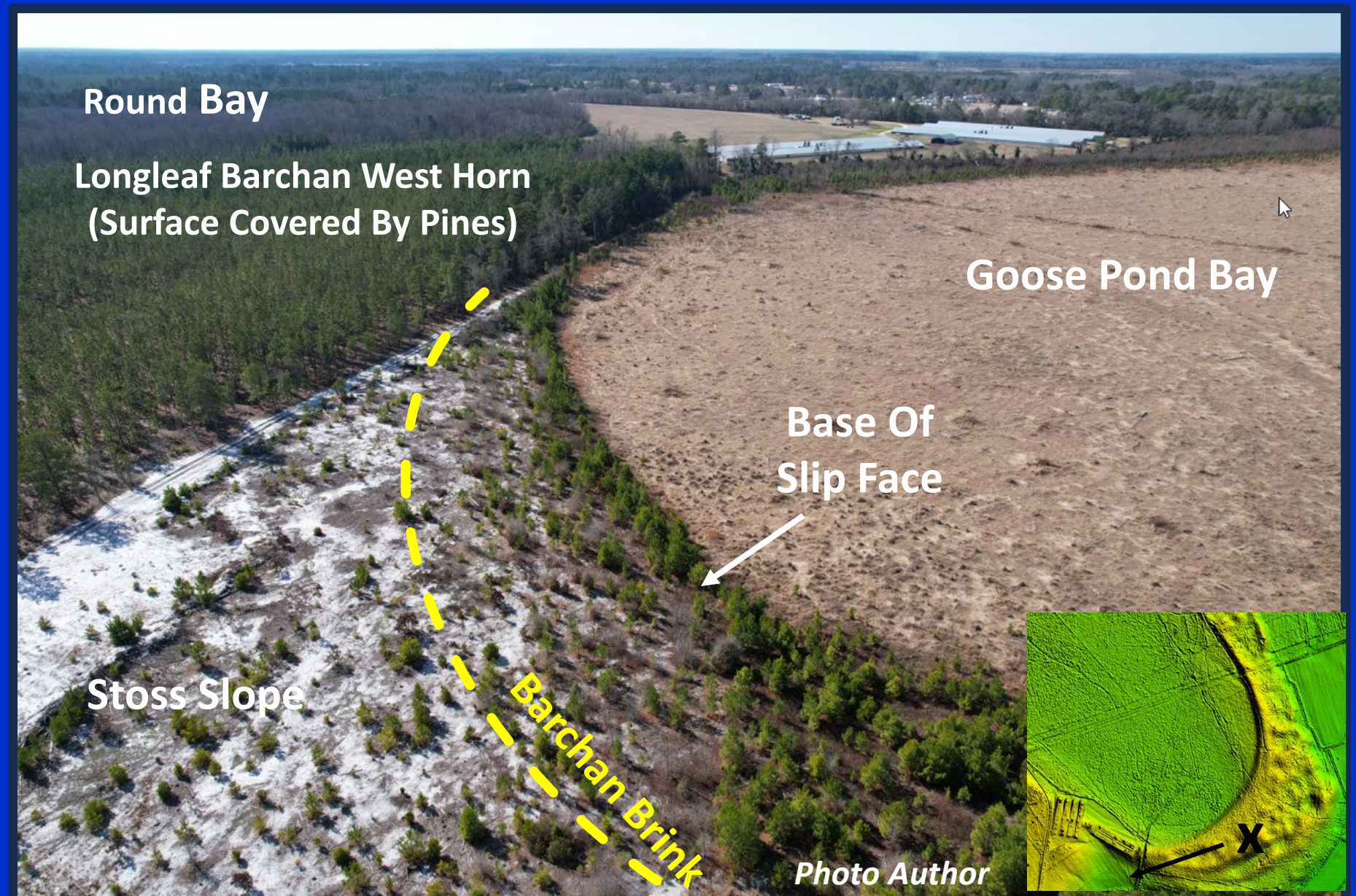
LONGLEAF BARCHAN - OVERLOOKING SLIP FACE AND GOOSE POND BAY 15’ BELOW

THE BARCHAN DUNE CAROLINA BAY MODEL

LONGLEAF BARCHAN – WEST HORN, SLIP FACE AND GOOSE POND BAY

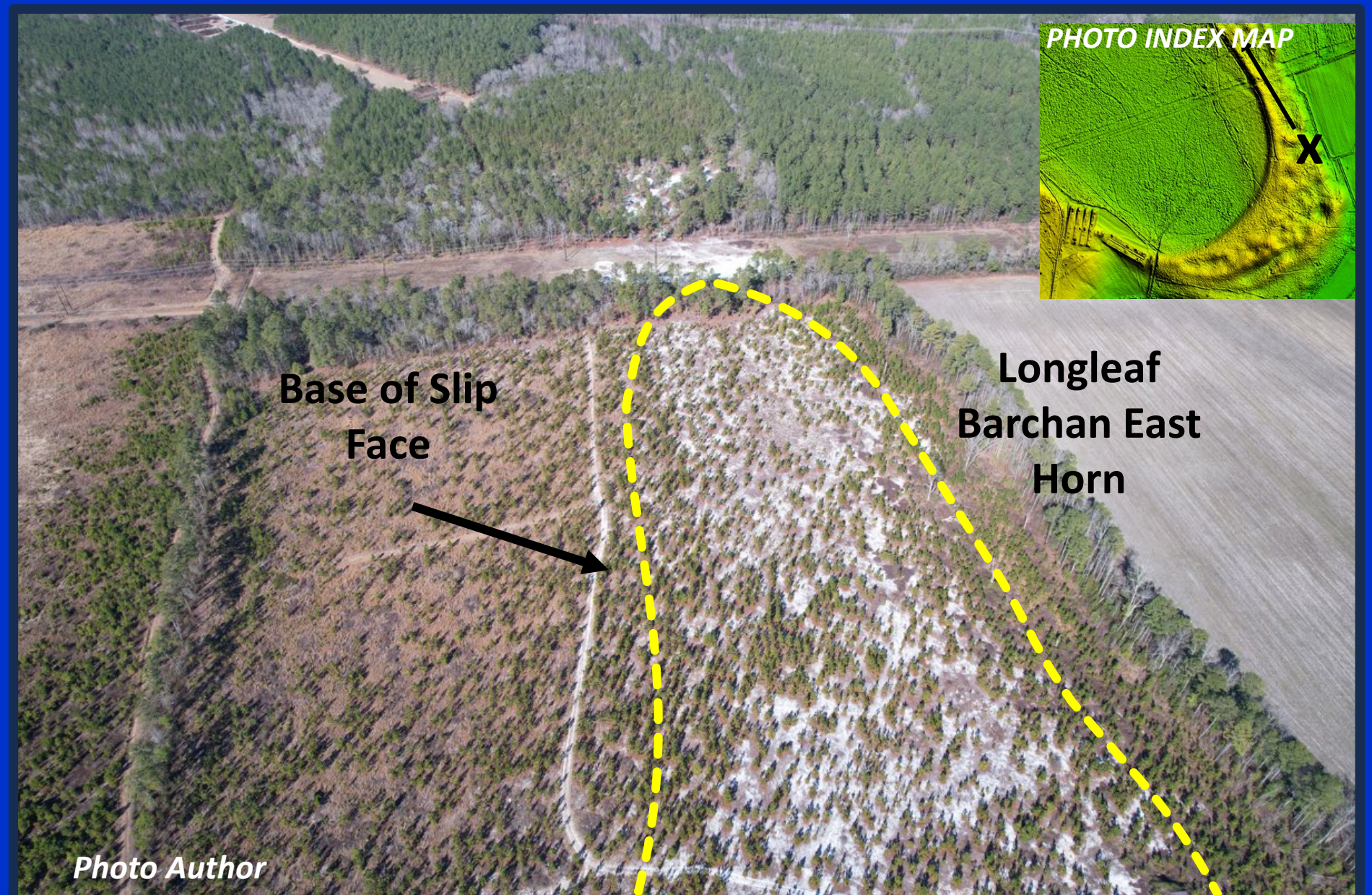
THE BARCHAN DUNE CAROLINA BAY MODEL

LONGLEAF BARCHAN – WEST HORN, SLIP FACE AND GOOSE POND BAY



THE BARCHAN DUNE CAROLINA BAY MODEL

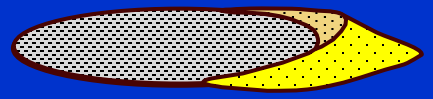
LONGLEAF BARCHAN – EAST HORN AND SLIP FACE



THE BARCHAN DUNE CAROLINA BAY MODEL

LONGLEAF BARCHAN – CREST: WHITE, WELL-SORTED UNCONSOLIDATED QUARTZ SAND

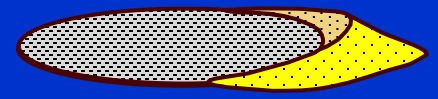
THE BARCHAN DUNE CAROLINA BAY MODEL



CONCLUSIONS SO FAR, BASED ON THE EVIDENCE

- LONGLEAF SAND BODY, FEATURING CRESCENT SHAPE, STOSS SLOPE, SLIP FACE, TWO HORNS AND WELL-SORTED, CLEAN QUARTZ SAND, IS A REMNANT LARGE EOLIAN BARCHAN SAND DUNE
- BASE OF SLIP FACE OF LONGLEAF BARCHAN DEFINES SOUTHEAST LOBE OF GOOSE POND BAY; HORNS FORM PART OF LATERAL BAY MARGINS
- DEPOSITIONAL ENVIRONMENT: COASTAL PLAIN DESERT
- WIND DIRECTION: ONSHORE FROM SOUTHEAST

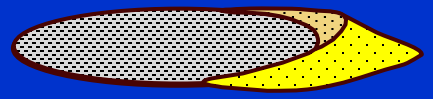
THE BARCHAN DUNE CAROLINA BAY MODEL



THUS FAR WE HAVE:

- A BARCHAN DUNE AND ITS INTEGRAL ADJACENT CAROLINA BAY

THE BARCHAN DUNE CAROLINA BAY MODEL



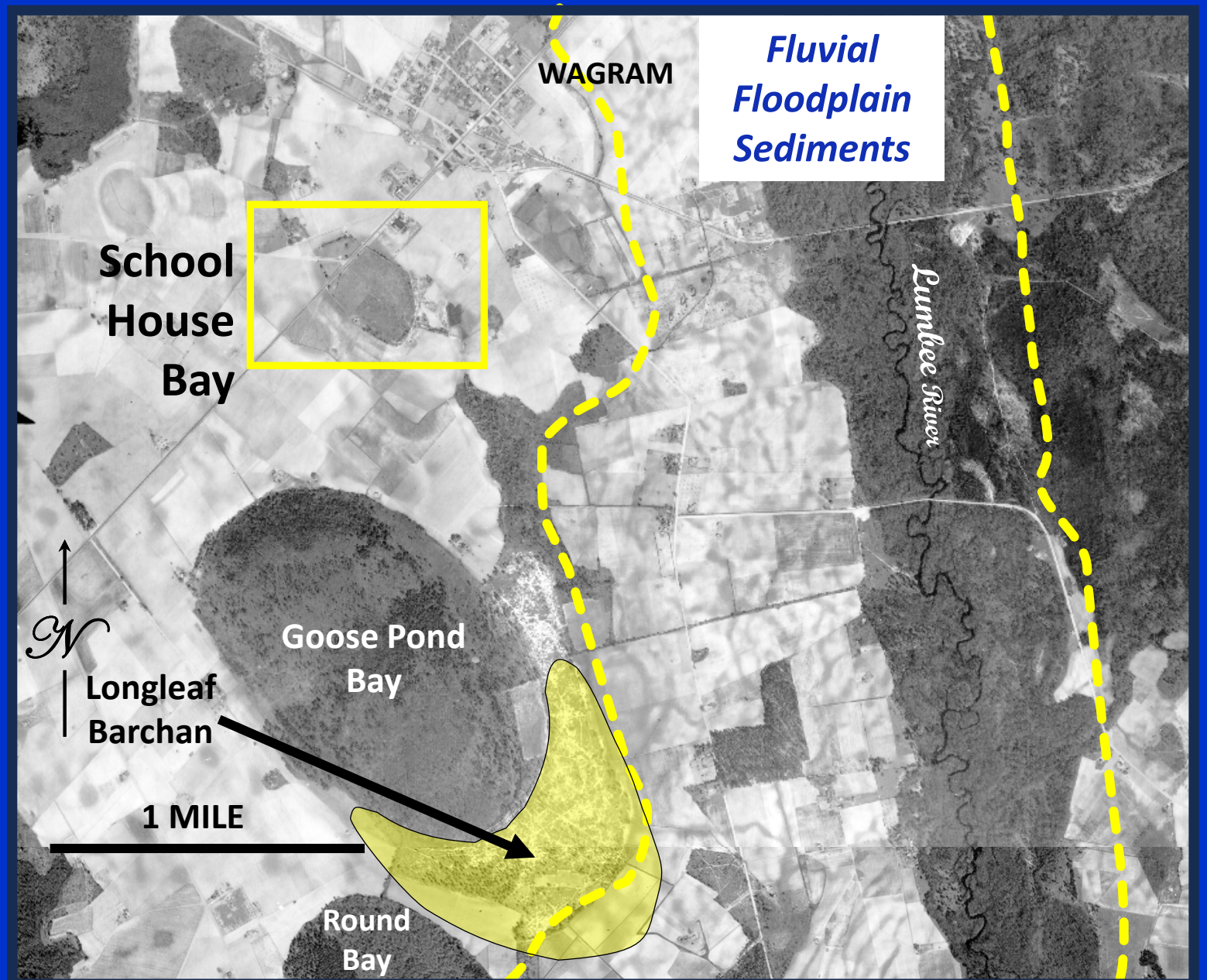
CAROLINA BAY STRATIGRAPHY EXPOSED AT SCHOOL HOUSE BAY;

A SAND/PEAT SEQUENCE REVEALED

THE BARCHAN DUNE CAROLINA BAY MODEL

CHANCE OUTCROP OF A CAROLINA BAY SEDIMENTARY SEQUENCE

USDA AIR PHOTO SERIES 1938

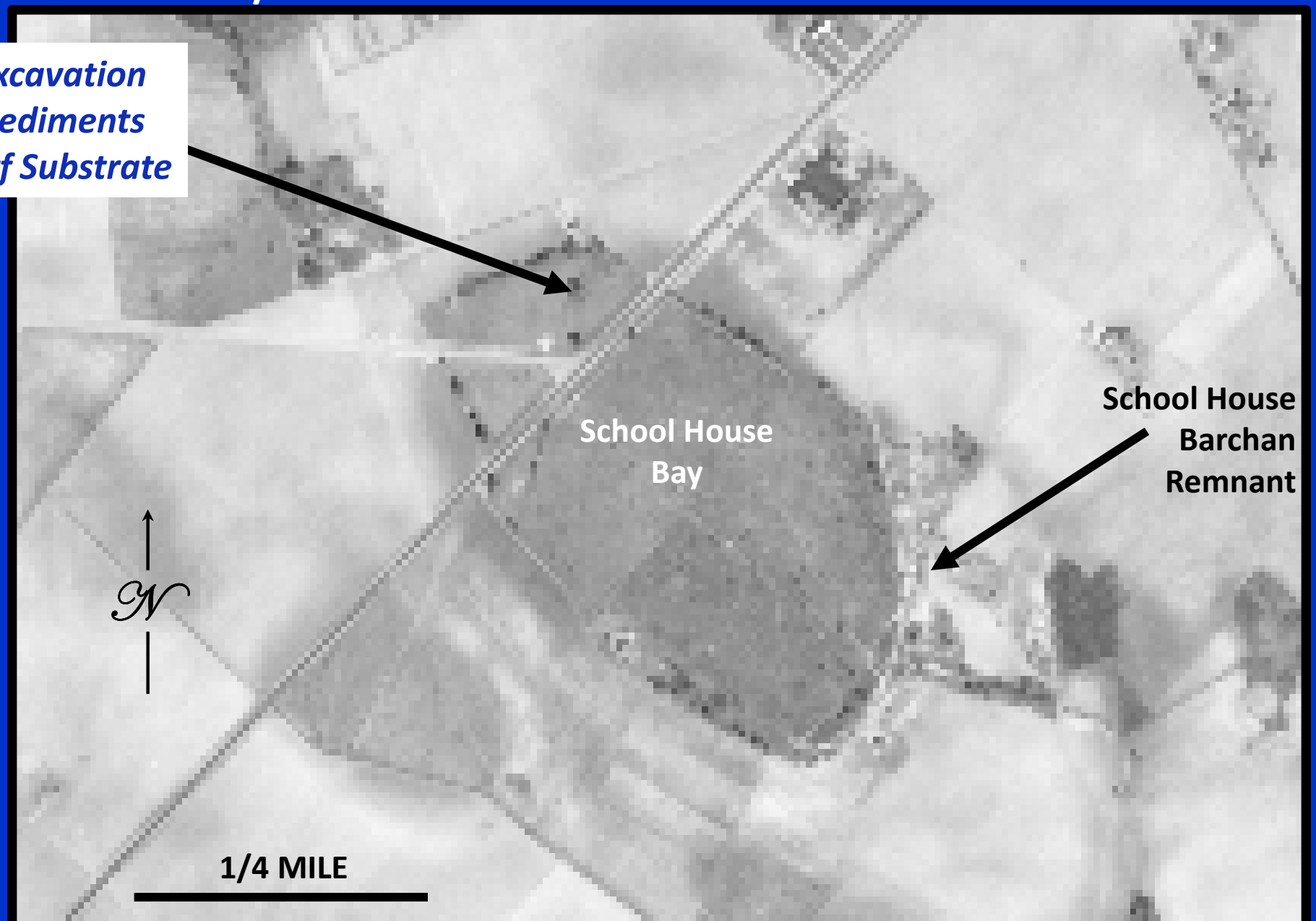


THE BARCHAN DUNE CAROLINA BAY MODEL

SCHOOL HOUSE BARCHAN/BAY

USDA AIR PHOTO SERIES 1938

Commercial Excavation Exposes Bay Sediments And Middendorf Substrate



THE BARCHAN DUNE CAROLINA BAY MODEL

SCHOOL HOUSE BAY WITH DUNE OVERLAY

USDA AIR PHOTO SERIES 1938

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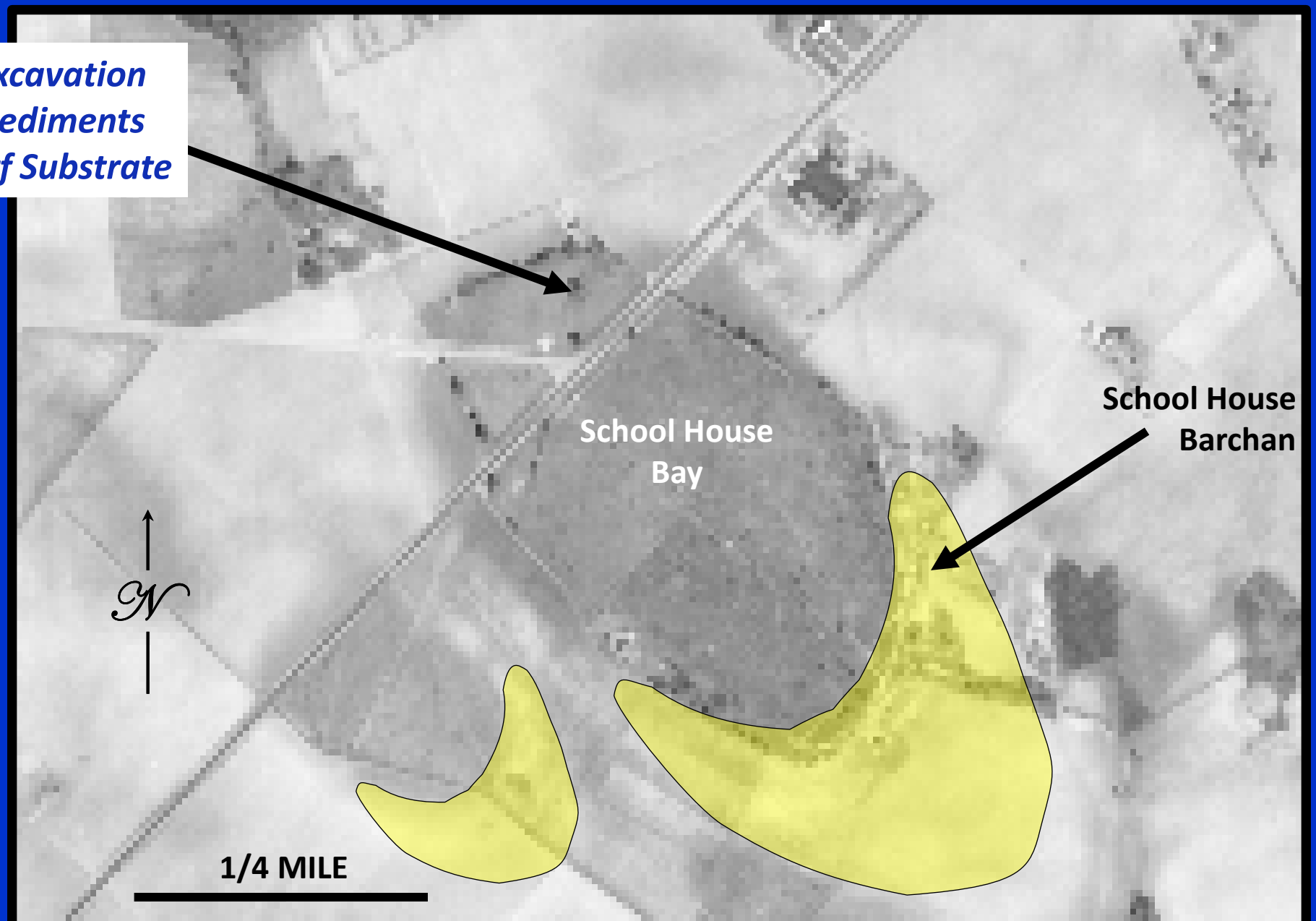
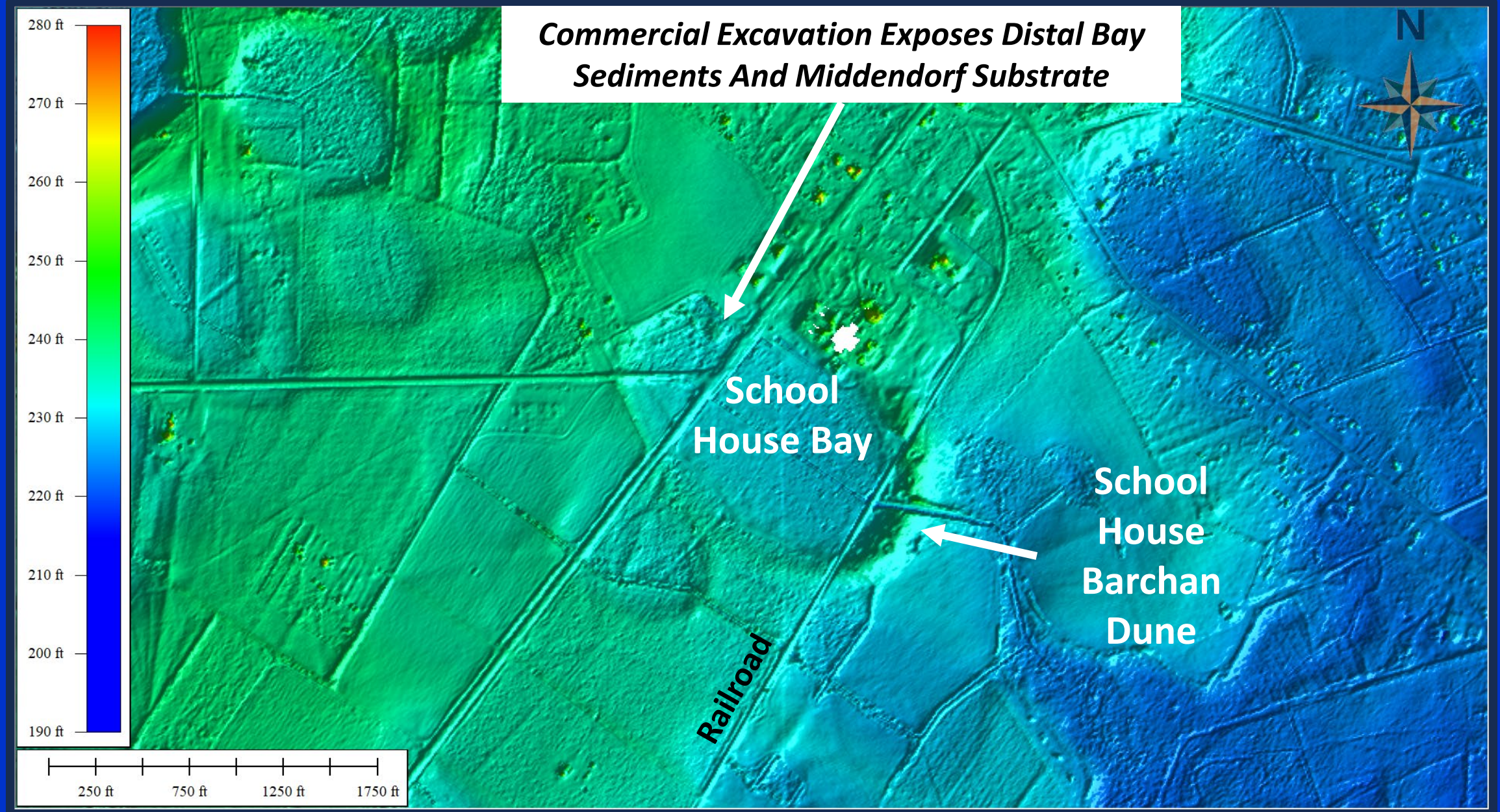


THE BARCHAN DUNE CAROLINA BAY MODEL

A HAPPENSTANCE OUTCROP OF BAY SEDIMENTS

GRIDDED 2014 LiDAR ELEVATION DATA



THE BARCHAN DUNE CAROLINA BAY MODEL

A TIMELY HAPPENSTANCE OUTCROP OF SCHOOL HOUSE BAY SEDIMENTS

PHOTO AUTHOR

THE BARCHAN DUNE CAROLINA BAY MODEL

EXCAVATION FOR FUEL TANK INSTALLATION

PHOTO: PIEDMONT PUMP & TANK, LLC

THE BARCHAN DUNE CAROLINA BAY MODEL

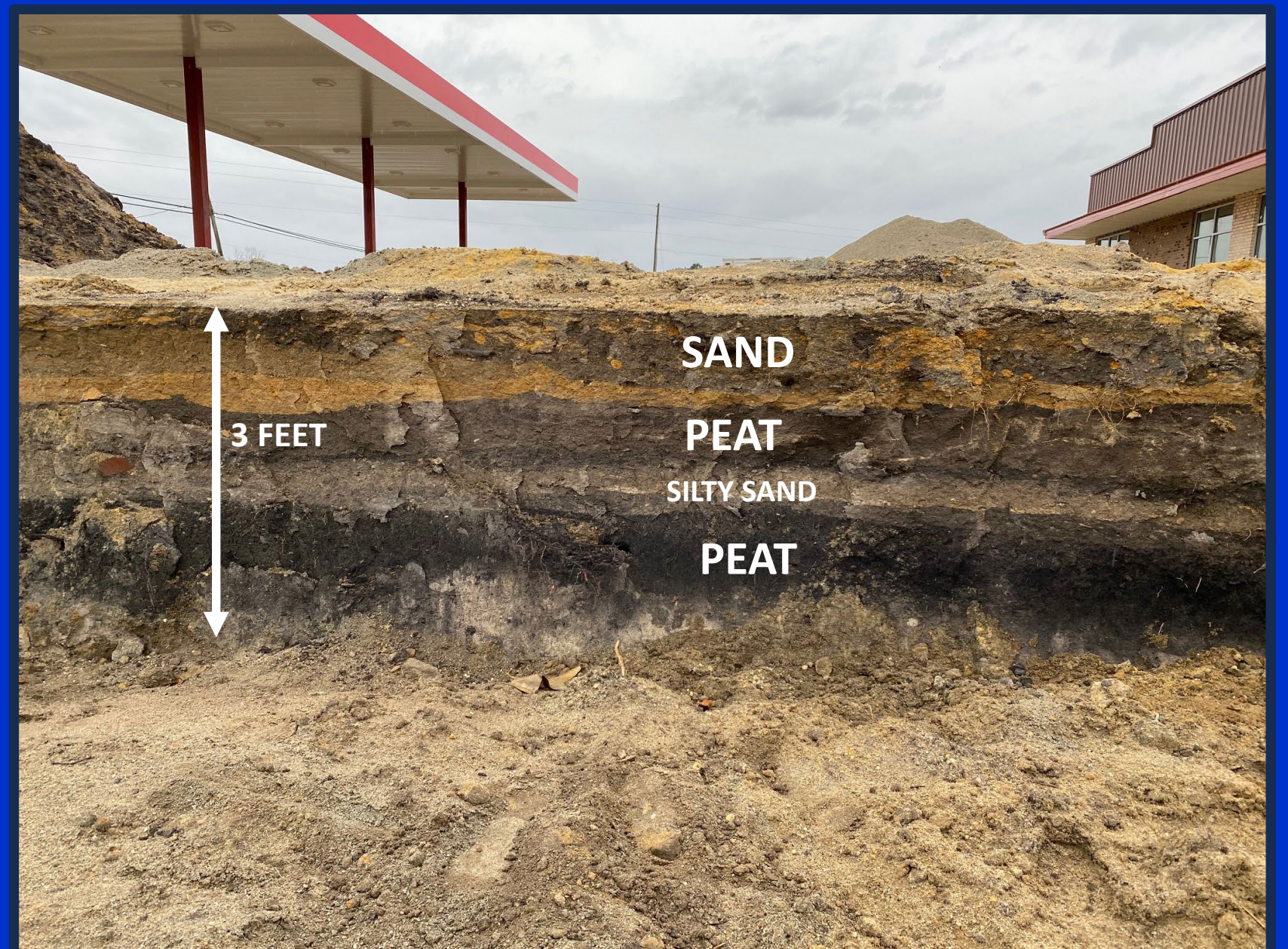
TRUCK STOP STRATIGRAPHY

PHOTO: PIEDMONT PUMP & TANK, LLC

THE BARCHAN DUNE CAROLINA BAY MODEL

SCHOOL HOUSE BAY - BAY SEDIMENTARY SUCCESSION REVEALED

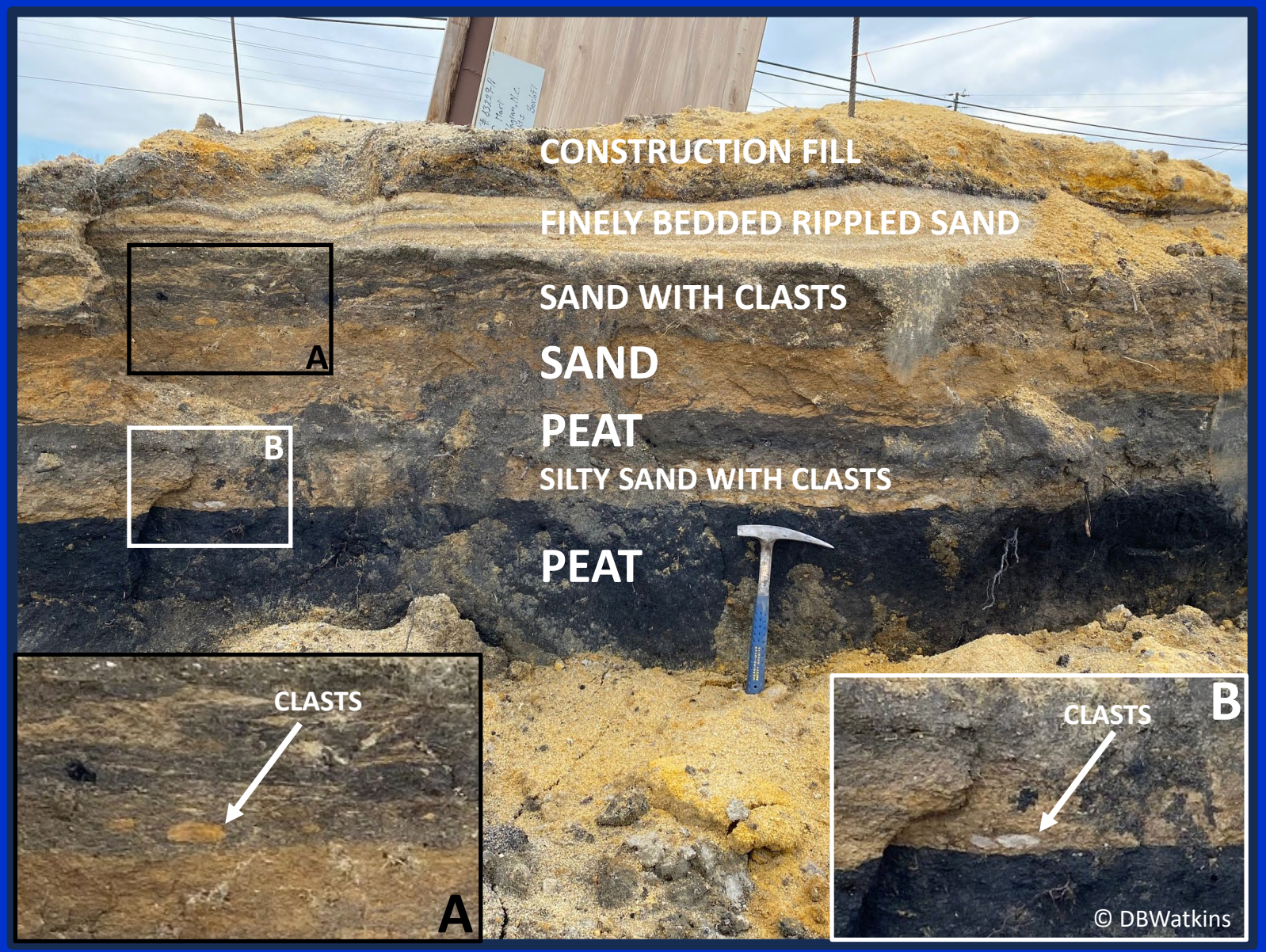
PHOTO: AUTHOR



THE BARCHAN DUNE CAROLINA BAY MODEL

SCHOOL HOUSE BAY - DISTAL BAY STRATIGRAPHY REVEALED

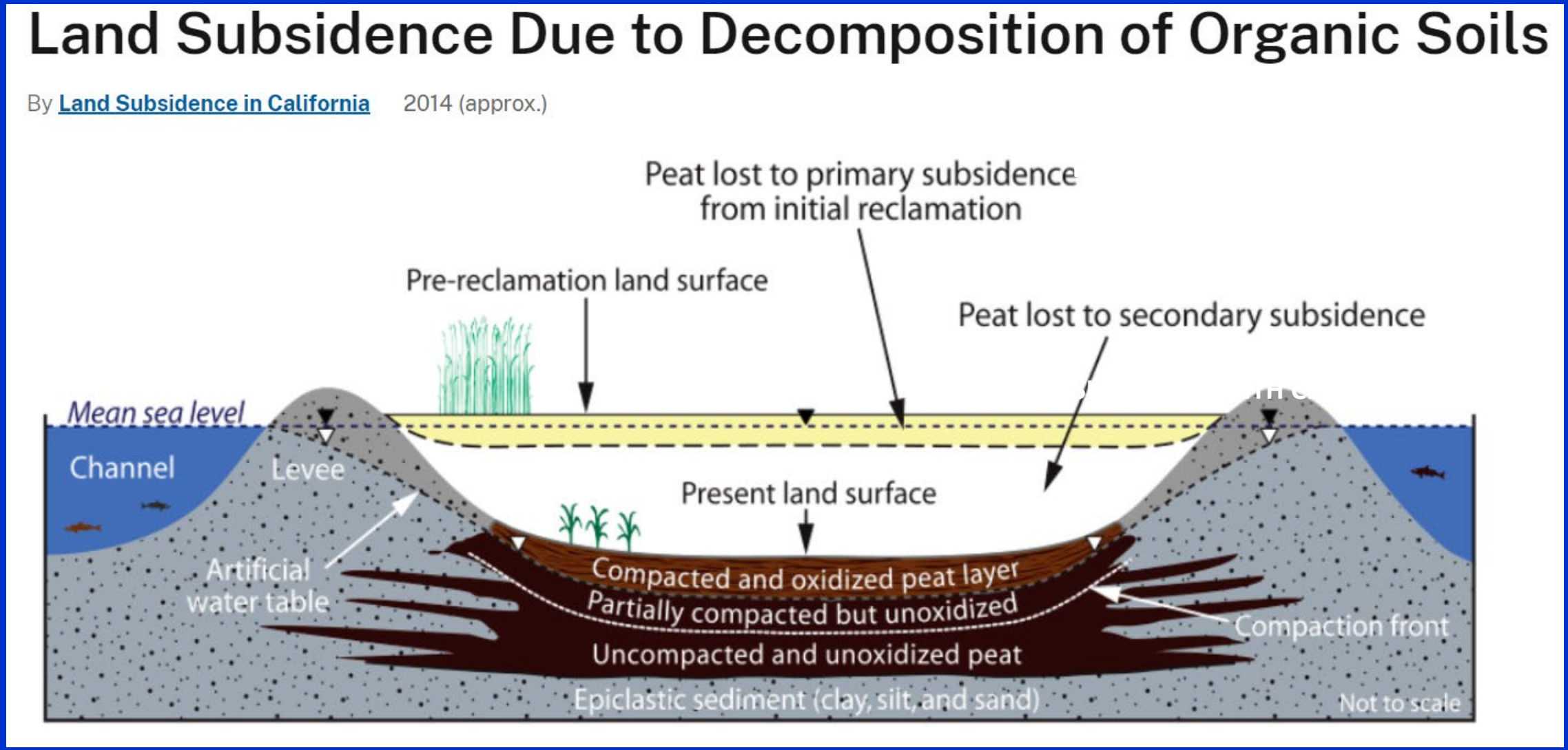
PHOTOS AUTHOR



THE BARCHAN DUNE CAROLINA BAY MODEL

PEAT COMPACTION AND LAND SUBSIDENCE IN CALIFORNIA

USGS 2014



THE BARCHAN DUNE CAROLINA BAY MODEL

PEAT AUTOCOMPACTION

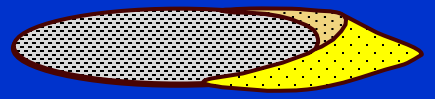
KAYE AND BARGHOORN 1964

AUTOCOMPACTION OF PEAT

Compaction of sediments beneath a weight is a well-known geological process that in recent years has been extensively investigated by students of soil mechanics.[1] It involves the collapse of the solid soil fabric and the squeezing out of the interstitial water of the saturated sediment. The theory of the compaction of soils as a function of time, pressure, and physical parameters was first worked out by Terzaghi (1925) and has been confirmed and refined many times since.

Peat is the most compressible of all natural soils because of its very high porosity and its weak skeletal framework of vegetable fiber. Not only will it compress beneath an applied load, but under certain conditions it will also compress under its own weight, a process which can be called *autocompaction* to distinguish it from compaction by externally applied loads.

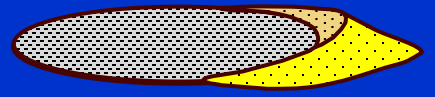
THE BARCHAN DUNE CAROLINA BAY MODEL



SIGNIFICANCE OF SCHOOL HOUSE BAY EXPOSURE

- AS OTHERS HAVE DEMONSTRATED, PEAT IS CONFIRMED AS A SIGNIFICANT ELEMENT OF LOCAL BAY STRATIGRAPHY, EXPLAINING BOTH THE DARK ORGANIC SOIL CONTENT AND SUBSIDENCE
- PEAT IS THE MOST COMPACTABLE OF ALL SOILS
- COMPACTION OF PEAT LIKELY CONSTITUTES MAJORITY OF BAY SUBSIDENCE
- DEPOSITIONAL ENVIRONMENT: INTERGLACIAL TEMPERATE FORESTED BOG WHICH, IN SOME CASES, PERSISTS TO THIS DAY

THE BARCHAN DUNE CAROLINA BAY MODEL



THUS FAR WE HAVE:

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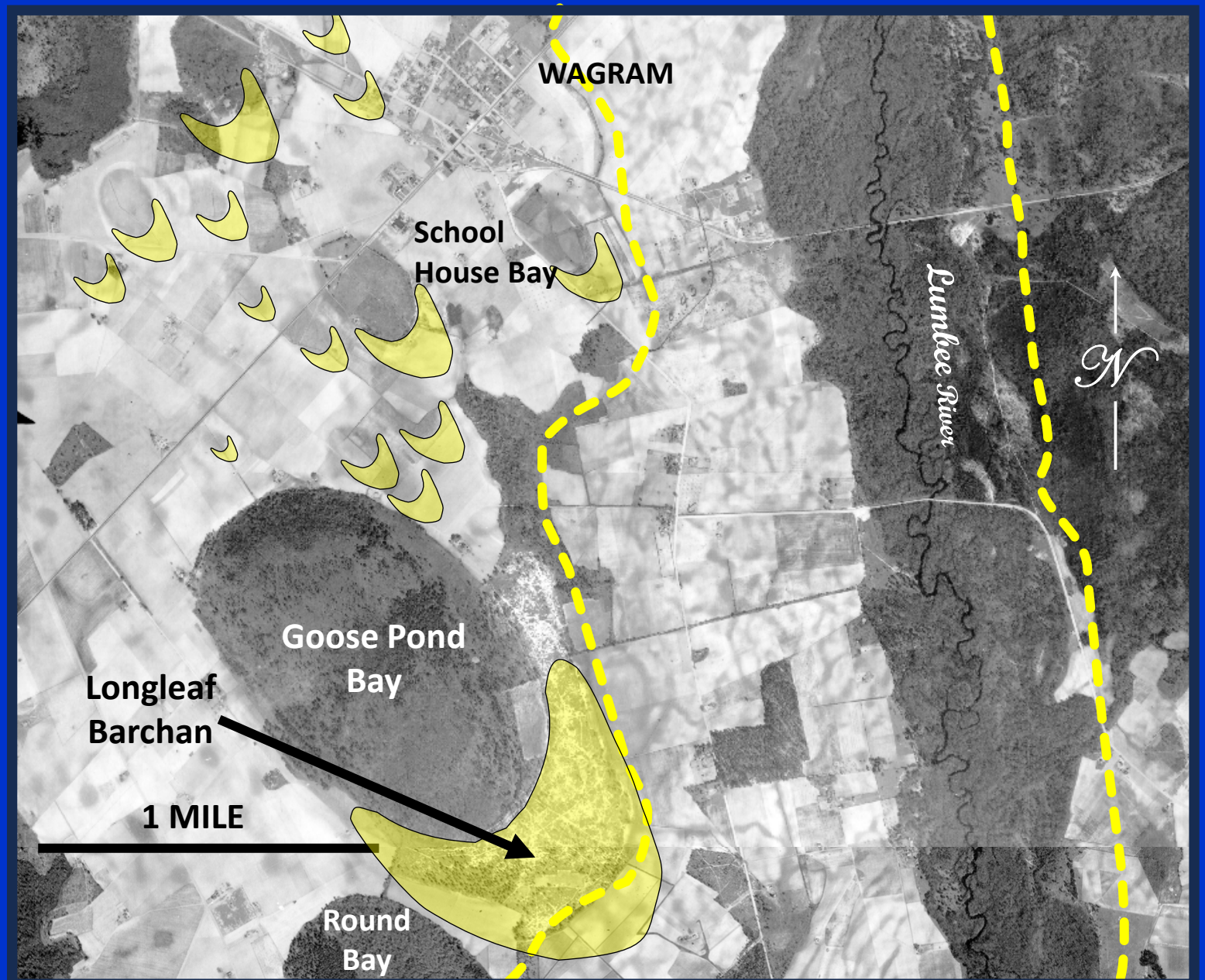
- A CAROLINA BAY PEAT-RICH SEDIMENTARY SEQUENCE

THE BARCHAN DUNE CAROLINA BAY MODEL

BAYS WITH DUNE OVERLAY

USDA AIR PHOTO SERIES 1938



THE BARCHAN DUNE CAROLINA BAY MODEL

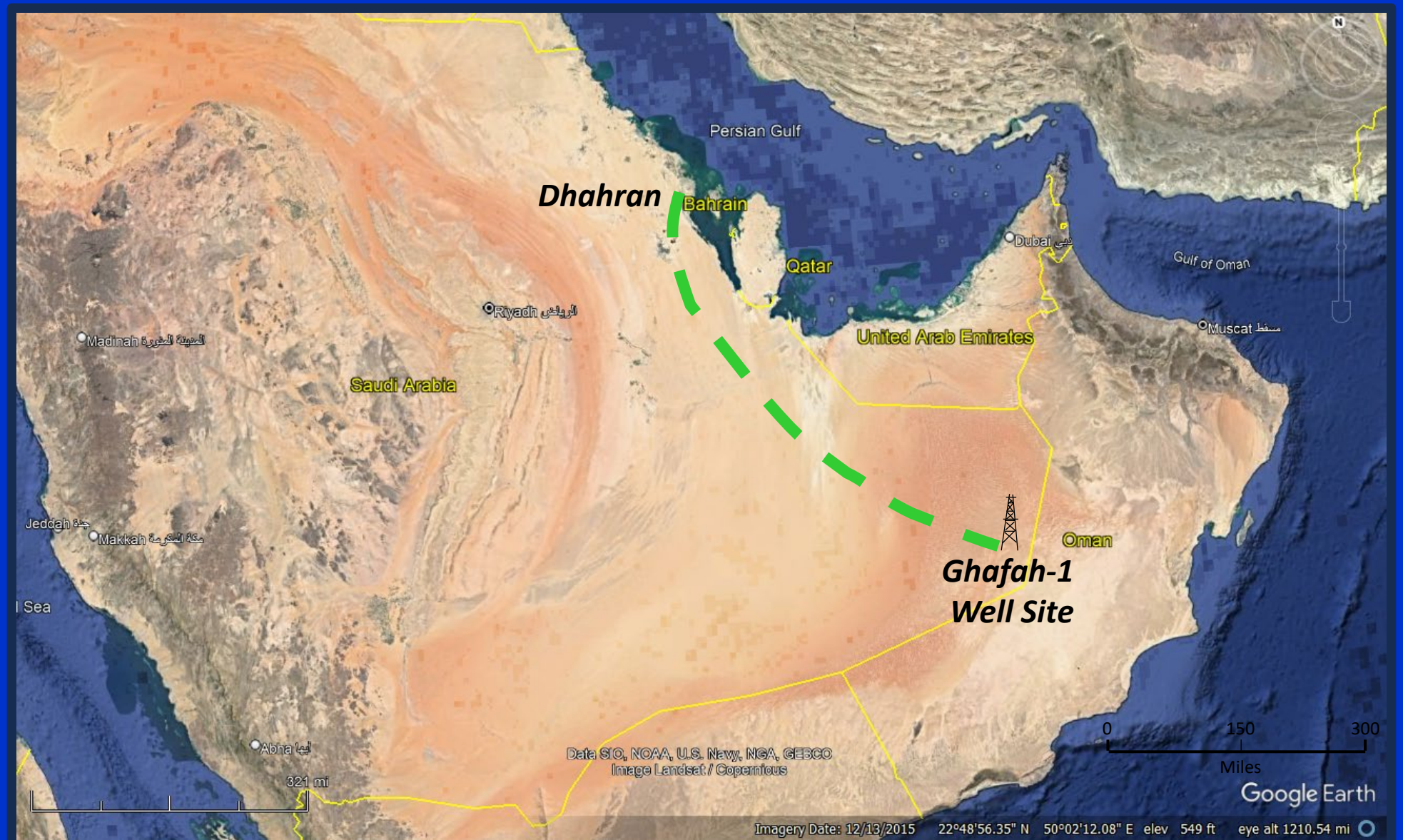
VEGETATION OBSCURES MOST OF THE BAYSBARCHAN REMNANTS

GOOGLE EARTH IMAGE 2021

THE BARCHAN DUNE CAROLINA BAY MODEL

A MOMENT OF ENLIGHTENMENT: NOVEMBER 1986 FLIGHT PATH TO GHAFAH-1 WELL SITE, KINGDOM OF SAUDI ARABIA

GOOGLE EARTH IMAGE 2015



THE BARCHAN DUNE CAROLINA BAY MODEL

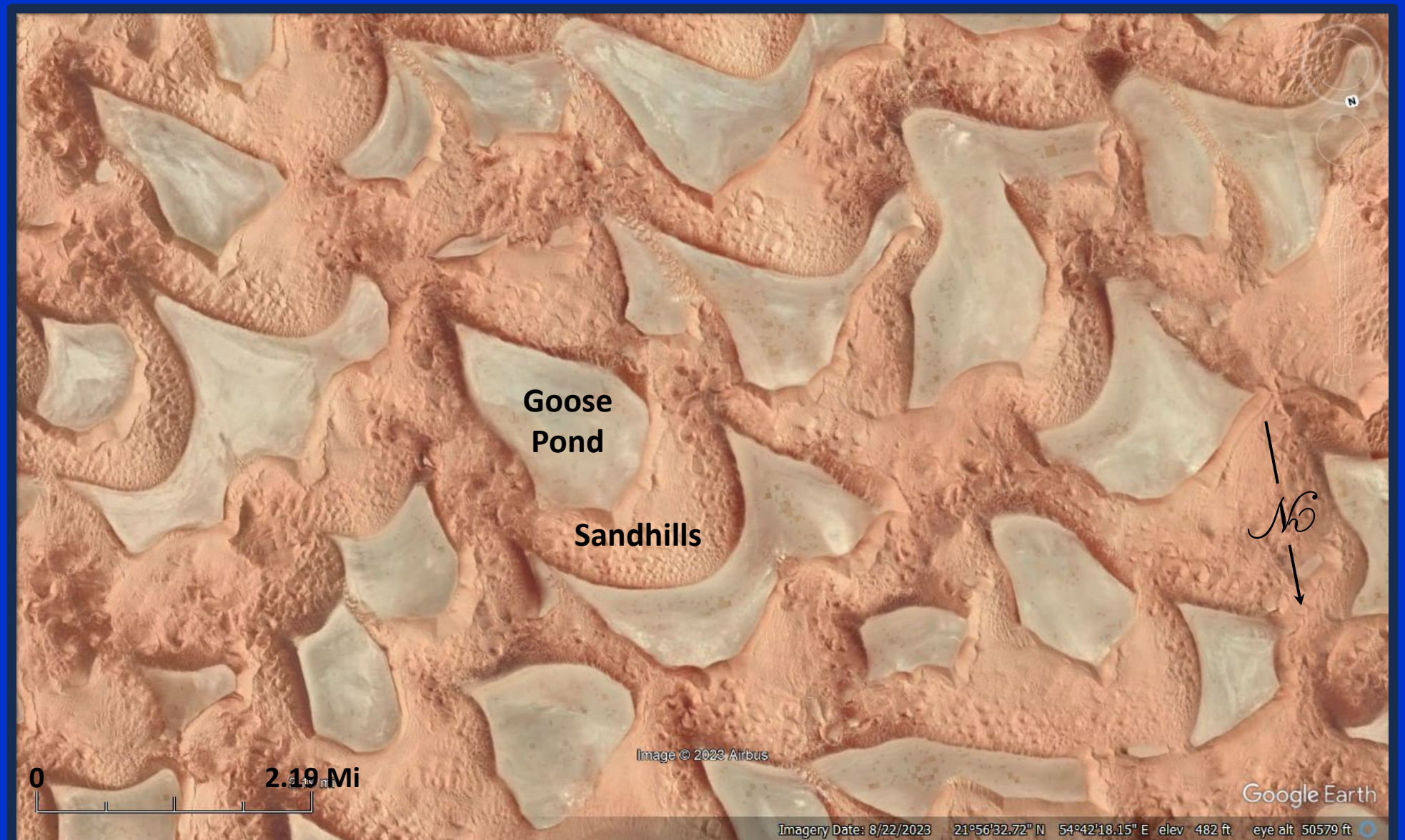
A MOMENT OF ENLIGHTENMENT – RUB' AL-KHALI, SAUDI ARABIA

GOOGLE EARTH IMAGE 2021

THE BARCHAN DUNE CAROLINA BAY MODEL

IN THE MIND'S EYE – BACK IN THE SANDHILLS

GOOGLE EARTH IMAGE 2021



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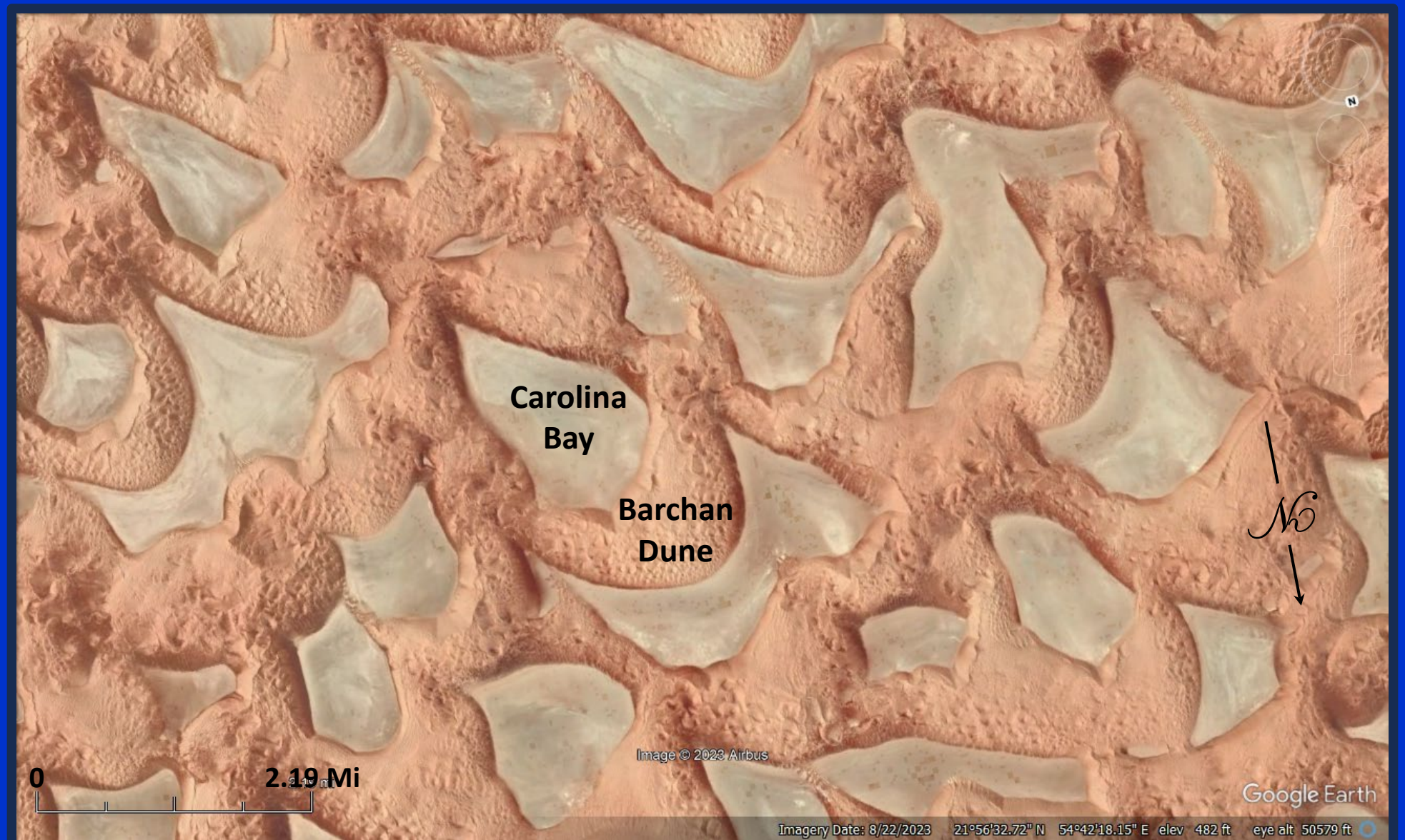
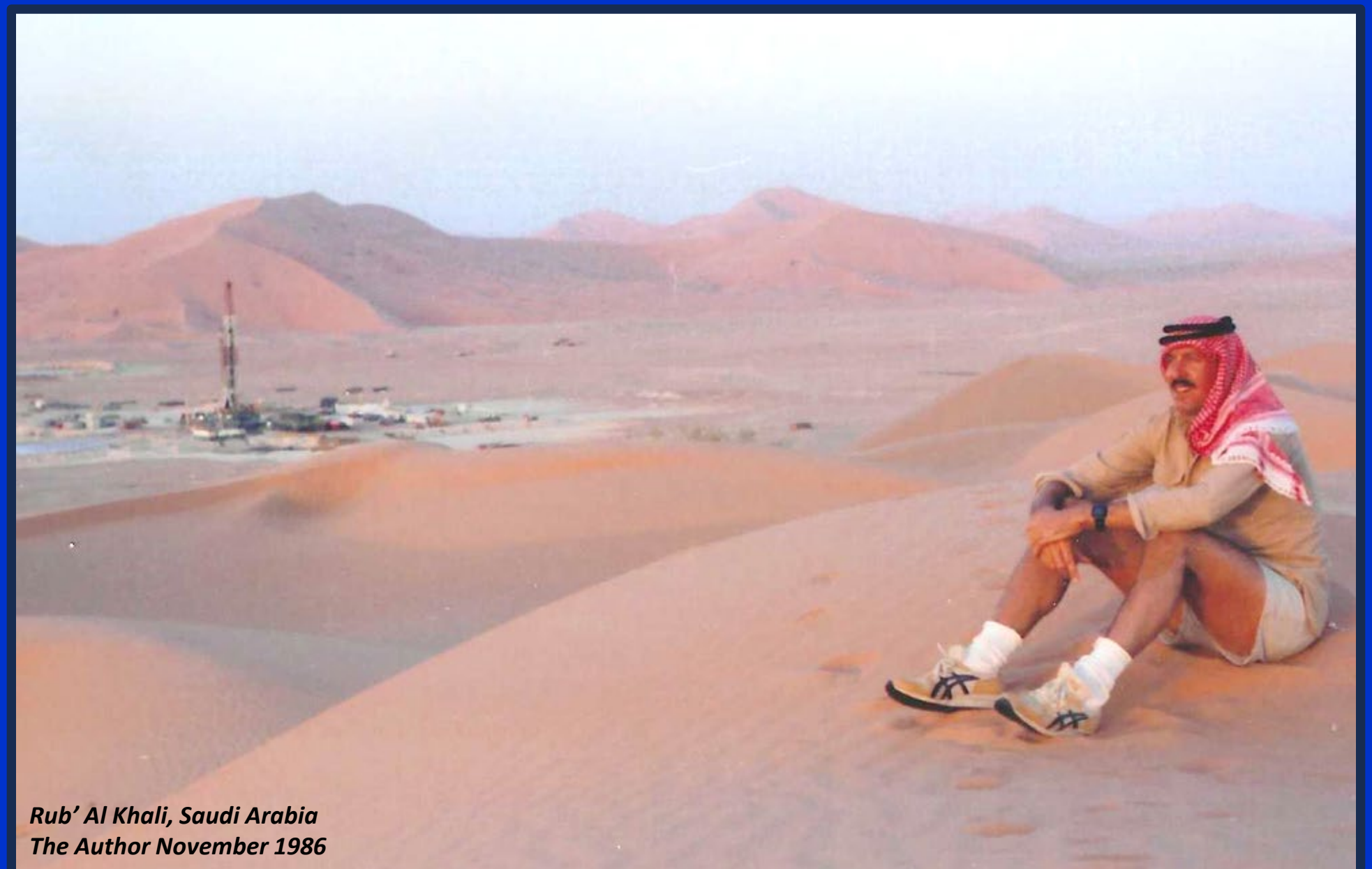
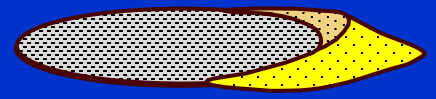


THE BARCHAN DUNE CAROLINA BAY MODEL

GHAFAH-1 WELLSITE – TRANSVERSE DUNES, 450-500 FT IN HEIGHT



Rub' Al Khali, Saudi Arabia
The Author November 1986

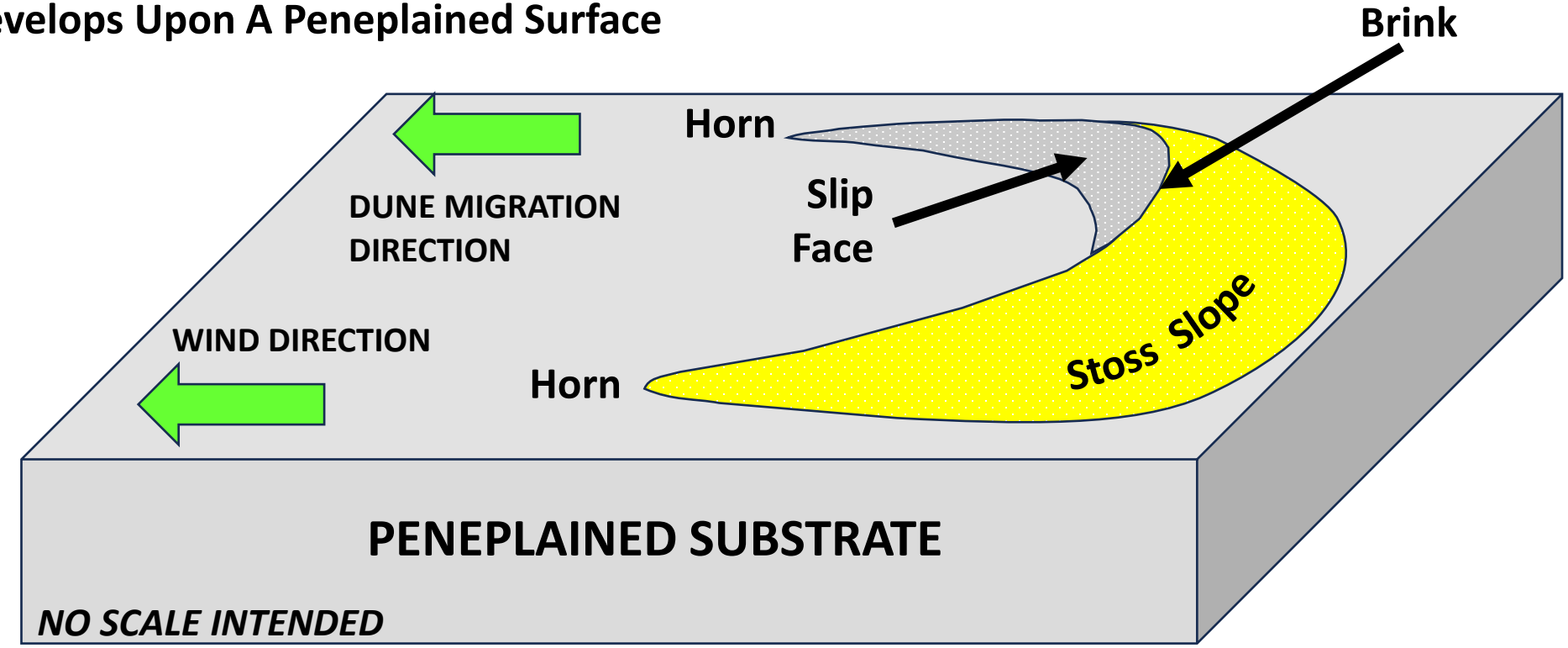


THE BARCHAN DUNE CAROLINA BAY MODEL

THE BARCHAN DUNE CAROLINA BAY MODEL

BARCHAN DUNEOLOGY 101

- Crescent Shaped Sand Dune
- Gentle Convex Stoss Slope Faces Wind; Steep Concave Leeward Slip Face
- Horns Point Downwind; Dune Migrates Via Slumping Of Slip Face @ Angle Of Repose
- Forms Under Consistent Wind Field
- Develops Upon A Peneplained Surface



THE BARCHAN DUNE CAROLINA BAY MODEL

PHYSICS OF THE FINE-GRAINED BAY SEDIMENT ACCUMULATION

B — **Simplified Longitudinal Cross Section** — **B’**

C-C’ TIE

After: Barbara Horvat
Universa v Ljubljani, Slovenia

Suspended Load Of Fine Sand, Silt and Clay Size Settle In The Separation Bubble And Accumulate In Lee of Dune (Wind Shadow)

PREVAILING WIND DIRECTION

Flow Separation Bubble

Grain Saltation

Flow Reattachment

Fine-Grained Dark Bay Sediments Thin Away From Dune

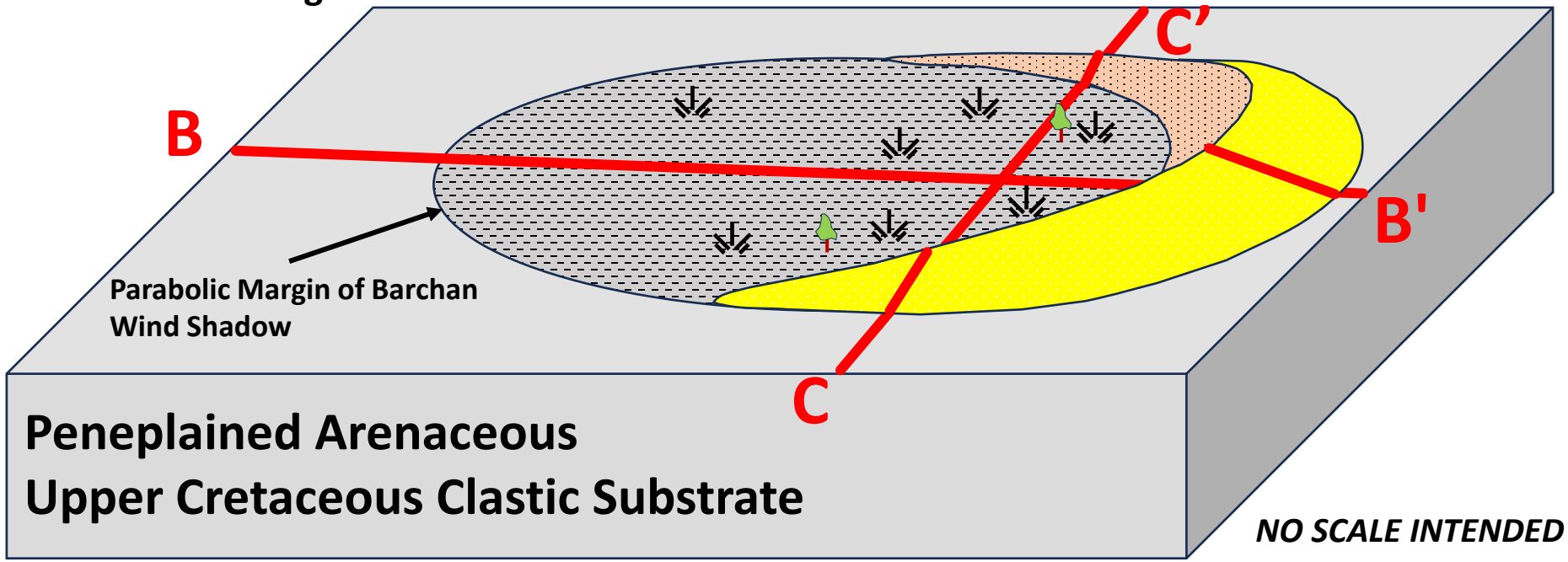
NO SCALE INTENDED

THE BARCHAN DUNE CAROLINA BAY MODEL

CONCEPTUAL EVOLUTIONARY STAGES

CAROLINA BAY EVOLUTION STAGE I

- Pleistocene Glacial Low Stands Create A Broad Desert (Erg) With Barchan Dune Fields
- Abundant Sand Supply (Marine Shelf, Arenaceous Substrate), Extensive Wind Fetch
- Fine Grained Suspended Sediments Accumulate In Lee Of Barchan; Forms Aquiclude
- Differential Compaction Of Fine Bay Sediments Initiates Topographic Low
- Soil Development and Emergent Vegetation Anchors Soils Of Bay Floor
- Dunes Cease Migration



THE BARCHAN DUNE CAROLINA BAY MODEL

CONCEPTUAL EVOLUTIONARY STAGES

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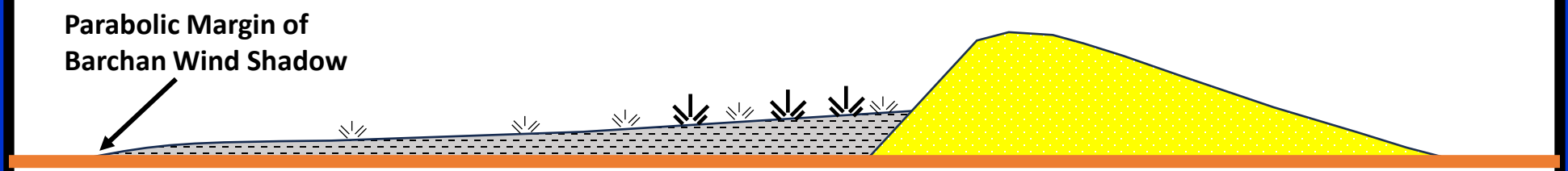


Fine-Grained Bay Sediments Thin Away From Dune

Carolina Bay

Barchan Dune

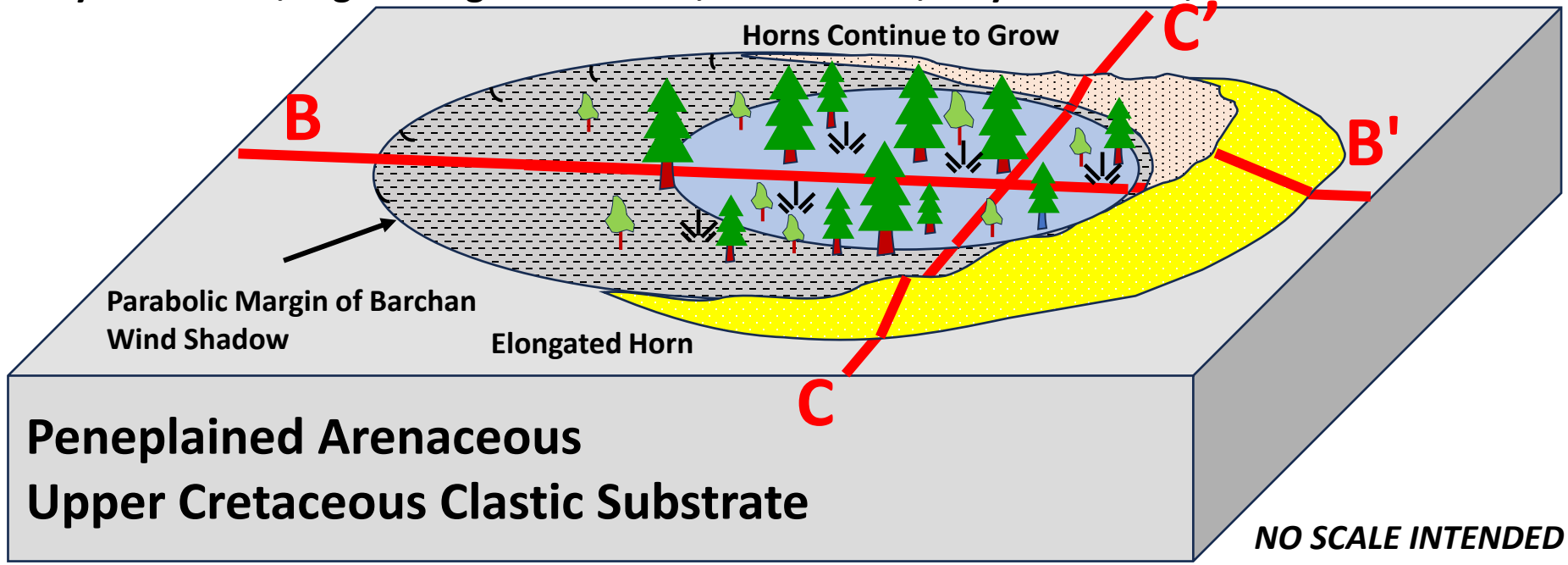
NO SCALE INTENDED

THE BARCHAN DUNE CAROLINA BAY MODEL

CONCEPTUAL EVOLUTIONARY STAGES

CAROLINA BAY EVOLUTION STAGE II

- More Temperate Climate; Erosion And Deflation Commences
- Fine Grained Bay Sediments Still Accumulate; Differential Compaction Forms Topo Low
- Denser Vegetation (Including Ephemeral Peat Bogs) Develop And Indurate Bay Sediments
- Compaction, Soil Development, Diagenesis, Anchor Soils Of The Bay Floor
- Differential Compaction (Particularly Of Peat) Forms Topo Low
- Bay Sediments, High In Organic Content, Include Silts, Clays And Peat; Perched Water Table



THE BARCHAN DUNE CAROLINA BAY MODEL

CONCEPTUAL EVOLUTIONARY STAGES

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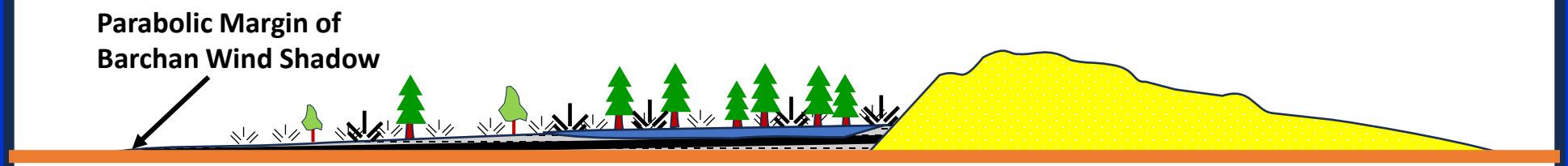


Carolina Bay Compacts

Barchan Dune
Erodes/Deflates

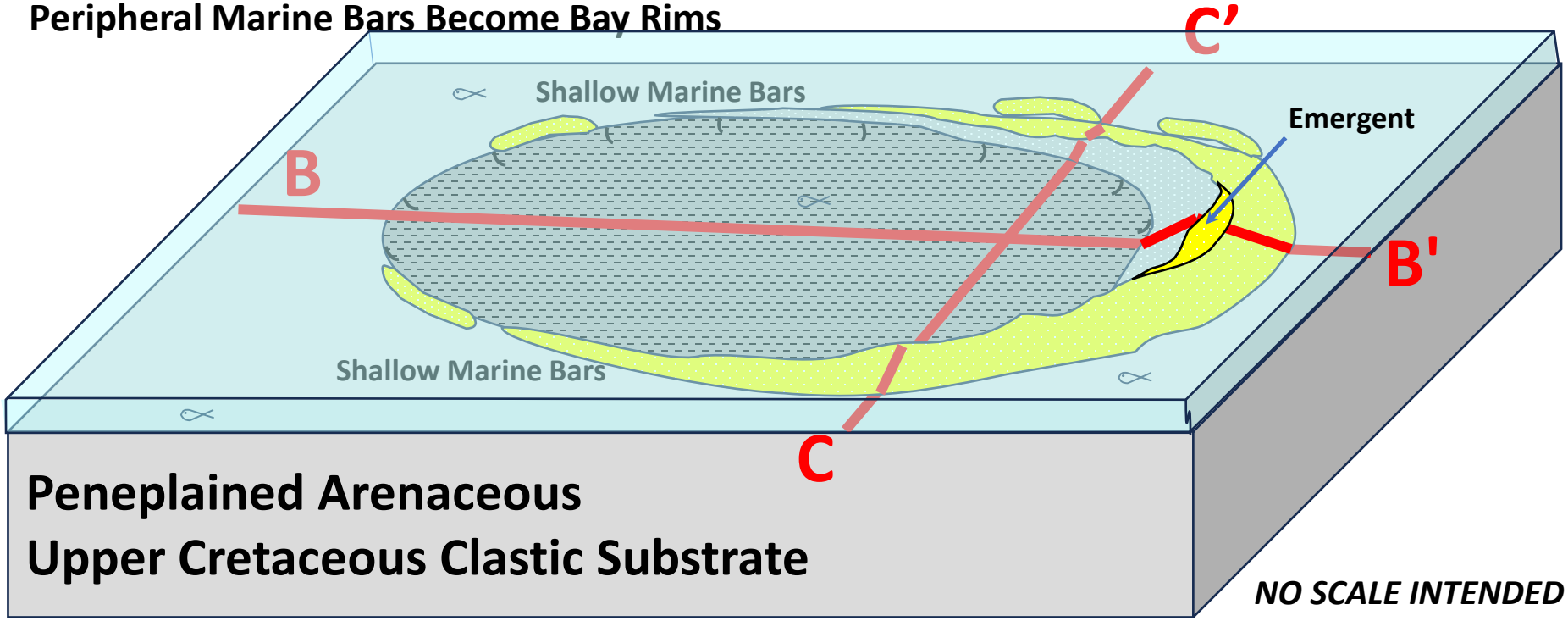
NO SCALE INTENDED

THE BARCHAN DUNE CAROLINA BAY MODEL

CONCEPTUAL EVOLUTIONARY STAGES

CAROLINA BAY EVOLUTION STAGE III

- Multiple Inter-Glacial High Stand Marine Incursions (Cooke 1936)
- Unconsolidated Dune Sands Easily Redeposited Laterally Into Interdune Aprons, Bars And Bay Rims. Oblique Longshore Currents Elongate Barchan Remnants Along East Bay Margin
- Bay Sediment Mat Resistant To Littoral Marine Erosion
- Bay Becomes Mud-Prone Lagoon During Marine Incursions
- Peripheral Marine Bars Become Bay Rims



THE BARCHAN DUNE CAROLINA BAY MODEL

CONCEPTUAL EVOLUTIONARY STAGES

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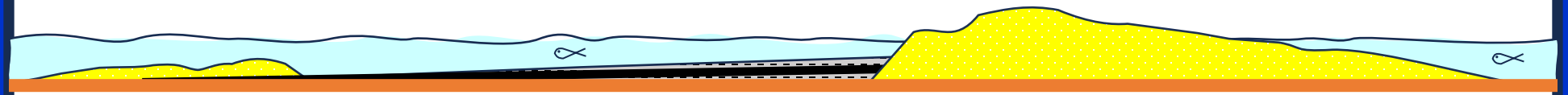


Sand Bar

Indurated, Compacting Carolina Bay Sediments Are Protected By Marine Sand Bars

Eroding Barchan Dune

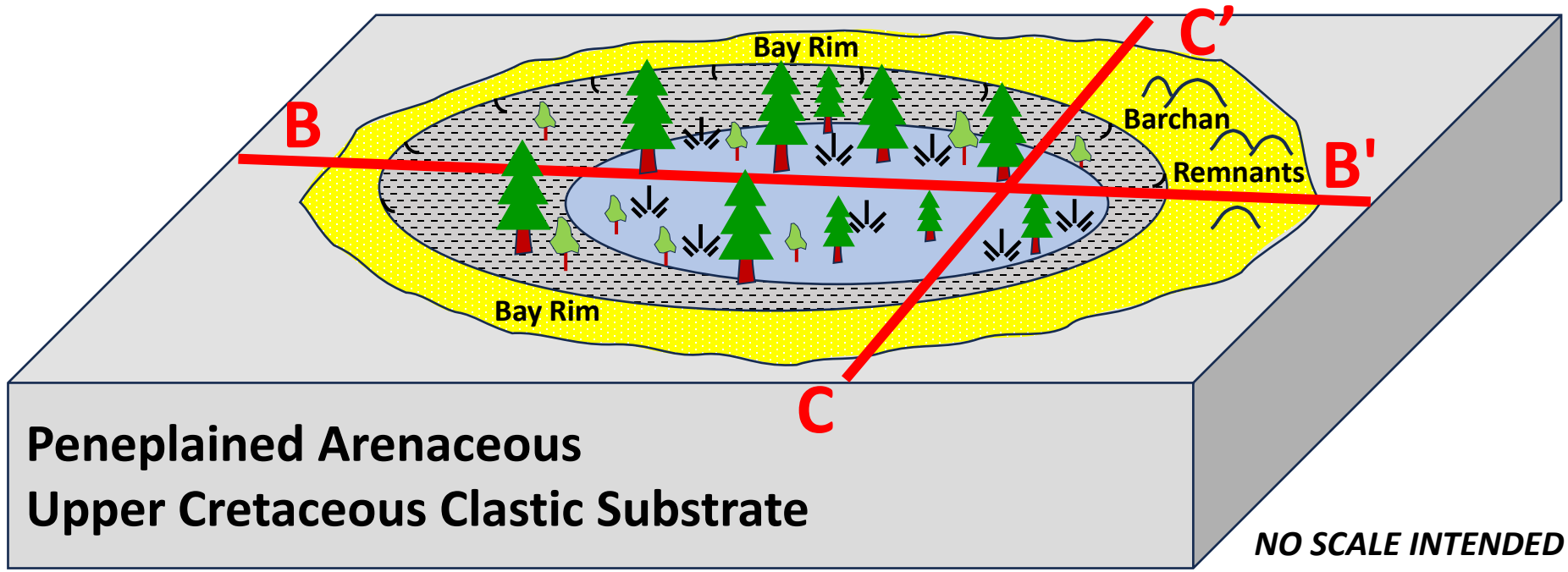
NO SCALE INTENDED

THE BARCHAN DUNE CAROLINA BAY MODEL

CONCEPTUAL EVOLUTIONARY STAGES

CAROLINA BAY EVOLUTION STAGE IV

- Present Day
- Terrigenous Bay Ecosystem Reestablished
- Remnant Barchan And Bay Rims Further Deflate, Bay Subsidence Continues
- Ephemeral Perched Lakes Form Due To Bay Floor Aquiclude
- Evolutionary Stages Are Likely Repeated Numerous Times During Pleistocene



THE BARCHAN DUNE CAROLINA BAY MODEL

CONCEPTUAL EVOLUTIONARY STAGES

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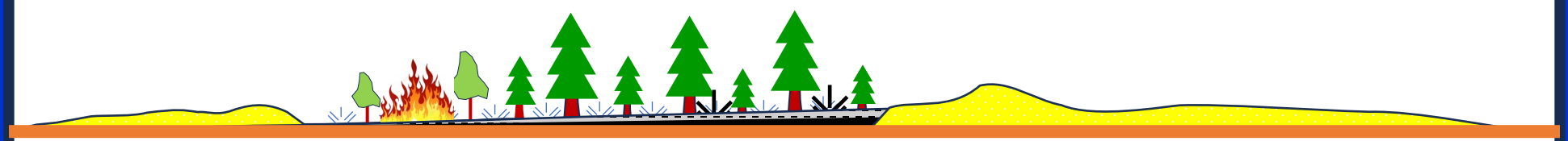
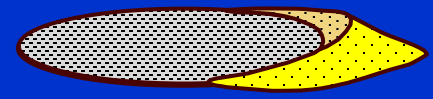


Bay Rim

Compacted Carolina Bay

Remnant Barchan
(Bay Rim)

THE BARCHAN DUNE CAROLINA BAY MODEL

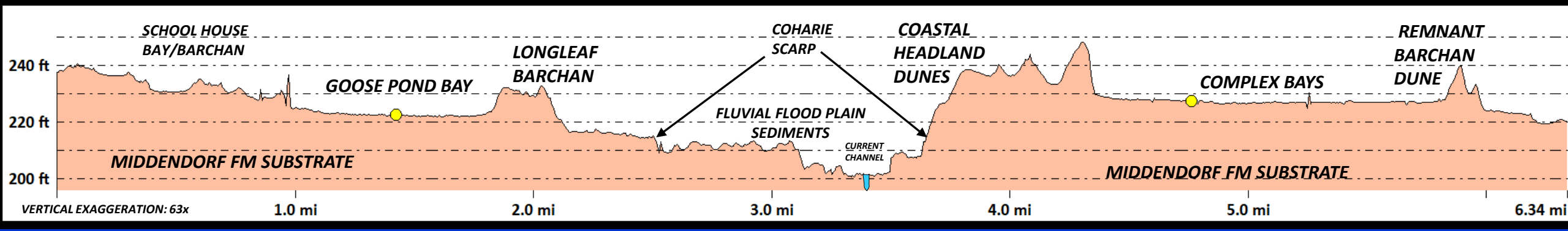


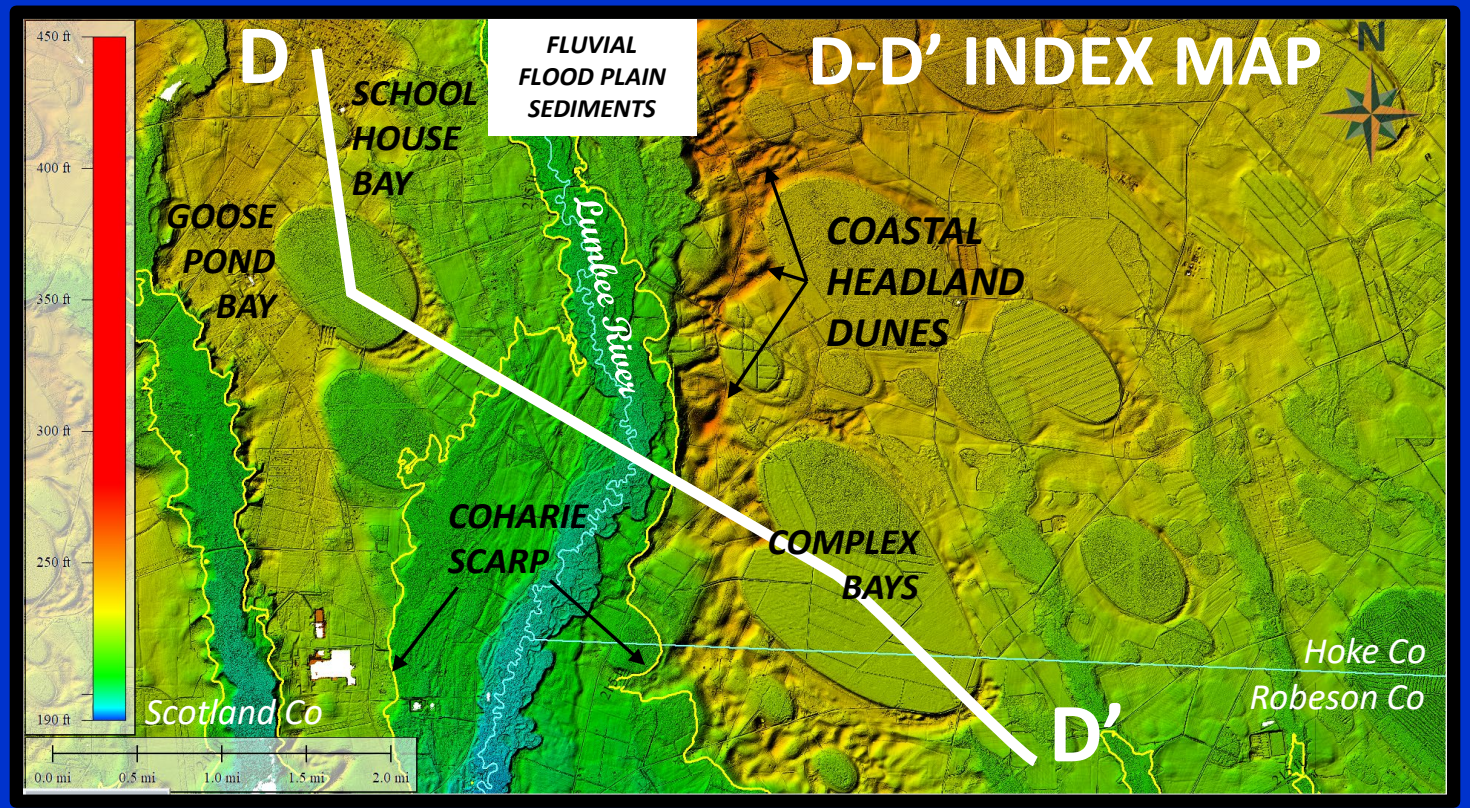
HOW THE MODEL FITS INTO THE LOCAL SHALLOW SUBSURFACE GEOLOGY

THE BARCHAN DUNE CAROLINA BAY MODEL

REGIONAL CROSS-SECTION D-D'- ELEVATION PROFILE

D NORTHWEST — SOUTHEAST D'



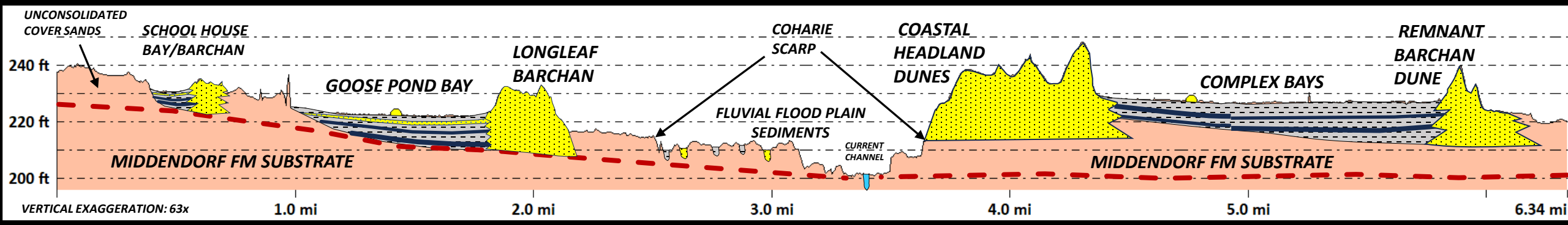


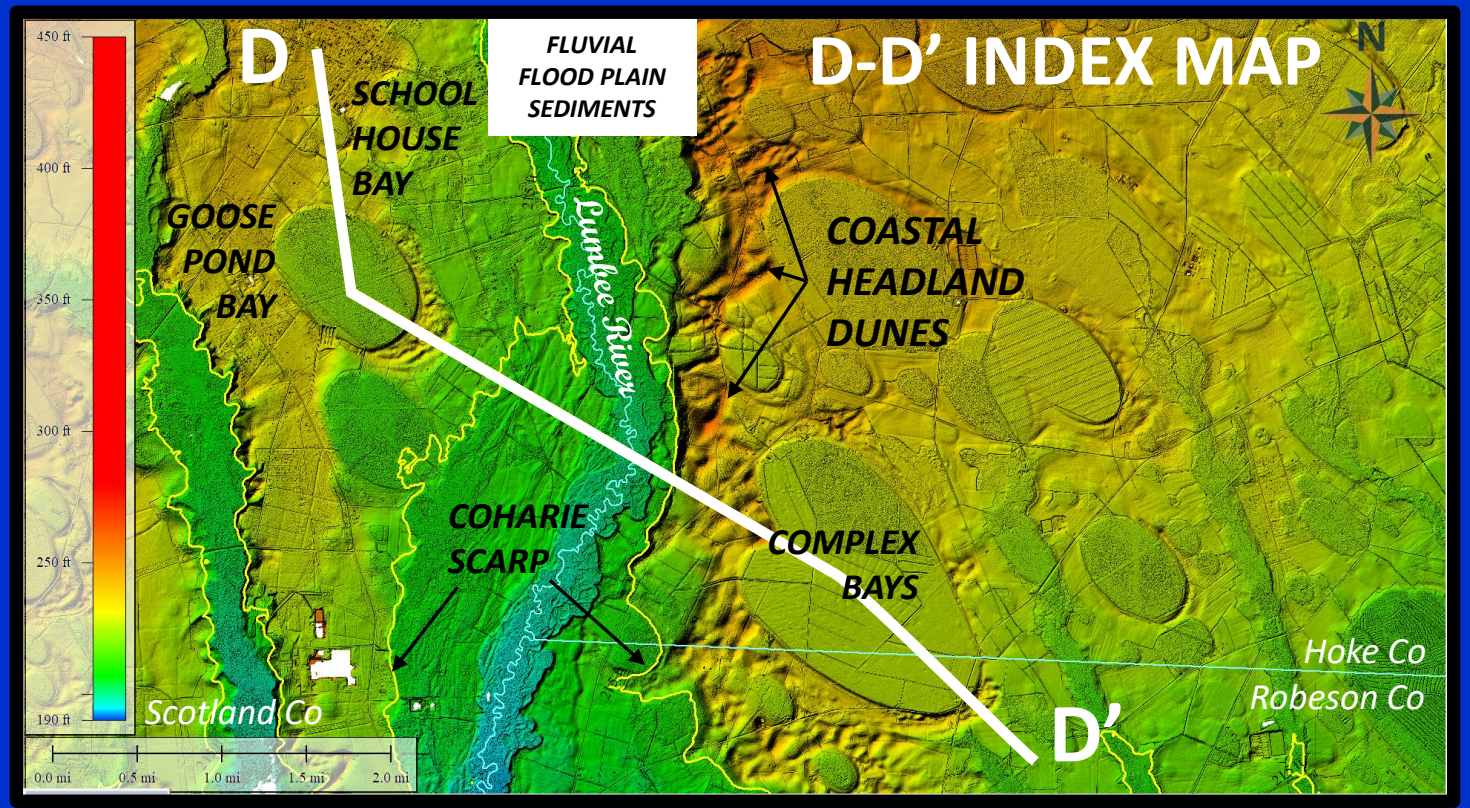
THE BARCHAN DUNE CAROLINA BAY MODEL

REGIONAL CROSS-SECTION D-D' SHALLOW SUBSURFACE INTERPRETATION

D NORTHWEST

SOUTHEAST D'

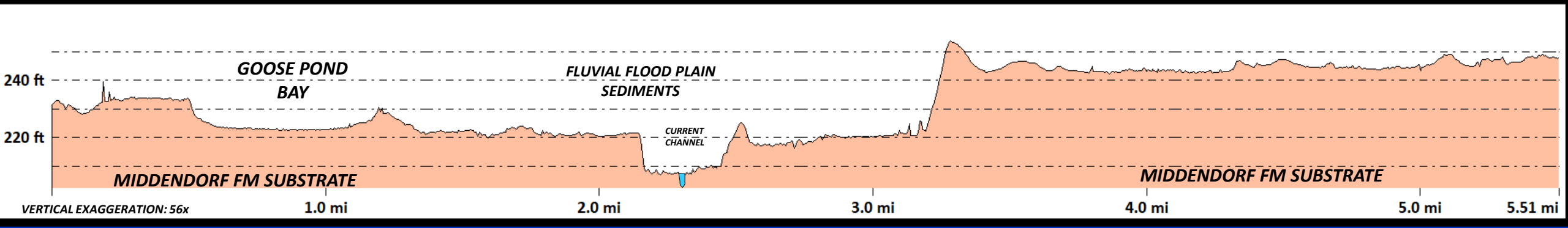




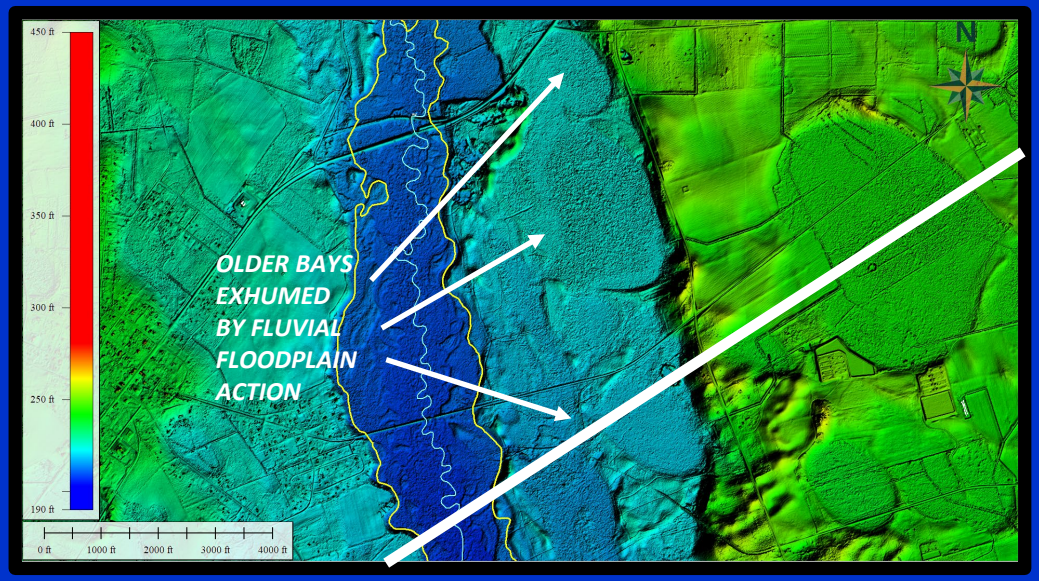
THE BARCHAN DUNE CAROLINA BAY MODEL

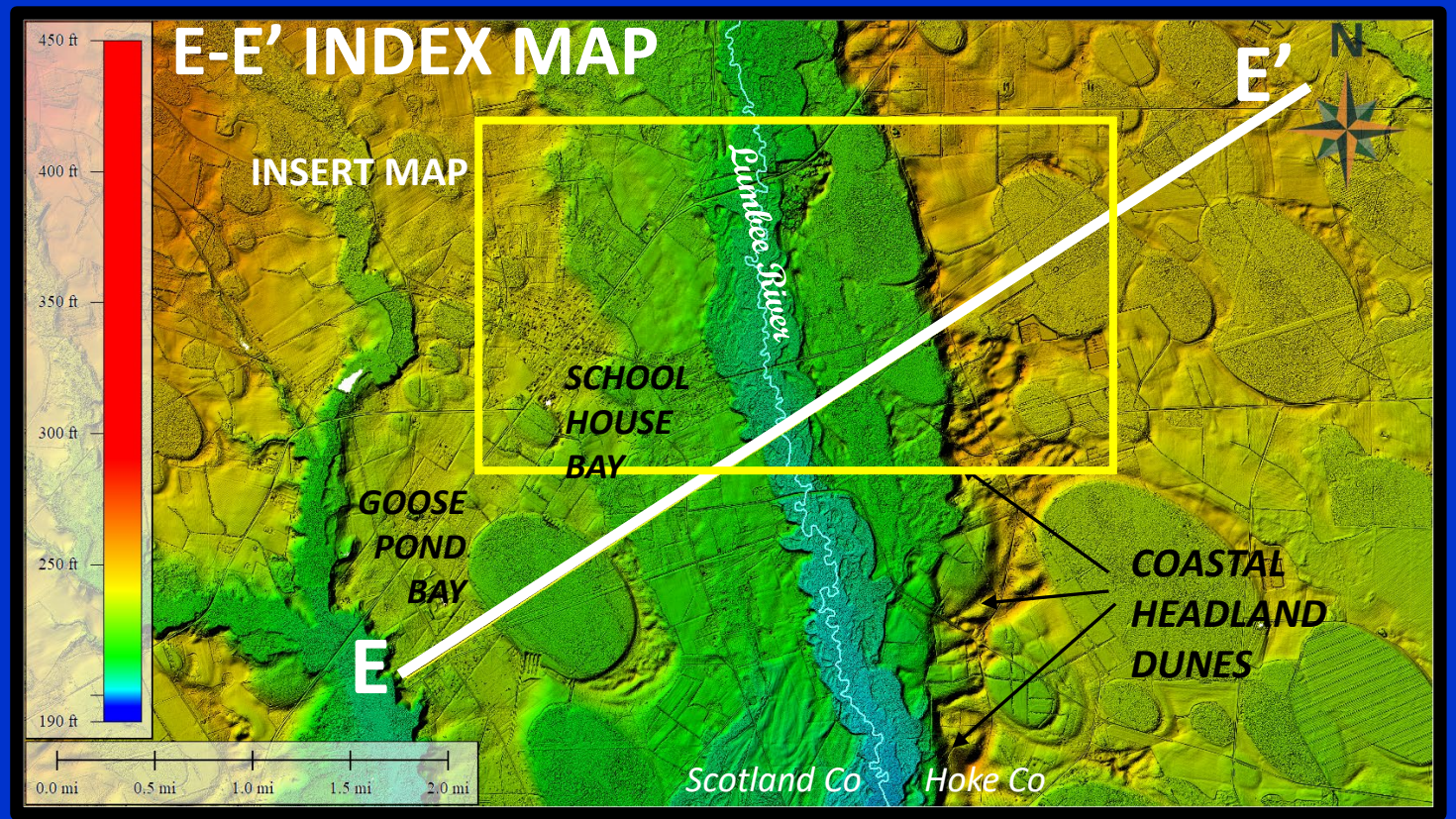
REGIONAL CROSS-SECTION E-E' ELEVATION PROFILE

E SOUTHWEST — NORTHEAST E'



AT LEAST TWO SEPARATE BAY EPISODES

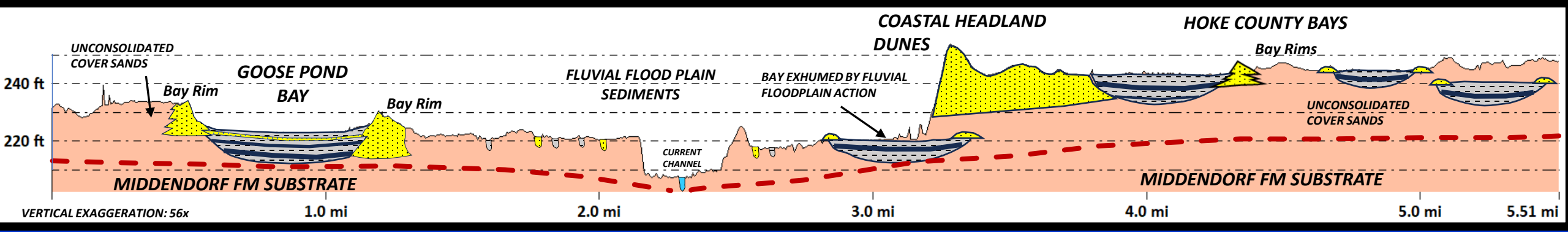




THE BARCHAN DUNE CAROLINA BAY MODEL

REGIONAL CROSS-SECTION E-E' SHALLOW SUBSURFACE INTERPRETATION

E SOUTHWEST — NORTHEAST E'



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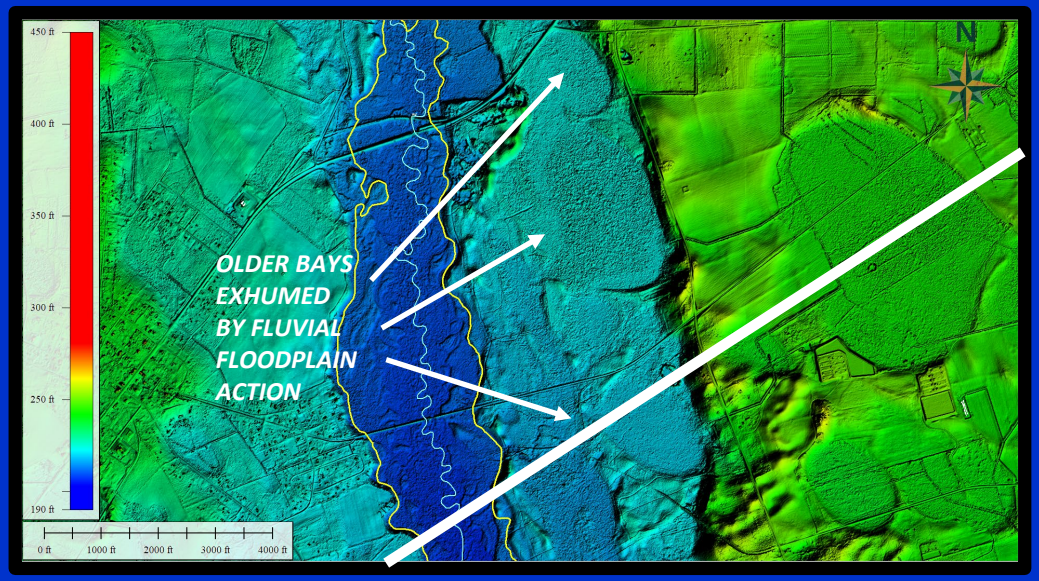

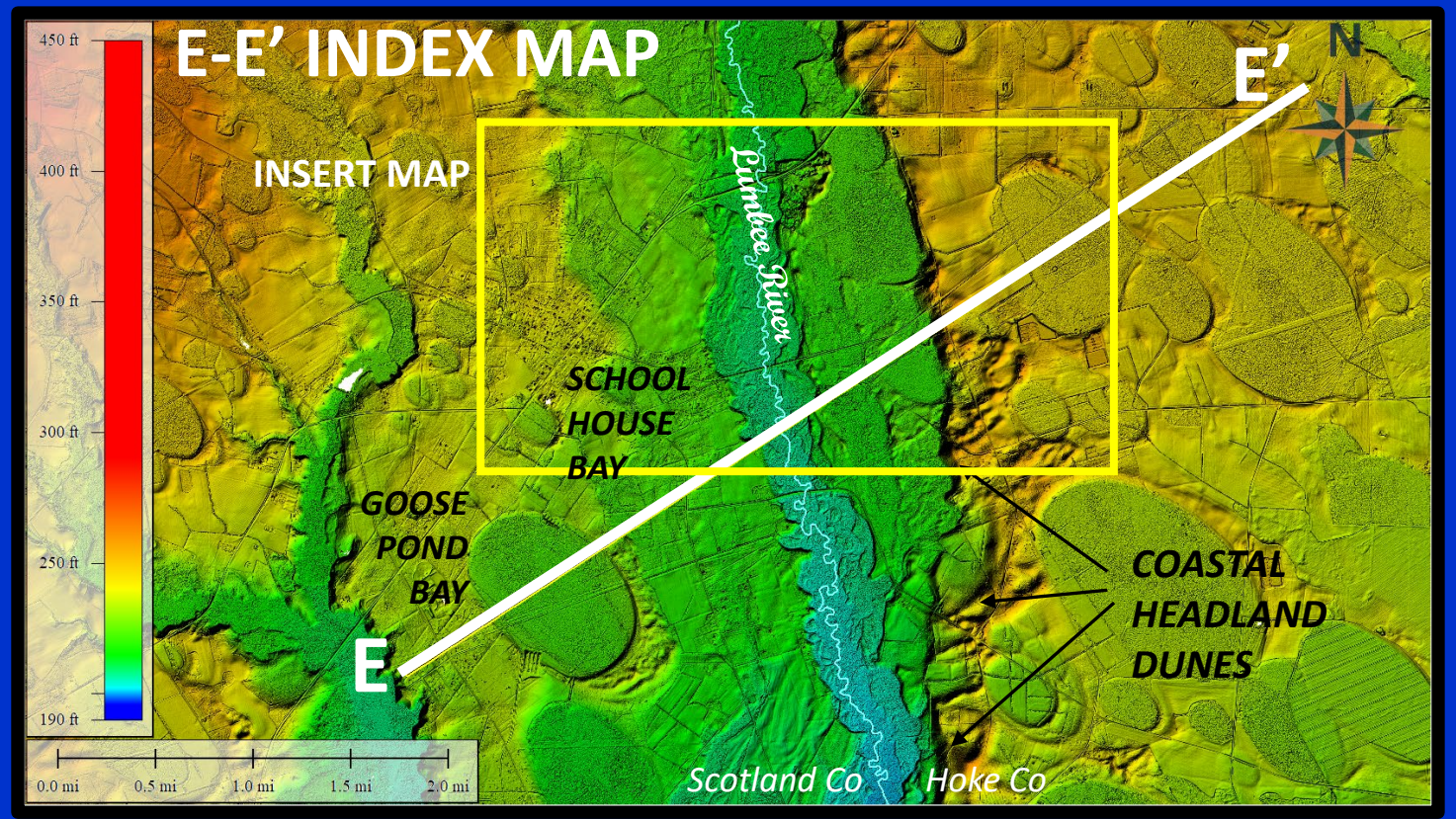

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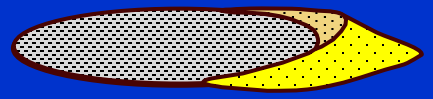

THUS FAR WE HAVE:

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- A DEMONSTRATED CAROLINA BAY PEAT-RICH SEDIMENTARY SEQUENCE
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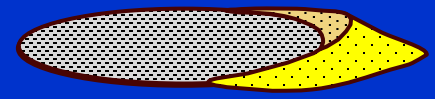
THE BARCHAN DUNE CAROLINA BAY MODEL



TIMING OF

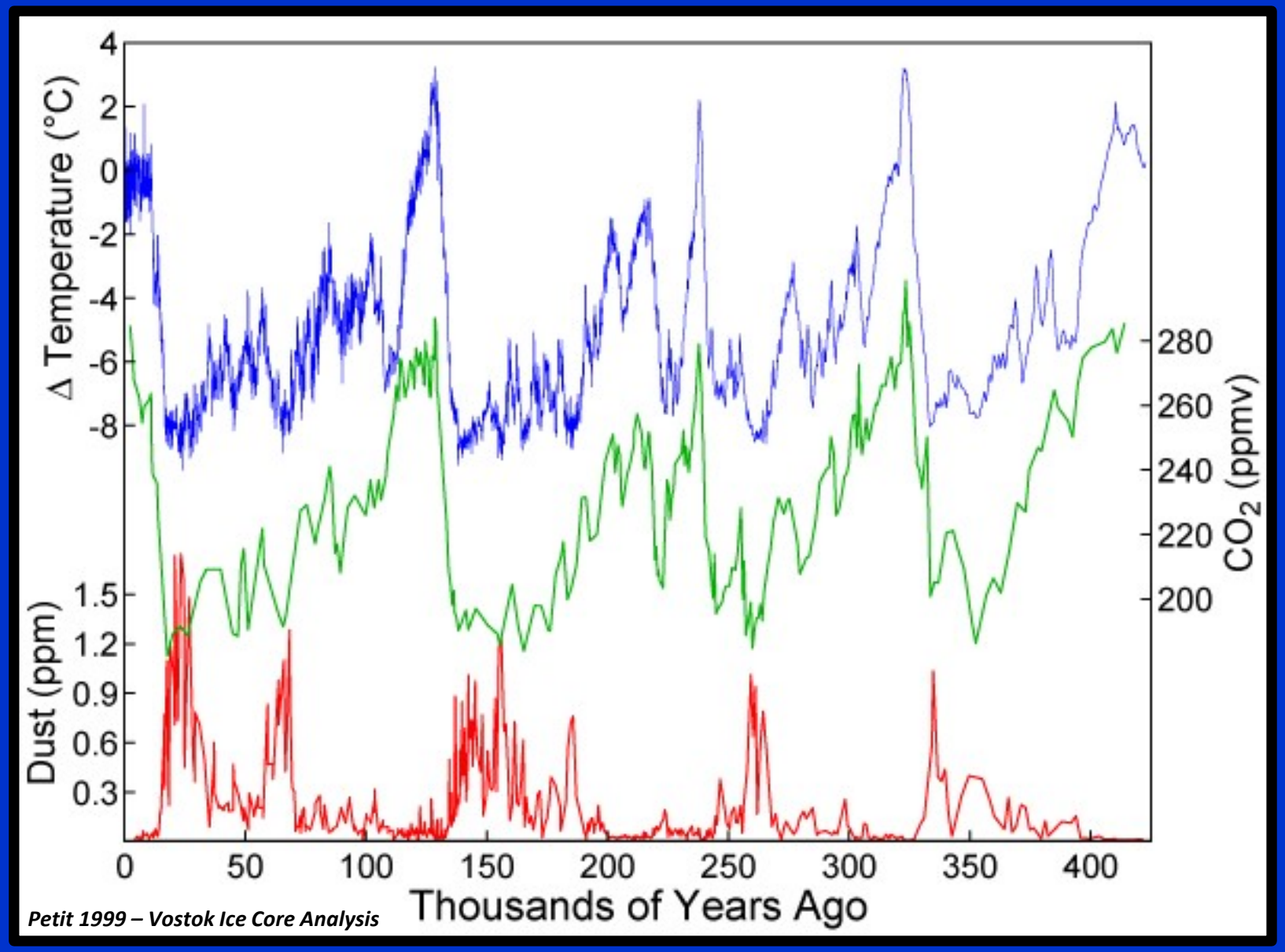
PLEISTOCENE DESERTIFICATION, BARCHAN

FORMATION AND DESERT EROSION

THE BARCHAN DUNE CAROLINA BAY MODEL

PLEISTOCENE GLACIAL CYCLES FROM ICE CORE ANALYSIS

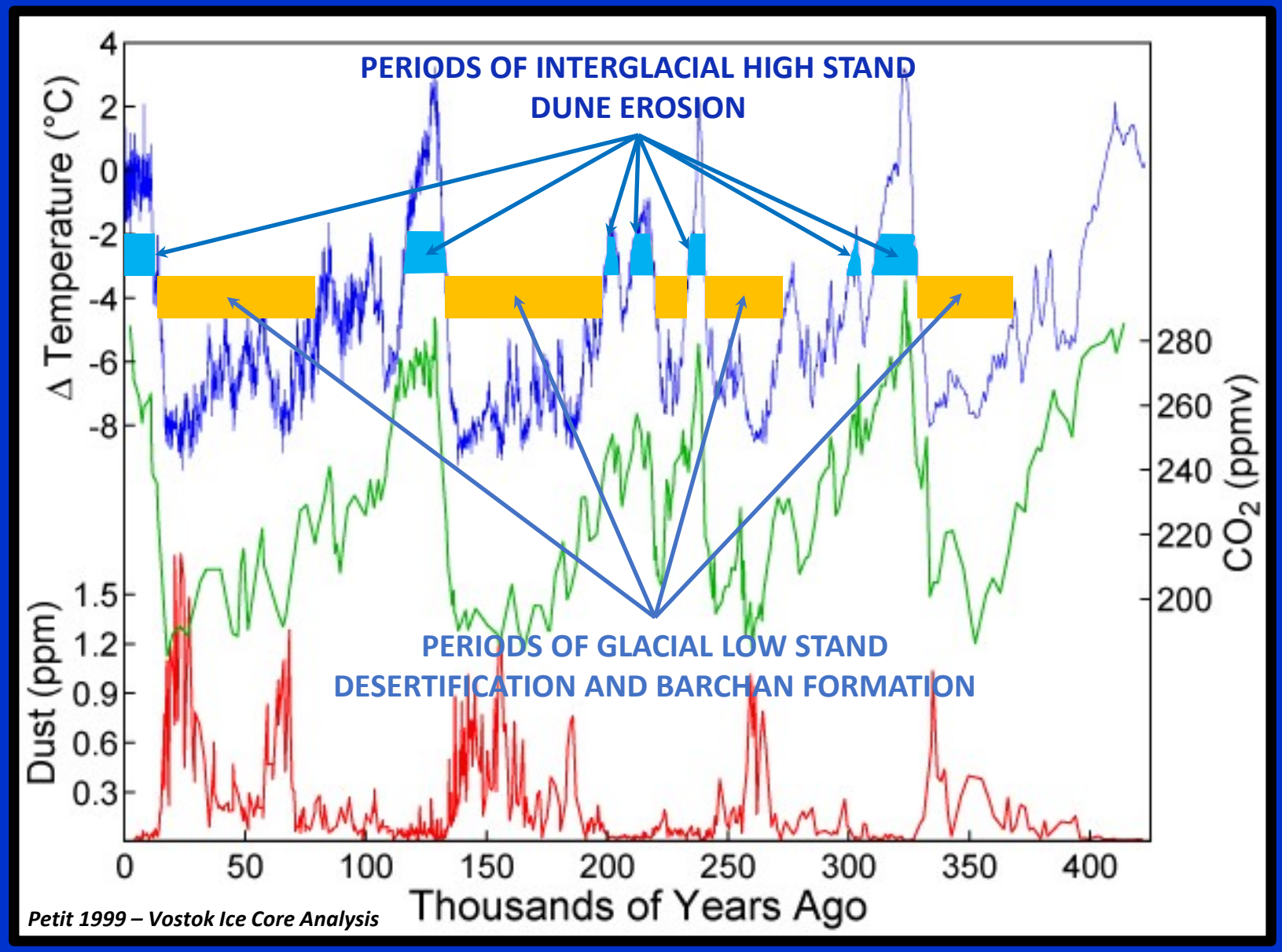
FROM PETIT 1999



THE BARCHAN DUNE CAROLINA BAY MODEL

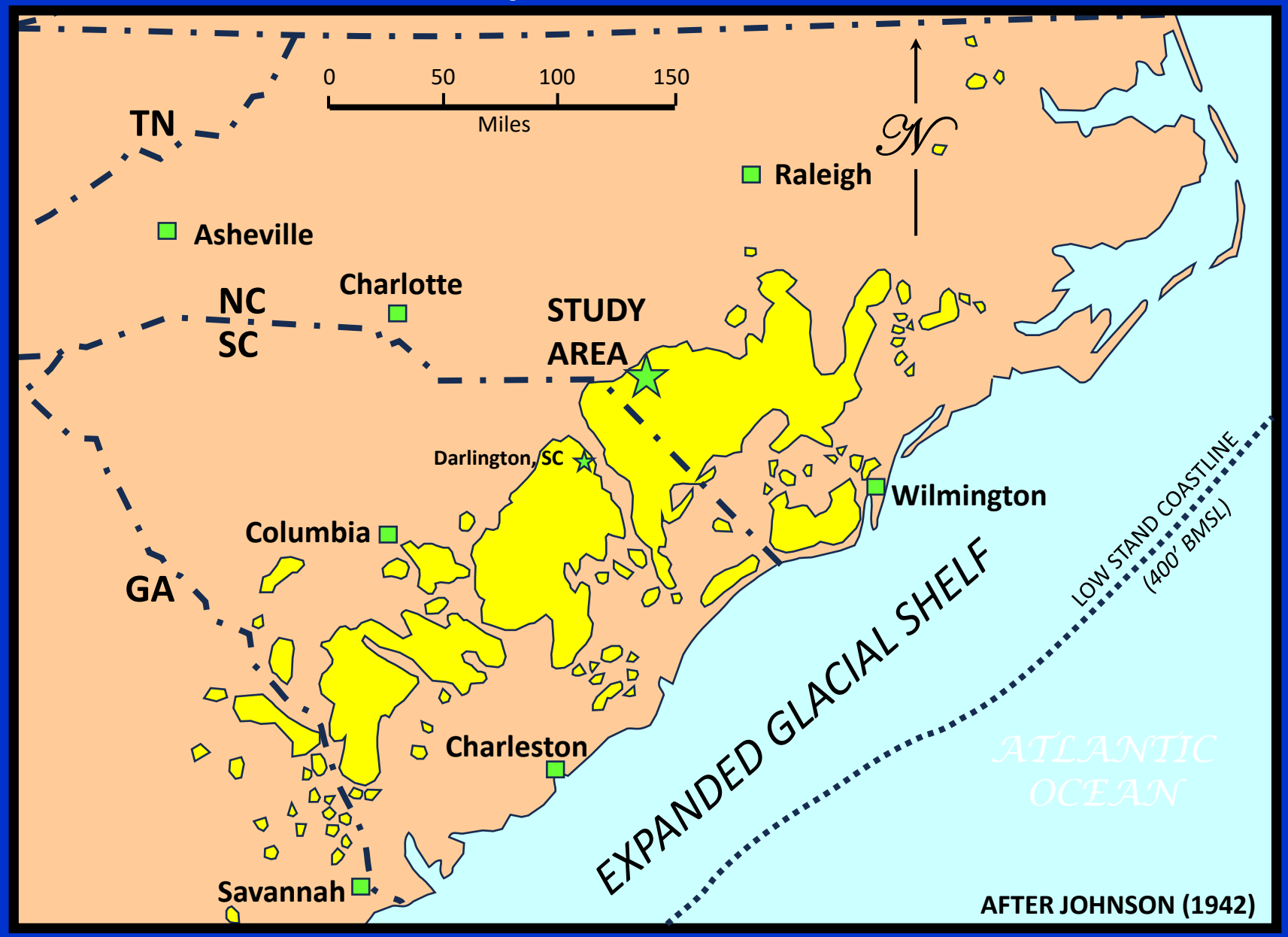
PLEISTOCENE GLACIAL CYCLES FROM ICE CORE ANALYSIS

FROM PETIT 1999

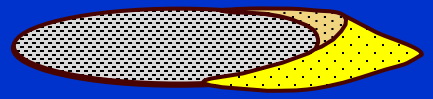


THE BARCHAN DUNE CAROLINA BAY MODEL

INTERPRETED COASTAL PLAIN ERG (JOHNSON'S CAROLINA BAY DISTRIBUTION)



THE BARCHAN DUNE CAROLINA BAY MODEL



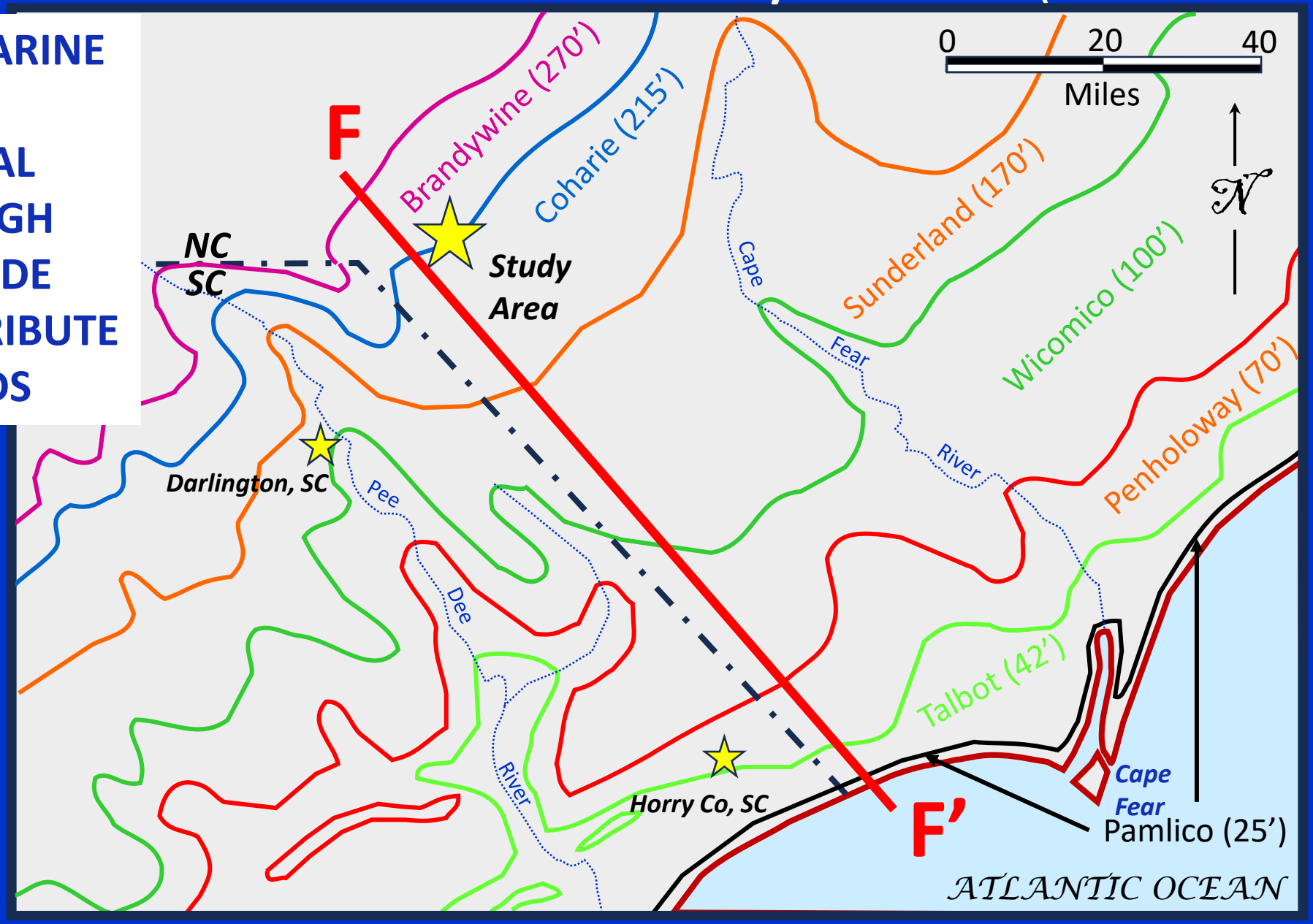
EXAMPLES OF BARCHAN DUNE PRESERVATION, EROSION AND SAND REDISTRIBUTION; REMNANT DUNES AS REVEALED BY VINTAGE AIR PHOTOS, LiDAR IMAGING AND CONTOURING

THE BARCHAN DUNE CAROLINA BAY MODEL

NC/SC PLEISTOCENE INTERGLACIAL TERRACES/SCARPS

(After Cooke 1936 and Frey 1950)

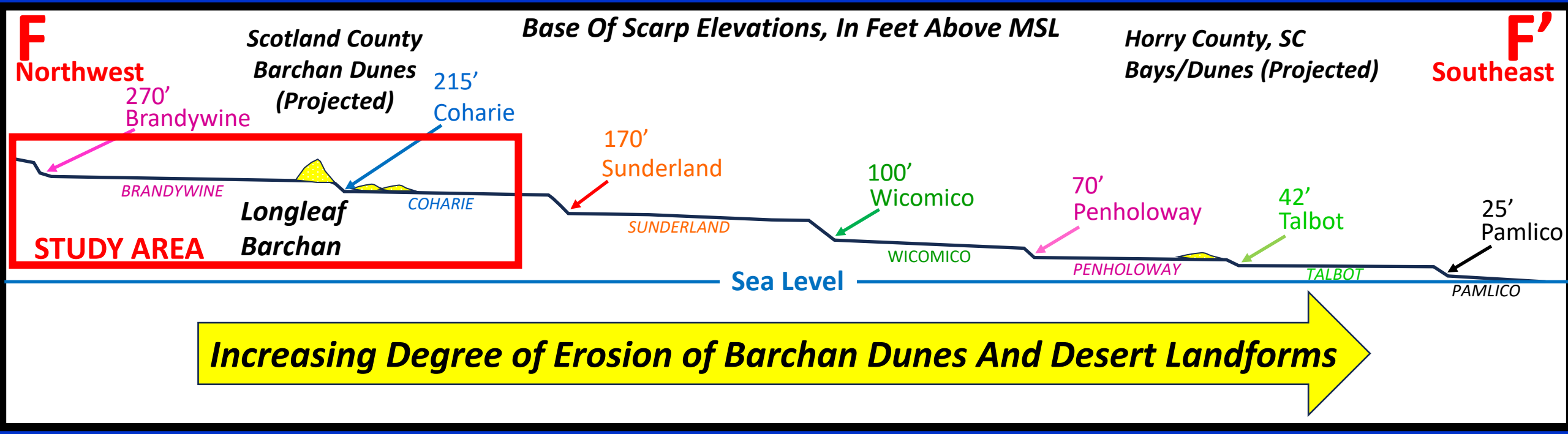
MULTIPLE MARINE INCURSIONS (INTERGLACIAL SEA-LEVEL HIGH STANDS) ERODE AND REDISTRIBUTE DESERT SANDS



THE BARCHAN DUNE CAROLINA BAY MODEL

PLEISTOCENE INTERGLACIAL HIGH STAND SCARPS AND TERRACES

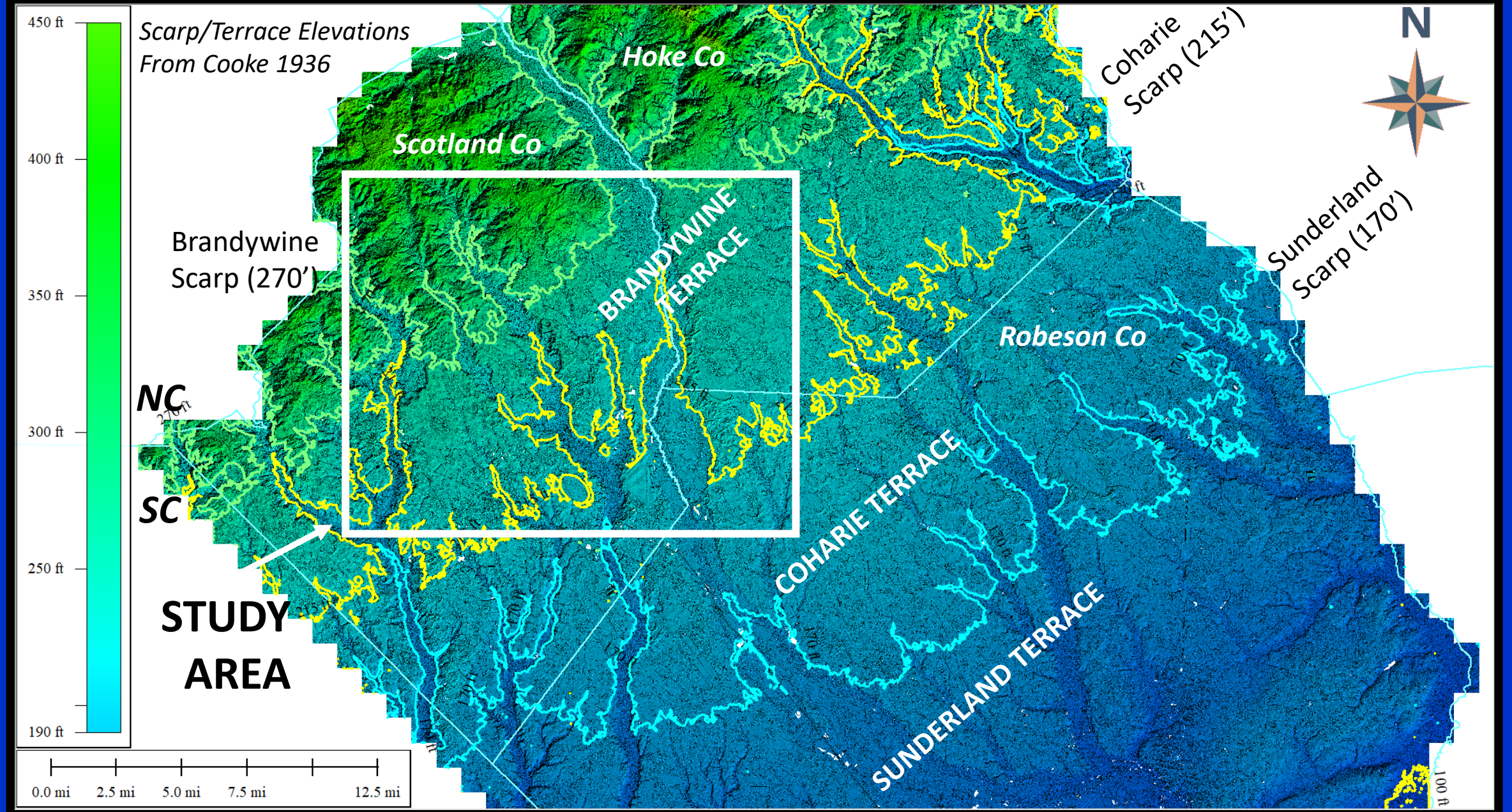
AFTER COOKE 1936 USGS BULLETIN 867



THE BARCHAN DUNE CAROLINA BAY MODEL

STUDY AREA - TERRACES/SCARPS

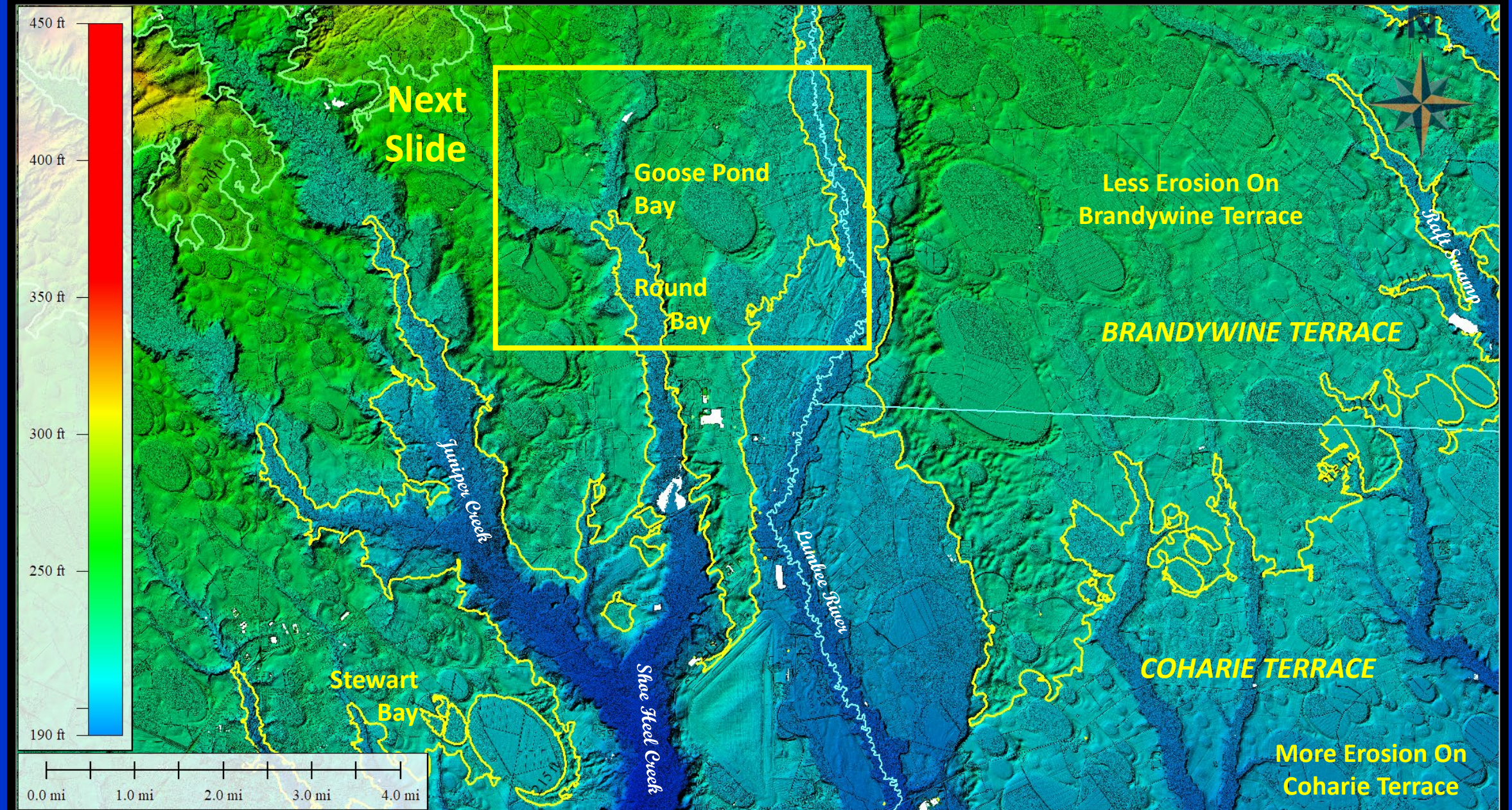
GRIDDED/CONTOURED 2014 LiDAR ELEVATION DATA



THE BARCHAN DUNE CAROLINA BAY MODEL

INDEX MAP – DUNE EROSION, SAND REDISTRIBUTION

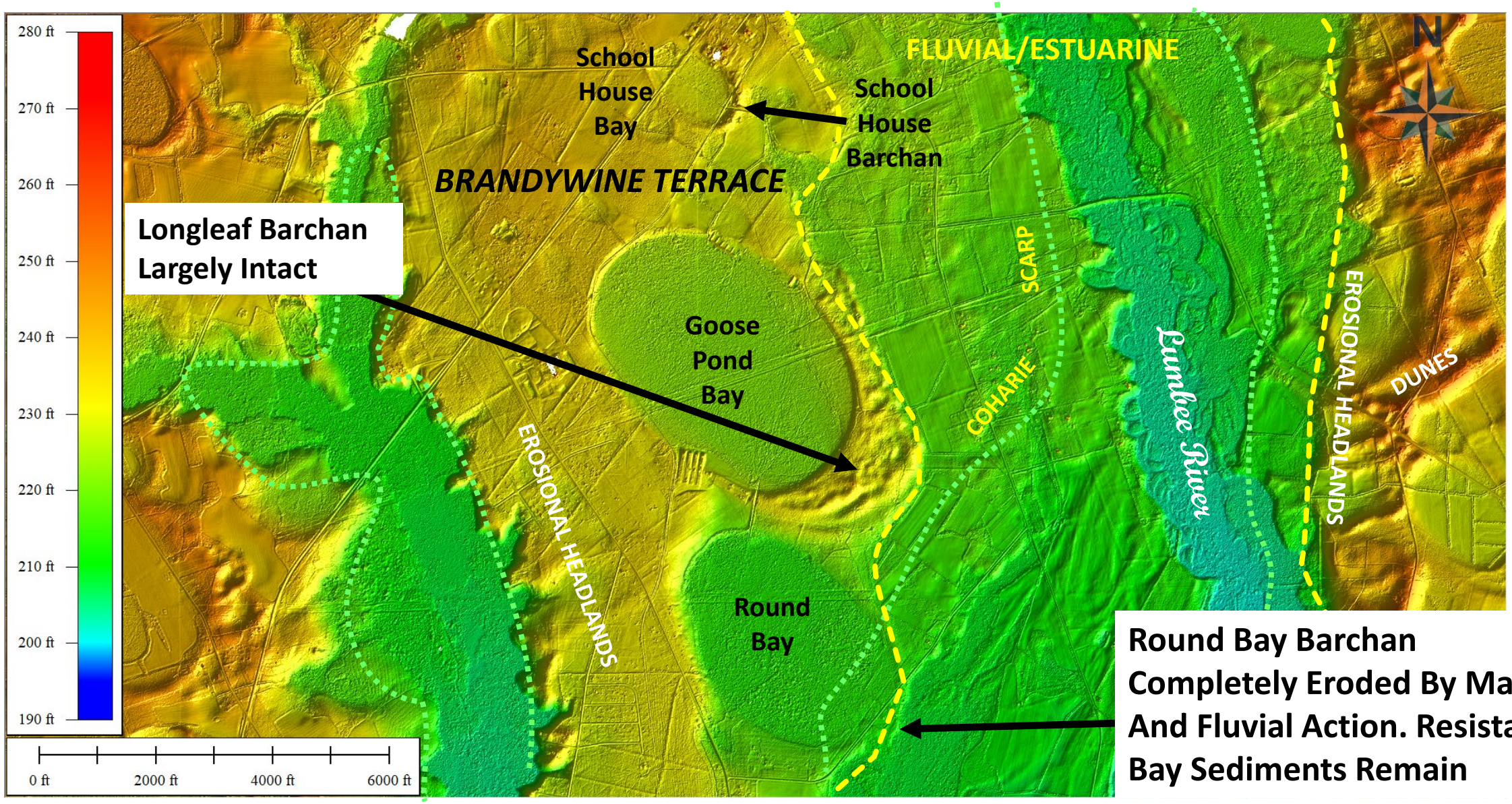
GRIDDED 2014 LiDAR ELEVATION DATA



THE BARCHAN DUNE CAROLINA BAY MODEL

LONGLEAF PRESERVED, ROUND BAY BARCHAN REMOVED

GRIDDED 2014 LiDAR ELEVATION DATA



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INDEX MAP – DUNE EROSION, SAND REDISTRIBUTION

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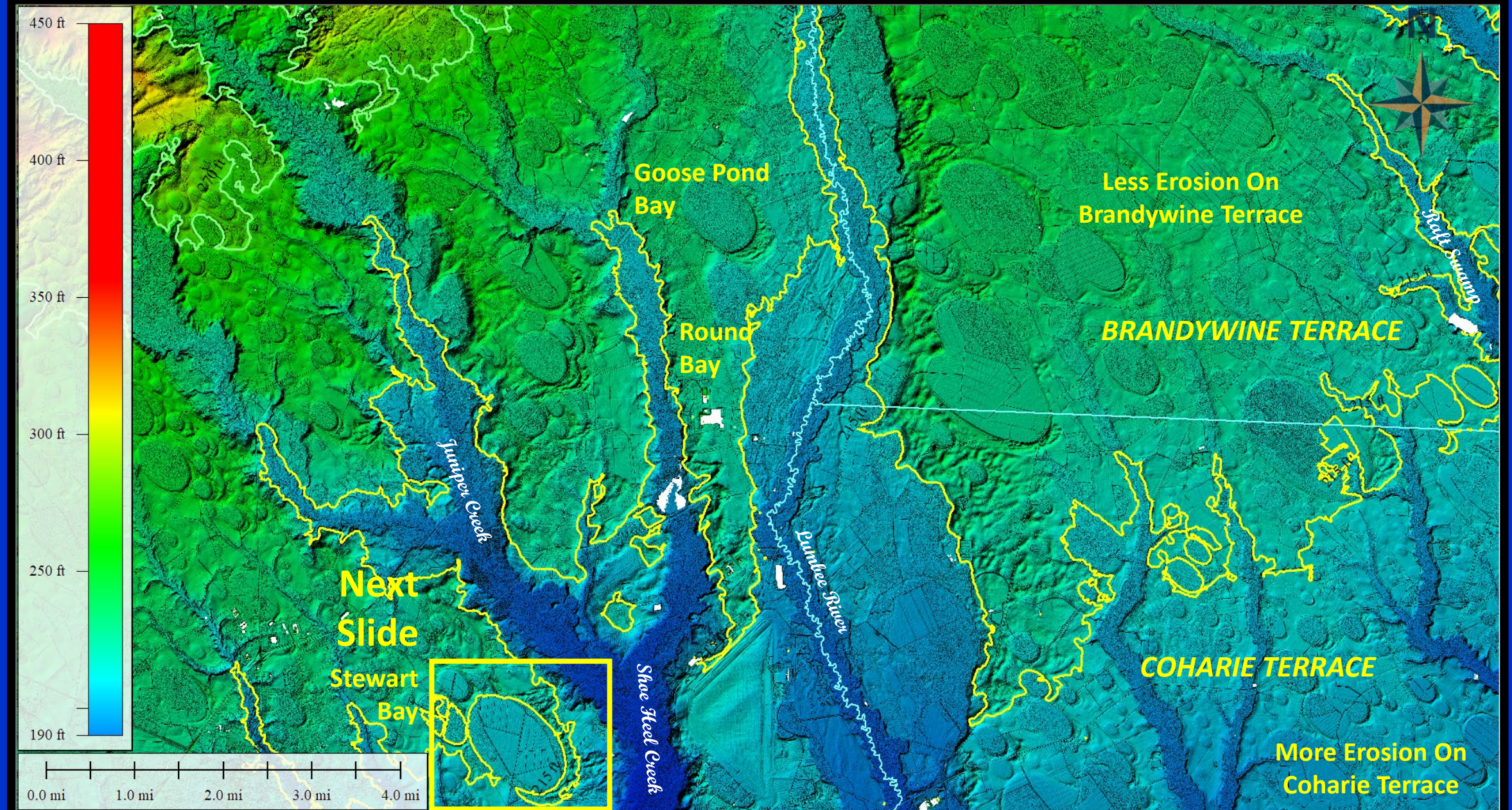
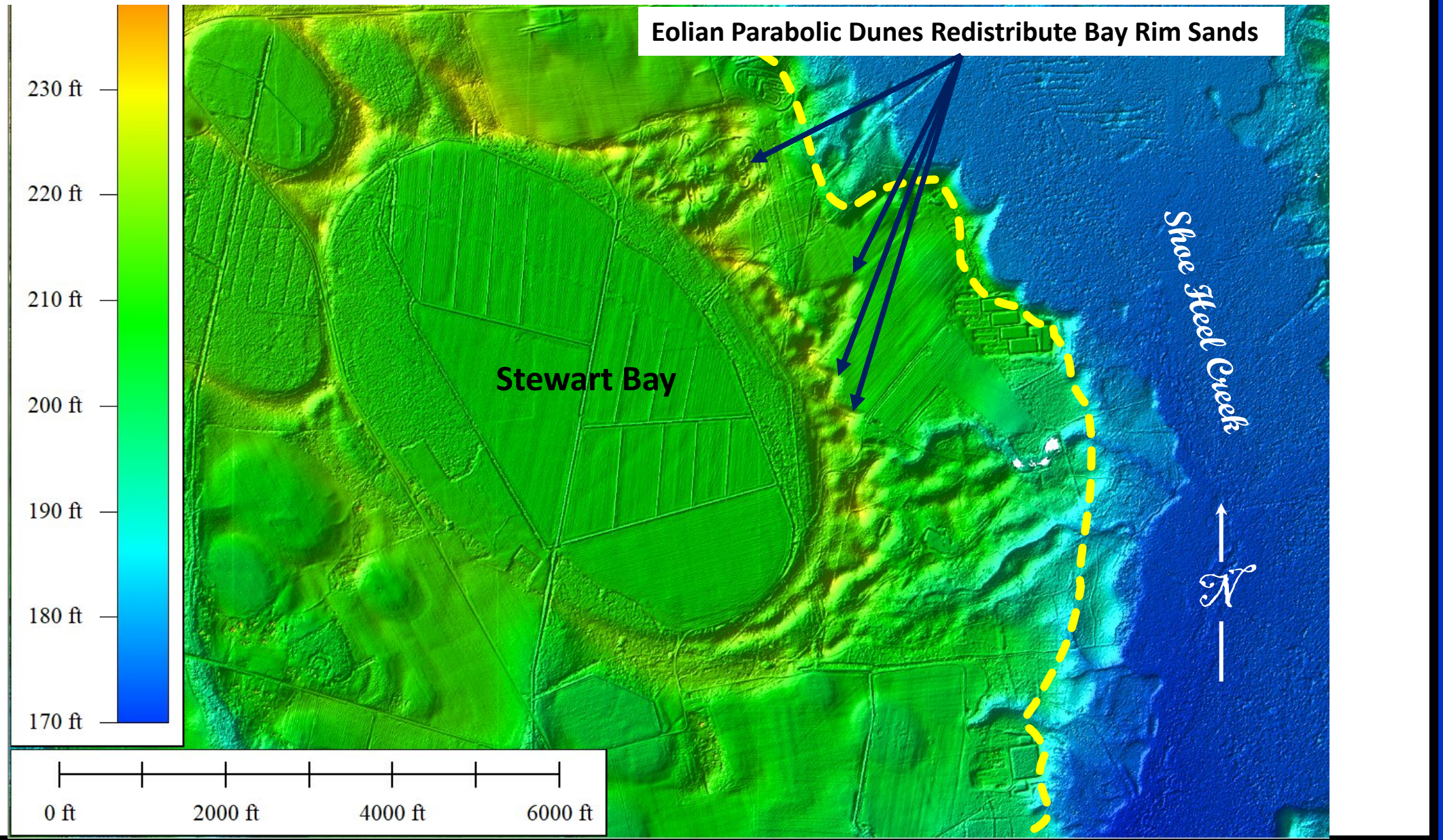


THE BARCHAN DUNE CAROLINA BAY MODEL

DEFLATING STEWART BARCHAN DUNE/BAY RIM

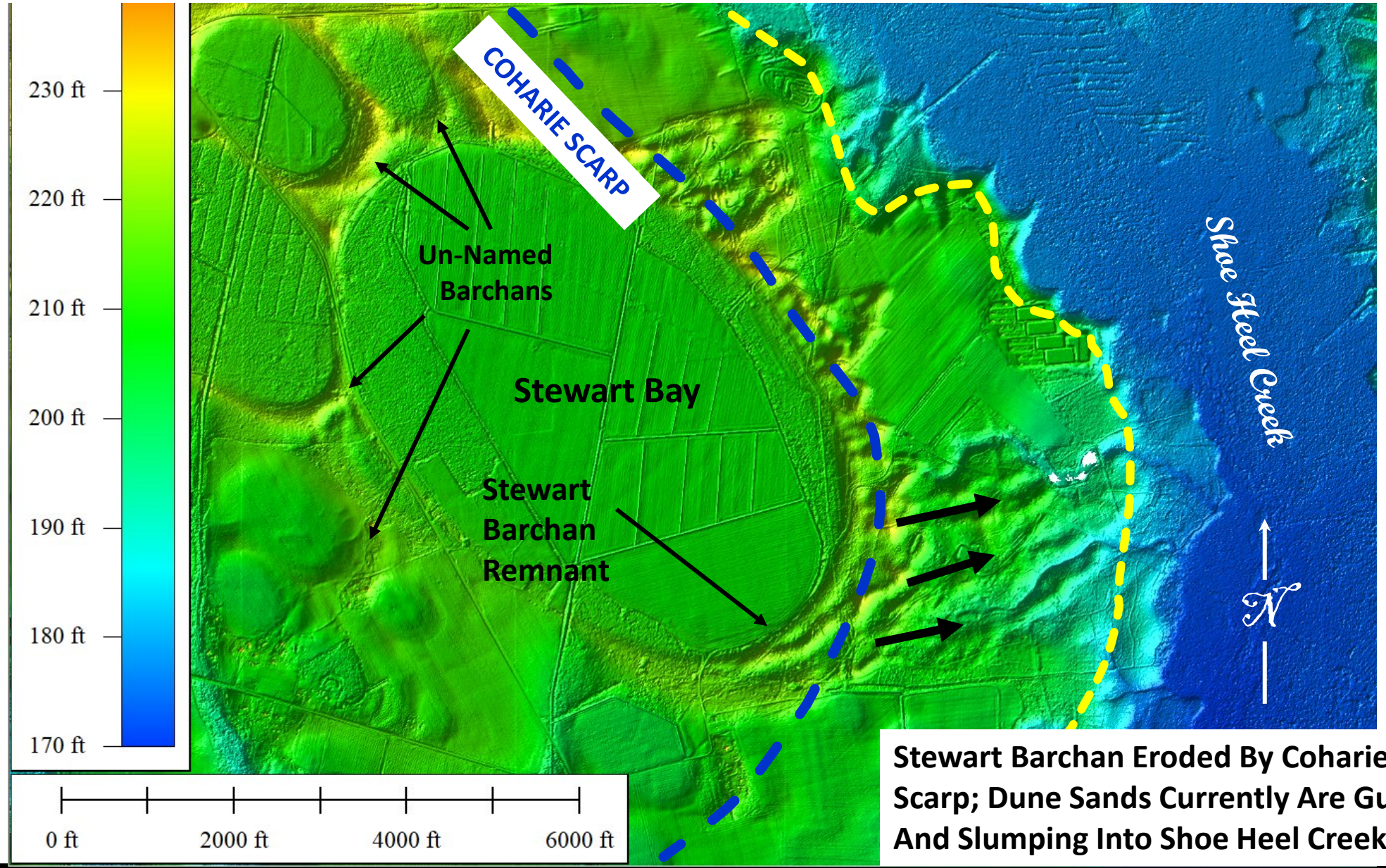
GRIDDED 2014 LiDAR ELEVATION DATA



THE BARCHAN DUNE CAROLINA BAY MODEL

ERODING STEWART BARCHAN DUNE

GRIDDED 2014 LiDAR ELEVATION DATA

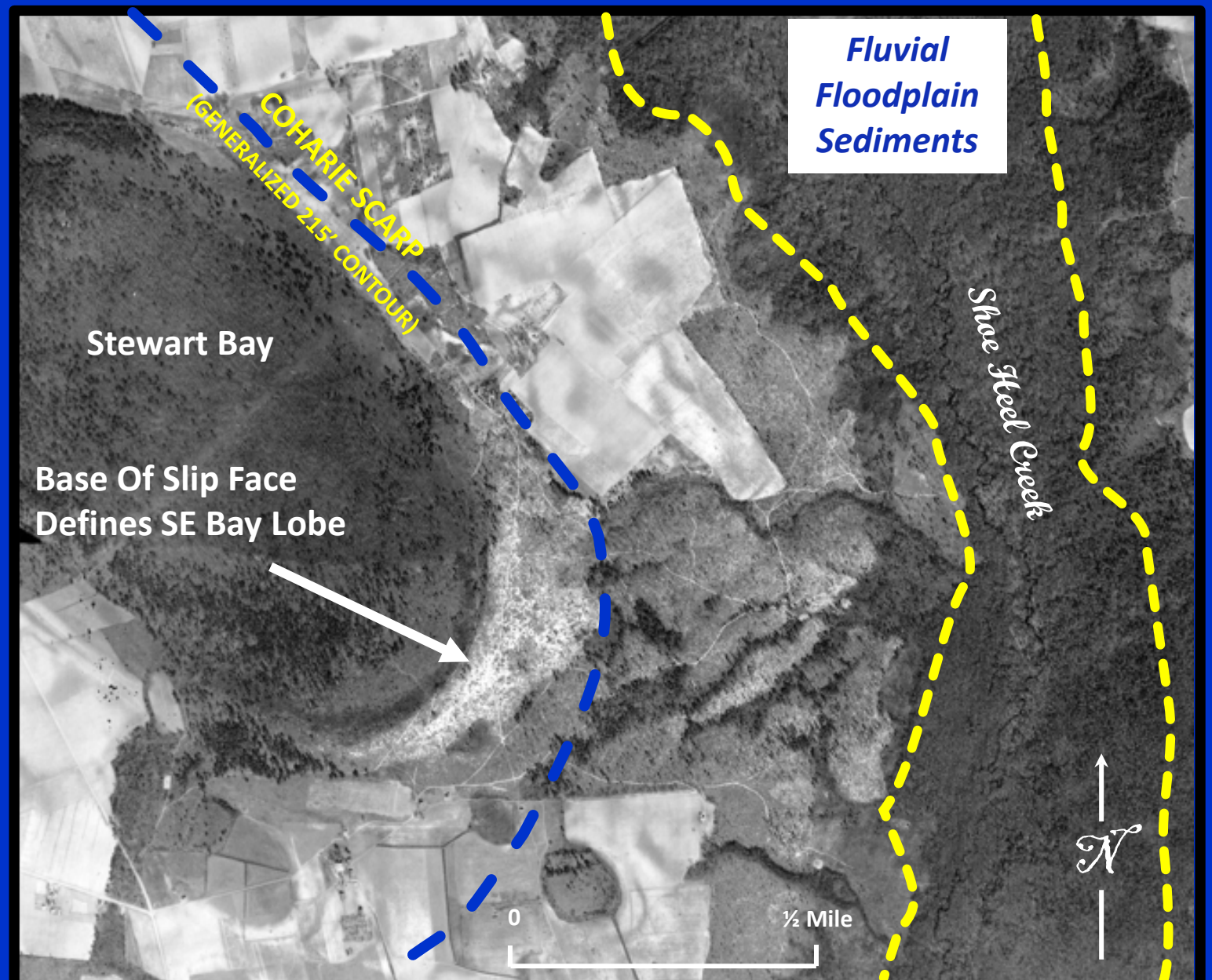


Stewart Barchan Eroded By Coharie Scarp; Dune Sands Currently Are Gullied And Slumping Into Shoe Heel Creek

THE BARCHAN DUNE CAROLINA BAY MODEL

ERODING/DEFLATING STEWART BARCHAN DUNE

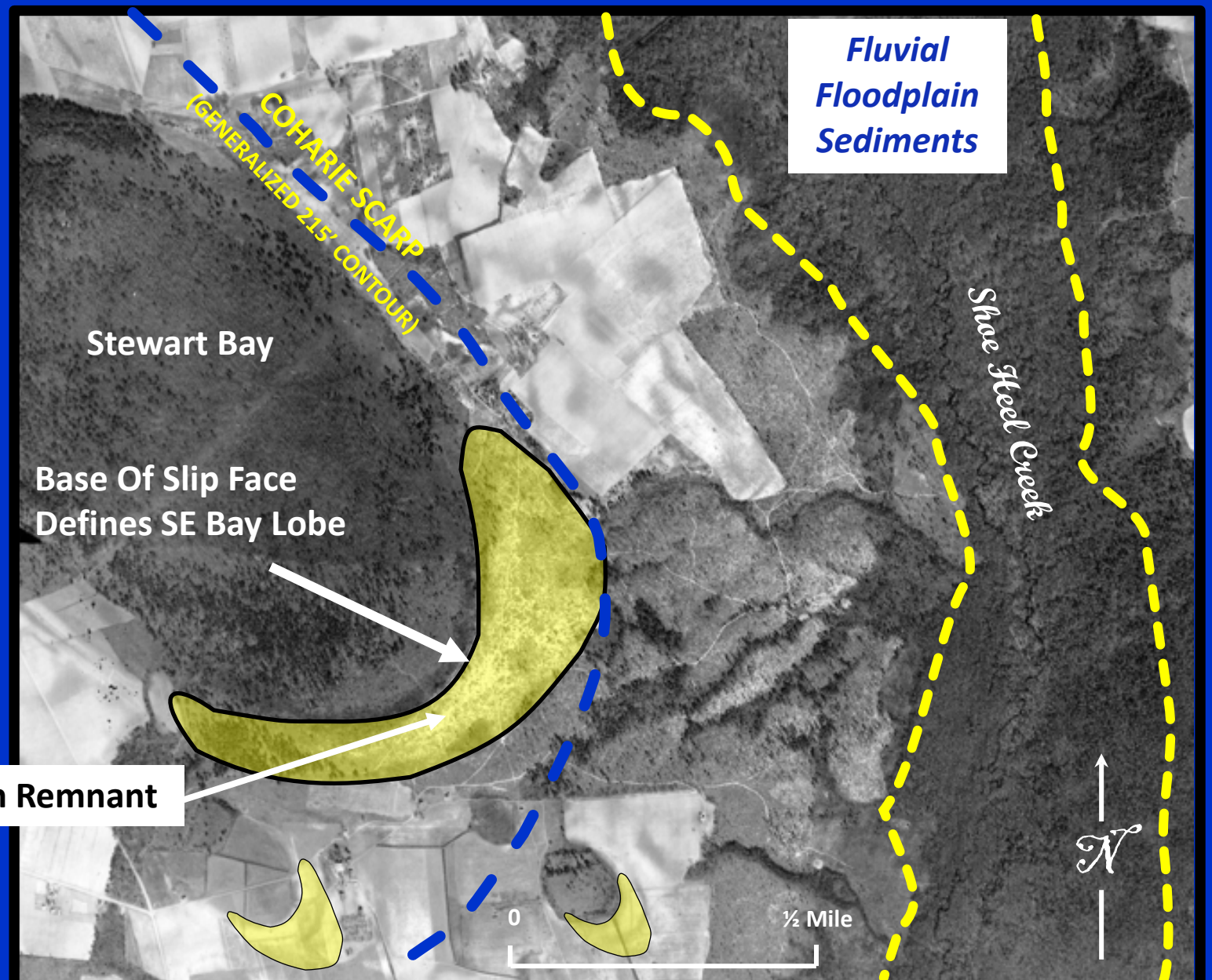
USDA AIR PHOTO SERIES 1938



THE BARCHAN DUNE CAROLINA BAY MODEL

ERODING/DEFLATING STEWART BARCHAN DUNE

USDA AIR PHOTO SERIES 1938



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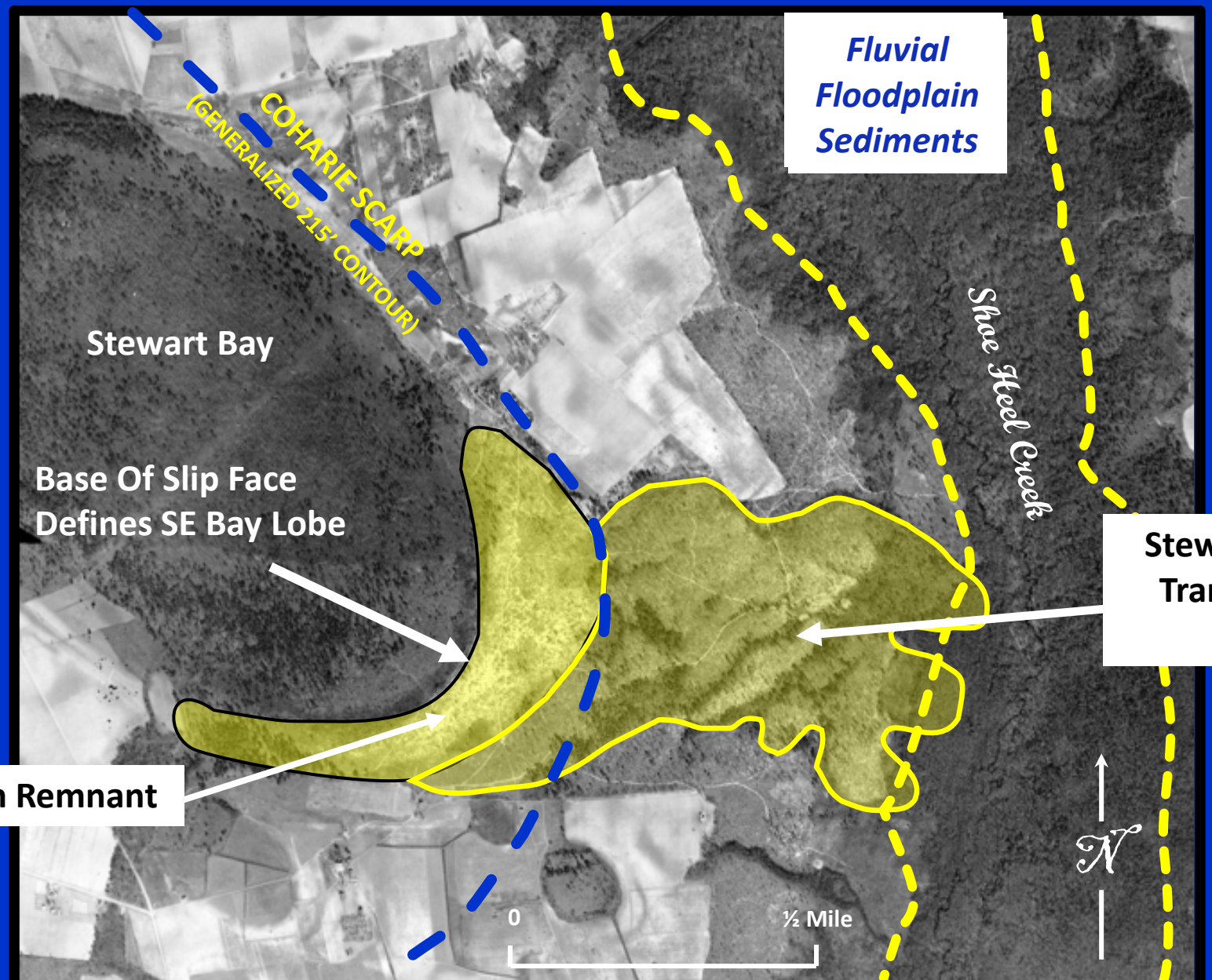
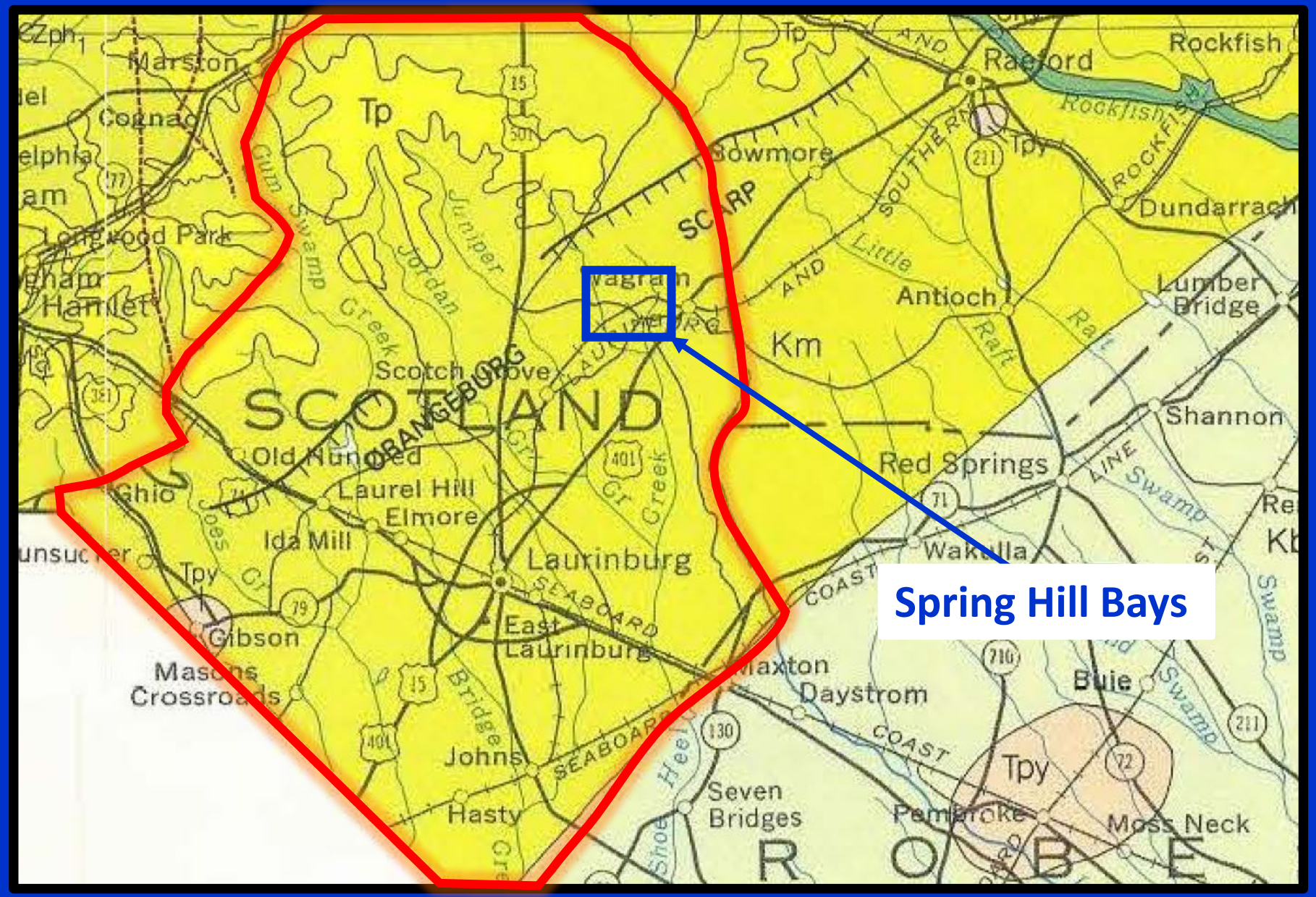
USDA AIR PHOTO SERIES 1938



THE BARCHAN DUNE CAROLINA BAY MODEL

LOCATION MAP, SPRING HILL, NC

NC GEOLOGIC MAP 1985

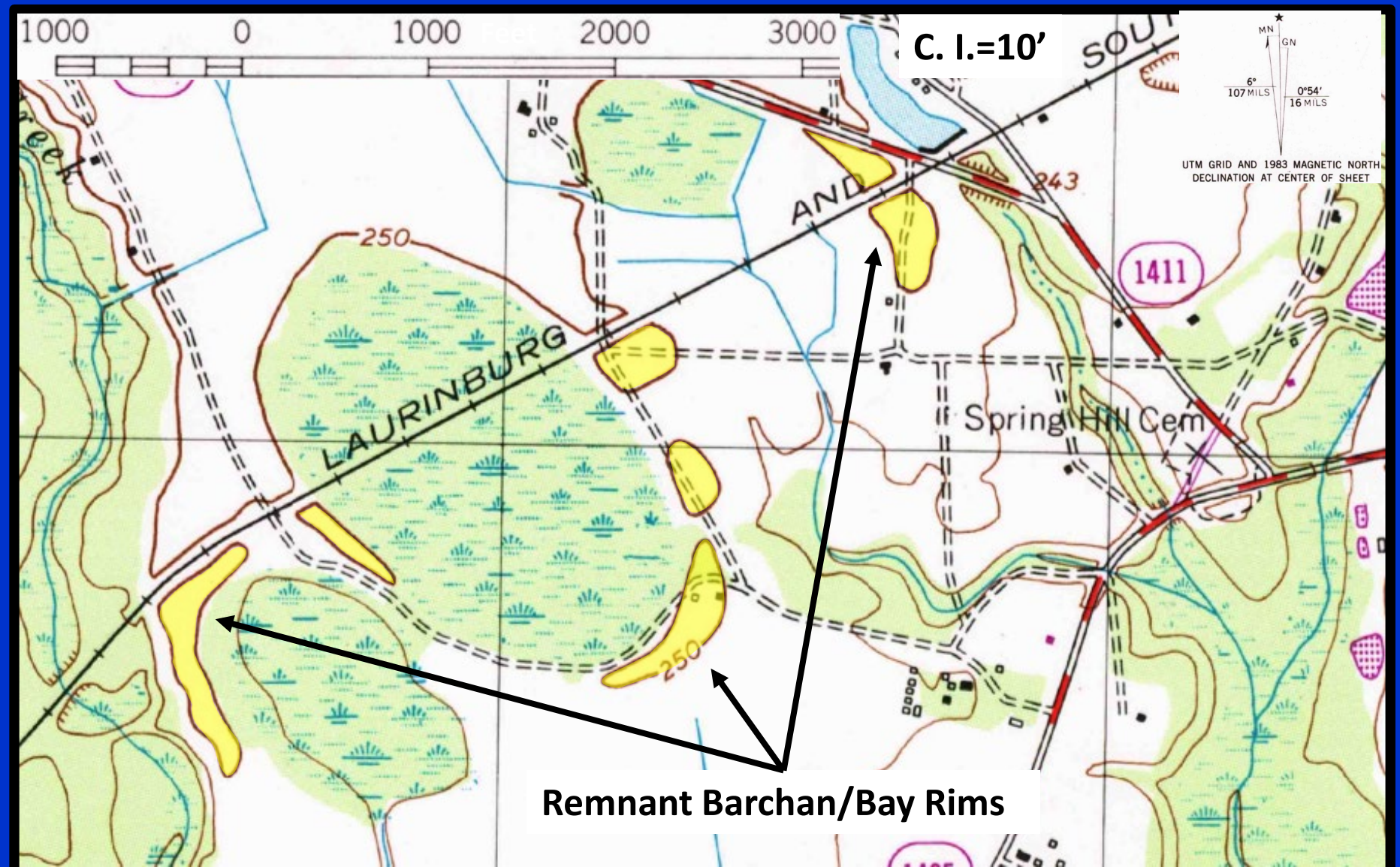


THE BARCHAN DUNE CAROLINA BAY MODEL

SPRING HILL BAYS

1:24,000 TOPO – SILVER HILL QUAD

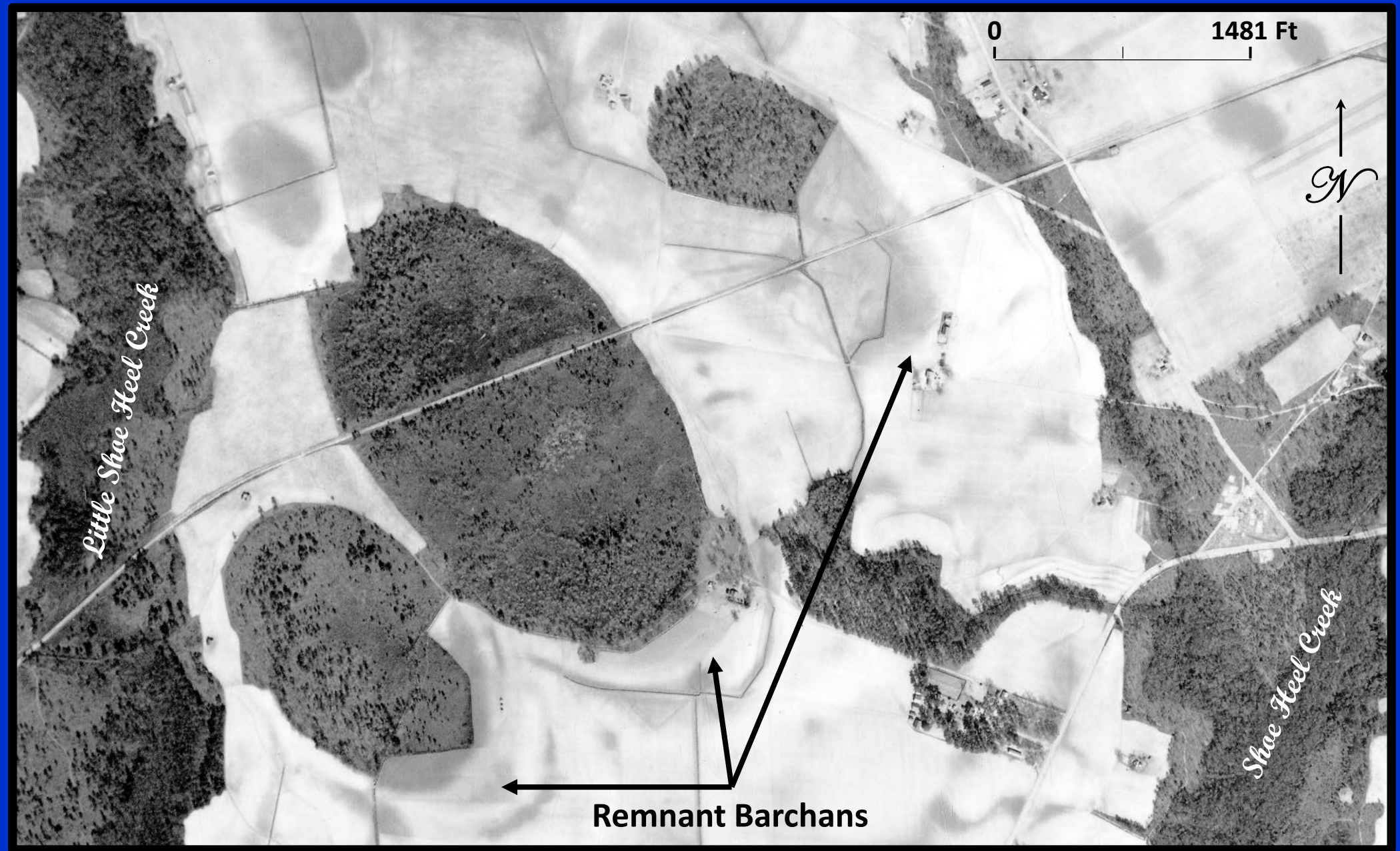
BAY RIMS AND REMNANT BARCHAN EXPRESSED AS 250’ TOPO HIGHS



THE BARCHAN DUNE CAROLINA BAY MODEL

SPRING HILL BAYS - NOTE SANDY INTERBAY AREAS

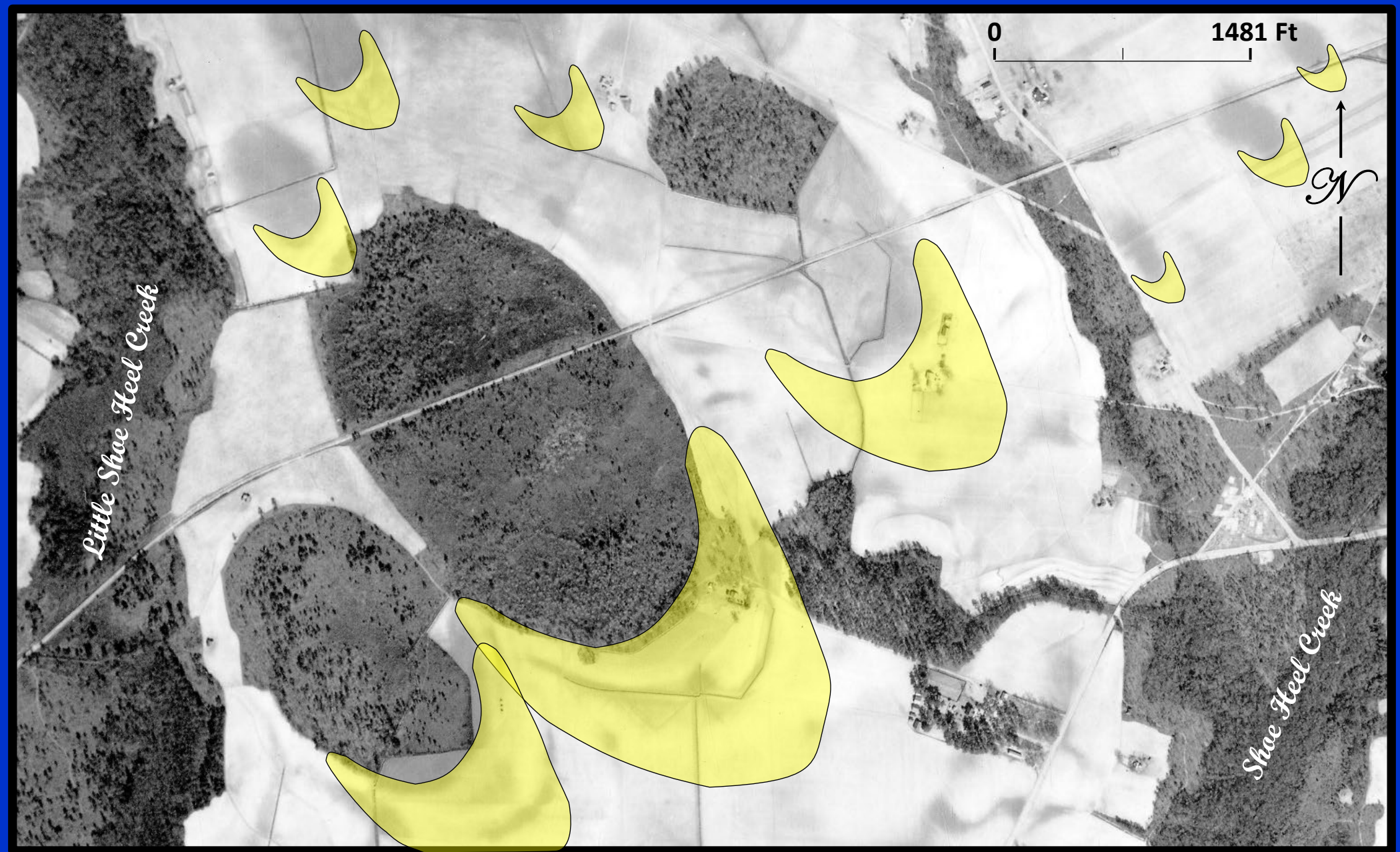
USDA AIR PHOTO SERIES 1938



THE BARCHAN DUNE CAROLINA BAY MODEL

SPRING HILL BAYS - WITH DUNE OVERLAY

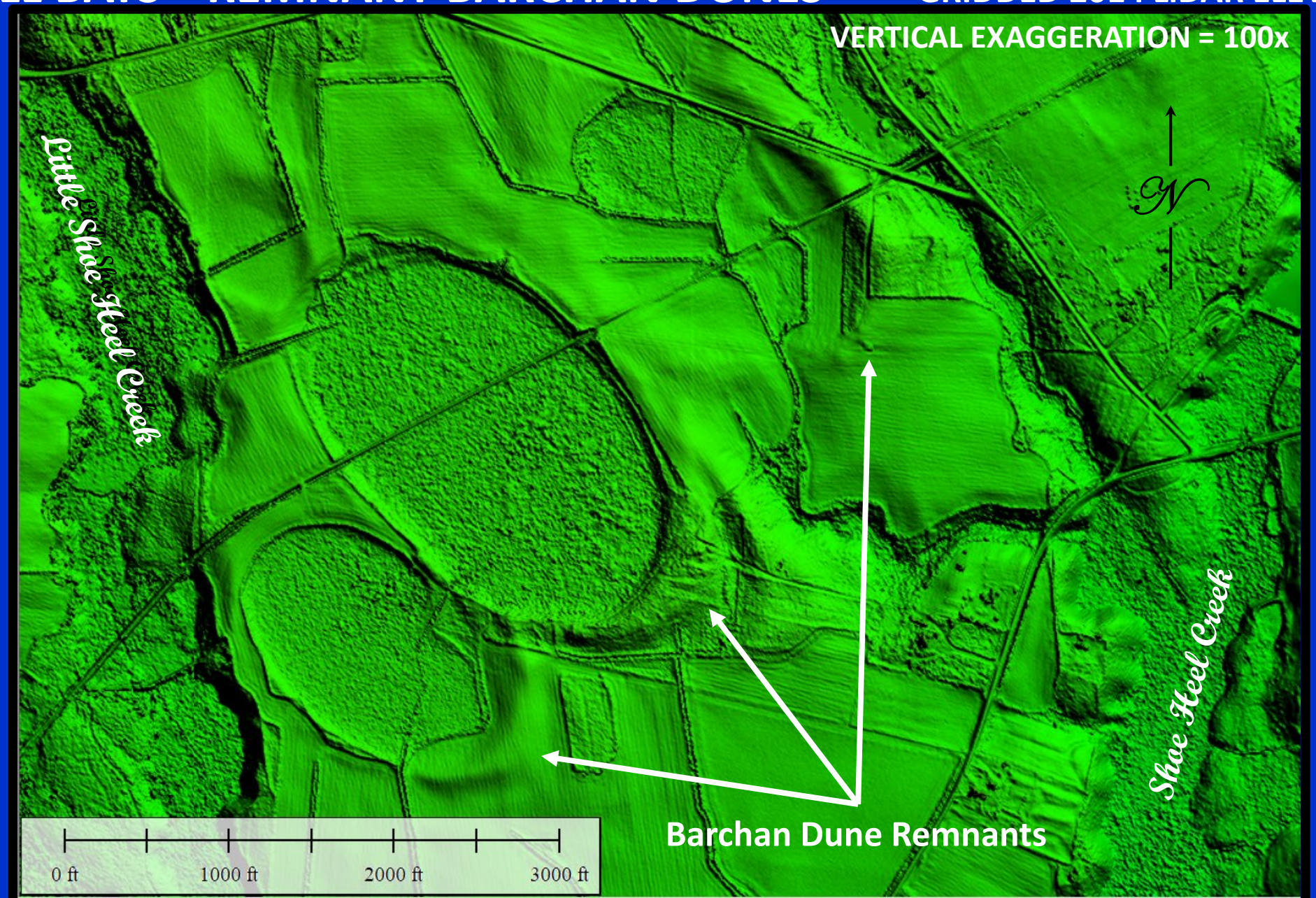
USDA AIR PHOTO SERIES 1938



THE BARCHAN DUNE CAROLINA BAY MODEL

SPRING HILL BAYS - REMNANT BARCHAN DUNES

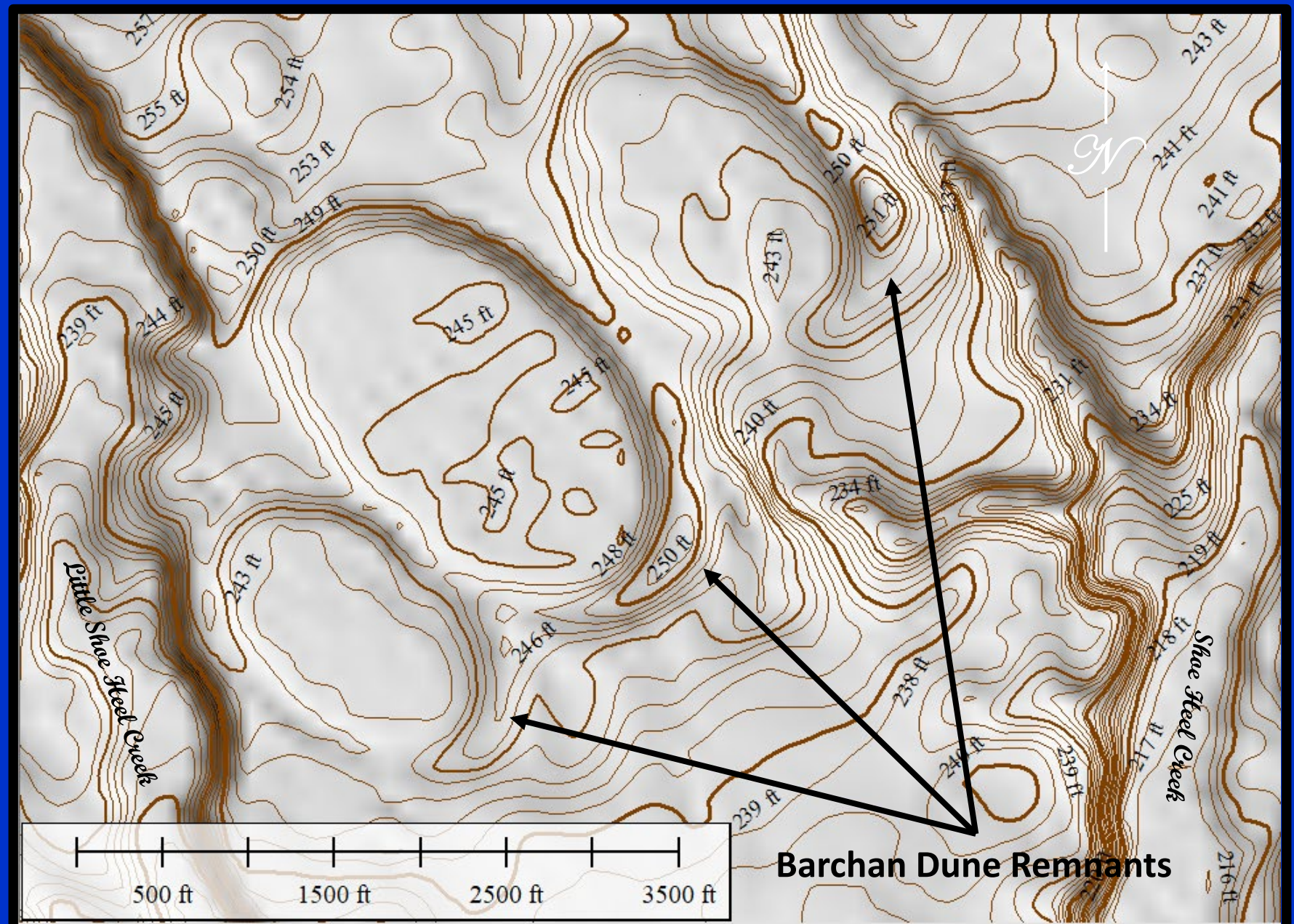
GRIDDED 2014 LiDAR ELEVATION DATA



THE BARCHAN DUNE CAROLINA BAY MODEL

SPRING HILL BAYS - CONTOUR MAP C. I. = 1 FT

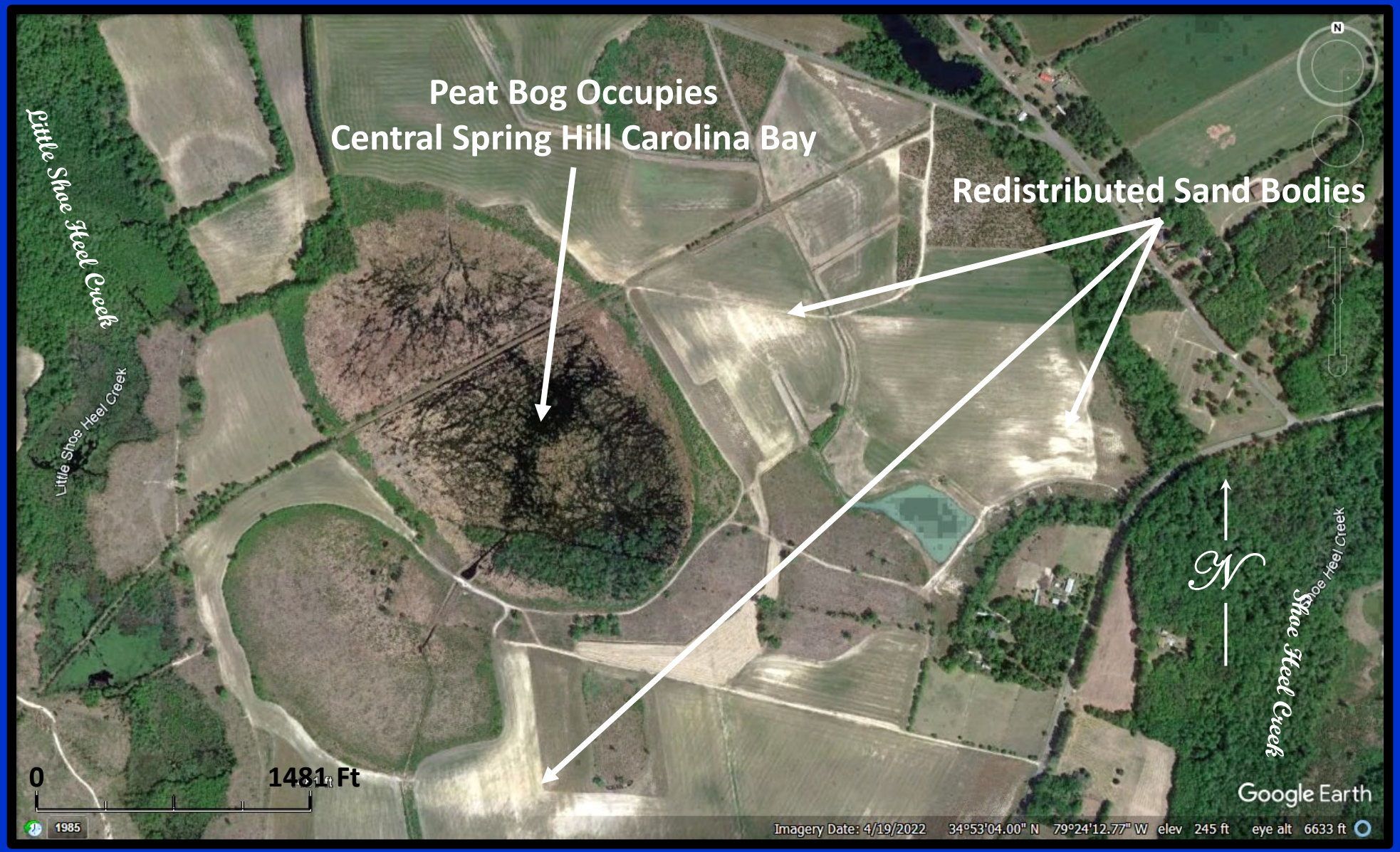
GRIDDED, CONTOURED 2008 LiDAR ELEVATION DATA



THE BARCHAN DUNE CAROLINA BAY MODEL

SPRING HILL BAYS - REMNANT DUNES AND SAND BODIES

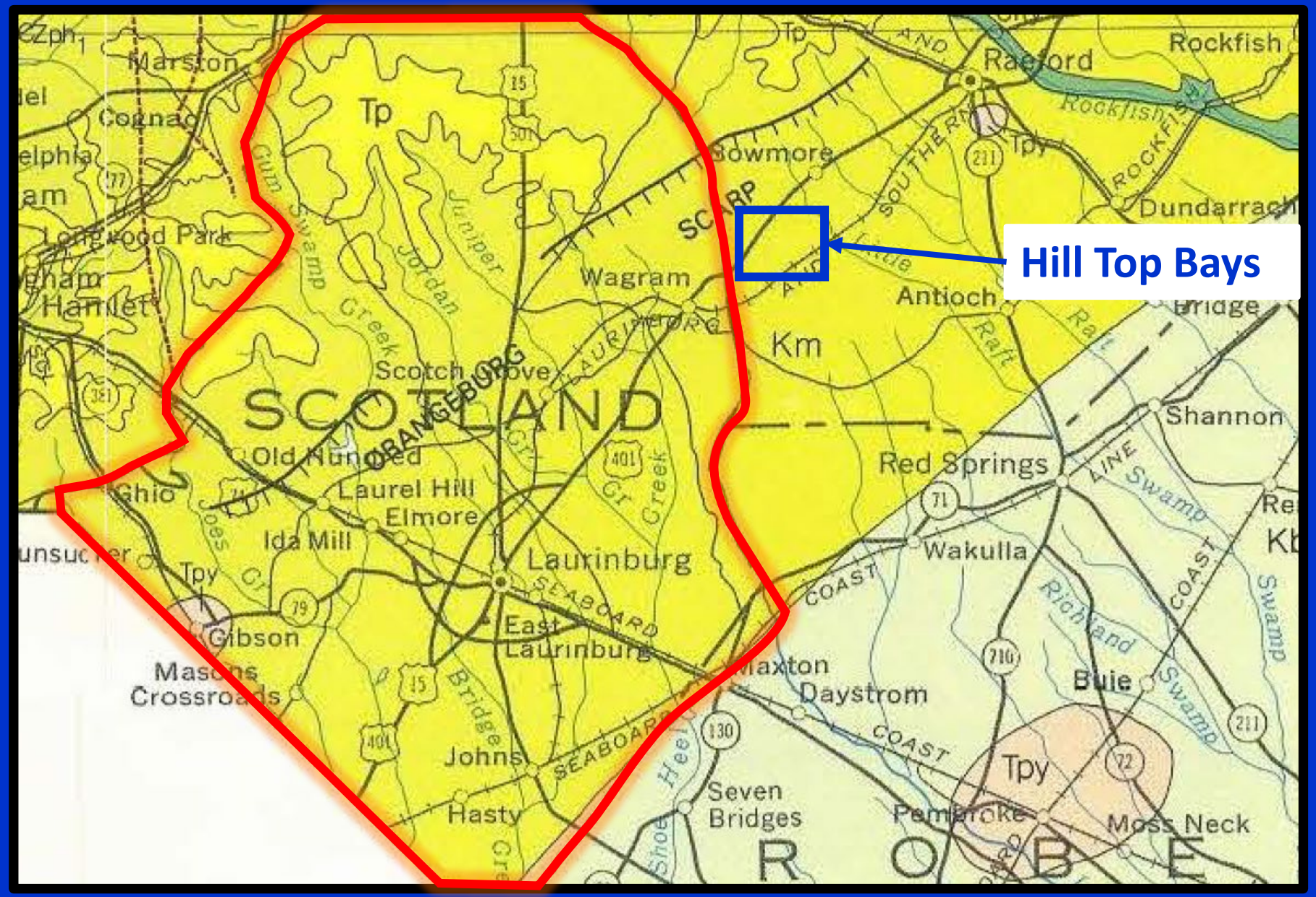
GOOGLE EARTH 2022 IMAGE



THE BARCHAN DUNE CAROLINA BAY MODEL

LOCATION MAP, HILL TOP BAYS – HOKE COUNTY

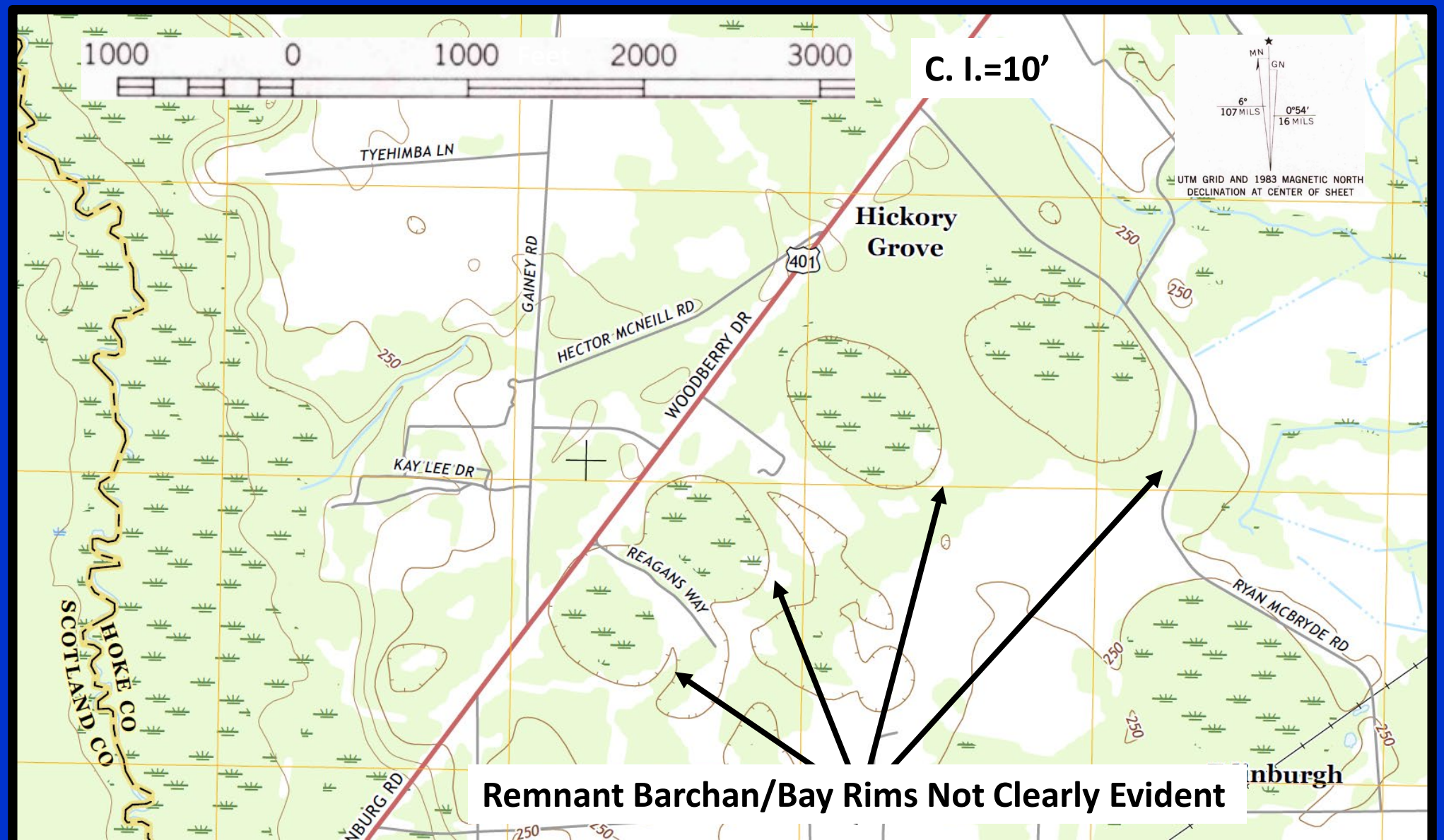
NC GEOLOGIC MAP 1985



THE BARCHAN DUNE CAROLINA BAY MODEL

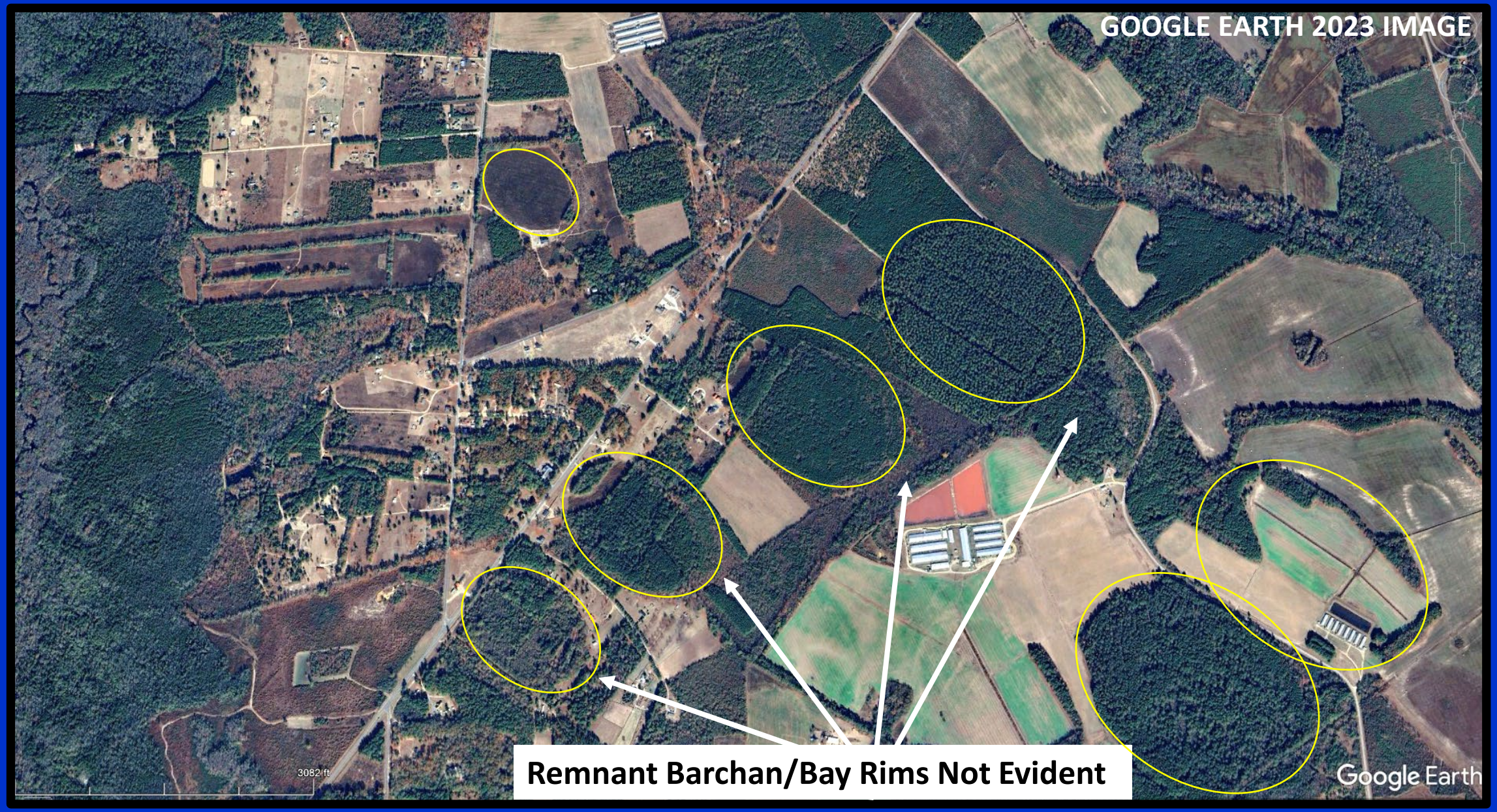
HILL TOP BAYS - BAY RIMS/REMNANT BARCHANS NOT EVIDENT ON TOPO

1:24,000 TOPO – WAGRAM QUAD



THE BARCHAN DUNE CAROLINA BAY MODEL

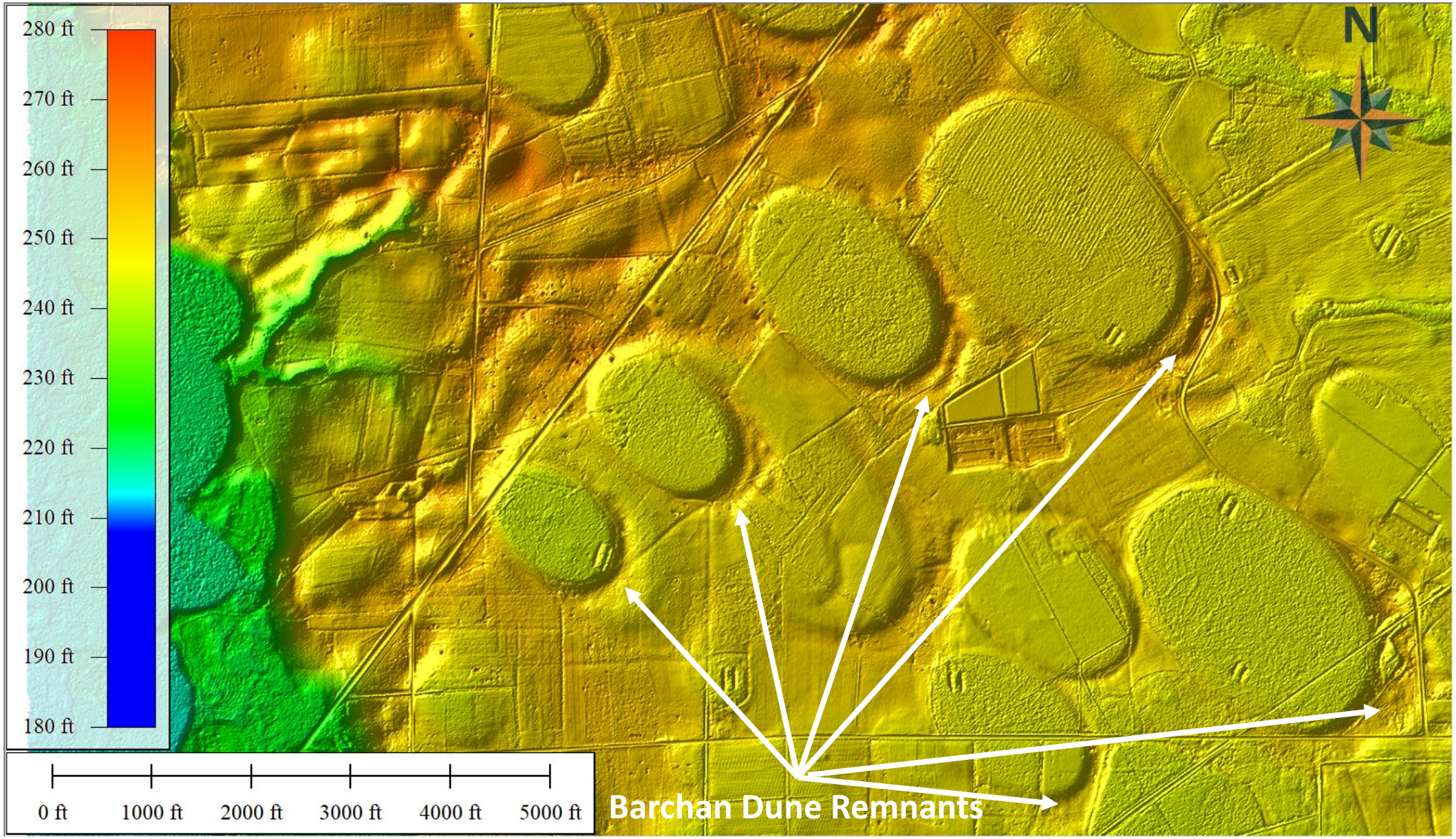
HILL TOP BAYS - BAY RIMS/REMNANT BARCHANS NOT EVIDENT GOOGLE EARTH



THE BARCHAN DUNE CAROLINA BAY MODEL

HILL TOP BAYS - BARCHAN DUNES AND RIMS

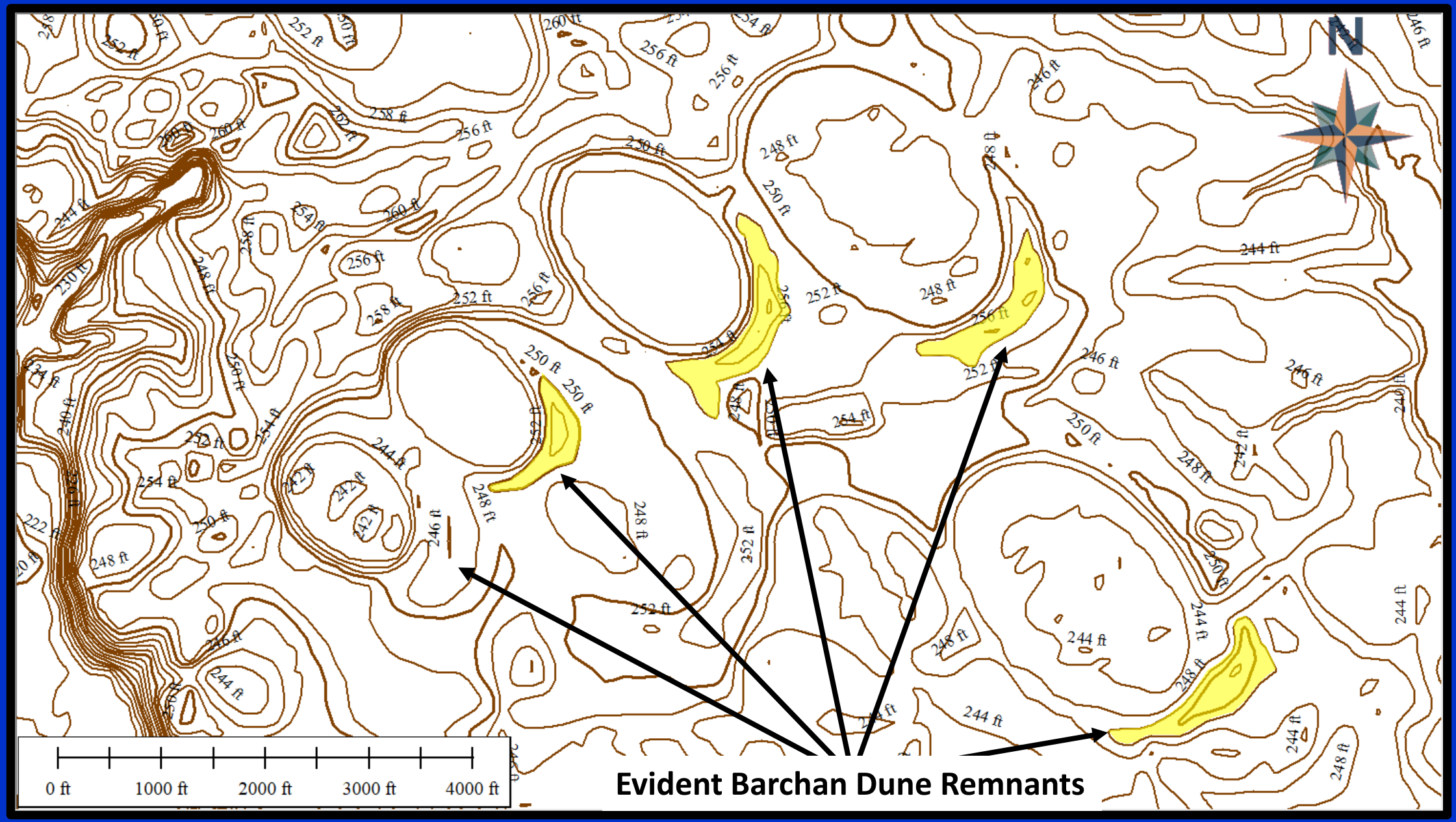
GRIDDED 2014 LiDAR ELEVATION DATA



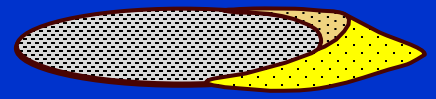
THE BARCHAN DUNE CAROLINA BAY MODEL

HILL TOP BAYS - CONTOUR MAP C.I. = 2 FT

GRIDDED 2014 LiDAR ELEVATION DATA



THE BARCHAN DUNE CAROLINA BAY MODEL



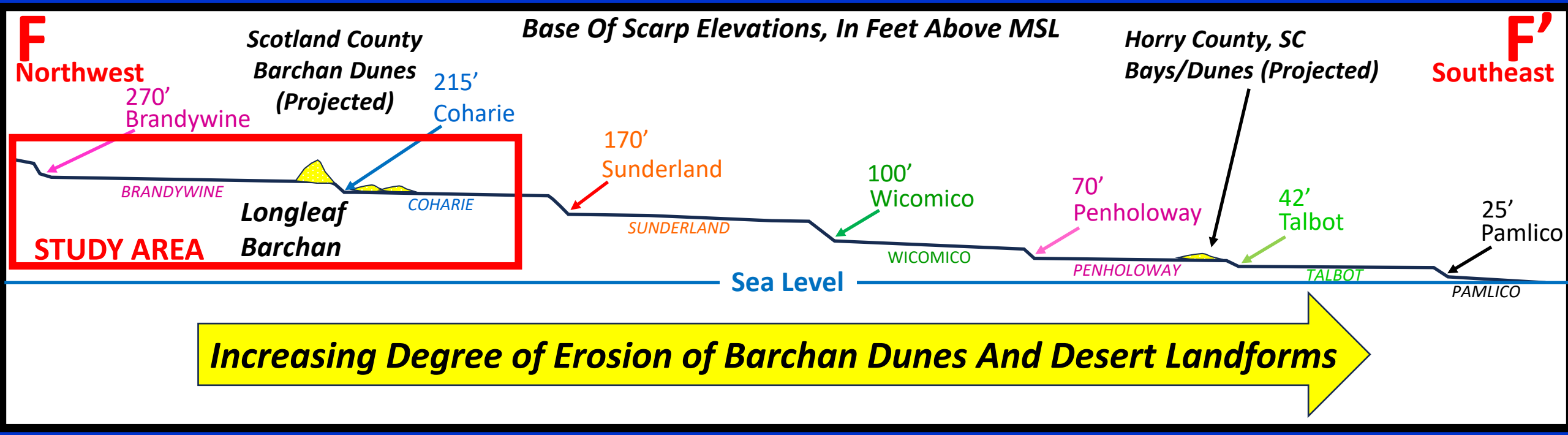
A COMPARISON WITH

COOKE'S 1954 BAYS IN HORRY CO., SC

THE BARCHAN DUNE CAROLINA BAY MODEL

PLEISTOCENE INTERGLACIAL HIGH STAND SCARPS AND TERRACES

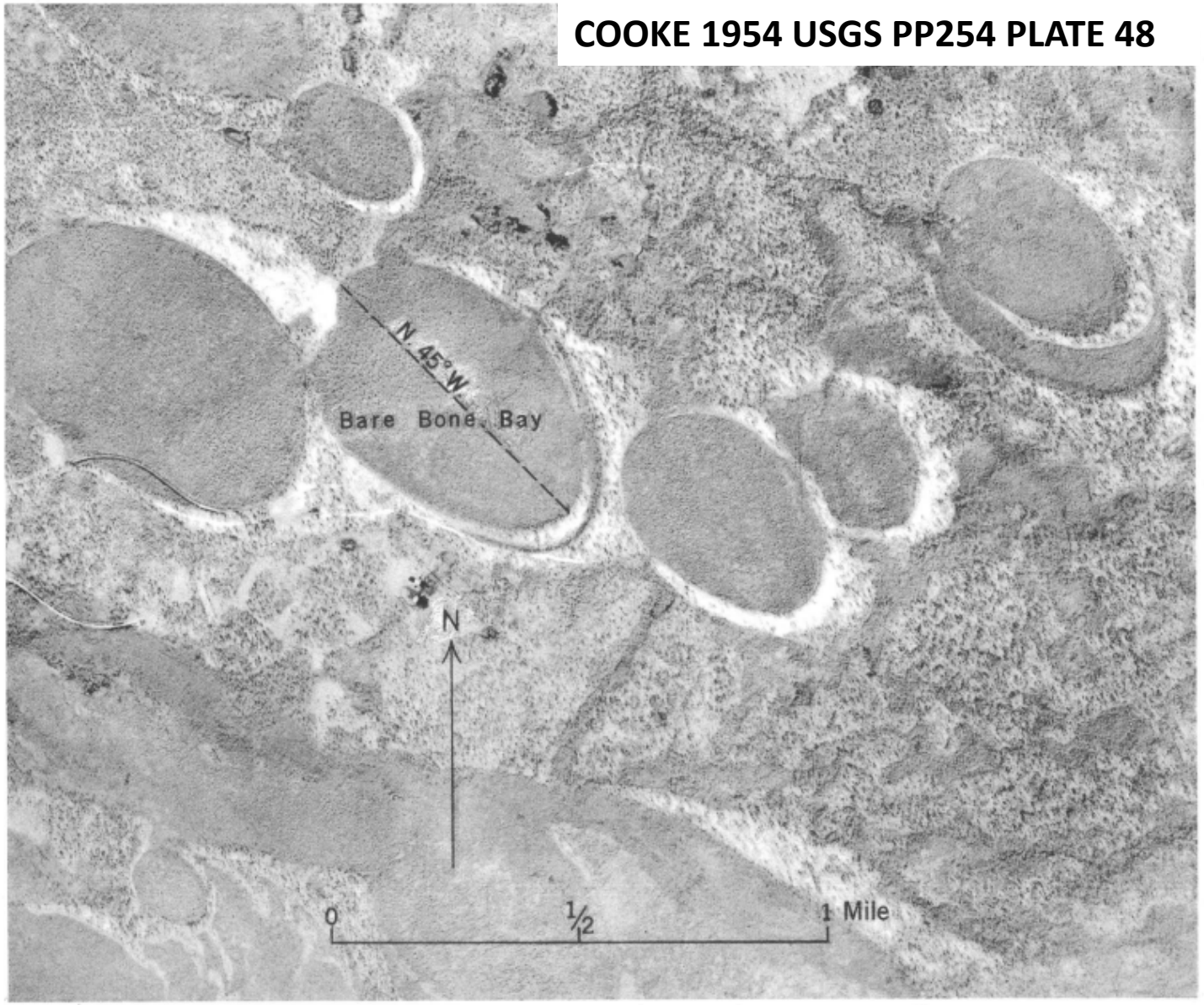
AFTER COOKE 1936 USGS BULLETIN 867



THE BARCHAN DUNE CAROLINA BAY MODEL

BAYS ON THE PENHOLOWAY TERRACE – HORRY CO, SC

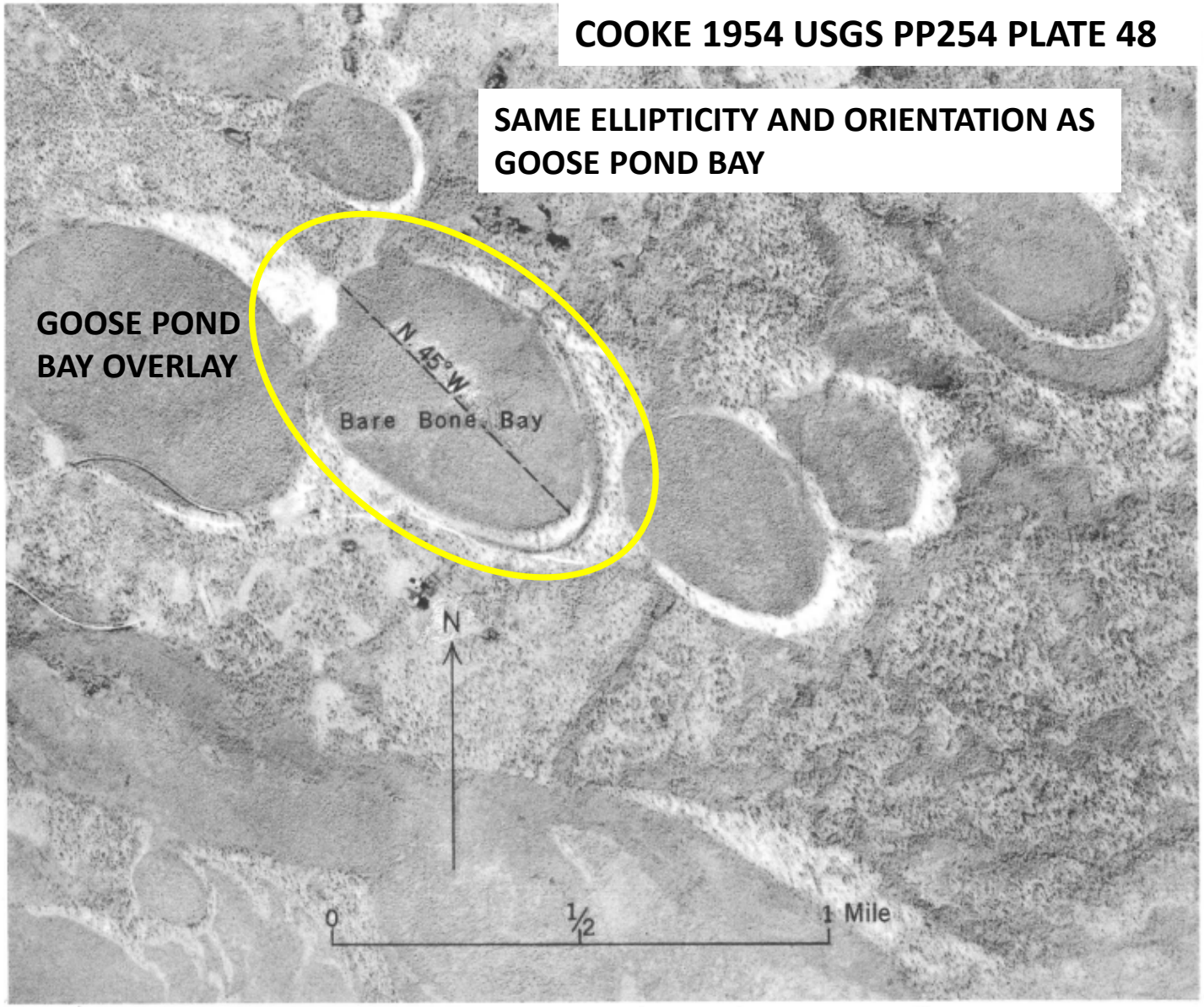
COOKE 1954 USGS PP254 PLATE 48



A GROUP OF BAYS IN HORRY COUNTY, S. C.

THE BARCHAN DUNE CAROLINA BAY MODEL

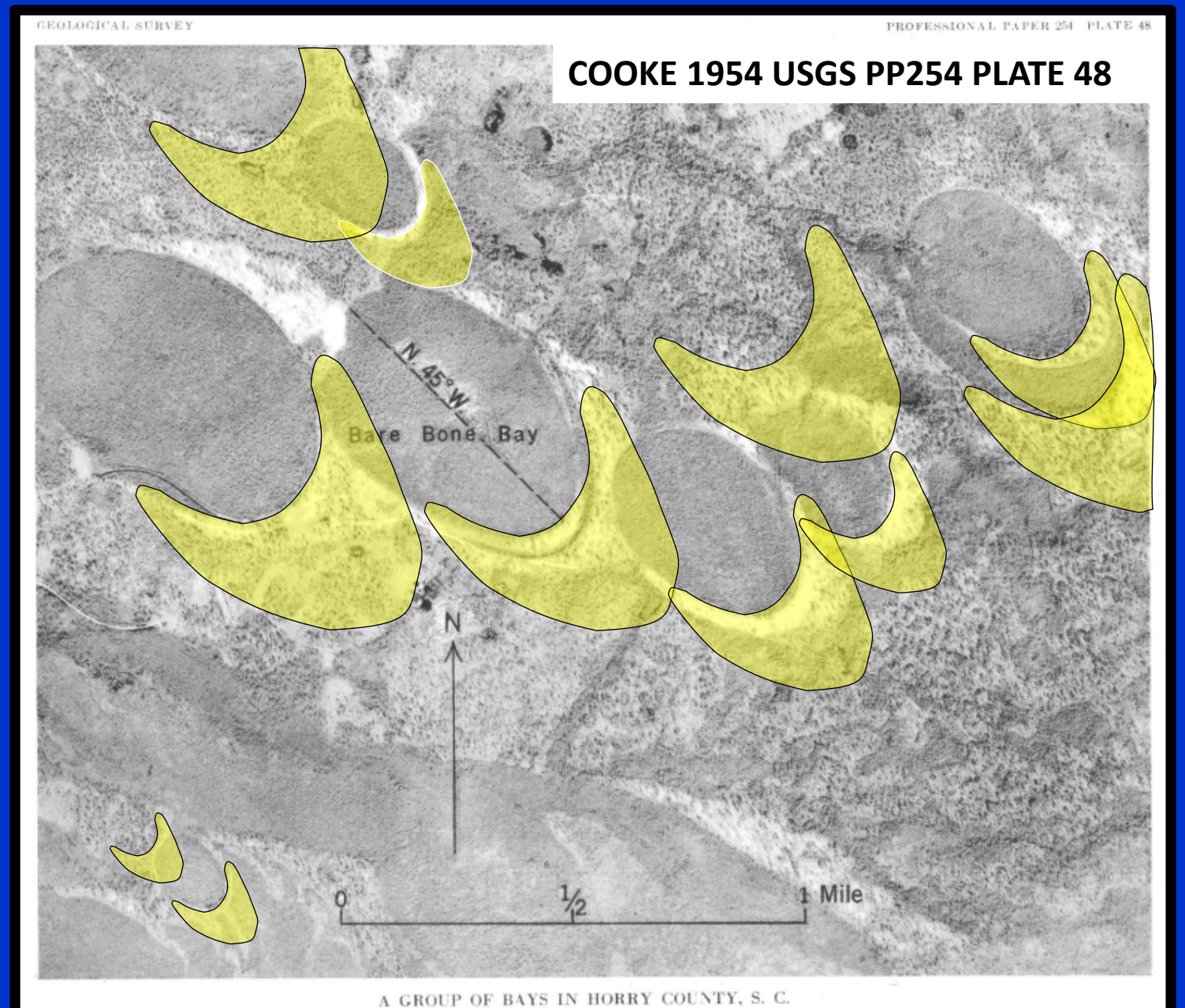
BAYS ON THE PENHOLOWAY TERRACE – HORRY CO, SC



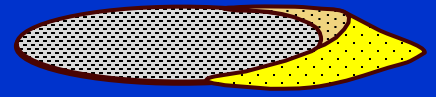
A GROUP OF BAYS IN HORRY COUNTY, S. C.

THE BARCHAN DUNE CAROLINA BAY MODEL

BAYS ON THE PENHOLOWAY TERRACE – DUNE OVERLAY



THE BARCHAN DUNE CAROLINA BAY MODEL



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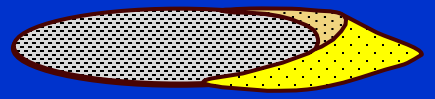


MODERN BARCHAN DUNE ANALOGS

THE BARCHAN DUNE CAROLINA BAY MODEL

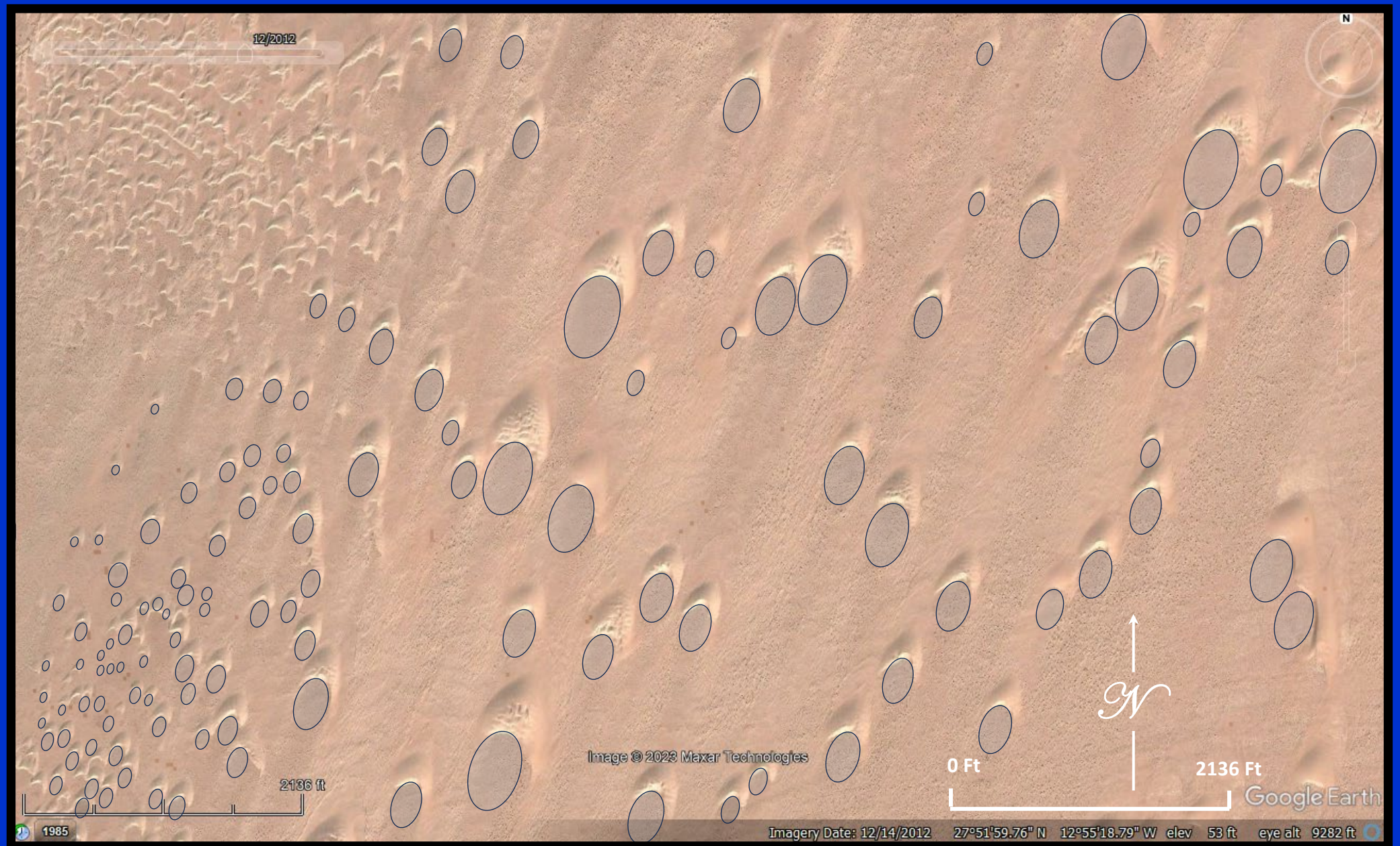
MODERN BARCHAN DUNE FIELDS – WIND SHADOWS

WESTERN SAHARA – NORTH AFRICA

THE BARCHAN DUNE CAROLINA BAY MODEL

MODERN BARCHAN DUNE FIELDS – BAY OVERLAY

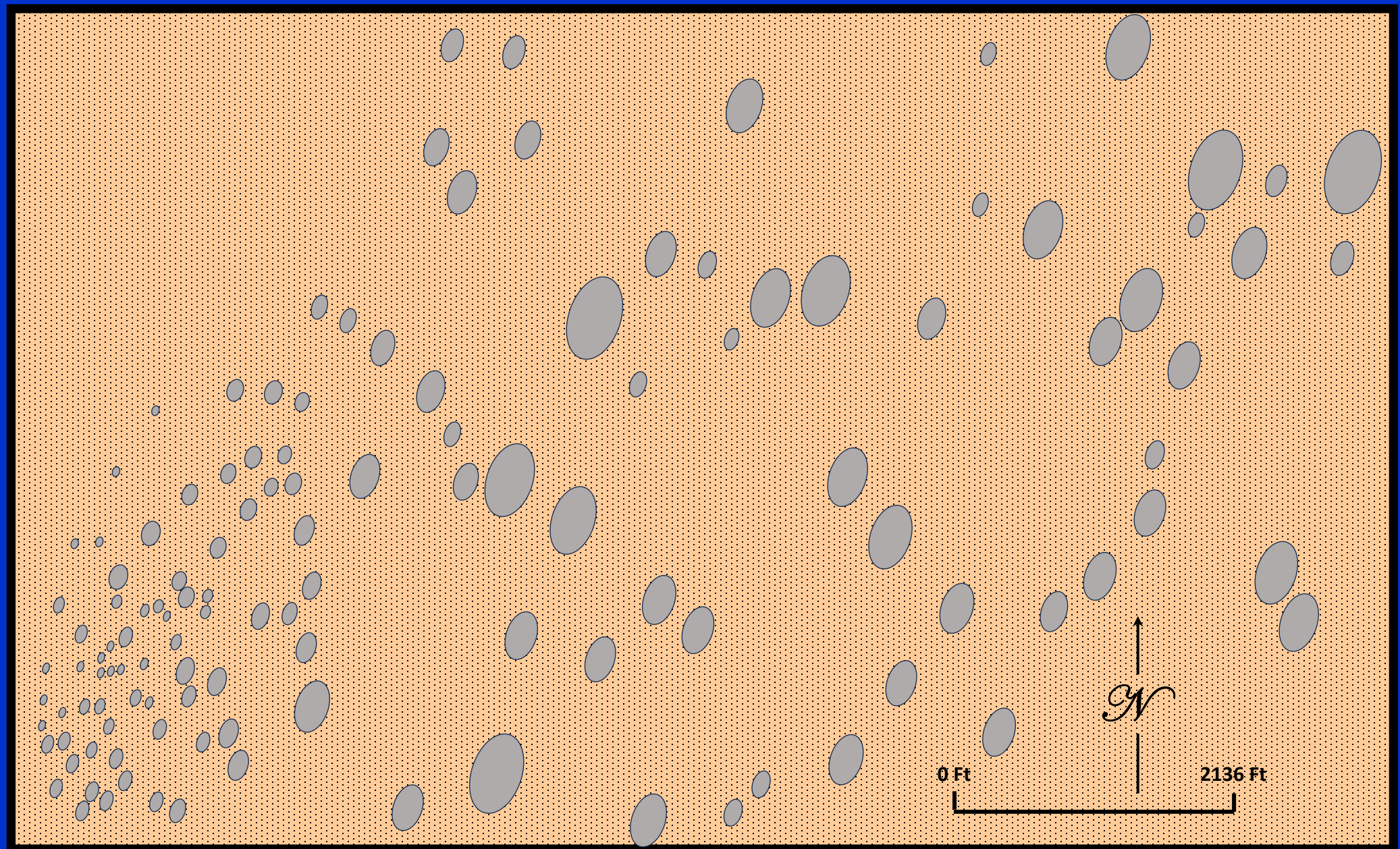
WESTERN SAHARA – NORTH AFRICA



THE BARCHAN DUNE CAROLINA BAY MODEL

MODERN BARCHAN DUNE FIELDS – BAYS, SOME DAY?

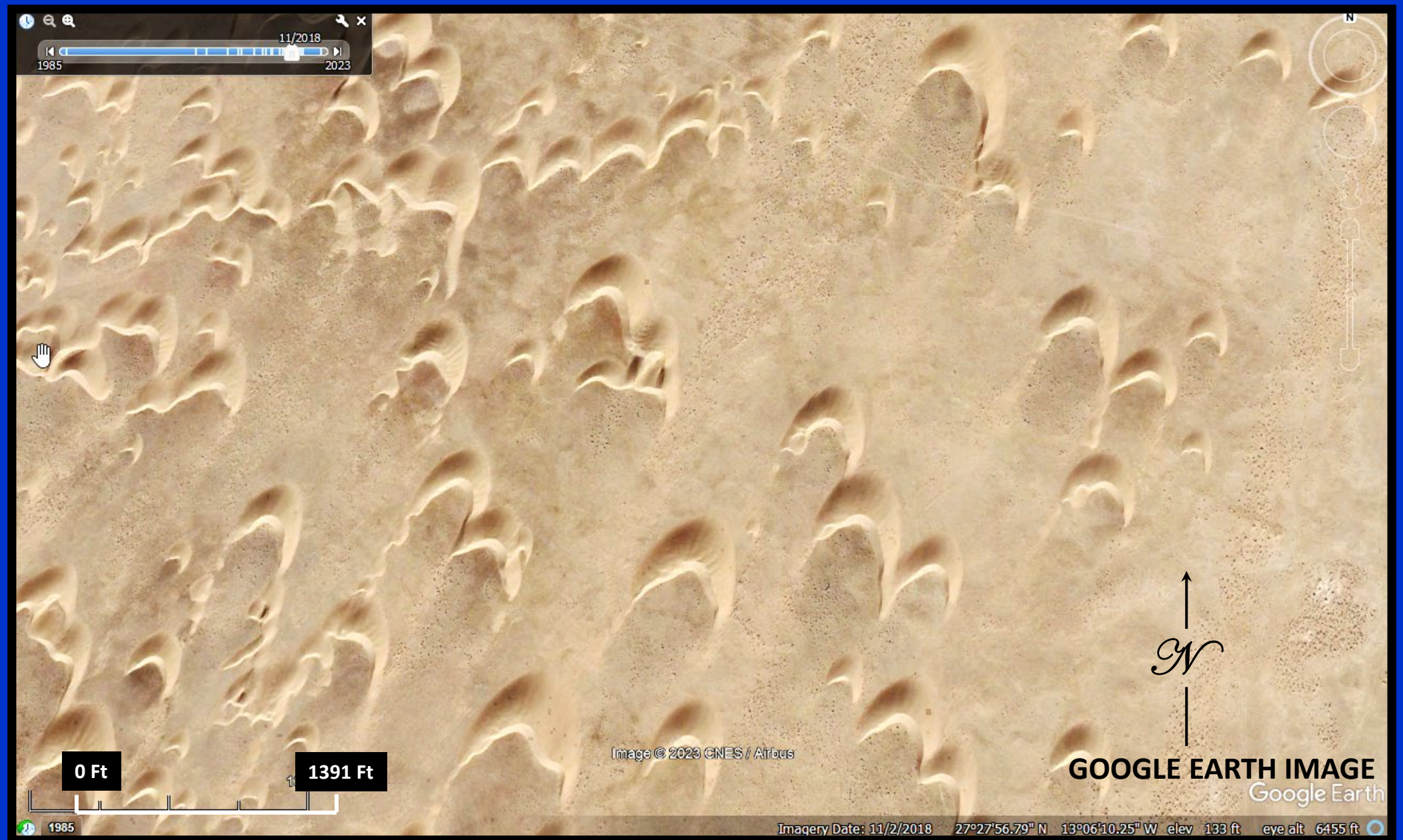
WESTERN SAHARA – NORTH AFRICA



THE BARCHAN DUNE CAROLINA BAY MODEL

MODERN BARCHAN DUNE FIELDS – WIND SHADOWS

WESTERN SAHARA – NORTH AFRICA

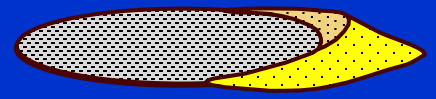


THE BARCHAN DUNE CAROLINA BAY MODEL

MODERN BARCHAN DUNE FIELDS – BAY OVERLAY

WESTERN SAHARA – NORTH AFRICA

THE BARCHAN DUNE CAROLINA BAY MODEL



A RELATED OBSERVATION…

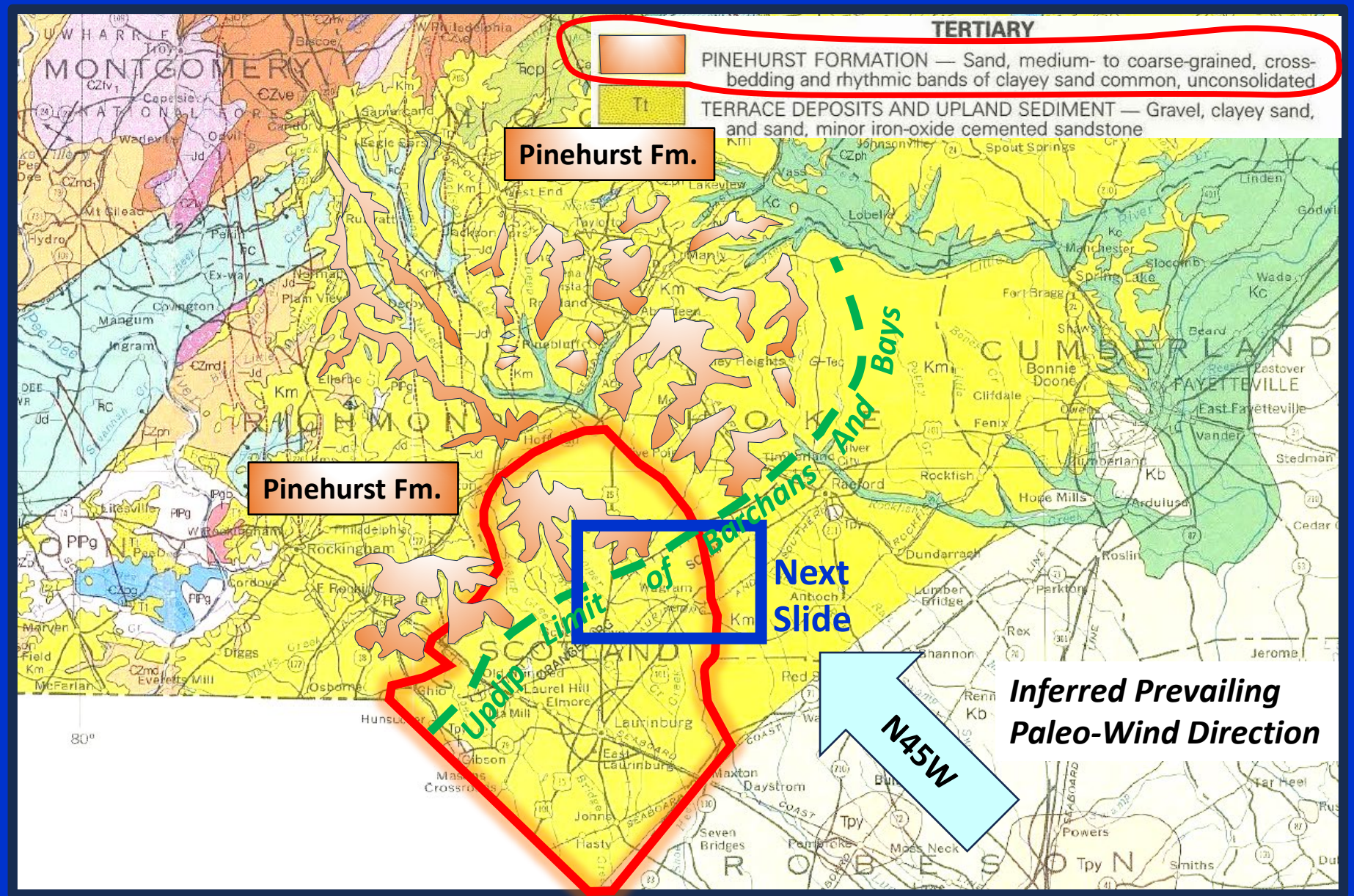
THE PINEHURST FORMATION:

MAPPED AS PLIOCENE, HOWEVER AUTHOR INTERPRETS IT TO BE THE UPLAND EOLIAN EQUIVALENT TO THE COASTAL PLAIN PLEISTOCENE BARCHAN DUNES, PART OF THE SAME ERG

THE BARCHAN DUNE CAROLINA BAY MODEL

PINEHURST FM: UPLAND EQUIVALENT OF COASTAL PLAIN BARCHANS, ABOVE THE PENEPLAIN?

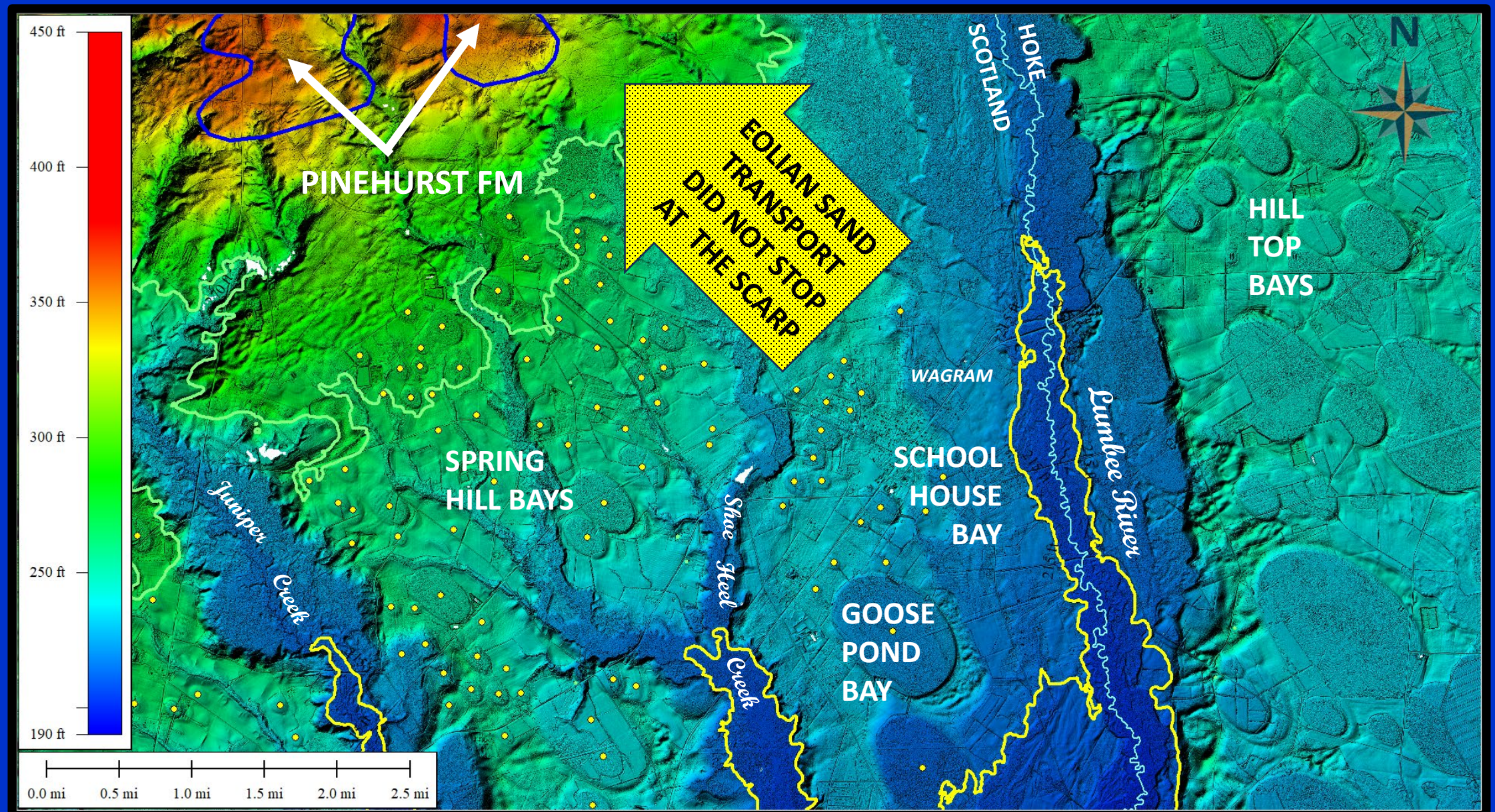
NC GEOLOGIC MAP 1985



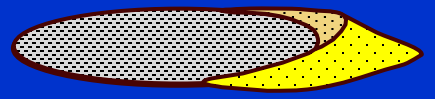
THE BARCHAN DUNE CAROLINA BAY MODEL

STUDY AREA LiDAR INDEX MAP

GRIDDED 2014 LiDAR ELEVATION DATA

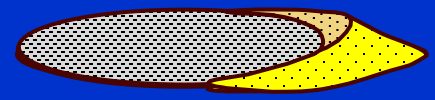


THE BARCHAN DUNE CAROLINA BAY MODEL



CONCLUSIONS

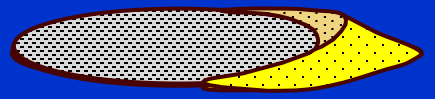
THE BARCHAN DUNE CAROLINA BAY MODEL



STUDY CONCLUSIONS

- Bays Formed In The Wind Shadow Of Barchan Dunes On The Coastal Plain Desert During Glacial Low Stands
- Finer Grained Sediments Accumulated On The Bay Floor Creating A Separate Landform Behind the Dune; Dune Migration Ceased; Bay Peat Bogs And Forests Developed
- Differential Compaction Of Fine-Grained Sediments, And In Particular Peat Beds, Created The Bay Structural Depression
- Compaction, Diagenesis, Soil Formation and Vegetation Anchored The Bay Sediments, Making Them Resistant To Submarine and Subaerial Erosion

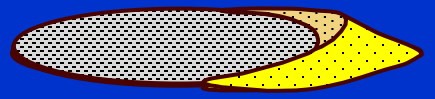
THE BARCHAN DUNE CAROLINA BAY MODEL



STUDY CONCLUSIONS

- Multiple Marine Inter-Glacial Incursions Removed Most Evidence Of Barchans Leaving The Bay, Barchan Dune Remnants, Sand Rims and Widespread Sheet (Cover) Sands
- The Carolina Bay Sediment ‘Mat’ Remained Intact Amidst The Erosion/Redistribution Of Unconsolidated Desert Sands
- Bay Size Is Directly Proportional To Parent Barchan Dune Size; Ellipticity Proportional To Wind Velocity
- Bays Likely Extend Into The Submerged Shelf Offshore

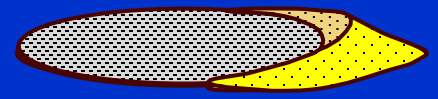
THE BARCHAN DUNE CAROLINA BAY MODEL



ISSUES RAISED

- Nomenclature Issue: One Landform Creating Another?
- Barchan Removed, Is The Bay An ‘Ichno-Landform’?
- Pinehurst Formation: Upland Eolian Sands Laterally Equivalent To Downdip Pleistocene Scotland County Barchans?

THE BARCHAN DUNE CAROLINA BAY MODEL



DOUGLAS JOHNSON “THE ORIGIN OF THE CAROLINA BAYS” - 1942

“THE HYPOTHESIS OF COMPLEX ORIGIN”

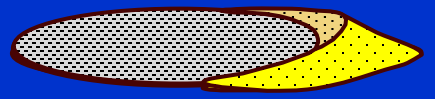
“the artesian-solution-lacustrine-aeolian hypothesis”

DOUGLAS WATKINS (THIS STUDY) - 2024

AN ALTERNATIVE ‘HYPOTHESIS OF COMPLEX ORIGIN’:

“the eolian barchan-wind shadow-peat bog-differential compaction-dune deflation-marine/eolian overprint hypothesis”

THE BARCHAN DUNE CAROLINA BAY MODEL



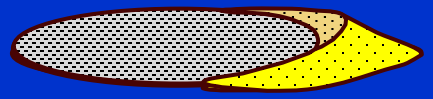
OR, MORE SIMPLY PUT:

“…BARCHANS BEGAT BAYS…”

THE BARCHAN DUNE CAROLINA BAY MODEL

DEDICATED TO MY TWINS, LOVE YOU GUYS!

THE BARCHAN DUNE CAROLINA BAY MODEL



WITH THANKS TO

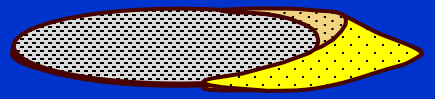
R L McMILLAN

MARY MAC ZEIGLER

JOHN COOLEY

BOBBY CREECH

THE BARCHAN DUNE CAROLINA BAY MODEL



QUESTIONS?