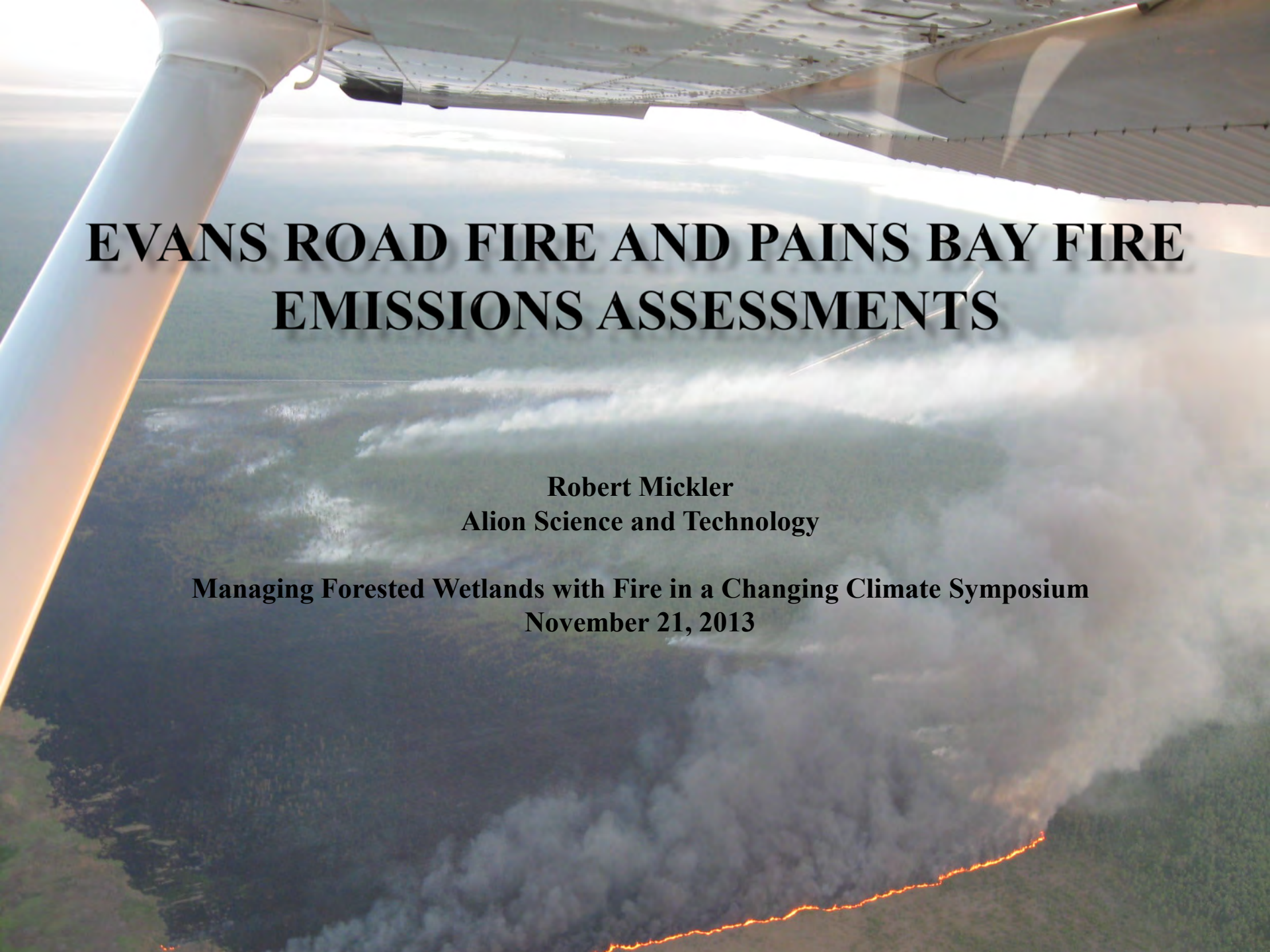


EVANS ROAD FIRE AND PAINS BAY FIRE EMISSIONS ASSESSMENTS

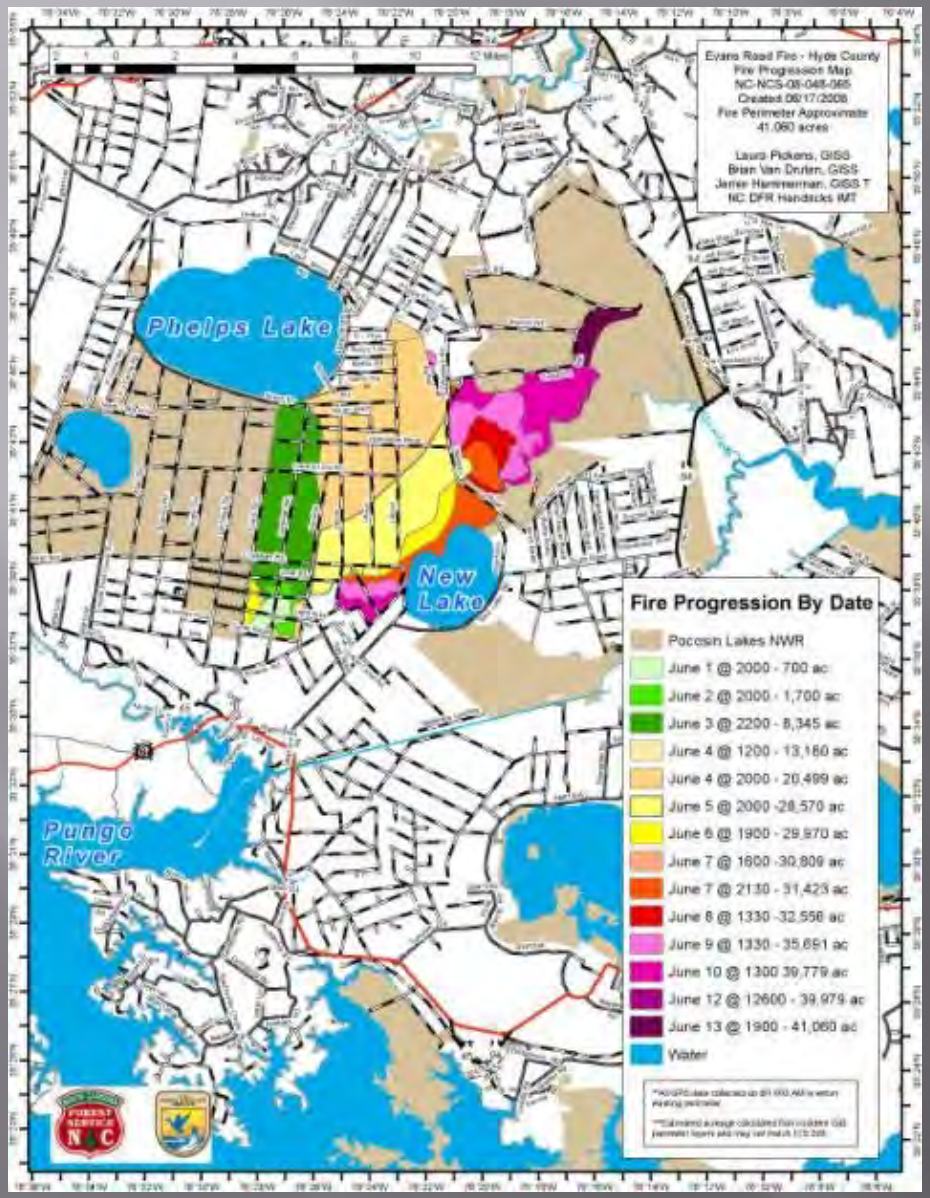
Robert Mickler
Alion Science and Technology

Managing Forested Wetlands with Fire in a Changing Climate Symposium
November 21, 2013

Evans Road Fire Behavior

Organic Soil Fire Consumption

Chronology



The chronology of the Evans Road Fire :

June 1, 2008 – Fire starts from lightning strike

June 2, 2008 – NC IMT dispatched to 700 acre fire

June 3, 2008 – Team arrives to 1,250 acre fire

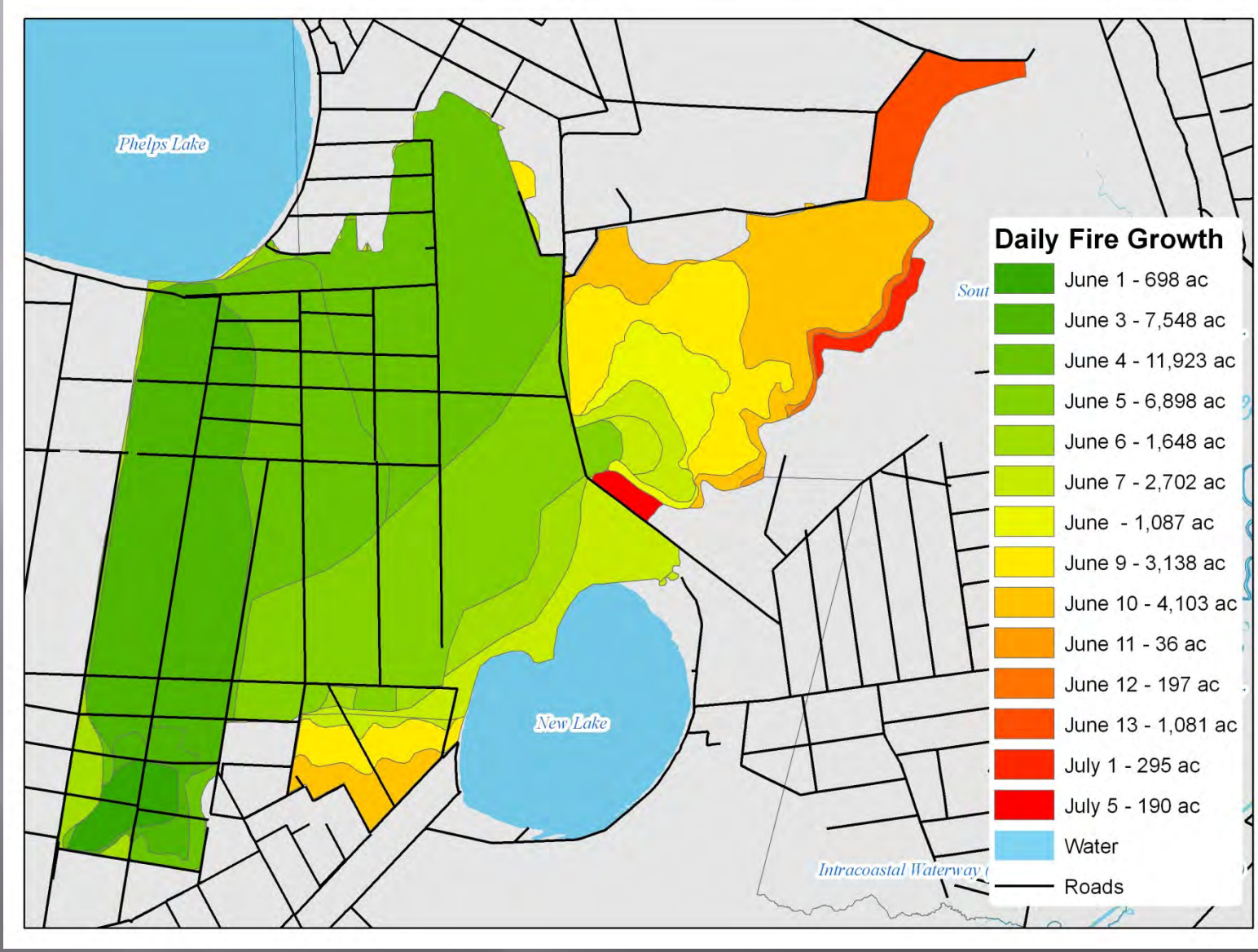
June 4, 2008 – Team goes to bed managing 8,000 acre fire

June 14, 2008 – The fire had reached 41,000 acres in size

June 3rd and August 8th, Six Type 2 Incident Management Teams managed the Evans Road fire.

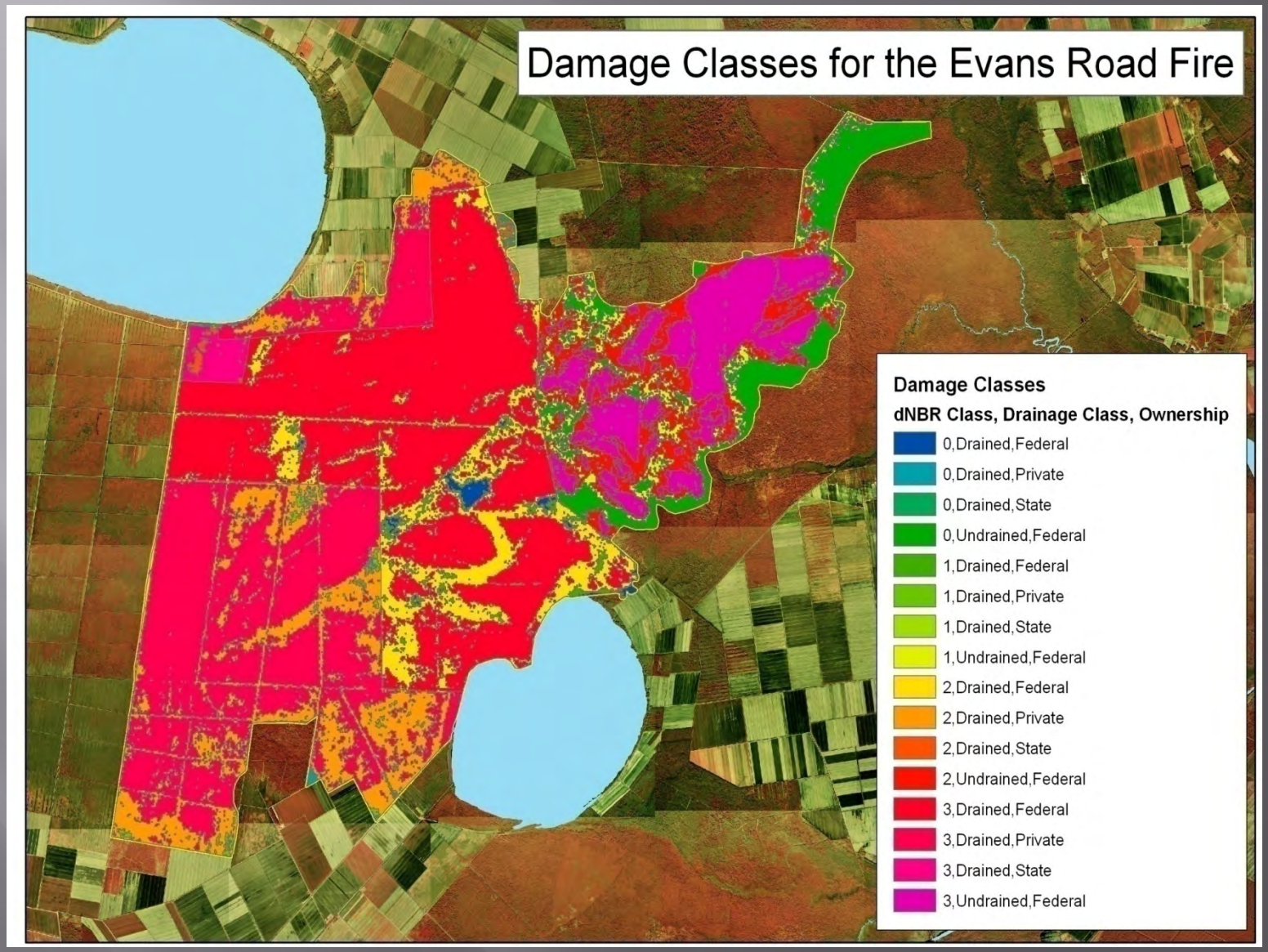
Over the course of the fire, priorities changed from evacuation, protection, and containment, to pumping, to rehab.

Daily Fire Growth

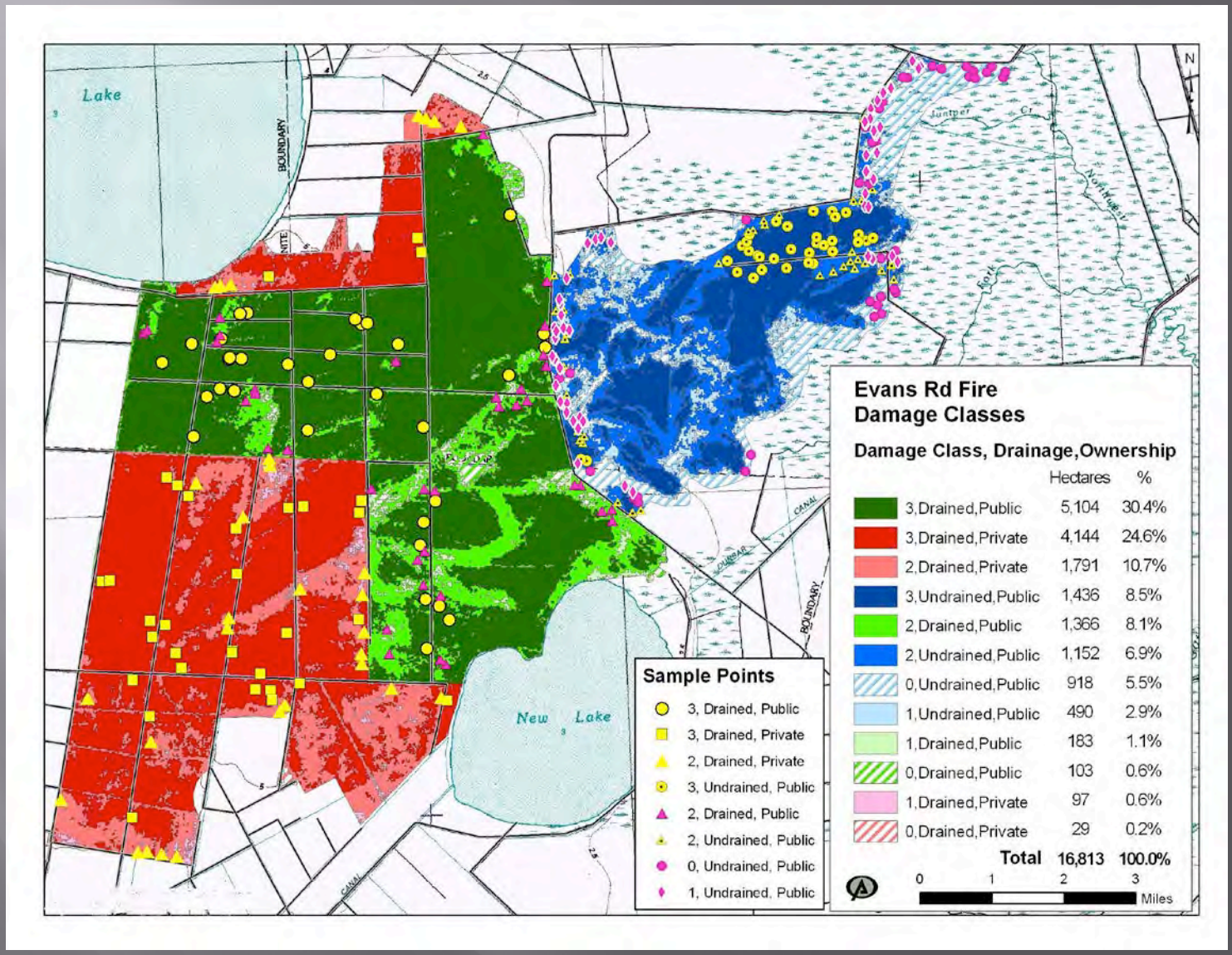


Differential Normalized Burn Ratio

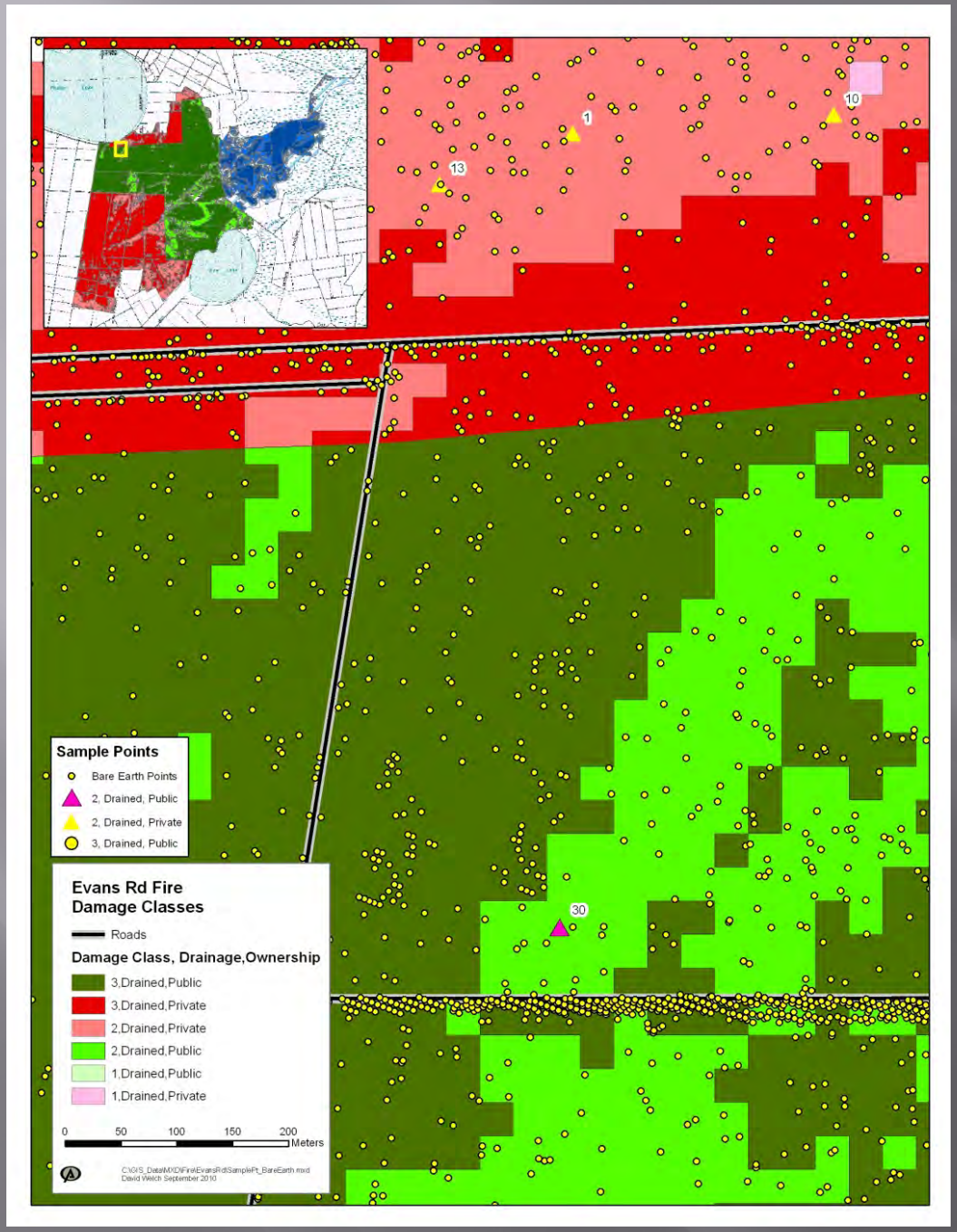
Damage Classes



Field Survey



PLNWR/Farm Border Gated Culvert
Damage Class 3, Drained, Private



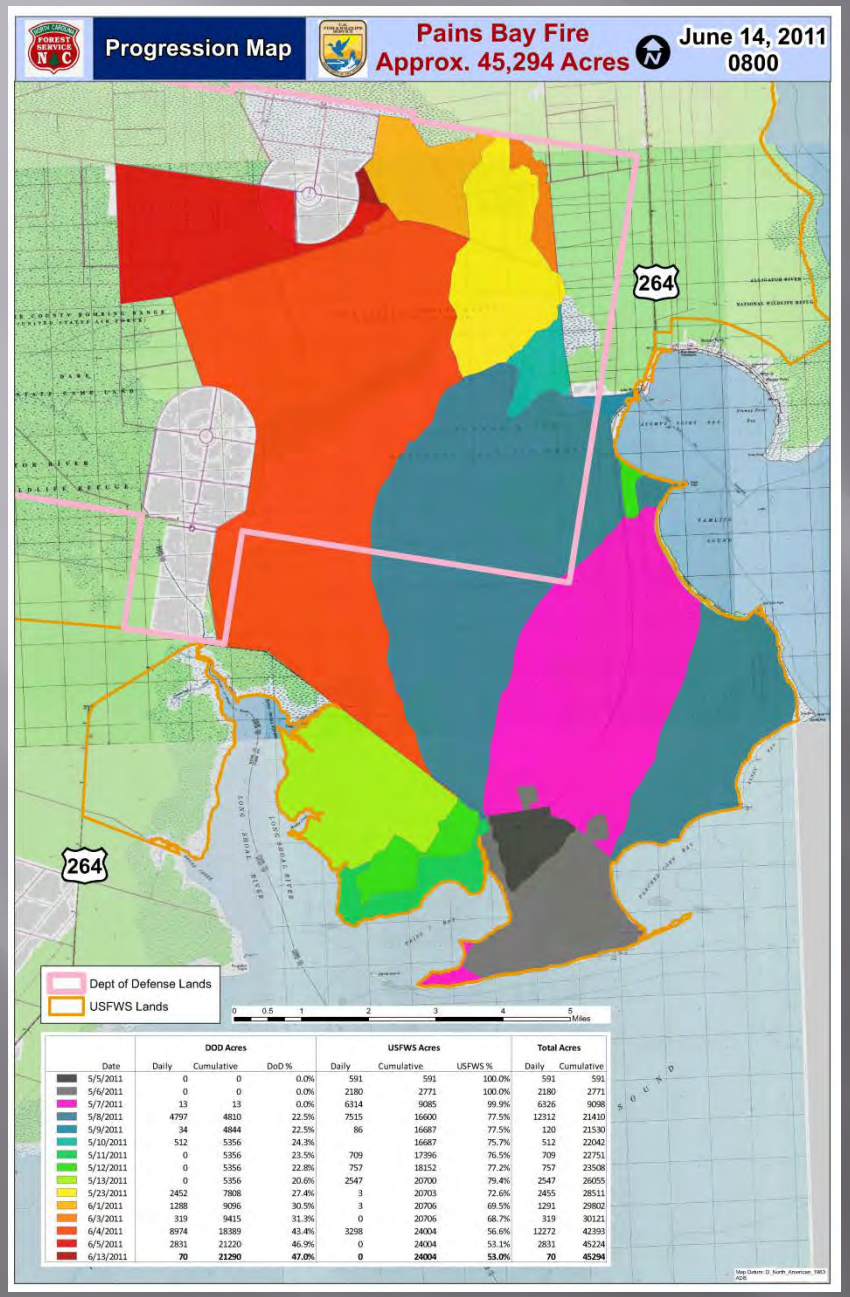
LiDAR Ground Return Data

- LiDAR canopy return points were used to delineate low and high pocosin vegetation for estimating above ground vegetation consumption
- LiDAR ground return points were used to determine pre-burn elevation for organic soil consumption

Trimble Survey Equipment
Base Station, Transmitter, and Rover

Organic Soil Carbon Emissions

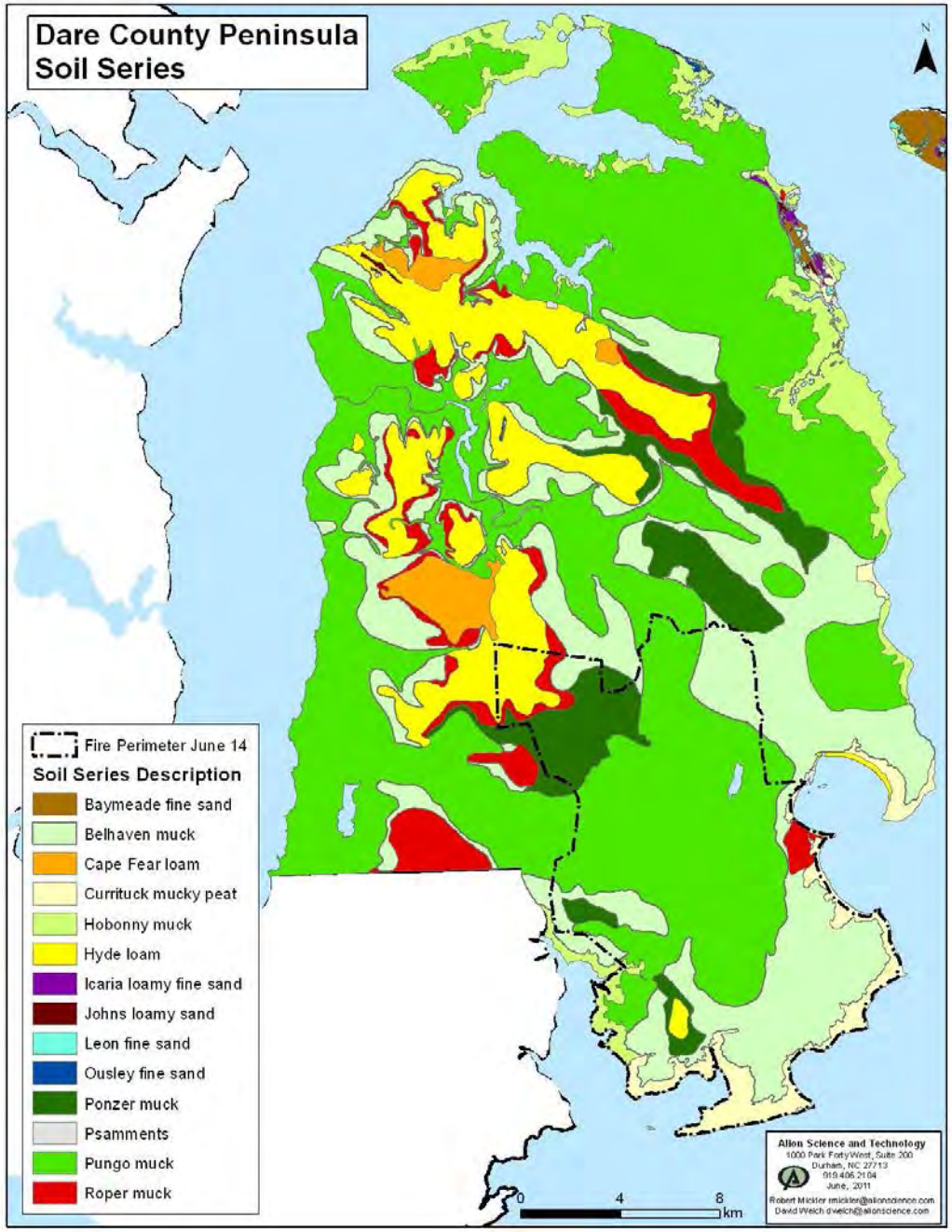
Ranking	dNBR Category	Drainage Category	Ownership Category	Count of Points Collected	Carbon Emissions (Metric Tons)	Acres
1	3	Drained	Public	35	1,906,622.13	12,611.0
2	3	Drained	Private	37	3,607,045.35	10,240.4
3	2	Drained	Private	33	1,934,011.97	4,424.8
4	3	Undrained	Public	32	1,163,551.57	3,549.2
5	2	Drained	Public	34	272,861.51	3,373.8
6	2	Undrained	Public	43	357,531.43	2,847.1
7	0	Undrained	Public	19	-84,575.12	2,268.7
8	1	Undrained	Public	22	7,597.20	1,210.1
Unranked	-	-	-	-		1,018.7
Sum					9,164,646.04	41,543.7



Pains Bay Fire Chronology

The chronology of the Pains Bay Fire :

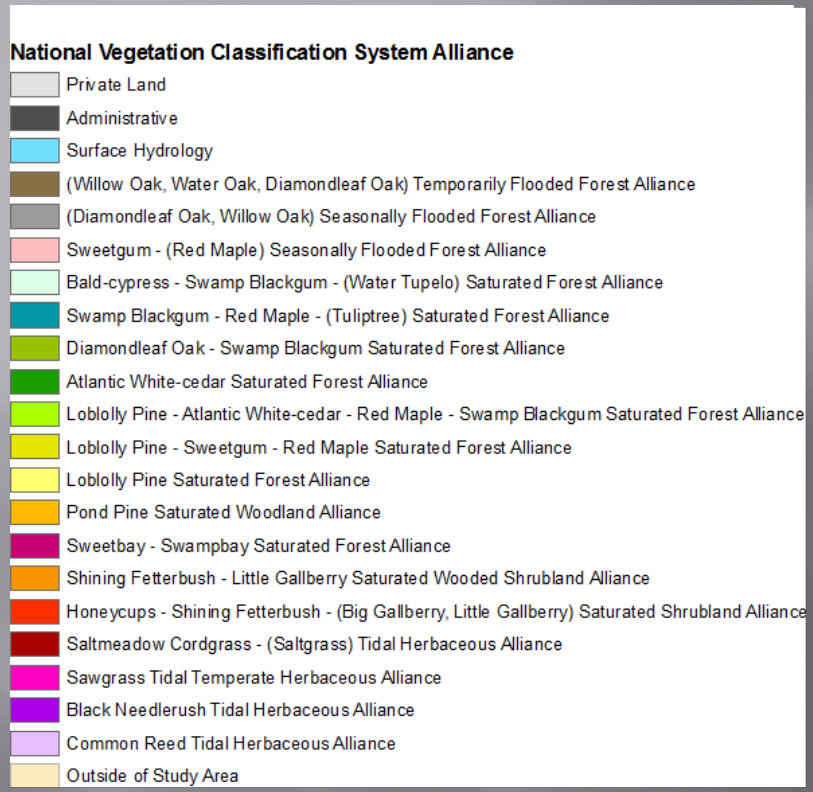
May 4, 2011 – Fire starts from lightning strike near Pains Bay
May 6, 2011 – Fire jumps Hwy 264
May 7, 2011 – Fire enters the DCBR
May 8, 2011– Fire increases to 21,410 acres
May 10, 2011 – The fire is being managed by a Type 1 IMT
May 23, 2011 – Thirty mile per hour winds cause fire to jump low pocossin firelines and jump Jackson Rd.
June 3, 2011 – Backfire Bow Tie Tract
June 4, 2011 – Backfire east of Air Force Impact Area
June 5, 2011 – Fire jumps into Navy Impact Area. Backfire area.
June 14, 2011 – The fire had reached 45,294 acres in size with significant organic soil groundfire
July 19, 2011 – Fire declare 100% contained.
August 24, 2011 – Pains Bay Fire declared out at a cost of $14.2 Million

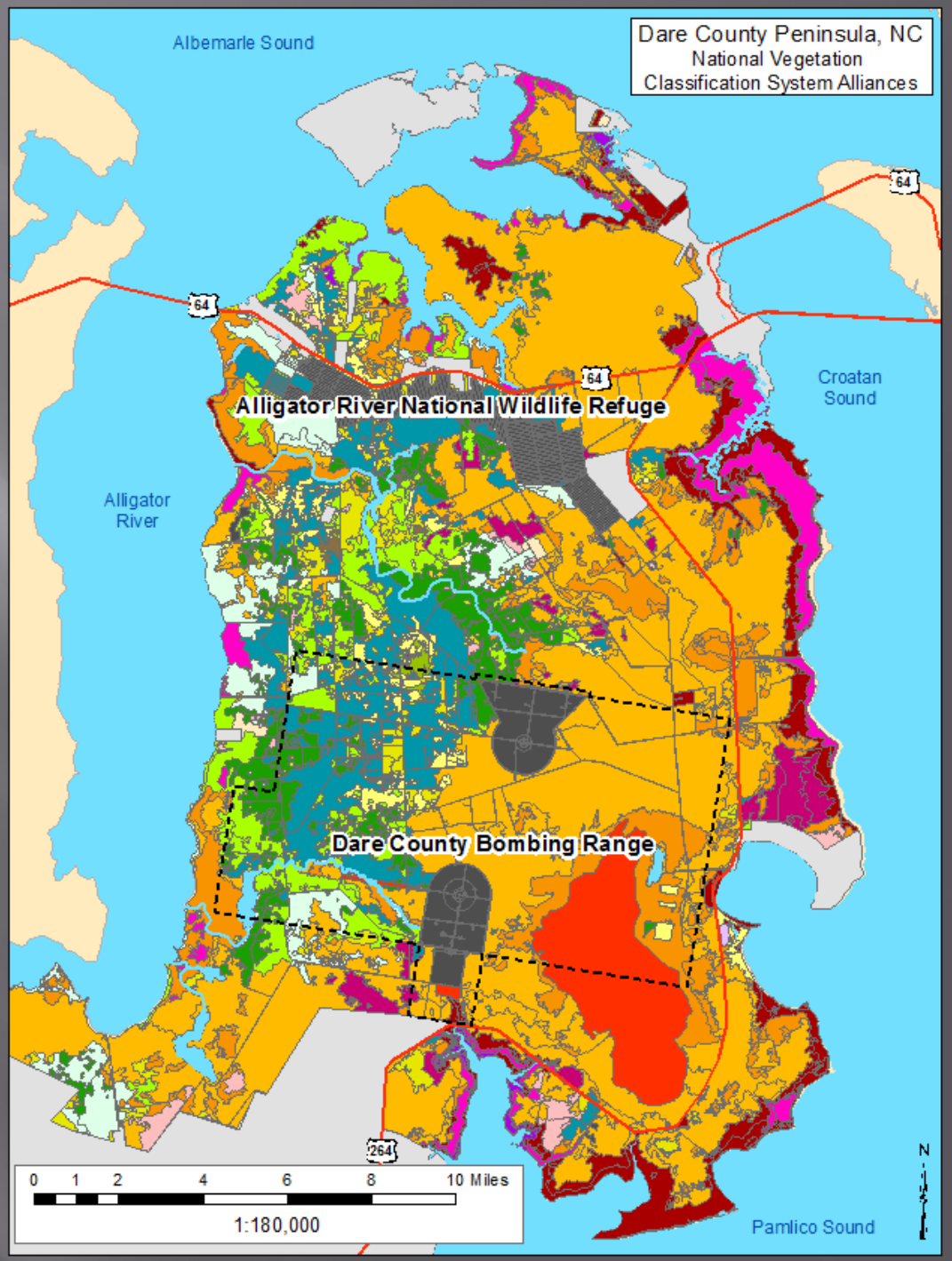


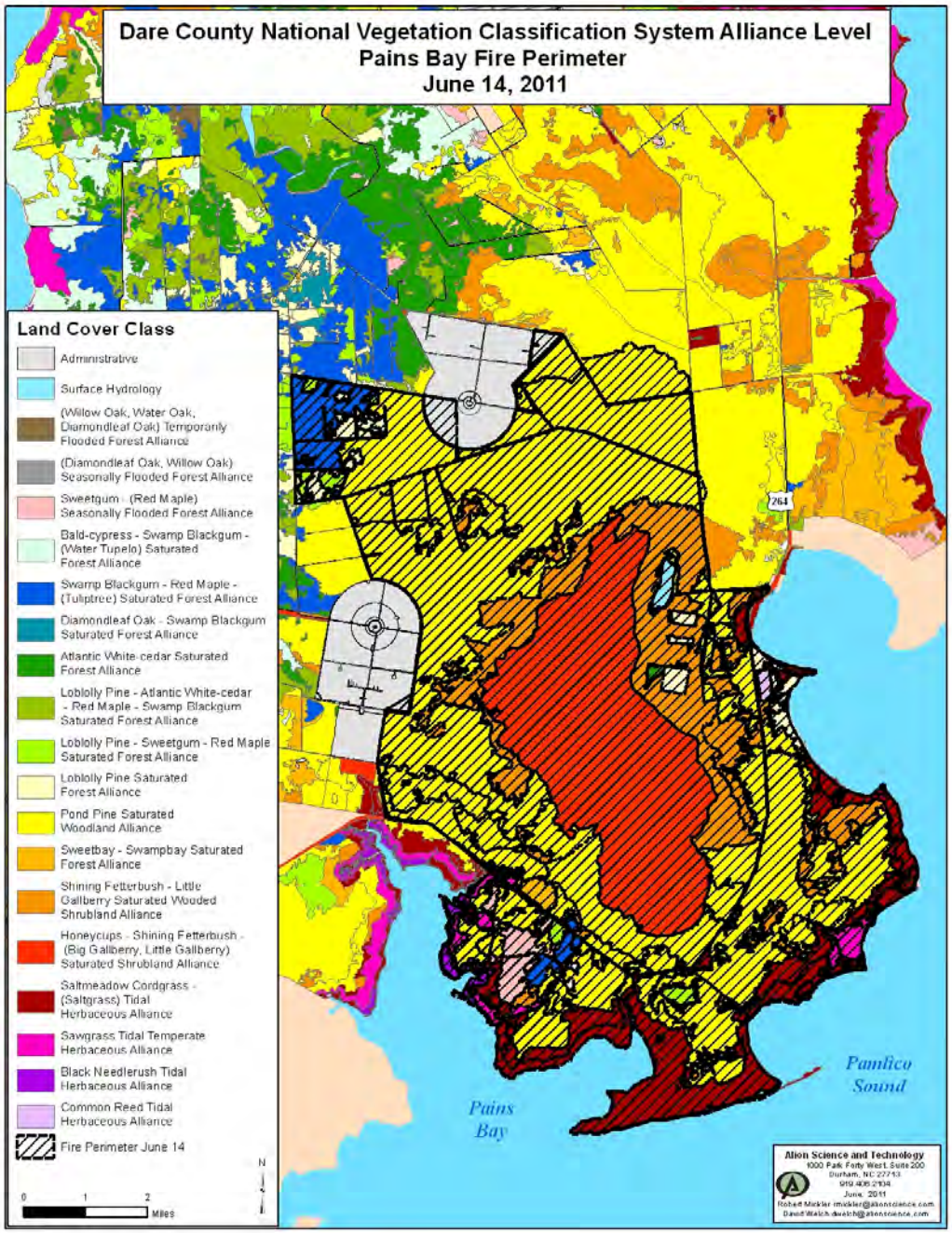
Pains Bay Fire Soil Series

The Dare County peninsula soil series are dominated by deep histosols. Cape Fear and Hyde loam soils are in rapid transition to organic soils such as Roper muck as the last of the Holocene and eroded Pleistocene mineral soils are overlaid by accumulating organic soil horizons and the Albemarle-Pamlico region continues to undergo subsidence (1.2 meter since European settlement of the Roanoke Colony in the 1580s).

Dare County Vegetation Classification





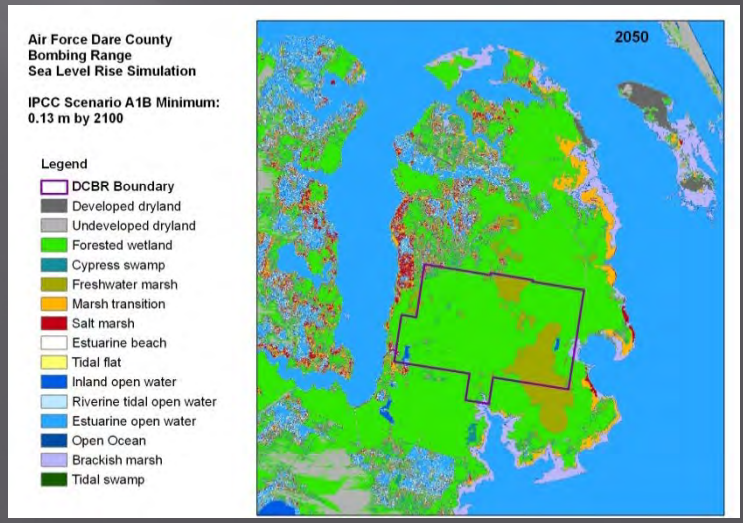


Pains Bay Fire Vegetation

Pains Bay Fire vegetation dominated by low pocossin shrub, pond pine woodlands, and tidal herbaceous communities. Elevations range from the highest point in the low pocossin dome to at sea level in saltmeadow and black needlerush vegetation. With the exception of the northwest corner of the fire, the area is comprised of deep organic (peat) histosol soil series.

Dare County Digital Elevations

The Dare County peninsula elevations range from below sea level in agricultural farm fields that have undergone oxidation of organic soils to 1.2 m in the low pocossin dome. The region's subsidence and sea level rise rate is currently accelerating changes to soils and vegetation.



Pains Bay Fire Extreme Fire Behavior

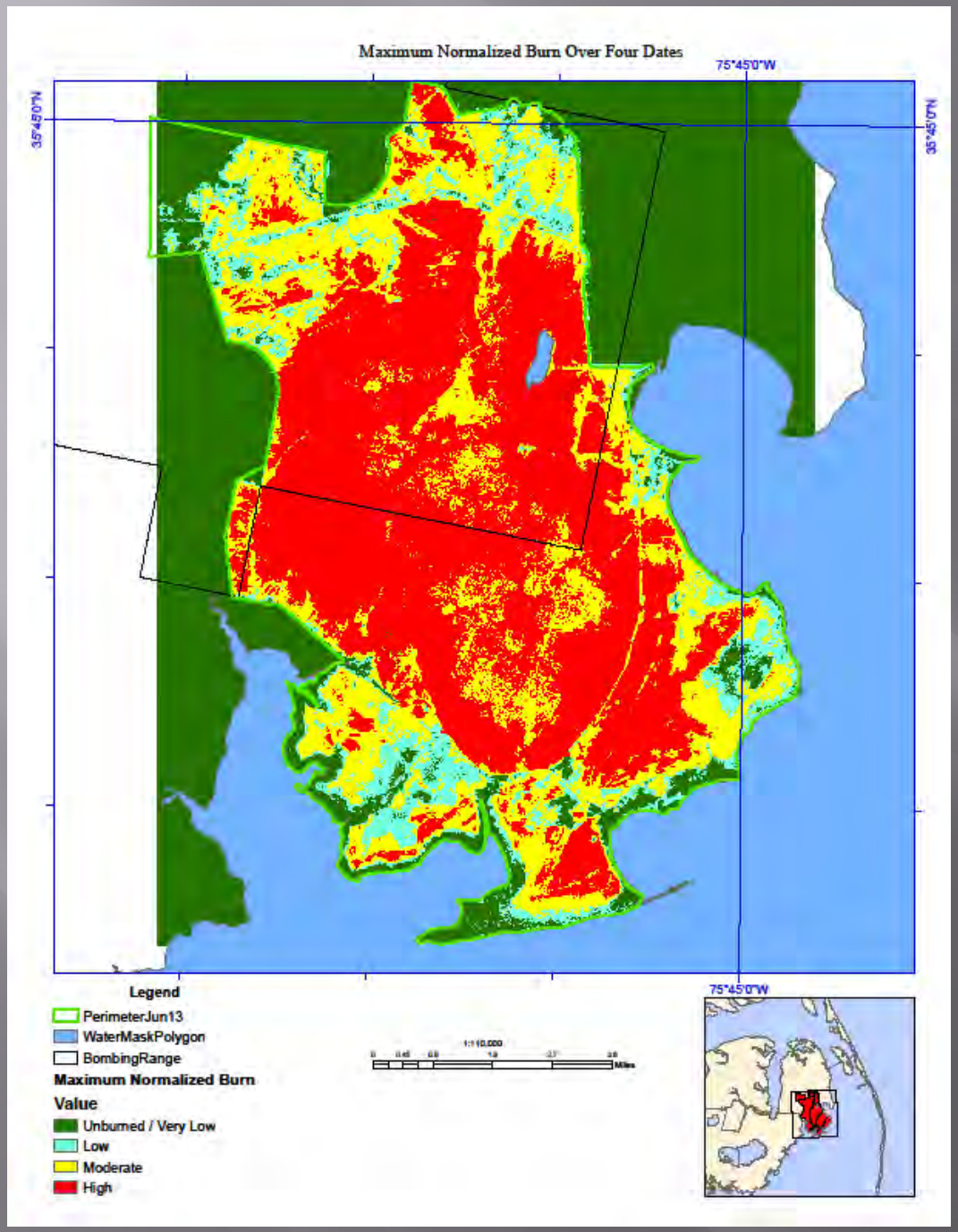
Pains Bay Fire Carbon Budgets

Fine and Course Fuels,Vegetation, Organic Soil Groundfire

Pains Bay Fire Carbon Budget
Smoke and Smoke

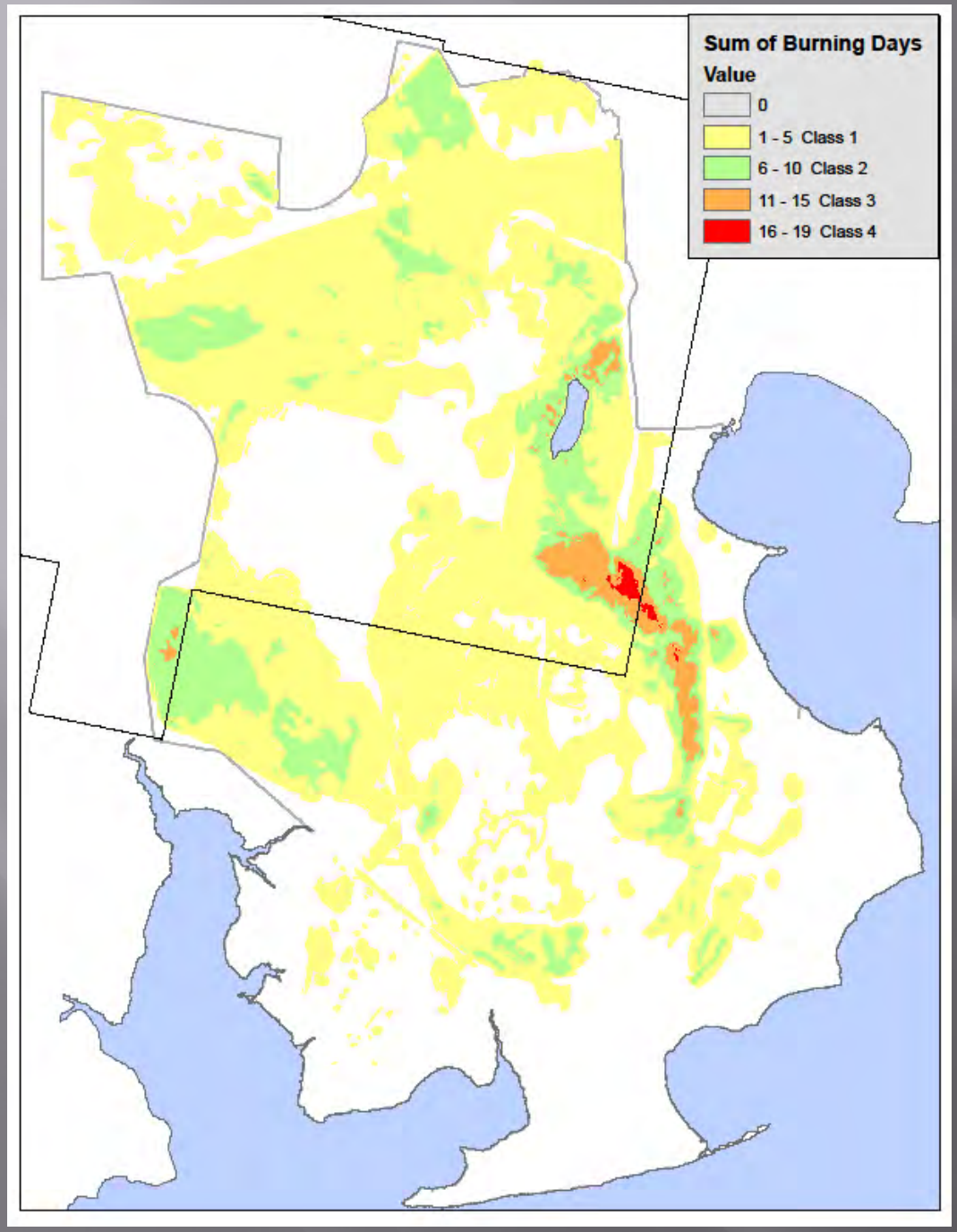
Super Fog at Morning Fire Brief with church steeple in background and fire fighters in foreground

- Multiple super fog events and road closures
- NC DAQ Code Red Air Quality
- EPA Ambient Air Quality Standards for PM
- Smoke on highways and road closures



Pains Bay Fire Normalized Burn Ratio

A dNBR mosaic image was constructed from USGS images from four dates during the flaming phase of the fire. Each of the four images was gridded and the maximum grid value was determined for each grid cell to comprise the mosaic dNBR image. The mosaic eliminates the greening that occurred post flaming phase over the time period of the four DNBR images.

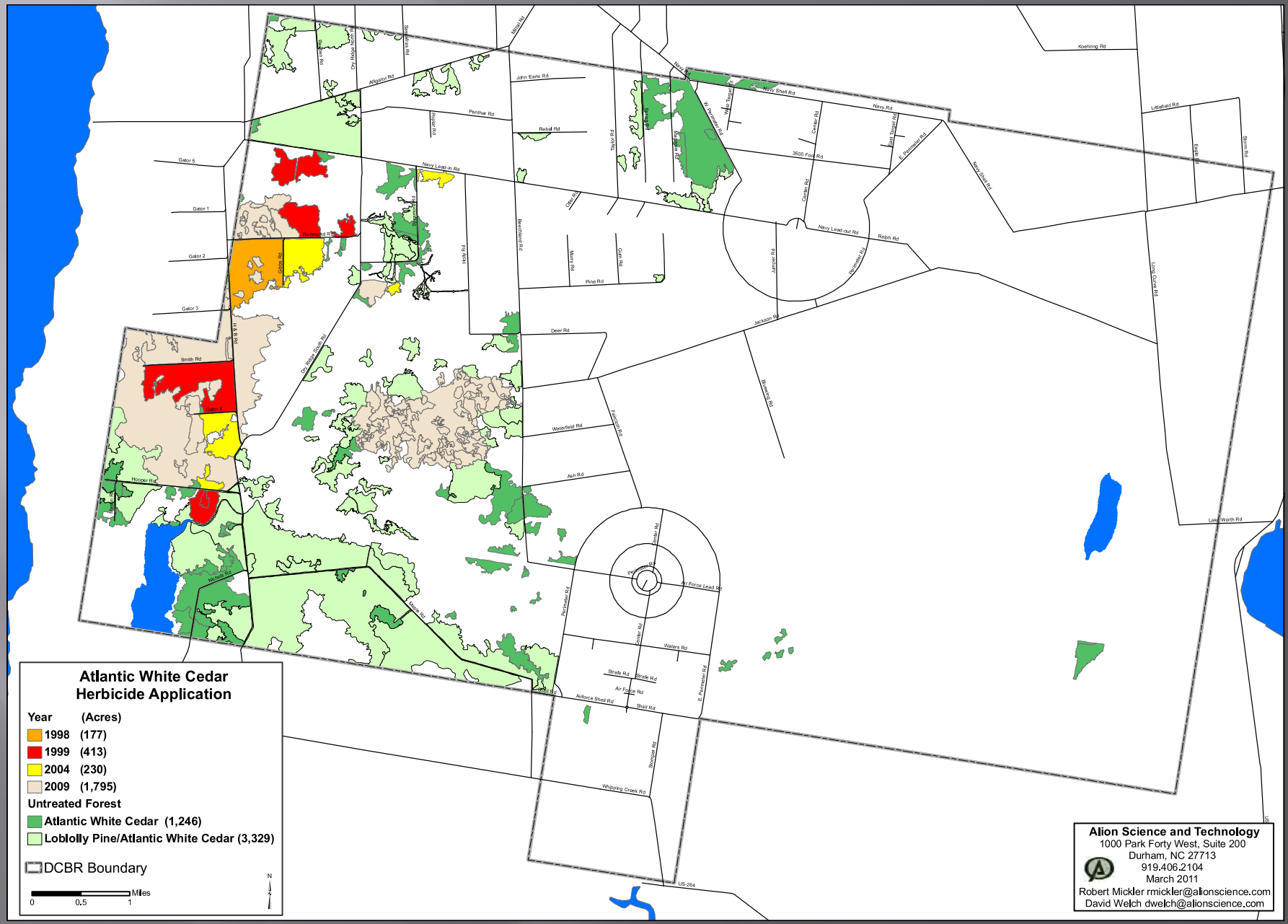


Pains Bay Fire
Ground Fire Detects

Ground fire detect were comprised of DoD satellite images, NC DFR aerial heat detects, and US FWS aerial heat detects. All spatial imagery was gridded and heat detects for each grid cell were counted into five ground fire detect classes (0 – 19 heat detect images).

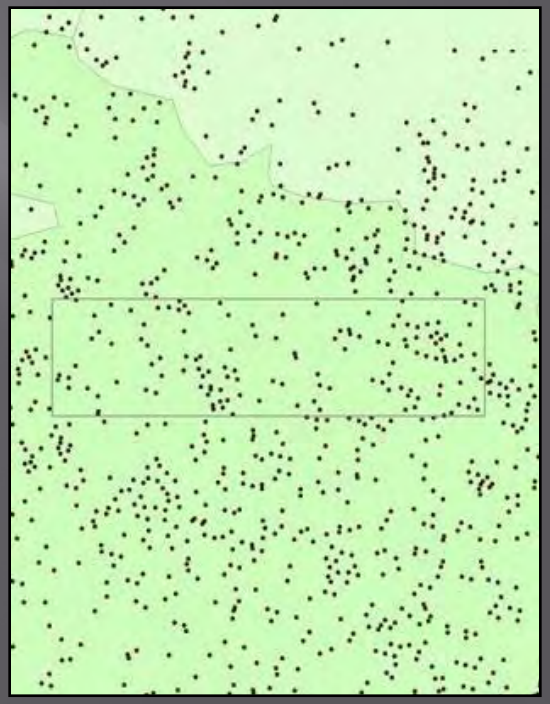
Pains Bay Fire
Vegetation Class and Acreage Consumption

	BurnRatio																Total
	0			1			2					3					
	GroundFireClass			GroundFireClass			GroundFireClass					GroundFireClass					
	0	1	2	0	1	2	0	1	2	3	4	0	1	2	3	4	
Vegetation																	
Administrative	89	12	8	152	44	11	172	73	9	.	.	49	15	0	.	.	635
Atlantic White-Cedar	.	.	.	.	.	1	.	0	14	1	.	13	5	9	12	.	56
Black Needlerush Tid	201	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	203
Common Reed Tidal He	7	.	.	20	.	.	37	.	.	.	.	0	.	.	.	.	64
Honeycups - Shining	.	.	.	.	.	.	1,045	693	0	.	.	2,923	3,370	39	.	.	8,070
Loblolly Pine - Atla	.	.	.	4	.	.	.	.	.	.	.	.	.	9	.	.	12
Loblolly Pine - Swee	106	78	.	27	9	.	101	27	.	.	.	47	2	.	.	.	397
Loblolly Pine Satura	126	101	.	142	50	.	120	94	5	0	.	3	59	46	97	.	842
Pond Pine Saturated	439	127	1	1,509	1,306	12	2,944	3,894	593	13	0	3,178	6,020	2,158	212	39	22,446
Private Land	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
Saltmeadow Cordgrass	1,593	2	.	944	3	.	1,390	18	0	.	.	312	5	4	.	.	4,270
Sawgrass Tidal Tempe	230	.	.	102	.	.	184	.	.	.	.	.	.	.	.	.	516
Shining Fetterbush -	32	0	.	100	9	.	564	242	53	9	.	1,514	2,097	920	354	26	5,919
Surface Hydrology	34	2	.	100	9	.	44	25	0	.	.	2	3	0	.	.	220
Swamp Blackgum - Red	456	272	.	110	59	.	36	23	.	.	.	6	.	.	.	.	962
Sweetbay - Swampbay	1	0	.	3	.	.	23	12	.	.	.	61	34	.	.	.	134
Sweetgum - (Red Mapl	10	1	.	57	28	.	267	116	.	.	.	31	19	0	.	.	528
Total	3,324	595	9	3,272	1,518	25	6,926	5,218	674	22	0	8,138	11,628	3,187	676	64	45,276


Atlantic White Cedar
Herbicide Application
Year (Acres)
1998 (177)
1999 (413)
2004 (230)
2009 (1,795)
Untreated Forest
Atlantic White Cedar (1,246)
Loblolly Pine/Atlantic White Cedar (3,329)
DCBR Boundary
Miles
0 0.5 1
N
Alion Science and Technology
1000 Park Forty West, Suite 200
Durham, NC 27713
919.406.2104
March 2011
Robert Mickler rmickler@alionscience.com
David Welch dwelch@alionscience.com

Pains Bay Fire
LIDAR Ground Points and Elevation Transects

There are 1.52 million pre-burn LIDAR ground points within the Pains Bay Fire perimeter. East/West transects were randomly selected within vegetation and dNBR class, and 50 LIDAR points were co-located and ground surveyed for post-fire elevations.



Field Survey Equipment

- Trimble R4 GPS Receiver - A Base Station and Rover Receiver for RTK GPS / GNSS Surveying
- Trimble TSC2 Controller and Trimble Survey Controller Software
- Trimble RTX Verizon Cellular Data
  Correction Services – Cellular Network of GNSS Reference Stations

Honeycups Shining Fetterbush Saturated Shrubland Alliance
dNBR Class 3

Honeycups Shining Fetterbush Saturated Shrubland Alliance
dNBR Class 2

Pond Pine Saturated Woodland Alliance
dNBR Class 3

Pond Pine Saturated Woodland Alliance
dNBR Class 2

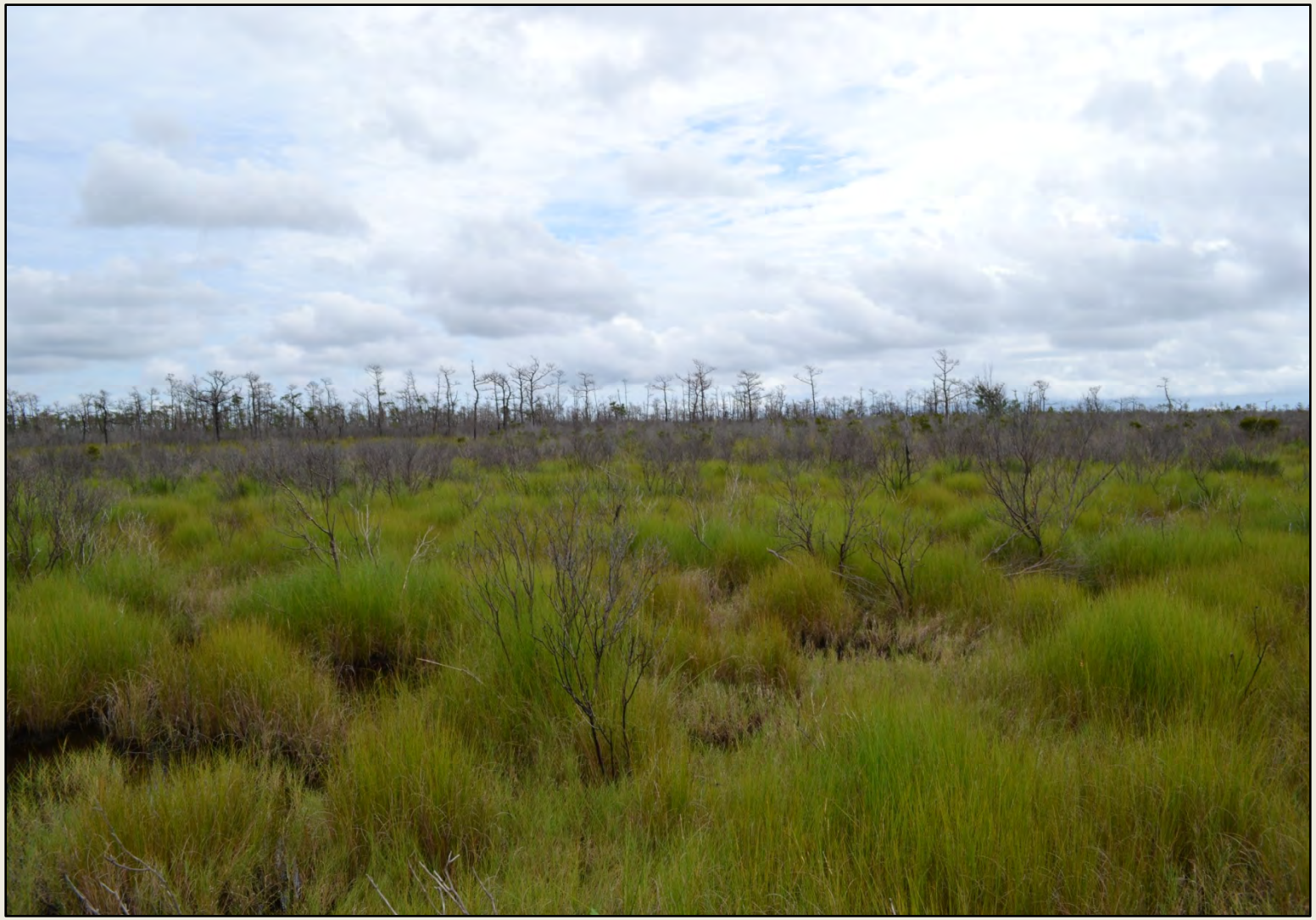
Pond Pine Saturated Woodland Alliance
dNBR Class 1

Pond Pine Saturated Woodland Alliance
dNBR Class 0

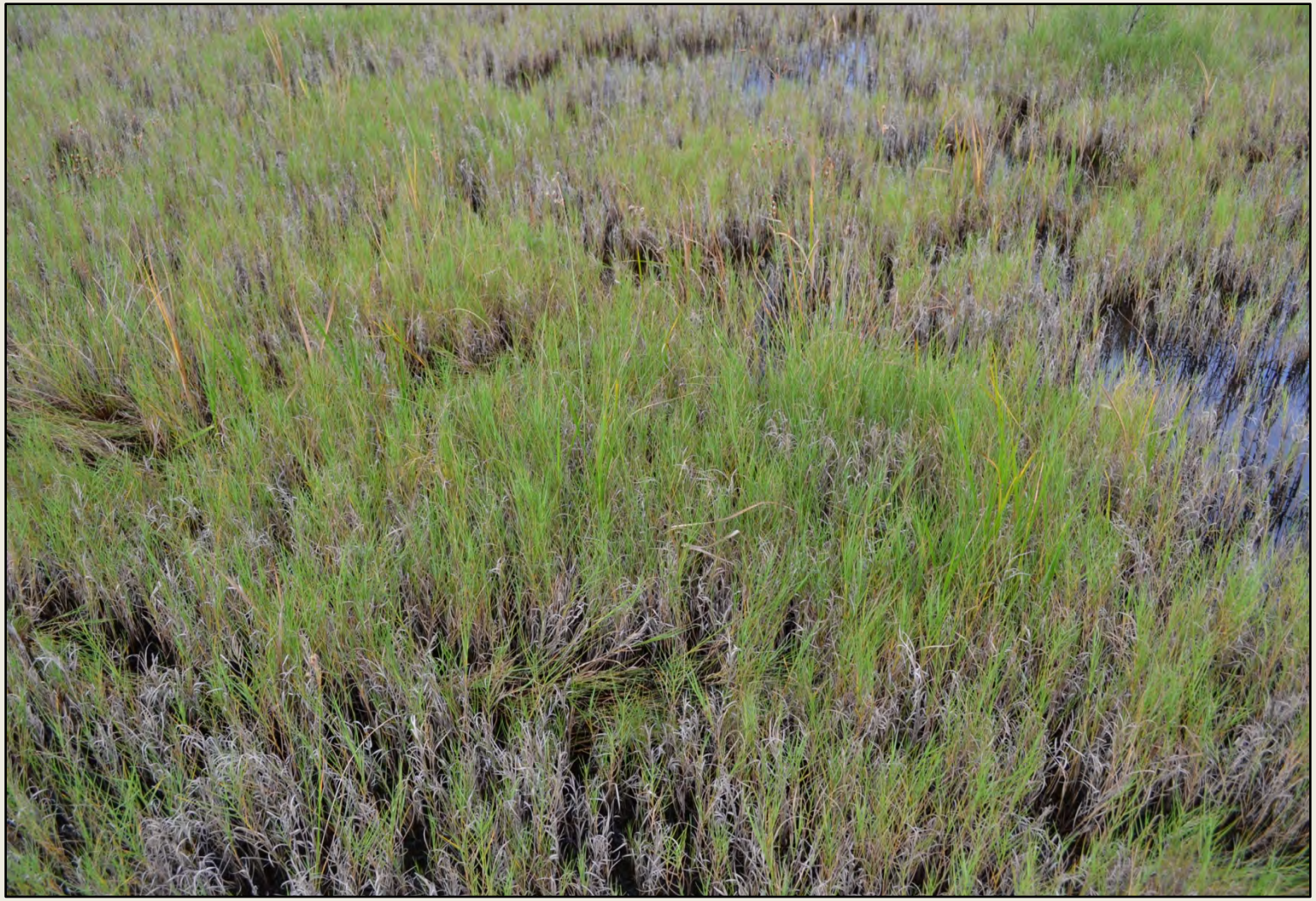
Saltmeadow Cordgrass Tidal Herbaceous Alliance
dNBR Class 3

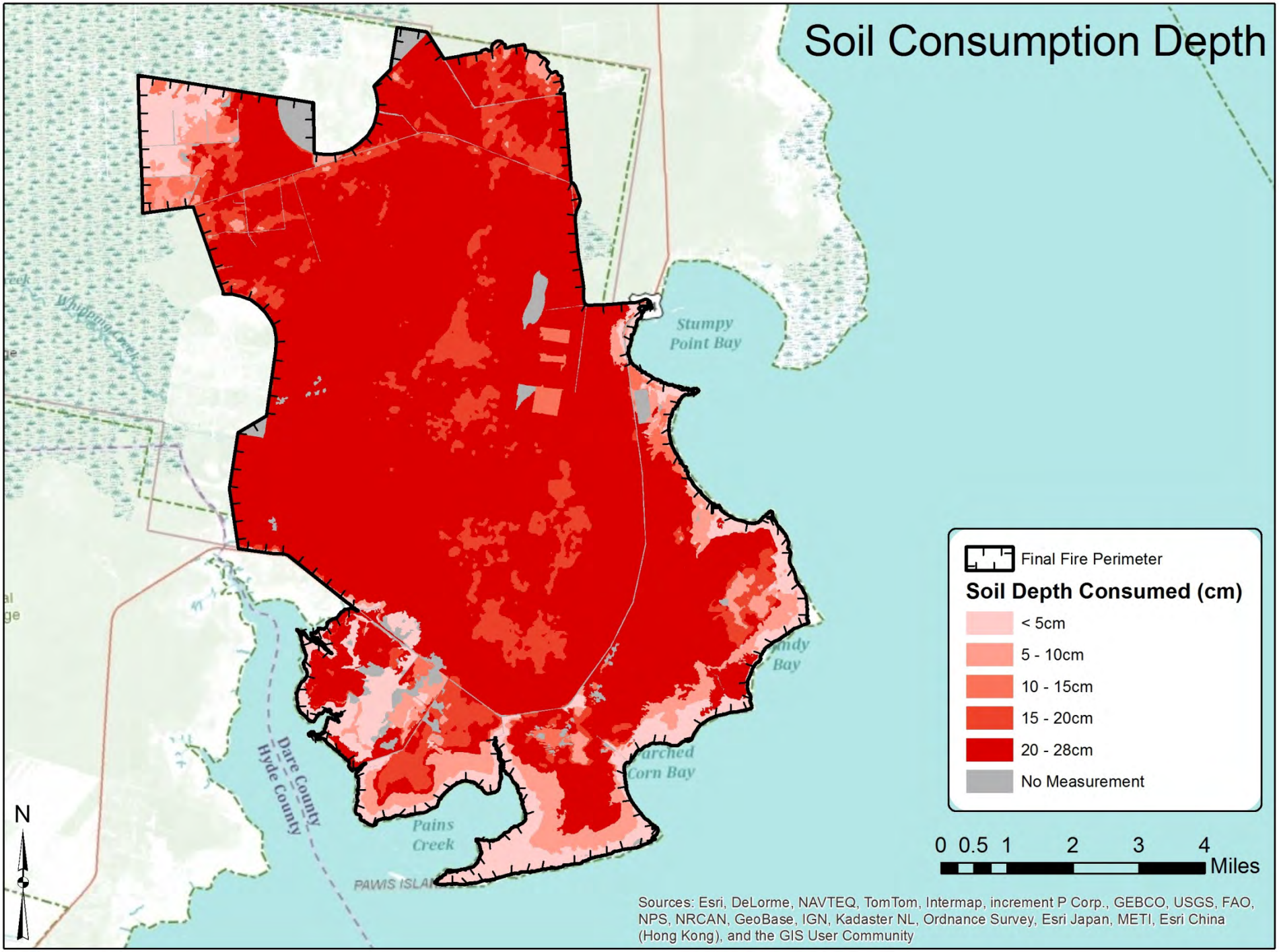
Saltmeadow Cordgrass Tidal Herbaceous Alliance
dNBR Class 2

Saltmeadow Cordgrass Tidal Herbaceous Alliance
dNBR Class 1



Saltmeadow Cordgrass Tidal Herbaceous Alliance
dNBR Class 0




Soil Consumption Depth
Stumpy Point Bay
Dare County
Hyde County
Pains Creek
Corn Bay
Final Fire Perimeter
Soil Depth Consumed (cm)
< 5cm
5 - 10cm
10 - 15cm
15 - 20cm
20 - 28cm
No Measurement
0 0.5 1 2 3 4
Miles
N
Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community

Pains Bay Fire Soil Carbon Emissions (t Carbon) by Vegetation Alliance and dNBR Class

	dNBR Class				
Vegetation Type	0	1	2	3	Grand Total
Pond Pine Saturated Woodland Alliance	19,915	276,690	1,089,799	1,799,167	3,185,571
Honeycups - Shining Fetterbush - (Big Gallberry, Little Gallberry) Saturated Shrubland Alliance	0	0	192,344	807,846	1,000,190
Shining Fetterbush - Little Gallberry Saturated Wooded Shrubland Alliance	0	13,099	106,732	704,845	824,676
Saltmeadow Cordgrass - (Saltgrass) Tidal Herbaceous Alliance	31,943	20,149	34,476	8,119	94,687
Sawgrass Tidal Temperate Herbaceous Alliance	28,132	12,183	21,268	0	61,583
Loblolly Pine Saturated Forest Alliance	6,006	6,826	8,861	12,549	34,241
Loblolly Pine - Sweetgum - Red Maple Saturated Forest Alliance	5,819	0	8,895	0	14,714
Swamp Blackgum - Red Maple - (Tuliptree) Saturated Forest Alliance	6,871	4,364	0	0	11,236
Sweetgum - (Red Maple) Seasonally Flooded Forest Alliance	0	0	9,536	0	9,536
Sweetbay - Swampbay Saturated Forest Alliance	0	0	0	1,989	1,989
Black Needlerush Tidal Herbaceous Alliance	1,087	0	0	0	1,087
Grand Total	99,774	333,311	1,471,912	3,334,514	5,239,510

Pains Bay Fire Soil Carbon Emission (t Carbon) by Vegetation Alliance

Vegetation Type	Mean Carbon (t)	Min/Max Carbon Range (t)
Pond Pine Saturated Woodland Alliance	3,185,571	(1,447,770 – 5,110,122)
Honeycups - Shining Fetterbush - (Big Gallberry, Little Gallberry) Saturated Shrubland Alliance	1,000,190	(629,881 – 1,527,461)
Shining Fetterbush - Little Gallberry Saturated Wooded Shrubland Alliance	824,676	(460,597 – 1,286,446)
Saltmeadow Cordgrass - (Saltgrass) Tidal Herbaceous Alliance	94,687	(33,669 – 155,927)
Sawgrass Tidal Temperate Herbaceous Alliance	61,583	(26,200 – 97,214)
Loblolly Pine Saturated Forest Alliance	34,241	(17,178 – 53,726)
Loblolly Pine - Sweetgum - Red Maple Saturated Forest Alliance	14,714	(5,751 – 23,831)
Swamp Blackgum - Red Maple - (Tuliptree) Saturated Forest Alliance	11,236	(4,710 – 17,788)
Sweetgum - (Red Maple) Seasonally Flooded Forest Alliance	9,536	(4,229 – 15,385)
Sweetbay - Swampbay Saturated Forest Alliance	1,989	(1,005 – 3,118)
Black Needlerush Tidal Herbaceous Alliance	1,087	(544 – 1,631)
Grand Total	5,239,510	(2,631,534 – 8,292,649)

Pains Bay Fire Vegetation Carbon Emissions (t Carbon) By Vegetation Alliance and dNBR Class

Vegetation Type	dNBR Class	Litter Biomass	Shrub Biomass	Foliage Biomass	Total Biomass
Pond Pine Saturated Wodland Alliance	0	321	0	0	321
	1	4,001	4,026	688	8,716
	2	10,535	16,964	16,312	43,811
	3	24,640	31,410	26,848	82,898
Honeycups - Shining Fetterbush - (Big Gallberry, Little Gallberry) Saturated Shrubland Allia	2	3,015	12,614	23	15,652
	3	13,042	54,571	90	67,703
Shining Fetterbush - Little Gallberry Saturated Wooded Shrubland Alliance	0	14	0	0	14
	1	118	494	0	613
	2	1,506	6,300	12	7,817
	3	10,116	42,324	70	52,510
Saltmeadow Cordgrass - (Saltgrass) Tidal Herbaceous Alliance	0	0	0	829	829
	1	0	0	1,231	1,231
	2	0	0	2,929	2,929
	3	0	0	835	835
Sawgrass Tidal Temperate Herbaceous Alliance	0	0	0	202	202
	1	0	0	224	224
	2	0	0	647	647
Loblolly Pine Saturated Forest Alliance	0	141	0	0	141
	1	298	0	0	298
	2	543	0	0	543
	3	636	0	0	636
Loblolly Pine - Sweetgum- Red Maple Saturated Forest Alliance	0	212	0	0	212
	2	236	0	0	236
Swamp Blackgum - Red Maple - (Tuliptree) Saturated Forest Alliance	0	291	0	0	291
	1	108	0	0	108
Sweetgum - (Red Maple) - Seasonnaly Flooded Forest Alliance	2	95	0	0	95
Black Needlerush Tidal Herbaceous Alliance	0	68	0	0	68
Grand Total					289,578

Wildfire vs. Prescribed Fire VOCs

	Pains Bay Wildfire (Sm)	ARNWR Rx (Fl)	ARNWR Rx (Sm)	PLNWR Rx (Sm)	PLNWR Rx (Sm)
EPA Method TO-15					
Dichlorodifluoromethane (Freon 12)	NF	0.47 ppbv	0.54 ppbv	NF	NF
Chloromethane	17.95 ppbv	2.66 ppbv	NF	NF	NF
Vinyl chloride	NF	NF	NF	NF	NF
1,3-Butadiene	9.32 ppbv	NF	NF	NF	NF
Bromomethane	4.41 ppbv	NF	NF	0.22 ppbv	NF
Trichloromonofluoromethane	NF	0.29 ppbv	0.28 ppbv	0.3 ppbv	NF
Ethanol	1.08 ppbv	2.35 ppbv	8.53 ppbv	4.26 ppbv	1.21 ppbv
Carbon disulfide	NF	NF	NF	4.06 ppbv	NF
Isopropyl alcohol	NF	1.38 ppbv	0.84 ppbv	1.26 ppbv	0.6 ppbv
Methylene chloride	NF	6.27 ppbv	3.97 ppbv	4.8 ppbv	2.65 ppbv
Acetone	74.56 ppbv	27.67 ppbv	NF	43.87 ppbv	9.22 ppbv
Hexane	15.02 ppbv	1 ppbv	0.93 ppbv	NF	NF
Vinyl acetate	2.05 ppbv	0.96ppbv	NF	NF	NF
Cyclohexane	2.24 ppbv	NF	NF	NF	NF
Ethyl Acetate	9.05 ppbv	0.61 ppbv	0.58 ppbv	NF	NF
2-Butanone	NF	2.65 ppbv	NF	NF	NF
Heptane	10.86 ppbv	NF	NF	NF	NF
Benzene	68.14 ppbv	9.4 ppbv	3.23 ppbv	1.05 ppbv	1.59 ppbv
Trichloroethylene	NF	NF	NF	NF	0.66 ppbv
Toluene	28.75 ppbv	5.54 ppbv	1.98 ppbv	1.74 ppbv	1.59 ppbv
Ethylbenzene	7.03 ppbv	NF	NF	0.53 ppbv	0.49 ppbv
Chlorobenzene	NF	NF	NF	NF	0.36 ppbv
m/p-Xylene	9.93 ppbv	2.49 ppbv	0.89 ppbv	1.78 ppbv	1.33 ppbv
o-Xylene	9.38 ppbv	0.76 ppbv	NF	0.59 ppbv	0.55 ppbv
Styrene	3.96 ppbv	0.95 ppbv	0.30	NF	NF
1-ethyl-4-methylbenzene	NF	0.67 ppbv	0.27 ppbv	NF	0.66 ppbv
1,3,5-trimethylbenzene	NF	0.68 ppbv	0.26 ppbv	0.26 ppbv	Below MDL
1,2,4-trimethylbenzene	2.30 ppbv	1.1 ppbv	NF	1.08 ppbv	0.76 ppbv
Benzyl chloride	1.97 ppbv	NF	NF	NF	NF

Acetone, benzene, and toluene had the highest concentrations for prescribed and wildfires. Emissions from the Pains Bay Fire exceeded flaming and smoldering emissions from prescribed fires on comparable vegetation and soils.

Wildfire vs. Prescribed Fire Aldehydes

	Pains Bay Wildfire (Sm)	ARNWR Rx (Fl)	ARNWR Rx (Sm)	PLNWR Rx (Fl)	PLNWR Rx (Sm)
EPA Method TO-11A/8315 HPLC					
Formaldehyde	0.384 µg/L	0.066 µg/L	0.011 µg/L	0.061 µg/L	0.005 µg/L
Acetaldehyde	0.404 µg/L	0.038 µg/L	0.005 µg/L	0.035 µg/L	0.016 µg/L
Acrolein & Acetone	<0.001 µg/L	0.011 µg/L	0.004 µg/L	0.013 µg/L	0.009 µg/L
Propionaldehyde	0.236 µg/L	0.014 µg/L	0.002 µg/L	0.003 µg/L	<0.001 µg/L
Crotonaldehyde	<0.001 µg/L	0.002 µg/L	<0.001 µg/L	0.003 µg/L	<0.001 µg/L
Butyraldehyde	<0.001 µg/L	<0.001 µg/L	<0.001 µg/L	0.003 µg/L	0.001 µg/L
Benzaldehyde	0.090 µg/L	0.015 µg/L	0.002 µg/L	0.014 µg/L	<0.001 µg/L
Isovaleradehyde	0.207 µg/L	<0.001 µg/L	<0.001 µg/L	0.003 µg/L	<0.001 µg/L
Valeradelhyde	0.100 µg/L	0.005 µg/L	<0.001 µg/L	0.005 µg/L	<0.001 µg/L
o-Tolualdehyde	0.121 µg/L	0.028 µg/L	0.004 µg/L	0.002 µg/L	<0.001 µg/L
m-Tolualdehyde	<0.001 µg/L	<0.001 µg/L	<0.001 µg/L	0.026 µg/L	<0.001 µg/L
p-Tolualdehyde	0.031 µg/L	<0.001 µg/L	<0.001 µg/L	<0.001 µg/L	<0.001 µg/L
Hexaldehyde	<0.001 µg/L	0.002 µg/L	<0.001 µg/L	0.003 µg/L	<0.001 µg/L
2,5-Dimethylbenzaldehyde	<0.001 µg/L	0.006 µg/L	0.001 µg/L	0.003 µg/L	<0.001 µg/L

Aldehydes concentrations were higher for the Pains Bay wildfire compared to the flaming and smoldering stages of prescribed fires on the same coastal forest ecosystems. The aldehyde concentrations for flaming stages of prescribed fires were higher than the smoldering stage. Formaldehyde and acetaldehyde were the major compounds for the smoldering and flaming stages of prescribed and wild fires.

Managing Forested Wetlands Recommendations

Evans Road Fire	Pains Bay Fire
Pocossin Lake NWR	Alligator River NWR
6/1/2008-1/5/2009	5/4/2011-8/24/2011
41,543 acres	45,294 acres
9,164,646 tC soil emissions	5,239,510 tC soil emissions
308,182 tC veg emissions	289,578 tC veg emissions

1. Water and vegetation management key to Rx and Wildfire organic soil conservation (Coastal refuges can no longer afford deep organic soil consumption. Sea level rise is here and now.)
2. Develop comprehensive strategy for managing surface water (gated culverts, tide gates, V-ditch management, and monitoring wells).
3. Implement vegetation restoration following wildfire with fire dependent vegetation communities (promote cane grass, discourage contiguous gallberry shrub understories, discourage loblolly bay mid-story in pine communities, manage pond pine as woodlands and not forests) as an ecological end point.
4. Use Rx to reduce fuel loading and promote fire dependent vegetation communities to reduce wildfire risk.
5. Use Rx to promote productivity in coastline marsh vegetation communities to increase sediment accretion rates (grow elevation) while managing coastline erosion.
6. Some wetland species cannot be managed with Rx burns (i.e. Atlantic white cedar regeneration and restoration needs to be managed with hardwood herbicides; Invasive species eradication and suppression).

Questions

Pains Bay Fire – Low Pocossin Backfire

Funding sponsors: