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Hurricane Harvey: Assessment of Flooded Soils and Cropland in Texas

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Summary

Following hurricane Harvey, significant flooding was observed in many areas of south and southeastern Texas impacting various agricultural and non-agricultural soils. Satellite data can be used to estimate land area covered by water and land use classifications. Data for maximum observed flooding is available through the University of Colorado. Select land use classes (National Land Cover Database, 2015) were identified in the affected region and land areas affected by flooding were calculated. An estimated 1.3 million acres of the selected land use classes were flooded. Brazoria (146,448), Wharton (142,503), and Harris (114,659) county had the greatest amount of area (acres) affected by flooding. For select land use in all counties, grassland/pasture represented 46%, field crop 21%, and developed areas accounted for 14% of flooded acres. Other land use classes accounted for less than 5% of flooded acres. Suggestions for managing flood affected soils are provided.

Introduction

Hurricane Harvey made landfall near Rockport Texas on August 26, 2017. The storm meandered over the coastal bend region for two days before reemerging in the Gulf near Matagorda on August 28. The storm made final landfall east of Port Arthur, TX on August 30. With multiple days of rain, large rainfall totals were reported across a broad region of southeast Texas. Widespread reports of 20+ inches of rain were found with isolated reports of 30-50 inches in the Houston and Beaumont areas. Excessive rainfall resulted in significant flooding of creeks, rivers and other low lying areas.

The duration and depth of flooding coupled with land use type will determine the potential impact to soils. Flood waters may have resulted erosion of topsoil, deposition of sediment, and/or introduction contaminants. Options for managing flood affected soils will vary by land use type and the amount of area requiring remediation.

Methods

To assess specific land use area affected by flooding due to hurricane Harvey, satellite imagery estimating land use and maximum observed flooding were compiled and analyzed using Arcmap 9.4. Data for maximum observed flooding was developed by Brakenridge and Kettner (2017) and obtain in raster format at 250 m resolution (http://floodobservatory.colorado.edu/Events/2017USA4510/2017USA4510.html). Essentially, the map identifies land area covered in water where water is not usually observed as water is easily detected using various sensors on satellites. Maximum observed flooding throughout the storm period is presented in Figure 1.

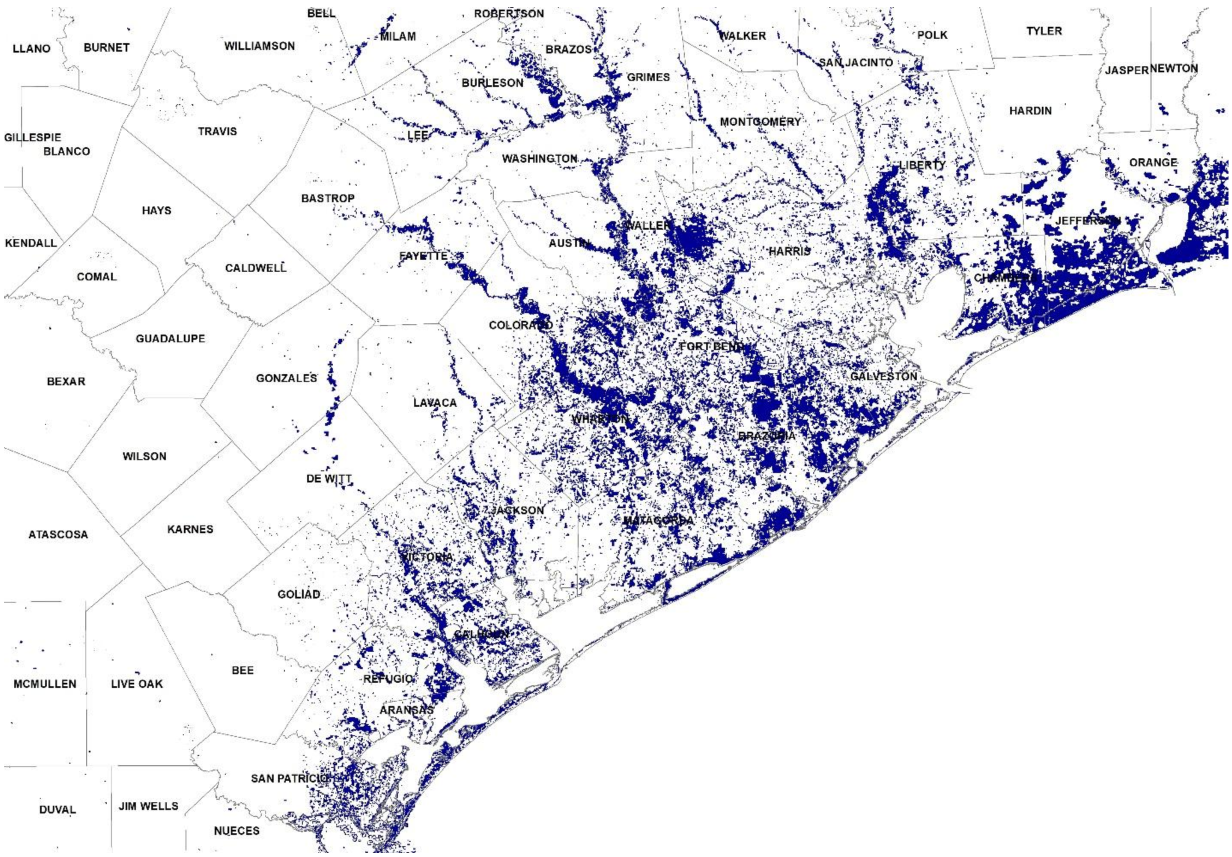

Figure 1. Maximum observed flooding due to hurricane Harvey.

The National Land Cover Database (NLCD) provides estimation of land cover (agricultural, urban, forest, etc.) at 30 m resolution for the U.S. Data was obtained from the USGS Geospatial gateway for Texas in raster format with 2015 being the current available dataset for Texas (Homer et al., 2012). Specific land classes were extracted, including corn, cotton, sorghum, soybeans, rice, peanuts, sod/grass seed, grassland/pasture, other hay/non alfalfa, and four levels of urban land use (Figure 2).

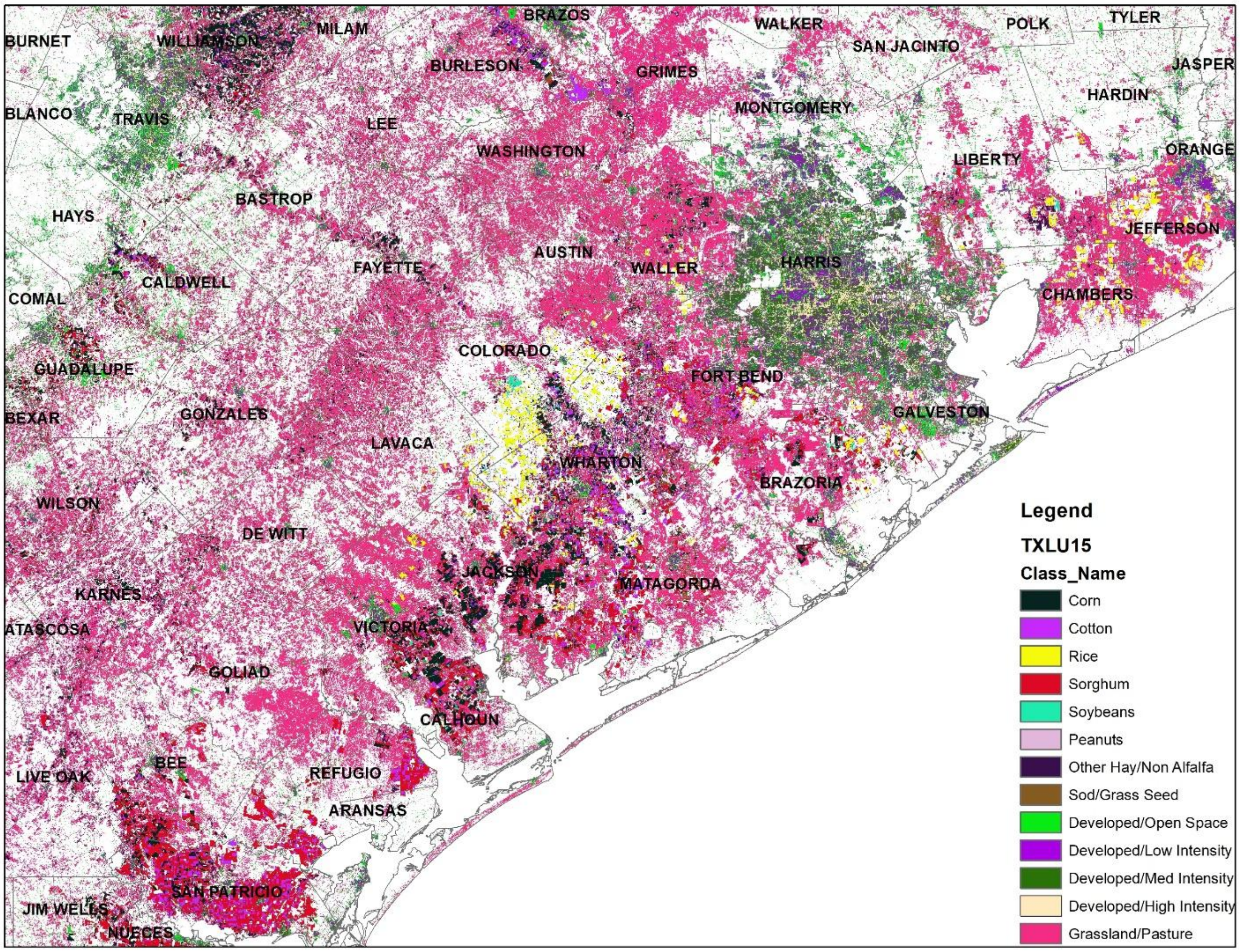

Figure 2. Estimated land use classes (2015) for Texas.

To estimate land use areas affected by flooding, specific land use area under the flood affected regions was extracted (Figure 3). Area (acres) affected by flooding for select land use types were calculated. Field crop classes of corn, cotton, sorghum, soybeans, and peanuts were combined to estimate field crop acres. Rice and sod/grass seed acres were calculated separately. Grassland/pasture and other hay/non alfalfa acres were calculated separately. Developed land use categories were combined.

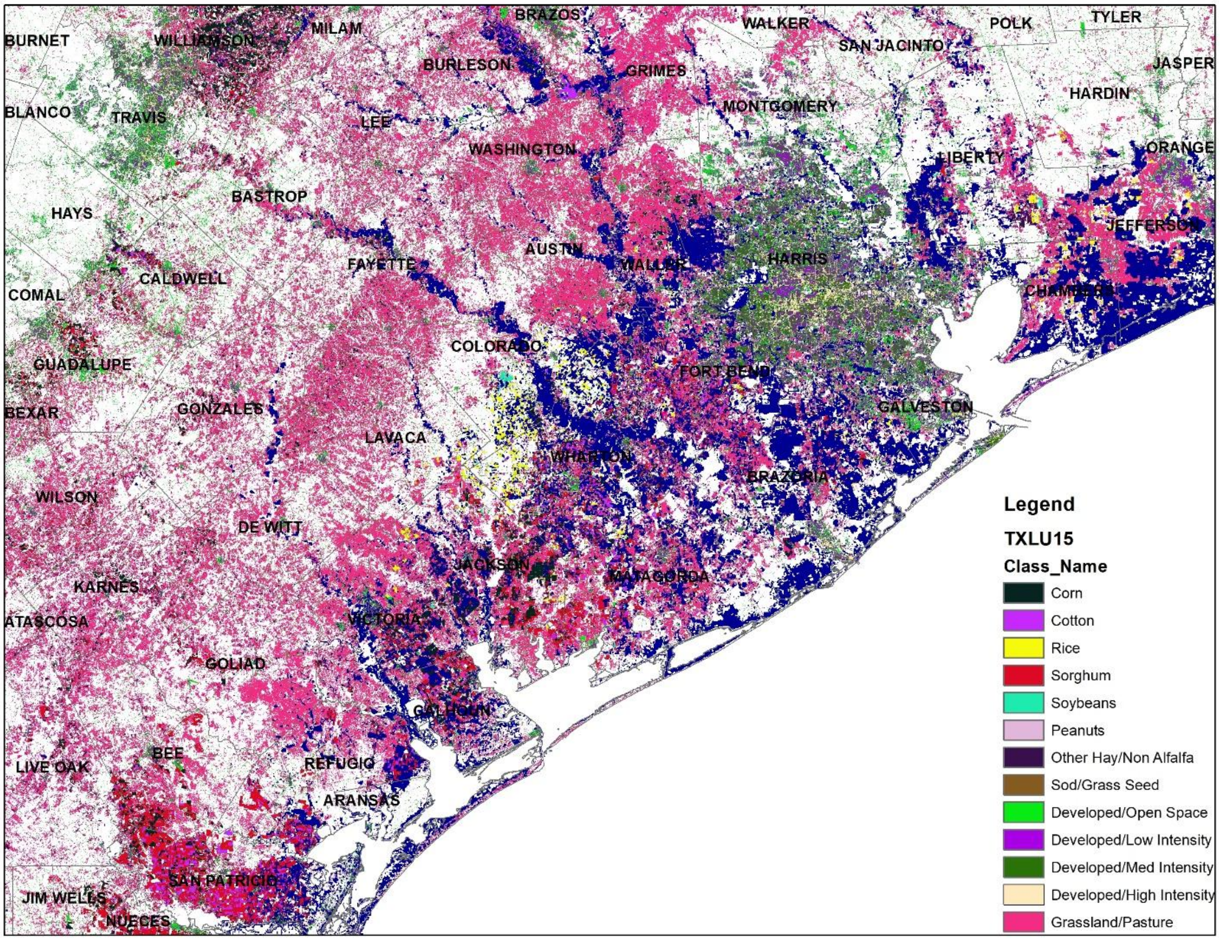

Figure 3. Maximum observed flooding over-laid on select land use classes.

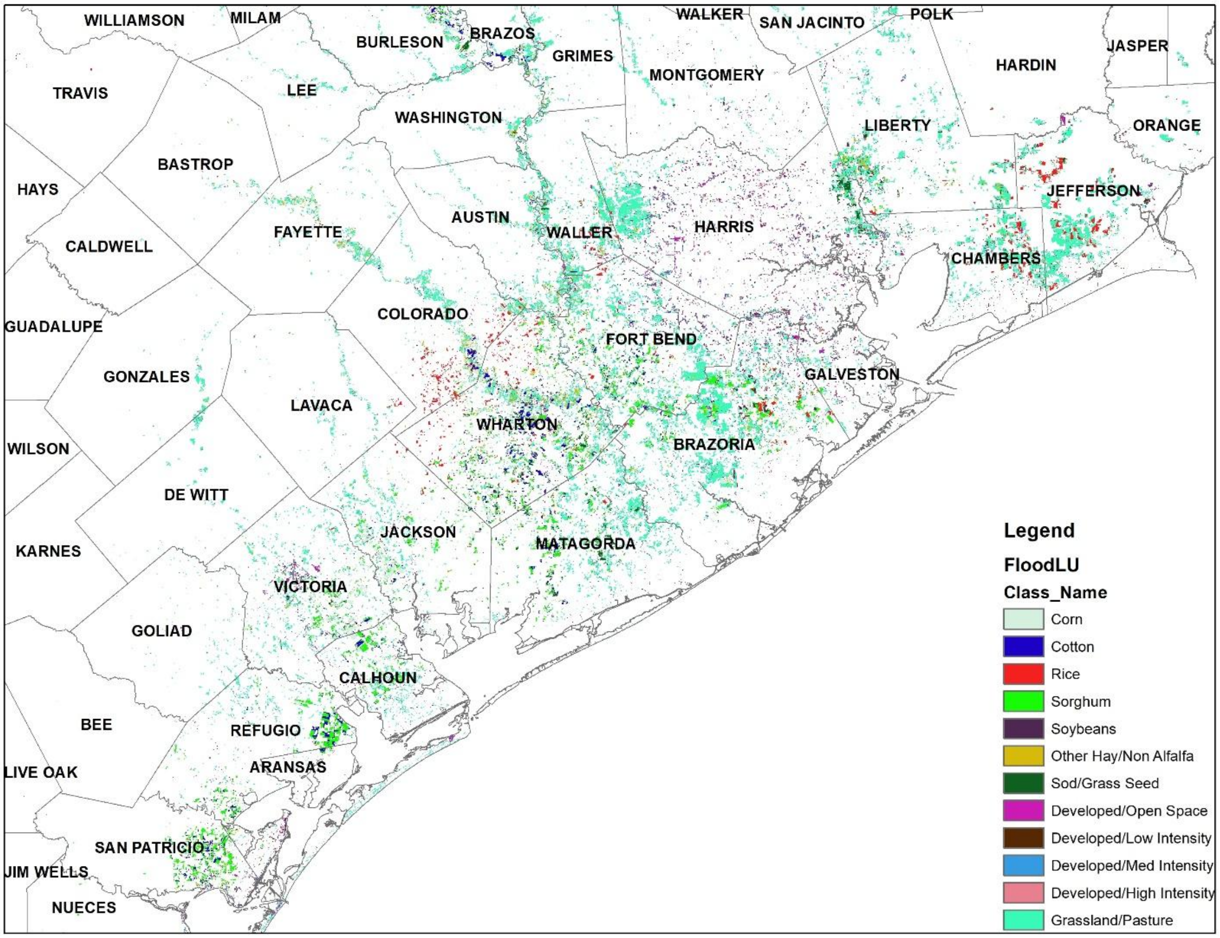

Figure 4. Select land use area affected by maximum observed flooding.

Results

Area (acres) for select land uses that flooded was summarized by land use class for each county (Table 1). Field Crops represents corn, cotton, sorghum, and soybean acres combined due to the use of 2015 land use classification for the 2017 flood event. Developed land use areas were combined (open, low, med, and high). This data represents the maximum observed flooding but may not fully capture short term storm surge (inundation).

It is estimated that greater than 1.3 million acres of the selected land use classes were affected by flooding due to hurricane Harvey. Approximately 82% of the total flooded area was in a 20 county area in south and southeastern Texas. Brazoria county had the greatest amount of area affected by flooding at 146,448 acres followed by Wharton at 142,503 and Harris at 114,659. With the exception of Harris county, agricultural soils comprised the majority of affected flood acres in each county. For select land use in all counties, grassland/pasture represented 46%, field crop 21%, and developed areas accounted for 14% of flooded acres. Other land use classes accounted for less than 5% of flooded acres.

The greatest amount of flooded grassland/pasture acres were in Brazoria county with 86,930 acres flooded. Seventeen counties had greater than 10,000 acres of grassland/pasture affected by flooding. The greatest amount of flooded field crop acres were in Wharton county, with 69,390 flooded acres. Ten counties had greater than 10,000 acres of field crop area flooded. While rice represented only 3.7% of select land use classes that were flooded, an estimated 50,947 acres of 165,000 planted acres (2017 USDA estimate) were flooded, or 31%.

Table 1. Land area (acres) affected by flooding for six selected land use classes by county.

	---Acres---						
County	**Developed**	**Grassland / Pasture**	**Other Hay/Non Alfalfa**	**Rice**	**Sod/Grass Seed**	**Field Crop**	**Grand Total**
Grand Total	**195,026**	**627,604**	**57,293**	**50,947**	**20,940**	**293,371**	**1,367,170**
BRAZORIA	17,065	86,930	5,109	4,942	1,198	31,205	146,448
WHARTON	10,389	38,313	13,463	7,456	3,491	69,390	142,503
HARRIS	55,186	50,326	2,197	437	5,060	1,453	114,659
FORT BEND	16,133	52,326	4,897	2,036	710	20,951	97,053
MATAGORDA	4,357	39,093	1,807	865	4,470	20,892	71,483
LIBERTY	6,198	42,594	4,678	1,129	1,345	3,302	59,246
JEFFERSON	7,312	35,936	369	14,164	680	258	58,719
VICTORIA	9,937	22,316	1,921	281		18,828	53,283
CHAMBERS	7,797	36,452	862	6,798	209	257	52,374
JACKSON	2,882	16,769	1,411	801	50	25,539	47,452
COLORADO	2,255	19,439	3,631	8,106	96	9,757	43,285
CALHOUN	5,700	15,017	634	34	7	15,696	37,088
REFUGIO	2,481	8,741	794	7		20,402	32,425
WALLER	3,238	21,168	2,336	2,573	1,140	1,701	32,156
SAN PATRICIO	5,181	556	877	10		23,908	30,533
AUSTIN	1,961	17,531	2,618	356	38	2,861	25,365
BURLESON	1,096	10,373	1,046	41	1,353	11,419	25,328
FAYETTE	1,183	12,865	2,826	41	10	3,616	20,540
GALVESTON	7,183	4,935	78	143	89	579	13,006
BRAZOS	654	6,970	824		592	3,764	12,804
GRIMES	696	10,122	426		30	1,147	12,422
WALKER	661	9,907	417			1,033	12,019
MONTGOMERY	4,048	7,210	89		17	61	11,423
NUECES	9,073	1,107	61			781	11,021
WASHINGTON	505	6,929	800		279	233	8,747
LAVACA	749	6,553	295	516		53	8,166
ARANSAS	3,046	1,128	286			1,319	5,779
SAN JACINTO	533	5,131	17				5,680
LEE	229	4,573	238			20	5,062
POLK	799	4,002		7			4,808
ORANGE	1,297	3,278	6	58	20	10	4,669
DE WITT	336	3,944	169			177	4,627

MILAM	280	2,042	1,083			1,220	4,624
MADISON	257	4,241	6	7	6	17	4,535
GONZALES	169	3,369	196			138	3,871
GOLIAD	235	2,808	69			125	3,238
ROBERTSON	158	1,445	37		17	857	2,515
BASTROP	310	1,739	328			51	2,428
HOUSTON	173	1,800	13			13	2,000
HARDIN	247	1,335	10	110	31		1,733
TRINITY	227	1,028	10				1,265
NEWTON	108	1,088		30			1,226
WILLIAMSON	26	595	217			156	993
NAVARRO	117	465	14				596
HENDERSON	349	75					425
LEON	58	364					422
BELL	103	261	13			15	392
MCMULLEN	34	293	20				347
KLEBERG	14	223	14			54	304
LIVE OAK	28	218	7			6	259
COMANCHE	67	123	53				243
TRAVIS	203	13					217
KENEDY	24	191					215
MCLENNAN	89	103					192
HILL	97	90					187
ZAPATA	17	165					182
LLANO	128	37					165
BROWN	123	14					136
SAN AUGUSTINE	109	27					136
JASPER	122	13					135
BURNET	126						126
CALDWELL	0	109	6			7	122
JIM HOGG	0	119					119
CORYELL	10	95					105
BROOKS	17	86					103
COMAL	96	7					103
MEDINA	41					61	102
BOSQUE	48	35					83
LA SALLE	17	62					79
SABINE	69	7					76
LIMESTONE	21	49					69
BANDERA	69						69
ANGELINA	49	14					63
DIMMIT	14	43					57
WEBB	21	35					56

SMITH	56						56
DUVAL	6	48					54
BEXAR	47	7					54
ZAVALA	30	23					54
SOMERVELL	29	24					53
FALLS	7					39	46
BEE	14	21	7				42
SHELBY	35						35
NACOGDOCHES	21	14					35
COLEMAN	28						28
ELLIS	0	28					28
FREESTONE	20	6					27
RUSK	14	7					21
MILLS	14	7					21
PANOLA	14	7					21
JIM WELLS	7	7					14
MASON	7		7				14
UVALDE	14						14
CHEROKEE	14						14
HAMILTON	7	7					14
FRIO	0	14					14
TAYLOR	6	6					13
KARNES	0	7					7
KIMBLE	7						7
ERATH	0	7					7

Managing Flood Affected Soils

The effect of flooding on soils ranges from severe erosion to the deposition of copious quantities of new soil, losses of plant available nutrients, changes in water and air infiltration, weed seeds, accumulation of plant tissues and other trash, brush, or foreign materials. Each of these influences can significantly impact both the near-term and long-term management of the impacted acreage. Property managers are encouraged to carefully evaluate these potential changes to their property and determine the best management to offset the flooding impacts.

While the majority of Hurricane Harvey flooding was fresh-water in origin, some coastal areas near the storm’s landfall may have been inundated with salt water. During Hurricane Harvey, several areas in and around Port Aransas were inundated by as much as 10 feet of seawater. Addressing salt-water impacts on landscapes requires additional considerations over those of fresh-water flooding. Specifically, salt-water introduces potential long-term impacts from salinity and sodium. The degree of these impacts is dependent on the initial moisture content of the soil, which in turn dictated the relative infiltration of salt-water into the surface and subsurface soil. Property managers and owners are strongly encouraged to soil test their properties for soil salinity and sodium levels prior to making any remediation steps. Two publications that address these subjects can be downloaded at: http://soiltesting.tamu.edu/publications/E-523.pdf (Pasture and Soil Management Following Tidal Saltwater Intrusion) and http://soiltesting.tamu.edu/publications/E-60.pdf (Managing Soil Salinity).

Deposition of large amounts of soil may improve or adversely impact soil quality depending on the characteristics of the original soil and the characteristic of the soil that was deposited (USDA NRCS, 1996). Fine particles deposited on sandy soils generally will not be a concern while coarse particles deposited on finer texture soils could cause problems. Deposition of sand particles, especially when deep deposition occurs (4+ inches), will dilute surface organic matter and nutrient content and affect soil water infiltration and retention which could affect forage or crop performance in the near future. It is recommended to mix sediment deposition with original soil layer if possible. This can be accomplished through moldboard plowing, chiseling, and deep chiseling of soil. Deep deposits (8+ inches) may need to be spread out to a depth that allows incorporation. Deposition greater than 24 inches justify excluding the area from crop production. Exercise caution when traveling across deep deposition sites as the soil may not be settled underneath and could collapse. The recovery period can take years depending on the depth of sediment.

Similar to sediment deposition, soil erosion reduces soil quality and may require remediation to recover previous levels of productivity (USDA NRCS, 1996). Soil erosion removes soil organic matter and nutrients along with topsoil depth. This will decrease crop rooting depth, reducing water and nutrient acquisition and reduce crop performance. Remediation involves initial land leveling followed by management to improve nutrient and organic matter levels in the topsoil. Planting cover crops, applying manures or compost and incorporation of residues will aid in recovery of soil quality.

Accumulation of crop residues and other debris may have occurred in some fields and will require management to allow normal agricultural practices (Shouse, 2011). Small residues and debris less than 4 inches thick can likely be managed through tillage operations. Thicker layers of debris may require spreading to allow incorporation. If it is too thick to spread, burning may be an option, provided no hazardous material are contained in the debris.

The final concern due to flooding is compaction. While the weight of water is significant (2.7 million pounds per acre foot), the weight of flood water actually exerts very low levels of pressure on soil and does not lead to compaction. Every foot of water flood water depth exerts 0.43 p.s.i. Compaction is usually a result of loss of soil quality, as described for soil deposition or erosion, that reduces soil structure. Remediating sediment deposition or erosion and controlling traffic on wet soils will reduce the effects of compaction.

After remediation of flood affected soils, whether it involved land leveling or residue management, soil nutrient levels should be tested. Routine testing for pH, salinity, and extractable nitrate, phosphorus, potassium (N-P-K) is certainly recommended. Testing for micro nutrients (including Zn, Fe, Mn, and Cu) may be required depending of the circumstances of the flood event. Soil sample submittal forms can be found at: http://soiltesting.tamu.edu/soilsubmittalformcalc3/soilsubmittalformcalc3.htm.

References

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