Monthly Technical Report

(Due to AQRP Project Manager on the 8th day of the month following the last day of the reporting period.)

PROJECT TITLE	Targeted Improvements in the Fire INventory from NCAR (FINN) Model for Texas Air Quality Planning	PROJECT #	14-011
PROJECT PARTICIPANTS (Enter all institutions with Task Orders for this Project)	The University of Texas at Austin ENVIRON International Corporation	**DATE SUBMITTED**	8/3/14
REPORTING PERIOD	**From:** July 1, 2015 **To:** July 31, 2015	**REPORT #**	2

A Financial Status Report (FSR) and Invoice will be submitted separately from each of the Project Participants reflecting charges for this Reporting Period. I understand that the FSR and Invoice are due to the AQRP by the 15th of the month following the reporting period shown above.

Detailed Accomplishments by Task *(Include all Task actions conducted during the reporting month.)*

Task 1 of this work is applying land cover data specific to Texas, as an alternative to global scale land cover mapping from the MODIS LCT product, which is the FINN default. In addition, for Task 2, a mapping of crop types will be developed for incorporation in the FINN land cover database that focuses on Texas and surrounding states, with extension as possible to the United States and neighboring countries. The team plans to use the following land use/land cover database for Texas and surrounding states:

Popescu, S. C., Stukey, J., Mutlu, M., Zhao, K., Sheridan, R., Ku, N.-W., & Harper, C., 2011. Expansion of Texas Land Use / Land Cover through Class Crosswalking and Lidar Parameterization of Arboreal Vegetation Secondary Investigators :
http://m.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/oth/5820564593FY0925-20110419-tamu-expension_tx_lulc_arboreal_vegetation.pdf

For the characterization of croplands, Dr. McDonald-Buller and Dr. Kimura have selected the following:

U.S. Department of Agriculture (USDA), National Agricultural Statistical Service (NASS) Cropland Data Layer (CDL): http://nassgeodata.gmu.edu/CropScape/

Dr. Kimura, with the assistance of a summer undergraduate research assistant (Jeff Zheng) in the Department of Civil, Architectural, and Environmental Engineering at the University of Texas at Austin, developed a mapping and cross-tabulation of land cover classifications associated with agricultural operations between the 2012 NASS and Popescu et al. (2011) databases for Texas. Dr. Kimura is using the spatial analyst package in ArcGIS for this task. This effort is described in detail below.

Preliminary Analysis (*Include graphs and tables as necessary.*)

The TCEQ's dataset from Popescu et al. (2011) was provided in a Lambert Conformal projection. It included 26 Texas land cover types, 9 "western" land cover types, and 17 land cover types derived from the Biogenic Emissions Landcover Database (BELD). The NASS CDL dataset was provided in the

Albers Conical Equal Area projection. It included 71 agricultural land cover types and an additional 15 land cover types derived from the National Land Cover Dataset (NCLD). Both datasets had a nominal horizontal resolution of 30 m.

 The CDL raster file was first clipped to a rectangle for TCEQ's current tx_12km air quality modeling domain. The domain includes all of Texas and most, if not all, of the states of New Mexico, Oklahoma, Arkansas, Louisiana. The CDL data were reprojected to match the projection of the TCEQ land cover data, with the resampling type "NEAREST" (which captures value s directly under the center of the new grid cell) and specification of the "snap grid" to be the TCEQ LC raster (i.e., the projected raster's individual cell aligns with the TCEQ land cover).

A cross-tabulation of land cover types from the two data sets was generated using the "tabulate area" tool from the spatial analyst package for ArcGIS. Pixels that were identified as originating from the BELD database in the TCEQ's dataset and those identified as "background", which were primarily associated with Mexico or the Gulf of Mexico, in the CDL data were ignored. The CDL data had a total of 86 land cover types within the 12km modeling domain. Of these, 71 were related to agricultural land cover types, typically for specific crops. The remaining fifteen were derived from the National Land Cover Database (NLCD; http://www.mrlc.gov/nlcd11_leg.php) with the exception that land cover types 81 (Pasture/Hay), 82 (Cultivated Crops) and 71 (Grassland/Herbaceous) were removed, and a new type, 76 Grassland/Pasture, was added instead. Under the *Frequently Asked Questions* for the CDL dataset, it is described that grassy land cover cannot be effectively distinguished (http://www.nass.usda.gov/research/Cropland/sarsfaqs2.htm#Section4_3.0), and consequently these land cover types were all assigned to a generic grassy class. Table 1 shows the CDL land cover types found within the area of interest in descending order by acreage. It shows that, for example, winter wheat is attributed to 3% of the entire area and 26% of agricultural pixels, shown in the "All LC Types" column and "Ag LC Types" column.

The TCEQ data had a total of 55 land cover types within the 12km modeling domain. Of these, 26 were identified by Popescu et al. (2011) and derived from Texas Land Cover Classification Systems; these accounted for 97% of pixels being studied. An additional nine land cover types were used to distinguish species differences between the eastern and western portions of the 12 km modeling domain. These typically occurred in Mexico, New Mexico and a small portion of west Texas. The remaining nineteen were from the BELD land cover data, which TCEQ used to "patch" small areas near the edge of the land cover raster that were not included in the original Popescu et al. (2011) study. In this work, these pixels were not included in the crosswalk, as the BELD land cover is not expected to share the same characteristics as that of the Popescu et al. (2011) dataset. Table 2 describes the TCEQ land cover types, sorted in descending order by acreage.

Table 3 shows a summary of each of the two datasets with respect to the amount of agricultural land. The CDL data had 71 agricultural land cover types that summed to 49 million acres, corresponding to 13% of the total area. The TCEQ land cover dataset had two agricultural land cover types (Herbaceous Cultivated or HC, and Cultivated Woody Vegetation or CWV), accounting for 55 million acres, or 15% of the total area. The two data sets were cross-tabulated by coincidence of each land cover type and summarized in Table 4. Table 4 shows how agricultural land cover types from the CDL are mapped to the TCEQ land cover, and vice versa. Within the CDL dataset, 38 of a total of 49 million acres (77%) were mapped to 69% of the land cover designated as agricultural in the TCEQ (i.e., Popescu et al., 2011) dataset. More than half (5.8 million acres) of the remaining CDL agricultural land cover was mapped to the "herbaceous natural" land cover type of the TCEQ dataset; 5.3 million acres mapped to non-agricultural land cover types in the TCEQ data. Similarly, the TCEQ agricultural land cover types that did not map to the CDL's non-agricultural land cover types primarily mapped to the "grass/pasture" land cover type of the CDL (10.7 million acres) or other land cover types (6.2 million acres).

Table 5 shows a portion of the cross-walk between the CDL and TCEQ land cover types. Only the top ten (according to acreage) agricultural land cover types of the CDL raster are shown, along with the total for all agricultural land cover types in the CDL dataset in the last row. Each row shows the top five TCEQ (Popescu et al., 2011) land cover types that were associated with a particular CDL land cover type, along with the acreage, percentage within the CDL land cover type, and its cumulative values. As shown in the last row, 77% of CDL agricultural acreage was mapped to TCEQ's Herbaceous Cultivated (HC) land cover type and 12 % was mapped to the Herbaceous Natural (HN) land cover type, together comprising 89% of the acreage. Among specific CDL land cover types listed, "Fallow/Idle Cropland" and "Other Hay, non-Alpha" had a relatively frequent mapping to the Herbaceous Natural land cover type. Other TCEQ land cover types that were associated with CDL agricultural land cover types included "Cold Deciduous Shrubs (CDS)", "Developed Open Space (DOS)" and "Mixed Shrub (MS)".

Table 6 shows a mapping of TCEQ agricultural land cover types, i.e., sum of Herbaceous Cultivated (HC) and Cultivated Woody Vegetation (CWV), to CDL land cover types. The single largest CDL land cover type associated with TCEQ agricultural lands was Grassland/Pasture, accounting for 19% of the TCEQ agricultural area. This was followed by five different crops in the CDL dataset: winter wheat, cotton, soybeans, corn, sorghum, and fallow/idle cropland.

Table 1. CDL land cover types, sorted in descending order by acreage within the 12 km modeling domain. Land cover types shaded in yellow are associated with agriculture. The "All LC Types" columns show the contribution of each CDL land cover type (individual and cumulative) and their ranks. The "Ag LC Types" columns show the percentages associated with agricultural pixels only (excluding grass/pasture) and their ranks.

	CDL Land Cover	Acres	All Land Cover Types			Ag. Land Cover Types		
			Rank	Indiv.	Cum.	Rank	Indiv.	Cum.
1	Shrubland	101,454,758	1	27%	27%	-	-	-
2	Grassland/Pasture	95,911,633	2	26%	53%	-	-	-
3	Evergreen Forest	35,371,608	3	10%	63%	-	-	-
4	Deciduous Forest	31,918,981	4	9%	71%	-	-	-
5	Woody Wetlands	20,020,992	5	5%	77%	-	-	-
6	Developed/Open Space	12,754,877	6	3%	80%	-	-	-
7	Winter Wheat	12,648,958	7	3%	83%	1	26%	26%
8	Cotton	9,311,103	8	3%	86%	2	19%	44%
9	Soybeans	7,224,111	9	2%	88%	3	15%	59%
10	Open Water	6,598,943	10	2%	90%	-	-	-
11	Fallow/Idle Cropland	5,304,660	11	1%	91%	4	11%	70%
12	Developed/Low Intensity	5,102,592	12	1%	92%	-	-	-
13	Corn	4,840,760	13	1%	94%	5	10%	80%
14	Mixed Forest	4,831,554	14	1%	95%	-	-	-
15	Herbaceous Wetlands	4,389,331	15	1%	96%	-	-	-
16	Sorghum	3,483,447	16	1%	97%	6	7%	87%
17	Rice	1,982,654	17	1%	98%	7	4%	91%
18	Developed/Med Intensity	1,688,532	18	0%	98%	-	-	-
19	Dbl Crop WinWht/Soybeans	1,236,812	19	0%	99%	8	3%	93%
20	Barren	1,193,945	20	0%	99%	-	-	-

	CDL Land Cover	Acres	All Land Cover Types			Ag. Land Cover Types		
			Rank	Indiv.	Cum.	Rank	Indiv.	Cum.
21	Developed/High Intensity	690,874	21	0%	99%	-	-	-
22	Sugarcane	551,482	22	0%	99%	9	1%	94%
23	Other Hay/Non Alfalfa	501,522	23	0%	99%	10	1%	95%
24	Alfalfa	491,858	24	0%	99%	11	1%	96%
25	Oats	364,124	25	0%	100%	12	1%	97%
26	Rye	292,597	26	0%	100%	13	1%	98%
27	Dbl Crop WinWht/Cotton	216,885	27	0%	100%	14	0%	98%
28	Aquaculture	195,684	28	0%	100%	-	-	-
29	Dbl Crop WinWht/Sorghum	187,959	29	0%	100%	15	0%	98%
30	Canola	132,325	30	0%	100%	16	0%	99%
31	Pecans	118,790	31	0%	100%	17	0%	99%
32	Peanuts	115,370	32	0%	100%	18	0%	99%
33	Dbl Crop WinWht/Corn	80,345	33	0%	100%	19	0%	99%
34	Sunflower	58,731	34	0%	100%	20	0%	99%
35	Triticale	52,523	35	0%	100%	21	0%	100%
36	Barley	40,703	36	0%	100%	22	0%	100%
37	Spring Wheat	33,277	37	0%	100%	23	0%	100%
38	Sweet Potatoes	30,192	38	0%	100%	24	0%	100%
39	Sod/Grass Seed	15,526	39	0%	100%	25	0%	100%
40	Herbs	13,413	40	0%	100%	26	0%	100%
41	Citrus	13,004	41	0%	100%	27	0%	100%
42	Onions	10,649	42	0%	100%	28	0%	100%
43	Other Crops	10,148	43	0%	100%	29	0%	100%
44	Potatoes	6,630	44	0%	100%	30	0%	100%
45	Peppers	5,697	45	0%	100%	31	0%	100%
46	Millet	5,583	46	0%	100%	32	0%	100%
47	Peas	5,369	47	0%	100%	33	0%	100%
48	Dbl Crop Soybeans/Oats	5,265	48	0%	100%	34	0%	100%
49	Dbl Crop Soybeans/Cotton	4,861	49	0%	100%	35	0%	100%
50	Watermelons	4,450	50	0%	100%	36	0%	100%
51	Dbl Crop Barley/Corn	3,895	51	0%	100%	37	0%	100%
52	Dbl Crop Oats/Corn	3,128	52	0%	100%	38	0%	100%
53	Dbl Crop Corn/Soybeans	2,511	53	0%	100%	39	0%	100%
54	Dbl Crop Barley/Sorghum	2,117	54	0%	100%	40	0%	100%
55	Sweet Corn	1,950	55	0%	100%	41	0%	100%
56	Switchgrass	1,926	56	0%	100%	42	0%	100%
57	Pumpkins	1,774	57	0%	100%	43	0%	100%
58	Durum Wheat	1,407	58	0%	100%	44	0%	100%
59	Dry Beans	1,340	59	0%	100%	45	0%	100%

	CDL Land Cover	Acres	All Land Cover Types			Ag. Land Cover Types		
			Rank	Indiv.	Cum.	Rank	Indiv.	Cum.
60	Peaches	1,289	60	0%	100%	46	0%	100%
61	Clover/Wildflowers	838	61	0%	100%	47	0%	100%
62	Cabbage	784	62	0%	100%	48	0%	100%
63	Oranges	589	63	0%	100%	49	0%	100%
64	Pop or Orn Corn	552	64	0%	100%	50	0%	100%
65	Dbl Crop Barley/Soybeans	509	65	0%	100%	51	0%	100%
66	Safflower	507	66	0%	100%	52	0%	100%
67	Blueberries	469	67	0%	100%	53	0%	100%
68	Tomatoes	413	68	0%	100%	54	0%	100%
69	Cantaloupes	352	69	0%	100%	55	0%	100%
70	Carrots	304	70	0%	100%	56	0%	100%
71	Apples	298	71	0%	100%	57	0%	100%
72	Lettuce	294	72	0%	100%	58	0%	100%
73	Greens	282	73	0%	100%	59	0%	100%
74	Perennial Ice/Snow	280	74	0%	100%	-	-	-
75	Pistachios	214	75	0%	100%	60	0%	100%
76	Squash	198	76	0%	100%	61	0%	100%
77	Vetch	161	77	0%	100%	62	0%	100%
78	Tobacco	113	78	0%	100%	63	0%	100%
79	Cherries	112	79	0%	100%	64	0%	100%
80	Grapes	81	80	0%	100%	65	0%	100%
81	Cucumbers	57	81	0%	100%	66	0%	100%
82	Olives	40	82	0%	100%	67	0%	100%
83	Turnips	26	83	0%	100%	68	0%	100%
84	Dbl Crop Lettuce/Cotton	8	84	0%	100%	69	0%	100%
85	Christmas Trees	5	85	0%	100%	70	0%	100%
86	Walnuts	0	86	0%	100%	71	0%	100%

Table 2. TCEQ land cover types sorted in descending order by acrege within the 12 km modeling domain. The "All LC Types" columns show the contribution of each CDL land cover type (individual and cumulative) and their ranks.

	TCEQ Land Cover Type		Acres	All Land Cover Types		
	Description	Abbr		Rank	Indiv.	Cum.
1	Herbaceous Natural	HN	81,638,807	1	22%	22%
2	Herbaceous Cultivated	HC	55,091,982	2	15%	37%
3	Cold Deciduous Forest	CDF	31,752,387	3	9%	45%
4	Mixed Shrub	MS	31,335,409	4	8%	54%
5	Cold Deciduous Shrub	CDS	29,582,496	5	8%	62%
6	Needle-leafed Evergreen Forest	NEF	26,090,796	6	7%	69%
7	Riparian Forested Wetland	RFW	18,730,920	7	5%	74%
8	Desert Scrub	DS	17,311,663	8	5%	78%
9	Mixed Forest	MF	15,211,871	9	4%	83%
10	Broad-leafed Evergreen Shrub	BES	11,509,823	10	3%	86%
11	Developed Open Space	DOS	9,151,482	11	2%	88%
12	Western Needle-Leafed Evergreen Forest	WNEF	7,254,160	12	2%	90%
13	Open Water	OW	6,838,720	13	2%	92%
14	Herbaceous Emergent Wetland	HEW	4,731,621	14	1%	93%
15	Developed Low Intensity	DL	4,589,235	15	1%	94%
16	Cold Deciduous Woodland	CDW	3,838,473	16	1%	95%
17	Barren Land (Rock/Sand/Clay/Unconsolidated Shore)	BL	2,502,151	17	1%	96%
18	Needle-leafed Evergreen Woodland	NEW	2,339,766	18	1%	97%
19	Western Needle-Leafed Evergreen Woodland	WNEW	2,324,065	19	1%	97%
20	Broad-leafed Evergreen Forest	BEF	2,220,039	20	1%	98%
21	Mixed Woodland	MW	2,133,808	21	1%	99%
22	Swamp Forested Wetland	SFW	1,733,165	22	0%	99%
23	Developed Medium Intensity	DM	1,537,005	23	0%	99%
24	Developed High Intensity	DH	642,756	24	0%	100%
25	Western Mixed Forest	WMF	572,363	25	0%	100%
26	Broad-leafed Evergreen Woodland	BEW	502,880	26	0%	100%
27	Western Mixed Woodland	WMW	152,819	27	0%	100%
28	Western Cold-Deciduous Forest	WCDF	128,357	28	0%	100%
29	Western Shrub Wetland	WSW	69,374	29	0%	100%
30	Western Cold-Deciduous Woodland	WCDW	36,110	30	0%	100%
31	Needle-leafed Evergreen Shrub	NES	369	31	0%	100%
32	Shrub Wetland	SW	21	32	0%	100%
33	Cultivated Woody Vegetation (Orchards/Vineyards/Groves)	CWV	20	33	0%	100%
34	Western Broad-Leafed Evergreen Forest	WBEF	2	34	0%	100%
35	Western Broad-Leafed Evergreen Woodland	WBEW	0	35	0%	100%

Table 3. Agricultural versus non-agricultural area from the CDL and TCEQ land cover datasets. The percentage indicates the contribution of each land cover type within the respective dataset.

	Agricultural	Non-Agricultural	Total
CDL	49,430,329 (13%)	322,124,583 (87%)	371,554,912 (100%)
TCEQ	55,092,001 (15%)	316,462,911 (85%)	371,554,912 (100%)

Table 4. Cross-walk between the CDL and TCEQ datasets for agricultural land cover types.

CDL Ag	TCEQ Ag	TCEQ HN	TCEQ Other	Total
	38,267,908 (77%)	5,862,736 (12%)	5,299,685 (11%)	49,430,329 (100%)

TCEQ Ag	CDL Ag	CDL grass/pasture	CDL Other	Total
	38,267,908 (69%)	10,657,892 (19%)	6,166,202 (11%)	55,092,001 (100%)

Table 5: Mapping of agricultural lands in the CDL dataset to TCEQ land cover types. The top ten land cover types sorted in descending order by acreage and the total for all agricultural lands (last row) are shown. The Columns under "TCEQ LC" shows the top five dominant TCEQ land cover types that were associated with particular CDL land cover types. Each cell has the TCEQ land cover abbreviation, acreage and individual/cumulative percentage of TCEQ land cover (in parentheses).

	CDL LC	Acres	TCEQ LC				
			#1	#2	#3	#4	#5
1	Winter Wheat	12,648,958	HC 9,271,178 (73|73)	HN 2,025,225 (16|89)	CDS 661,918 (5|95)	DOS 291,253 (2|97)	MS 179,800 (1|98)
2	Cotton	9,311,103	HC 7,935,462 (85|85)	HN 554,055 (6|91)	CDS 335,067 (4|95)	DOS 263,411 (3|98)	MS 77,155 (1|98)
3	Soybeans	7,224,111	HC 6,345,678 (88|88)	HN 417,858 (6|94)	DOS 143,514 (2|96)	RFW 114,847 (2|97)	OW 91,201 (1|98)
4	Fallow/Idle Cropland	5,304,660	HC 2,942,576 (55|55)	HN 1,033,655 (19|75)	MS 325,439 (6|81)	CDS 288,665 (5|87)	RFW 167,079 (3|90)
5	Corn	4,840,760	HC 4,084,666 (84|84)	HN 448,538 (9|94)	DOS 107,703 (2|96)	RFW 49,180 (1|97)	CDF 25,985 (1|97)
6	Sorghum	3,483,447	HC 2,574,075 (74|74)	HN 497,019 (14|88)	CDS 103,462 (3|91)	MS 78,961 (2|93)	DOS 70,770 (2|95)
7	Rice	1,982,654	HC 1,797,648 (91|91)	HN 72,600 (4|94)	OW 32,131 (2|96)	RFW 23,967 (1|97)	DOS 23,073 (1|98)
8	Dbl Crop Win Wht/Soybeans	1,236,812	HC 1,037,940 (84|84)	HN 117,662 (10|93)	DOS 30,751 (2|96)	RFW 17,725 (1|97)	NEF 6,066 (0|98)
9	Sugarcane	551,482	HC 489,041 (89|89)	HN 28,036 (5|94)	DL 12,260 (2|96)	RFW 8,202 (1|97)	HEW 3,893 (1|98)
10	Other Hay/Non Alpha	501,522	HN 271,213 (54|54)	HC 185,179 (37|91)	DOS 10,677 (2|93)	NEF 8,540 (2|95)	NEW 7,109 (1|96)
	Total Agricultural	49,430,329	HC 38,267,907 (77|77)	HN 5,862,736 (12|89)	CDS 1,488,149 (3|92)	DOS 1,080,570 (2|94)	MS 750,582 (2|96)

Table 6: Mapping of TCEQ agricultural lands to CDL land cover types. The top 25 CDL land cover types found for TCEQ's Herbaceous Cultivated (HC) or Cultivated Woody Vegetation (CWV) land cover types in the TCEQ data are shown along with their acreage, individual and cumulative percentages.

	CDL Land Cover type	Acres	Individual Percentage	Cumulative Percentage
1	Grassland/Pasture	10,657,892	19%	19%
2	Winter Wheat	9,271,178	17%	36%
3	Cotton	7,935,462	14%	51%
4	Soybeans	6,345,678	12%	62%
5	Corn	4,084,666	7%	70%
6	Fallow/Idle Cropland	2,942,577	5%	75%
7	Sorghum	2,574,075	5%	80%
8	Shrubland	2,059,829	4%	83%
9	Rice	1,797,648	3%	87%
10	Developed/Open Space	1,247,042	2%	89%
11	Dbl Crop WinWht/Soybeans	1,037,940	2%	91%
12	Deciduous Forest	917,912	2%	92%
13	Woody Wetlands	762,770	1%	94%
14	Sugarcane	489,041	1%	95%
15	Alfalfa	327,007	1%	95%
16	Developed/Low Intensity	278,177	1%	96%
17	Evergreen Forest	222,909	0%	96%
18	Rye	203,571	0%	96%
19	Open Water	199,899	0%	97%
20	Dbl Crop WinWht/Cotton	187,353	0%	97%
21	Other Hay/Non Alfalfa	185,179	0%	98%
22	Herbaceous Wetlands	178,612	0%	98%
23	Oats	156,890	0%	98%
24	Dbl Crop WinWht/Sorghum	156,278	0%	98%
25	Aquaculture	124,623	0%	99%

Data Collected *(Include raw and refine data.)*
As described above.

Identify Problems or Issues Encountered and Proposed Solutions or Adjustments
None this period.

Goals and Anticipated Issues for the Succeeding Reporting Period
The next step will be to actually incorporate the CDL land cover into the TCEQ land cover raster file. Our selected approach will be to overwrite TCEQ's Herbaceous Cultivated pixels with the overlaid CDL land cover types (i.e., representing specific agricultural crops). With this approach, 31% of the TCEQ Herbaceous Cultivated land cover will be associated with non-agricultural land cover types in the CDL data (ref. Table 4: 19% grass/pasture, 4% shrub, 2% developed open space, 2% deciduous forest). We will likely default to a generic cropland designation for these cases.

Detailed Analysis of the Progress of the Task Order to Date *(Discuss the Task Order schedule, progress being made toward goals of the Work Plan, explanation for any delays in completing tasks and/or project goals. Provide justification for any milestones completed more than one (1) month later than projected.)*
Ongoing.

Submitted to AQRP by:

Principal Investigator: <u>Elena McDonald-Buller</u>

(Printed or Typed)