

STATISTICAL COMMISSION and
ECONOMIC COMMISSION FOR EUROPE
CONFERENCE OF EUROPEAN STATISTICIANS

Working Paper No. 35
English only

Work Session on Geographical Information Systems
(Brighton, United Kingdom, 22-25 September 1997)

Item 6 of the provisional agenda

**USING GEOGRAPHICAL INFORMATION SYSTEMS (GIS) FOR DISSEMINATION OF
U.S. AGRICULTURAL STATISTICS**

Submitted by the National Agricultural Statistics Service, USA¹

¹ Prepared by George Hanuschak, Gale Wade, Michael Craig

* *Note: The version available on WWW contains text only*

I. INTRODUCTION

The National Agricultural Statistics Service (NASS) has the mandated responsibility for all the official agricultural statistics in the United States, including the 1997 Census of Agriculture. NASS staff began to evaluate geographic information systems technology as a data analysis and dissemination tool on a pilot research basis in 1990. NASS staff has also operationally utilized space borne remotely sensed data for construction of the national area sampling frame for agricultural statistics since the late 1970's and, on a research basis, for crop area estimation in selected States. NASS staff created an Internet Home Page in mid-1995 with free access to a considerable portion of the Agency's current and historic agricultural statistics. The combination of the timely and accurate conventional agricultural statistics, GIS, remotely sensed data, and the Internet made it feasible to accelerate the use of GIS and spatial color graphics products availability to the public. Among the relatively new NASS Internet products are spatial color theme maps for crop estimates at the county level and national vegetative index maps, provided on a biweekly basis, and on occasion, weather data contours, such as for an early freeze, overlaid on the vegetative index maps. Several examples will be provided in the body of this paper that illustrate how these new products were of value at important times of crop stress in the United States in the last several years.

II. DATA SOURCES FOR CROP ASSESSMENT AND GIS CAPABILITIES

NASS staff have access to several types of information on crop condition and yield (forecasts and final) during the crop season. First, there is the Weekly Weather and Crop Bulletin, which is an panel of crop experts, such as county extension agents. On a weekly basis, one or two experts per county report on their evaluation of crop stage and condition, including any observations of widespread crop disease or pest outbreaks. The data is then summarized to the Agricultural Statistics District level (a sub-state unit composed of several counties), the State level and the National level. The second type of data is from the Monthly Yield Survey of farm operators. A stratified sample of farm operators is selected from a list frame, and then monthly interviews are conducted to acquire the farmer's projection of crop yield and the final yield after harvest as well. The third type of data on crop yield is from the Objective Yield Survey. A self weighting sample of small plots are layed out in a statistical sample of fields and several types of observations, counts, measurements and weighing are done throughout the crop season. For example, for corn in the first month the plots are layed out and row space measurements and plant counts are collected. As the season progresses, other measurements are taken such as number of ears, the length and diameter of the ears, weights of ears, and several laboratory measurements such as corn shelling fraction and moisture content. After harvest, sample plots are gleaned for any harvest loss grain as well. Yield forecasting models are used during the season utilizing the above information and a final yield is derived using the grain weight and laboratory data and ear population. All three of the above sources of crop condition and yield information are quantified. An expert panel of NASS statisticians meets monthly to set a yield forecast or final estimate, using all of the above sources as inputs.

The newest type of information that NASS staff have about crop condition is vegetative index data from a polar orbiting weather satellite operated by the National Oceanic and Atmospheric

Administration (NOAA). The satellite configuration provides daily data from which a vegetative index can be calculated. The vegetative index used is called the Normalized Difference Vegetative Index (NDVI). The NDVI is the difference of visible light band from the near infrared band divided by their sum. The EROS Data Center in Sioux Falls, South Dakota then composites the daily vegetative index data into a bi-weekly product. The compositing procedure takes the maximum NDVI value for each pixel (one kilometer in size) for the two week period. A theme map of ranges of the NDVI's is then produced by EROS. The NASS staff then produce a ratio image comparing the closest annual calendar bi-weekly period from the previous year, as well as showing the two NDVI images side by side. The major strength of the NDVI data is that nearly complete spatial coverage of the U.S. is acquired and graphically displayed on a bi-weekly basis. For large area events, such as droughts, floods, diseases that reduce plant chlorophyll, or pest infestations that reduce plant chlorophyll, over large land areas (hundreds of thousands or millions of acres or hectares), the NDVI images have shown to be of considerable value in an early warning sense. The next two sections of this paper demonstrate such examples. However, there are also several limitations of the NDVI images. One of the major limitations has already been mentioned and that is the spatial resolution which is limited to one kilometer (approximately 230 acres). A second limitation which can vary from period to period is the amount of cloud cover on the composite image. When there is substantial cloud cover on the image, the author's observation has been that the pixels adjacent to the cloud covered areas also become questionable and usually are artificially low. A third limitation is that viewing only the images without a good working knowledge of crop stage and development for both years could lead to some questionable conclusions.

ARC/INFO GIS software is used to produce the graphic illustrations in this document. An enhanced Sun workstation is the hardware platform for the GIS work. However, since the Agency has 45 field office locations, a PC based software system, MAPINFO, has recently been distributed to these offices and similar GIS applications can be done at the State level. The Internet graphics files of the NDVI images found on the NASS Home Page at <http://www.usda.gov/nass> are formed by converting the ARC/INFO outputs to a gif format.

III. MAJOR FLOODING OF CROPLAND IN U.S. DURING 1993 SUMMER SEASON

The 1993 crop season for the major national crops of corn and soybeans was indeed a memorable one that ended with substantially reduced corn and soybean production levels due to several major weather related problems. First, there was late planting in several major States due to cool and wet weather during the spring season. For example, the percent of corn area planted for the U.S. was about two weeks behind normal in early May. Figures 1-4 illustrate the late planting for the States of Illinois, Iowa, Minnesota and for the U.S. (17 major corn producing States). Secondly, there were excessive rains during the early summer months of June and July that led to flooding of substantial corn and soybean area. Special surveys, based on interviews of farm operators, from both list and area-based random samples, were conducted in July and indicated that 4.5 million acres of corn and soybeans, in the midwestern U.S., were lost or abandoned after planting. The NASS staff were also monitoring NDVI images starting in late June. The image covering the bi-weekly period of June 25-July 8 showed extensive amounts of cropland, especially in northcentral Iowa and southcentral Minnesota, with much lower NDVI values than the previous year. Figures 5 and 6 illustrate this. The much lower values indicated water saturated fields. One of the effects of the saturated fields, that took weeks to dry out, was leaching of nitrogen from the soil which was one factor in the reduced yield potential. The Chief Economist and the Secretary of Agriculture each kept a series of the NDVI images for the entire corn and soybean seasons on display in their offices. Figure 7 shows the midwestern U.S. Crop Moisture profile as of July 3, 1993. As the season progressed, there were several more negative factors concerning lost yield potential for the corn and soybean crops in midwestern States. By the October Crop Report, another 750,000 acres were abandoned. Then in early October, a killing frost hit Minnesota, northern Iowa, South Dakota and Wisconsin and also moved across most of the Corn Belt by mid-October. The early freeze on corn and soybean crops that were already behind in their development was quite devastating. The number of accumulated growing degree days between the time period when the corn crop is 50 percent silked to the first fall freeze was dramatically shorter in 1993 compared to 1992. In fact, there were 27 less accumulated growing degree days during the specified portion of the crop season in 1993 when compared to 1992. The final end of season county level yield GIS maps are shown, in Figures 8-11, for both corn and soybeans for 1992 and 1993. As one can see from these maps, there is a yield hole in the 1993 maps that cuts through northern Iowa and southern Minnesota and considerable portions of the midwestern U.S. Corn Belt, compared to the 1992 maps.

IV. LARGE AREA DROUGHT IN U.S. WINTER WHEAT CROP OF 1996

The crop season for the southern Great Plains winter wheat crop, planted in the fall of 1995 and harvested in the summer of 1996, had several negative weather event effects that led to considerable abandoned acreage and reduced yields. The winter season (December 1995 - February 1996) was unusually dry, cold and windy. The early spring season brought little relief as precipitation was still quite rare. The Hard Red winter wheat area of eastern Colorado, into southwest Nebraska, western Kansas and Oklahoma, and the Texas panhandle was the driest since 1896, according to the U.S. National Weather Service. High winds swept the Plains States on April 25, lifting dust from the dry fields. States encompassing this territory plus South Dakota had apparent abandonment of 11.1 million winter wheat acres by May 1. Figure 12 shows the long term Palmer Drought Index for the southwestern U.S. as of May 11, 1996. The southwestern Region was under considerable stress due to lack of precipitation. There were some limited beneficial rains in late April and in May, for only a relatively small portion of the effected region. The NASS Objective Yield Survey data was also indicating reduced wheat head counts for the region. Starting in late March, the NASS staff began to monitor the NDVI vegetative index maps. Three time periods are shown in Figures 13-15 which have the 1995 and 1996 maps side by side. The NDVI maps show the rather dramatic difference in vegetation patterns between the two years. The first images for March 29 - April 11, Figure 13, show a very dramatic difference in vegetation between the two years as the lack of vegetative progress for 1996 is due to a long cold, windy, dry winter. The second set of images for April 26 - May 9 Figure 14, show a continued dramatic difference in the NDVI values for the two years. The Secretary of Agriculture requested extra copies of the images to be passed out to the agricultural media immediately after the May Crop Production Report. Observe the clouds in the 1995 image in westcentral/central Kansas and the low NDVI values surrounding the clouds. This is an example of when the composite NDVI image has clouds and the NDVI values surrounding the clouded area are also artificially low as they passed the cloud screening algorithm but don't reflect current vegetative conditions on the ground. The 1996 image is, however, cloud free and was the major image of interest for the drought situation. Figure 15 shows images from May 24 - June 6 and there is some more vegetative recovery from the Figure 14 images, especially in the eastern half of Kansas. Some of the limited rainfall in these areas at least prevented further declines in yield potential for winter wheat but in general for the region, it was too late for much yield recovery. Figure 16 shows the ratio of the season final winter wheat production for 1996 to 1995 for the States of Kansas and Oklahoma for the largest producing counties. Counties with less than 25,000 harvested acres were masked out in Figure 16. For contrast to the major drought and the cold, windy winter for the 1996 winter wheat crop in Kansas, the current (June 1) forecast for the 1997 winter wheat crop shows 1.9 million more acres available for grain harvest and production up an additional 43 percent above the 1996 crop.

SUMMARY

The use of geographic information systems software was valuable in releasing and explaining two relatively recent and major crop disasters in the United States. GIS enabled crop analysts to follow the temporal and spatial departures, for two quite unusual crop years, from historic years. The major flood of 1993 in the midwestern U.S. Corn Belt and the 1996 drought in the Southern Great Plains were illustrated with GIS graphics displays of all the various sources of data used to monitor and follow these events. Of course, GIS is only part of the tool set for data dissemination and the timeliness and accuracy of the underlying data sets remains the most important ingredient in the recipe for high quality agricultural statistics.

REFERENCES

- Allen, R., 1994. Forecasting Crop Acreages and Yields in the Face of and in Spite of Floods. U.S. Department of Agriculture, National Agricultural Statistics Service.
- Allen, R., G. Hanuschak, M. Craig, 1994. Forecasting Crop Acreages and Yields in Spite of and in the Face of Floods. (United Nations FAO, Eurostat Conference on Crop Yield Forecasting Methods, Villefranche-sur-Mer, France.
- Crop Production Report. May 10, 1996. USDA, National Agricultural Statistics Service.
- Crop Production Report. June 12, 1996. USDA, National Agricultural Statistics Service.
- Crop 1996 Annual Summary Report. USDA, National Agricultural Statistics Service.
- Crop Production Report. June 12, 1997. USDA/NASS, Kansas Agricultural Statistics Service.
- Doraiswamy, P., G. Hart, M. Craig, and P. Cook, 1994. The Anomalous '93 Growing Season -- How USDA Used AVHRR Data. Photogrammetry and Remote Sensing and the American Congress of Surveying and Mapping, Annual Convention, Phoenix, AZ.
- Eidenshink, J.C., 1992. Description of the 1992 AVHRR Conterminous U.S. AVHRR Data Set, U. S. Geological Survey, EROS Data Center, page 4.
- Holben, B., 1986. Characteristics of Maximum Value Composite Images from Temporal AVHRR Data, International Journal of Remote Sensing, 6:1271-1318.
- Korporal, K.D., and N.M. Hillary, 1993. The Statistics Canada Crop Condition Assessment Program, Statistics Canada Publication, Ottawa, Canada.
- Loveland, T.R., J.W. Merchant, D.O. Ohlen, and J. F. Brown, 1991. Development of a Land-Cover Characteristics Database for the Conterminous U.S., Photogrammetric Engineering & Remote

Sensing, 57:1453-1463.

Perry, C.R., Jr., and L.F. Lautenschlager, 1984. Functional Equivalence of Spectral Vegetation Indices. *Remote Sensing of Environment*, 14:169-182.

Tucker, C.J., C.O. Justice, and S.D. Prince, 1986. Monitoring the grasslands of the Sahel 1984-85. *International Journal of Remote Sensing*, 7:1571-1581.

Wade, G., R. Mueller, P. Cook, and P. Doraiswamy, 1994. AVHRR Map Products for Crop Condition Assessment: A Geographic Systems Approach. *Photogrammetric Engineering & Remote Sensing*. Vol. 60 No. 9, pp. 1145-1150.

ACKNOWLEDGMENTS

The authors wish to extend their special thanks to the USDA/NASS staff members from the Spatial Analysis Research Section, the Field Crops Section, the State Statistical Offices involved and to Rich Allen, the Chairperson of the Agricultural Statistics Board of NASS.

DISCLAIMERS

The opinions and judgements expressed in this paper are those of the authors and do not necessarily reflect those of USDA or NASS. Reference to any commercial products is for completeness only and does not constitute an endorsement of these products.