Continued Development of Predictive Logistic Models for Southwestern Corn Borer and Western Bean Cutworm Adult Emergence for the Texas High Plains

2011 Final Report to the Texas Corn Producers Board

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The objective of the research is the development of temperature-driven predictive models for Southwestern corn borer and Western bean cutworm. The project began in 2008, and data has been collected from the field for the last four years. We report on the 2011 data collection and incorporate these data into the models.

Materials and Methods: Pheromone traps for Southwestern corn borer and Western bean cutworm were sampled weekly from mid-April until the end of September, 2011. Eight traps (four for Southwestern corn borer and four for Western bean cutworm) were located at each site in Castro, Oldham, Hartley, Dallam, Moore, and Potter County. The Castro, Hartley, Dallam, and Moore county sites are in corn fields. The Oldham and Potter county sites are non-corn sites used to determine flights of the two pests through areas between the southern and northern corn-growing regions of the Panhandle. Data were compiled as the weekly trap counts came in. Weather data for this year and previous years is current to date.

Data analyses consisted of running the accumulated data for four years in SAS using the n-lin procedure (non-linear regression).

Results and Discussion: As all know, 2011 was a very harsh year with record high temperatures and record low rainfall (see Figures 1 and 2 for Dalhart as an example). Although this summer caused many problems with corn production and much suffering on the part of corn producers throughout our research area, the data we collected reflect a once-in-a-generation sampling of these corn pests under these conditions. Therefore, for the model we are developing, this was a great opportunity.

Table 1. Total number of Southwestern corn borer and Western bean cutworm moths collected from pheromone traps at four Panhandle locations from 2008-2011.

Year	Location				
	Dimmitt	Dumas	Etter	Dalhart	Average
			Southwestern corn borer		
2008	13	5,840	0	13,940	4,948
2009	74	2,335	1,513	1,313	1,309
2010	3,937	299	299	499	1,259
2011	1,437	1,456	1,416	1,371	1,420
			Western bean cutworm		
2008	13	658		644	438
2009	74	1523	853	892	836
2010	368	182	144	285	245
2011	1726	719	1732	1458	1,409

The total number of Southwestern corn borer moths caught in 2011 was rather consistent across all the locations. Much more so than in previous years, where total catch was quite variable across sites. . On the other hand, Western bean cutworm moth numbers were the highest we have recorded over the last four years with the exception of the Dumas site in 2009. These are interesting results and could possibly be due to the drought when one considers that in terms of water and temperatures, the drought is a "leveling event," i. e. all locations were similarly affected. This would be one observation that argues for continuing the research in 2012. Figure 1, a 14-day running average of air temperatures at Dalhart from 2008-2011, illustrates the record high temperatures experienced in 2011. Figure 2 illustrates how the air temperatures translated into accumulated degree days. Accumulated degree days for 2011 far outstripped the same parameter for 2010 which was also a relatively “hot” year when compared to 2008 and 2009. Since insects are cold-blooded animals, yearly accumulated degree days affect each species directly. Typically we would think that years with higher accumulated degree days would result in insects developing more rapidly than cooler years. For the most part this is true, but if temperatures are extremely high, there may be some associated mortality of young larvae. Again, this is an important reason why a number of years of data need to be collected for a model to be accurate and dependable.

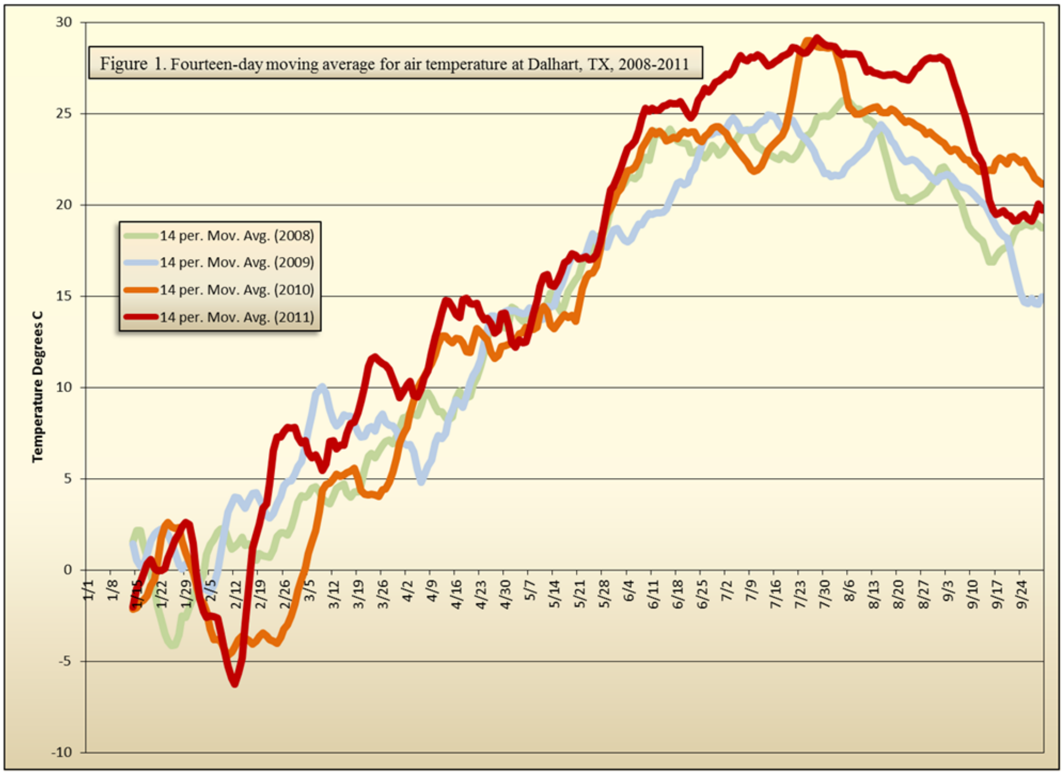

Figure 1. Fourteen-day moving average for air temperature at Dalhart, TX, 2008-2011

Table 2 summarizes the results for the three models, containing the predicted dates and accumulated degree days to reach 50% moth emergence for 1st and 2nd generation Southwestern corn borer and Western bean cutworm. The results are broken down by each site, and the average, minimum, maximum and spread across all sites. We focus on 50% emergence as a convenient and significant prediction point. If the information the model generates is to be used in pest management, the presence of the first moths are of little value in control programs except in the case of

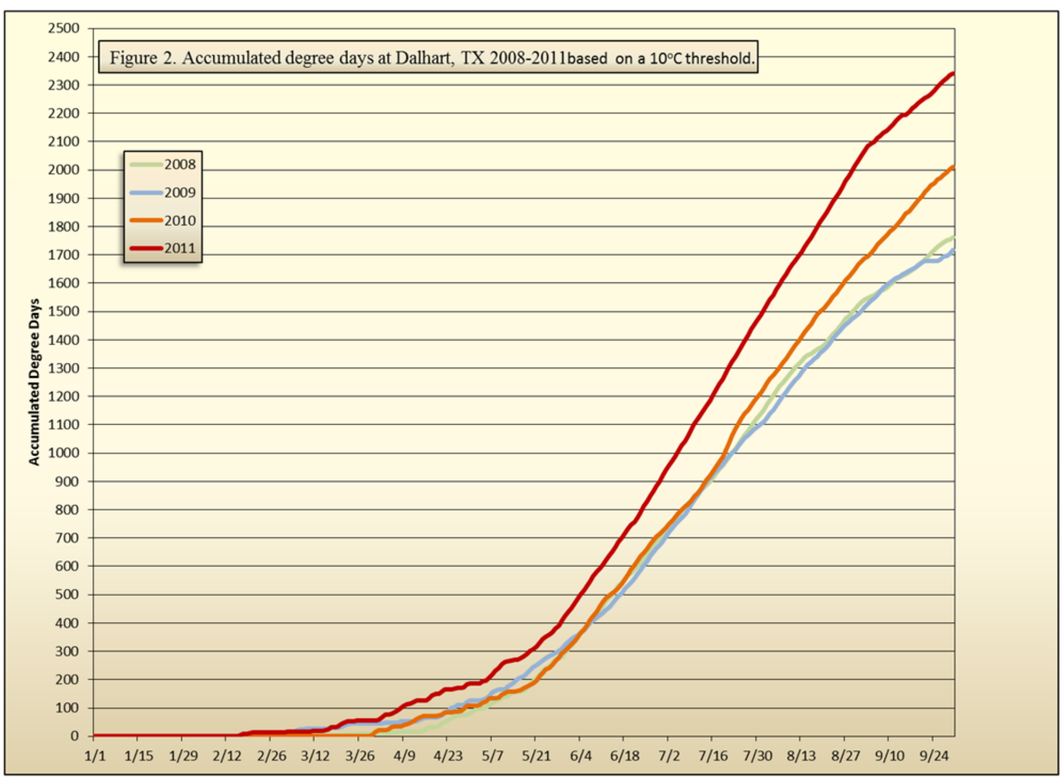

Figure 2. Accumulated degree days at Dalhart, TX 2008-2011 based on a 10°C threshold.

1st generation Southwestern corn borer, which is used to set a "biofix" point for the accumulation of 2nd generation degree days. The 50% threshold is important because any chemical control program would be focusing on the time when emergence is at its heaviest, and therefore the highest number and most fit moths would be present.

Looking at these results, which are a compilation of four year's data, across sites, the average

Table 2. Predicted date and accumulated degree days for 50% emergence of adult Southwestern corn borer and Western bean cutworm at four sites in the Texas Panhandle, the average across sites and minimum and maximum parameters based on a 95% confidence interval.

	Date and Degree Days Accumulated for 50% Moth Emergence							
	Dimmitt	Dumas	Etter	Dalhart	Average	Minimum	Maximum	Spread
1st generation Southwestern Corn Borer								
Date	5/27	5/29	5/30	6/14	6/1	5/23	6/11	19
Degree Days	754	721	618	770	716	674	758	84
2nd generation Southwestern Corn Borer								
Date	7/16	7/18	7/6	7/21	7/15	7/11	7/19	8
Degree Days	449	479	297	528	438	371	505	134
Western Bean Cutworm								
Date	7/16	7/17	7/5	7/20	7/14	7/10	7/18	7
Degree Days	1053	1068	886	1116	1031	975	1086	111

number of accumulated degree days to reach 50% moth emergence is 674, with a spread of 84 degree days. For 2nd generation Southwestern corn borer it takes an average of 438 degree days with a spread of 134 degree days. Finally, Western bean cutworm moths reach 50% emergence at 1031 degree days with a spread of 111 degree days. Although dates are included in the table for comparison purposes, we strongly recommend that dates not be used to interpret the results or for management strategies because they are inherently inaccurate, changing each year as the accumulated degree days varies. Degree days, on the other hand, are independent of date, and are closely associated with moth development. One useful factor of the calendar date is to compare across species. Here we can see that 2nd generation Southwestern corn borers and Western bean cutworm 50% emergence has occurred within one day of each other both at individual sites and in the average over all sites. Keep in mind that accumulation of degree days for 2nd generation Southwestern corn borer starts based on 1st generation emergence, therefore if you added the degree days accumulated for 1st generation Southwestern corn borers to the figure for 2nd generation borer emergence, you get, on the average, 1154 accumulated degree days, which is near to the 1031 accumulated degree days needed for Western bean cutworm emergence to reach 50%. The column entitled "Spread" indicates the difference between the minimum and maximum dates or degree day; the narrower the number, the more accurate the model. As the models currently stand, both 2nd generation Southwestern corn borer and Western bean cutworm models are predicting a spread of eight and seven days, respectively. This is a very workable treatment window for management practices. The same applies for degree days, but dates are a bit easier to comprehend. In practice, one would observe the accumulated degree days in a given year and when, say, Western bean cutworm accumulated degree days approaches 975, intense scouting of fields could begin. One would assume that moths would be approaching 50% emergence. If a decision was made to treat for the pest, there would be roughly a seven-day window from that time until moth numbers began to decline. There is room for variation and common sense. If the window was approaching and the area experienced a cool spell, or a very hot spell, accumulated degree days could be affected significantly. However, because degree days are easy to calculate, and an objective of this research is to make degree days for these pests easily available electronically, anomalies such as these should be easily coped with.

Figures 3 through 6 graphically illustrate the models for 1st and second generation Southwestern corn borer (Figures 3 and 4), Western bean cutworm (Figure 5), and a compilation of all three models on the same graph (Figure 6). Figures 3, 4, and 5 illustrate the value of collecting data over a number of years. In all three graphs, the line with red circles represents the model when run with data from 2008 and 2009. The line with green circles is the model using data from 2008-2010, and the line with blue circles is represents the model when run with four years of data (2008-2011). It is very easy to see that the 1st generation Southwestern corn borer model run with only 2008-2009 data is much different, and less accurate than the model run with 2008-2010 or 2008-2011 data. Just the addition of the 2010 data changed the model drastically, moving the 50% emergence mark from roughly 393 accumulated degree days to 721 degree days, nearly twice as many. Addition of the 2011 data did little to affect the 50% emergence mark, but had some effect on the predictions for early and late emergence percentage. The graph for 2nd generation Southwestern corn borer presents a somewhat different picture. This graph shows the model

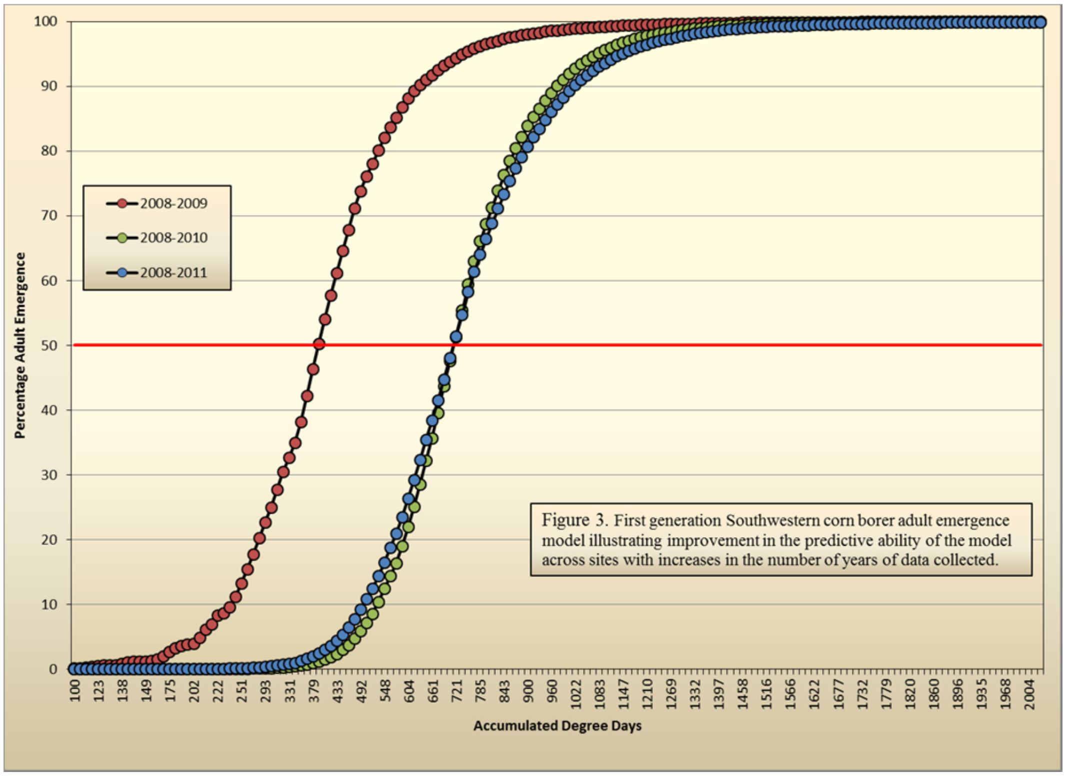

Figure 3. First generation Southwestern corn borer adult emergence model illustrating improvement in the predictive ability of the model across sites with increases in the number of years of data collected.

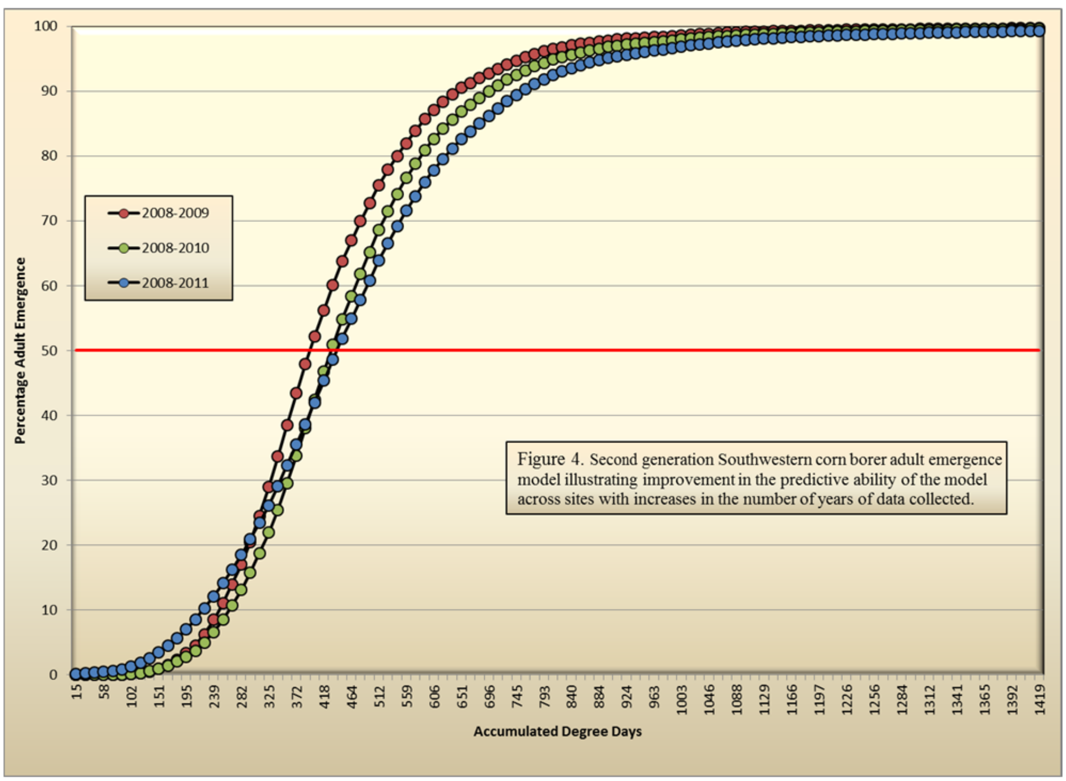

Figure 4. Second generation Southwestern corn borer adult emergence model illustrating improvement in the predictive ability of the model across sites with increases in the number of years of data collected.

to be rather robust even with only two years of data. The addition of 2010 and 2011 data moved the lines farther to the right of the graph, but at the 50% emergence mark, the difference was only 62 degree days. A reason for this may be that 2nd generation moths emerge at a time of the year when temperature swings are less than those experienced when 1st generation moths emerge. Referring back to Table 2, 1st generation moths generally reach 50% emergence in a window spanning May 23rd through June 11th, while 2nd generation moths reach 50% emergence between July 11th and July 19th. It is much more likely that larvae developing in the spring of the year might experience cold snaps, sudden cooling from thunderstorms, cooler nightly temperatures and abrupt temperature changes as weather fronts cross the Panhandle. The factors lead to more variability year to year, and thus as yearly data is added to the model, the oscillations due to this variability are softened. This is somewhat evident in Figure 1. First generation corn borers are subject to temperatures that are rising rapidly and more variably in the spring, while 2nd generation borers are present at a time when temperatures are consistently higher and change less rapidly.

Figure 5 illustrates the Western bean cutworm model. The result of the addition of yearly data for this model seems to straddle what was seen with 1st and 2nd generation Southwestern corn borers. Addition of the 2010 data moved the 50% emergence mark 89 degree days higher. Addition of the 2011 data moved the 50% emergence mark back a few degree days lower. It might be expected that the Western bean cutworm model would be more robust from the beginning since it is univoltine, and not dependent on prior generations. However, why there was such a difference in the graphs of the models for 1st generation Southwestern corn borer and Western bean cutworm in relation to including two or three years of data is curious. According to the Colorado State University Extension Service Fact Sheet 5.538, "Western bean cutworms complete a single generation each year. Fully-grown, nonfeeding larvae (prepupae) overwinter in the soil in earthen cells found at depths of three to nine inches. Pupation occurs in May and early June. The moths emerge between mid-July and early August." In contrast, Southwestern corn borers overwinter as larvae in the crowns of the previous season's corn plants, pupate in the spring and emerge shortly thereafter. Since Western bean cutworms remain in the soil as pupae and at greater depths than Southwestern corn borer until mid-summer, they, as with 2nd generation Southwestern corn borers escape harsh spring conditions that could impact 1st generation Southwestern corn borers.

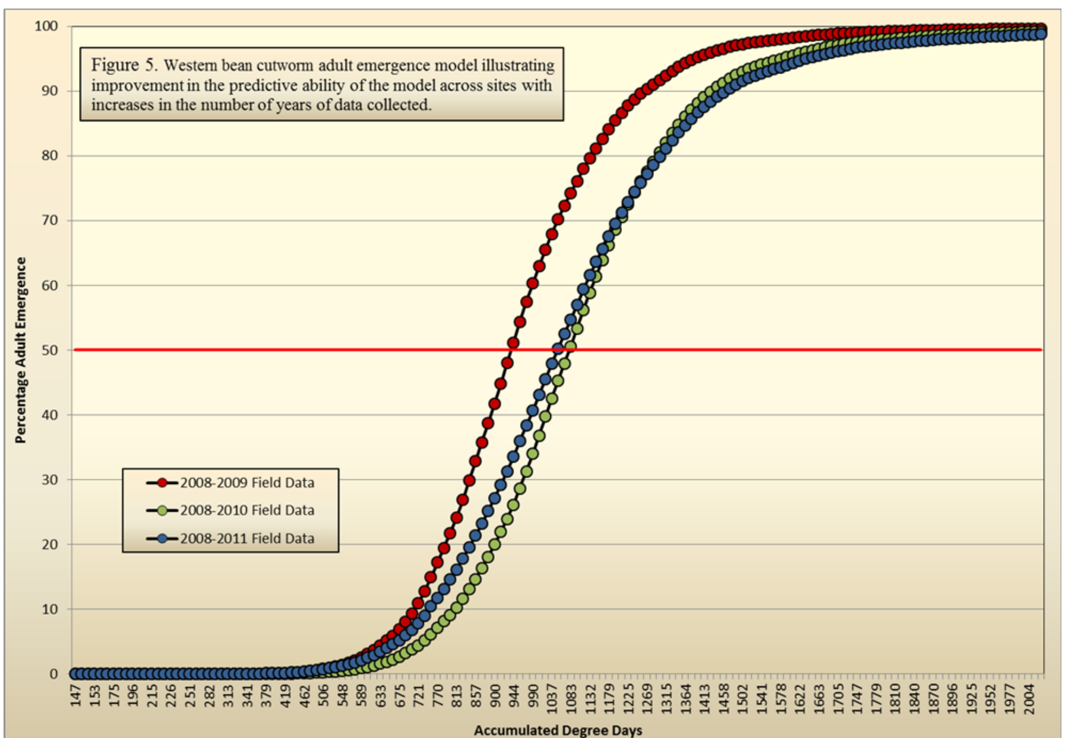

Figure 5. Western bean cutworm adult emergence model illustrating improvement in the predictive ability of the model across sites with increases in the number of years of data collected.

A comparison of all three models is presented in Figure 6. Please note that the x-axis has two scales. The upper scale is the accumulated degree days for 1st generation Southwestern corn borers and

Western bean cutworms while the lower scale is for 2nd generation Southwestern corn borers. This is necessary since accumulated degree days are reset for 2nd generation borers based on the biofix set by 1st generation borer emergence. This allows the three models to be presented on a chronological scale. On a yearly basis, 1st generation Southwestern corn borers emerge first, reaching 50% emergence around 716 degree days. These moths mate and lay eggs on the corn plant leaves. These eggs hatch, the larvae develop, and emerge as the second generation moths. This generation reaches 50% emergence around the time that 371 degree days are accumulated from the point of the biofix. Western bean cutworm adults follow an emergence pattern very similar to the 2nd generation borers., with almost exactly the same number of degree days accumulated by the time 50% of the adults have emerged. This is of great interest since if chemical control becomes part of a management plan, both insects should be present at roughly the same time, or at lease well within their respective windows.

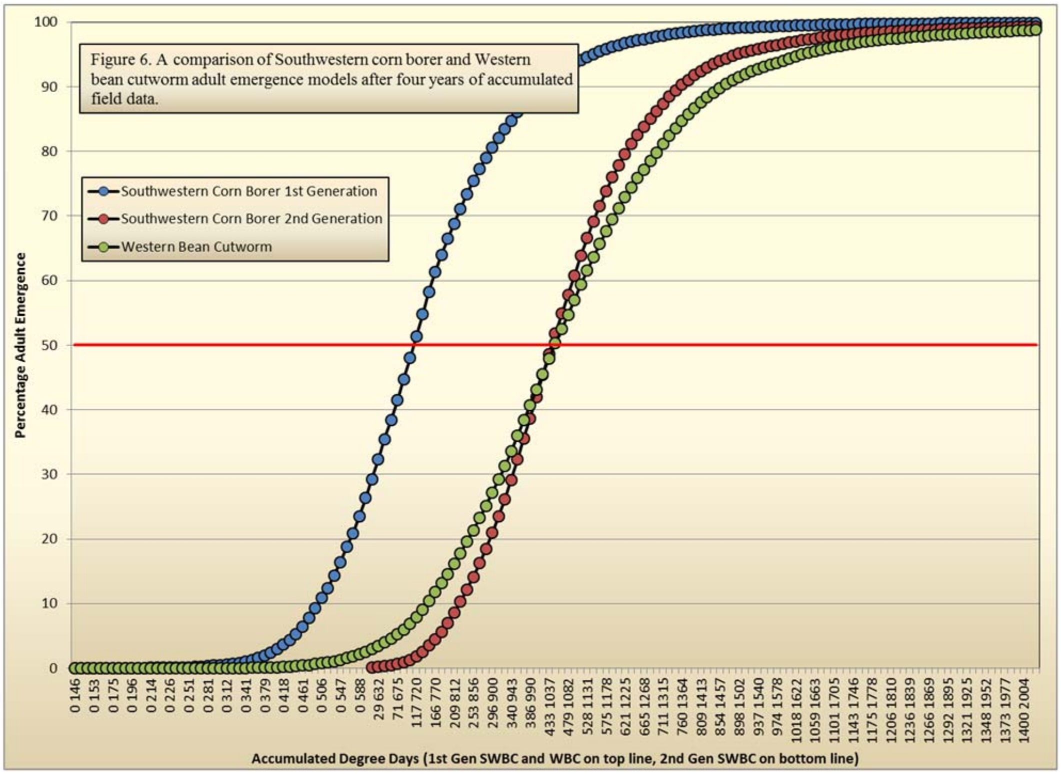

Figure 6. A comparison of Southwestern corn borer and Western bean cutworm adult emergence models after four years of accumulated field data.

Conclusions and Future Work: We believe the models are coming close to the strength they need to be made public as tools in the control of these corn pests. The drought, however, is a factor that must be considered in more than one way. Currently, we have collected data in what can be considered two rather normal years, 2008 and 2009, and two drought years, 2010 and 2011. It can possibly be argued that 2010 was not a significant drought year, but at best it was a precursor to the severe drought of 2011. Figures 1 and 2 illustrate the general increase in yearly temperatures rather dramatically. It is quite obvious that accumulated degree days were much greater in 2010 and 2011 than in 2008 or 2009. This leads us to ask if the data collection we've done to date should be considered complete. In our opinion, it is not. If we stop collecting data in the midst of a severe drought, we lose the ability to understand what will happen with these pests as the drought continues or lessens in the future. We believe that this project has a serendipitous opportunity to record the impact of a major climatic event on lepidopterous pests, and it should not be lost. It will be invaluable to include the moth data over the next few years.

We are also working with Dr. Ed Bynum, collecting additional Southwestern corn borer and Western bean cutworm data supplied from traps set up in his multi-county moth surveillance program. These data will provide additional points to be evaluated with our own 2011 data. Dr. Bynum, and his cooperating county agents have also been collecting fall armyworm data for the last two years, and we believe it would be valuable to start looking at these data too as the basis for another model.

Additional Comments: In 2011 we again compiled and distributed the TCPB-funded Western corn rootworm adult emergence mode. Weather data were collected each week, the model was run, and the results were posted to various county extension websites, sent to the TCPB website, and also sent to various researchers and administrators in the Texas AgriLife Research and Texas AgriLife Extension Service agencies.

Comments or questions are welcome. We intend to submit a proposal for support to continue this research in 2012. We have four years of data collected, and we believe that a fifth year will be of great values, especially coming on the heels of the severe drought and high temperatures in 2011. This may become even more important if the drought continues in 2012.

Western bean cutworm reference site - http://www.ext.colostate.edu/pubs/insect/05538.html