Geographic Information Systems to Produce Pest Risk Maps for South Texas Cotton and Sorghum Land Managers

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Introduction

South Texas is home to many crops that are damaged by insect pests. Geographic Information Systems (GIS), can be used to collect, store and display geospatial data. In our application, we used GIS tools to create 'pest risk' maps to help land managers decide when and where to use insecticides to obtain good pest control and secure good yields. We applied this technology to monitor insect pests cotton and sorghum of South Texas. There are many other insect species that damage crops, but the following three insects were the primary focus of this previous summer's research.

Cotton Fleahoppers (adult top left, nymph top right) feed on the small floral bud of the cotton plant known as a square(bottom right). This can result in damage to the square (bottom left).

Verde plant bugs adult (top left) and nymph(top right). These insects will penetrate and feed on the boll of the cotton plant causing visible damage (bottom left). This damage can cause the cotton boll not to bloom as cotton ball(bottom right).

Sugarcane Aphid (Left) usually are present in high numbers on sorghum grain or Johnson grass. Aphids in large densities can generate honeydew that latter becomes sooty mold, which can damage harvesting equipment.

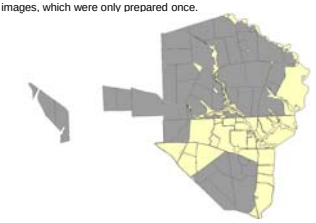
Experimental Question and Approach

Land managers need to know where insect pests are located and how abundant they are, to make good timely decisions about insecticide use. Without treatment, the insect populations can grow and cause economic yield reduction. Alternatively, if an excessive amount of insecticide is needlessly applied to areas that have little to no threat of insect damage, then unnecessary spray costs and other disruptions can occur. With these points in mind, the questions are the following: Can a method be produced that would show all the gathered invasive insect data at once? Can this method also be rendered so that all the data displayed can be understood at a glance by land managers to make better decision in a timely manner?

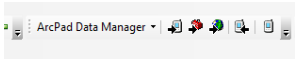
We explored a GIS solution to these questions working with land managers that farm large acreages of cotton and sorghum in South Texas. Using actual pests and plant information taking from field monitoring in summer 2015, we created maps that show the location of the pest insect along the perimeter of the fields. We used ESRI's ArcGIS software (ArcMap) to project spatial data onto a base map of our cotton and sorghum fields. With editing to classify abundance of the pests relative to their potential damage (pest risk categories), legible map files were distributed to our grower cooperator within 12 hours of data collection.

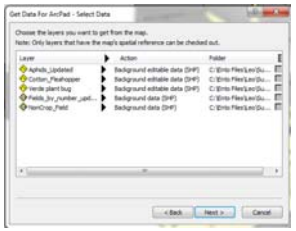
Before taking the first trip to the field, all the insect data to collect is prepared in an attribute table. Using a hand held GIS device, shapefiles corresponding to the different fields are also prepared to store the spatial information during our insect monitoring trips. The shapefiles were made up of vector images, which were only prepared once.

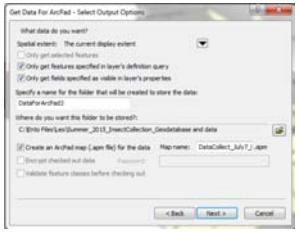
Left: Arc Catalog was used to create the three points needed for the field insect data. They each have an empty attribute table when opened. Right: ArcMap shows the base map and empty points that will be transferred.



In our application for pest insect monitoring, georeferenced points from a hand-held GPS devise were used to represent each of the three insects: Fleahoppers, Verde Plant Bugs and Sugarcane Aphids. For each insect monitoring stop around a field, the mapped point will be the same size but will have a different color to differentiate the abundance of the insect. The creation of these points will be made with Arc Catalog, a application that is used to organize and create shapefiles and other geographic information. The insect points were created inside a Geodatabase that served as a container for the points. This Geodatabase was set to the NAD 1983 coordinate system that is compatible with the handheld GPS device we used in the field (*Trimble Juno 3B)*. This Geodatabase can also be accessed and opened in ArcMap, the application that represents the different layers of geographic data on one screen and allows for editing and analysis of these layers. Initially, these points are empty and will have no attributes assigned to them. The GPS handheld allows for these points to be imported and modified in the filed by accessing the points and adding the data in the filed.







Top: The ArcPad Data Manager tool bar is necessary to convert the ArcMap shapefiles into ArcPad compatible shapefiles. Right: The process of transferring the shapefiles is simple, just select the shapefiles you want transferred, where they will be edited (insect data) or not (base map). ArcPad Data Manager toolbar will export the data into a .CAB file that will contain all the data you have chosen to export.

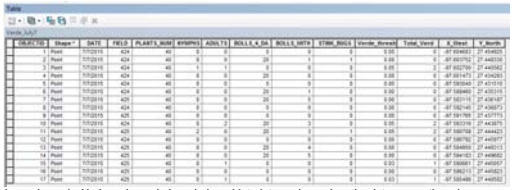
ArcMap makes use of toolbars that contain commands that help the user perform tasks like editing or performing analysis on a map. Among the many toolbars that are available for use in ArcMap, ArcPad manager is the toolbar to use for transferring the empty data shapefiles on to a hand held device. In order for the GPS handheld to accept and edit the data, the device must have ArcPad installed. ArcPad is essentially similar to ArcMap, but it requires a .CAB file instead of the standard .MXD Map Document file that is used in ESRI's ArcMap. A cabinet (.CAB) file is a compressed library of many smaller files that are all stored within a single bigger file. These .CAB files are the only ones that ArcPad will accept and open. Fortunately, the process of .CAB file creation is very simple and only requires a few clicks of the mouse to complete the transfer. Afterward, the transferred data should be in the GPS handheld and ready to use in the filed.

The Trimble Juno 3B was selected as the data collection device, because it is rugged, gets good GPS reception and can upload and download ArcMap shapefiles (left). The devise was easily used in the cotton and sorghum fields we visited in summer 2015 (right).

The Juno 3B hand held makes field data collection easier by allowing the user to input insect and plant data directly into the device. The data is then saved to the point shapefile and is georeferenced to the real world location that the data was collected (left).
We used a color-coded range classification on the map according to the concentration of insects found in it: dark green = low non-destructive numbers of insects , yellow = building populations needing management, to red = insects in damaging numbers (right).

Once the data has been collected, the data collection team can then return to the office, connect the device, download the collected data onto the computer and open in ArcMap. Each shapefile that was originally loaded without attributes should now have attributes populating the shapefile, such as how many insects were found and what field perimeter location they were found. With the data now displayed in ArcMap, symbology for visual display and ease of interpretation can be added. For our application, the symbology is a scale that shows the densities of insects found in each sampling area. A differing degree of colors will be used, dark green will show no detection of insects, yellow will show a moderate population of insects and red will mean that economic damage may by occurring. A color coded classification helps the land managers quickly make assessments about which areas in their field need spraying while leaving areas of the field that do not have any significant amounts of insect populations alone. These maps along with all the details in the attribute data are then made ready for simple transfer to our grower cooperator.

Left: The insect data is overlaid on the base map of the cotton fields on ArcMap's layout view. Here, the data is used to create a map and can have other information added to it like a legend that will tell the client what each colored symbol represents. The outline cast by the image signifies that the map will be able to be printed or exported as a .pdf file without any issues.
Right: The attribute table with values used to create the shapefiles were also included on the final document sent to the grower cooperator. This way the land managers can see other important data such as the total number of insects found and the number of plants observed with insect damage.



After the shapefiles have been edited and given a symbology, the data were then be placed in layout view. Here, the data were given a legend with the color coded symbology. Metadata such as when the data was gathered, map creation and point of contact information were also added. The finished maps are then converted to PDF format and saved to a archiving email address and sent off to the client, after a smartphone txt notifications (all occurring within 12 hours of data collection).

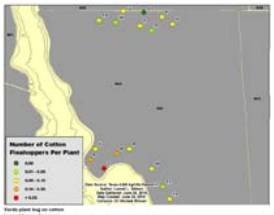
Summary Interpretation

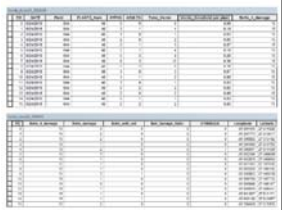
The mapping of crop damaging species of insects in a timely manner required the use of devices that were reliable and affordable. Compared to other systems and devices, ESRI's ArcPad and Trimble's Juno 3B handheld GPS were selected because of their ease of use of the software and solid design of the device. ArcGIS is very flexible software that allows the user to create new shapefiles form scratch and convert them to other file extensions that are compatible with other devices or systems such as the Juno 3B. Capturing the data with the Juno's in the field is easy and quick , it allows the user to simply type in the data and press the save button to create new attributes in different areas of the field. Upon the return to the lab, the Juno can be connected to a computer with ArcMap to download and display the data. ArcMap allows for manipulation editing of the data by adding a symbology and range to the data so that it can be interpreted by the user quickly and accurately. Adding a legend to the map will help the user by serving as a reference guide for what each color's range is so the user can 'see' where the crop is at risk from the pests. Finally, converting the map in to a easily transferable file type such as the PDF allows for easy transmission across the internet.

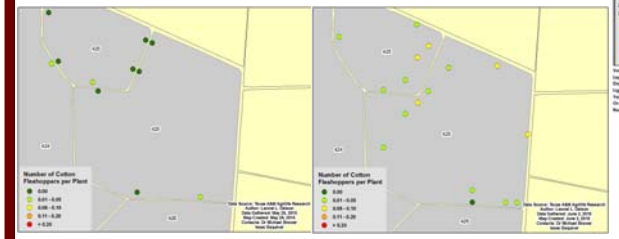
Results

The ultimate output of this GIS application for pest risk assessment are the PDF maps that are created and sent out to the land manager within the same day as data collection in the cotton and sorghum fields. The PDF maps were created to show not only the map but the data that was used to create it. The inclusion of the attribute table along with a legend that describes what each attribute column heading means and represents were added so that the land managers can tell see where the numbers on the map come from and how they were created.

To date, the land managers have embraced the maps and have given mostly positive reviews. Some updates from land manager input led to changing of the basemap color and addition of numbers to each sampling point on the map to correspond with numbers on the attribute table. This has enhanced map readability and transparency.







Both of these maps are of the same fields where Cotton Fleahoppers were found and collected. The one on the left shows Cotton Fleahoppers population numbers form May 26, 2015, the right shows the Cotton Felahoppers population in June 2, 2015. You can see that the number of Cotton Fleahoppers has increased within the span of only a week. These numbers indicate that the Fleahoppers Population is growing and the yellowing dot coding shows the side of the field most at risk to pest damage. The colors and time sequence allows timely and data-driven pest management decisions.

The final output of the entire collection process is a PDF file that contains the map, the attribute table, and metadata (explanations of variables and contact information).

Acknowledgements

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