DETECTING POTATO FIELDS IN THE COLUMBIA BASIN USING LANDSAT MULTISPECTRAL DATA*

Paul R. Baumann
Department of Geography
SUNY College at Oneonta
Oneonta, NY 13820

ABSTRACT: Cropix, Inc., a commercial company, was established in 1984 for the purpose of monitoring the growth and extent of the yearly potato crop in the Columbia Basin using digital remote sensing techniques. It provides an annual Columbia Basin Potato Survey to processing plants and farmers in the region. To obtain this information various image processing classification techniques are employed to identify and separate potatoes from other crops. Pivotal irrigation is used extensively within this semi-arid region. This study centers on a 12,500 acre farm near Hermiston, Oregon which grows several different crops including potatoes. Excellent ground truth information exists for this farm, and four 1985 Landsat MSS data sets are available covering the growing season from May to August. Several classification techniques are tested to determine what initial results can be ascertained from the MSS data with respect to detecting potato fields. This paper presents the results of these classifications.

INTRODUCTION

Cropix, Inc., a remote sensing and computer consulting company, was established in 1984 for the purpose of monitoring the growth and extent of the yearly potato crop in the Columbia Basin using digital remote sensing techniques based on Landsat and SPOT imagery. It provides an annual Columbia Basin Potato Survey and certain map products to nine processing plants and numerous farmers in the region. To obtain this information Cropix has developed different image processing classification techniques to identify and separate potatoes from other crops grown in the Basin such as wheat, corn, barley, and alfalfa.[1] The accuracy detection level, based on these techniques, is about 95 percent, a very high level but in providing information to people making decisions about the use of their farmland, one needs to obtain the highest accuracy level possible. Pivotal irrigation is used extensively within the region allowing the sage/range vegetation associated with the semi-arid conditions to separate well from cropland. This study centers on a 12,500 acre farm near Hermiston, Oregon which grows several different crops including potatoes. Detailed field records and good imagery are available for this particular farm. The primary goal of this study is to develop an image processing technique that provides an accuracy level greater than 95 percent for detecting potatoes. This particular paper represents the preliminary stage in this study and deals with some initial analyses of the Landsat data sets.

EASTERN OREGON FARMING COMPANY

The study area is the Eastern Oregon Farming Company which is owned and operated by

*The author wishes to express his deep appreciation for the assistance received from the Eastern Oregon Farming Company and Cropix in providing farm data and imagery. Without this type of data, the author would not have been able to verify the effectiveness of the different image processing techniques being tested.

Frank Lamb who also runs Cropix. With several other large potato farms, the Eastern Oregon Farming Company is located in northeast Oregon near Hermiston and Interstate 84. The Columbia River lies only three to four miles north of the farm and provides the farm with the necessary water to maintain its fields. The farm stretches across a large flat surface situated about 50 feet above the river at an elevation ranging from 140 to 190 feet. It maintains eighty-nine pivotal irrigation fields, seventy of which are one-fourth mile in diameter. The other fields are either smaller in size or partial circular fields. The total acreage for the farm is about 12,500 of which 10,335 acres are in cropland. Although the circular fields are laid out to make the most efficient use of the space and irrigation lines, much of the acreage which is not being used for cropland is empty area in between the fields.

In 1985, due to contractual arrangements with processing plants and general market conditions, the farm decided to plant twenty-four fields of potatoes and put its other fields in alfalfa, wheat, barley, and oats. Twenty fields were planted in Russet's and the remaining four fields in Norgold's potatoes. The fields were planted in late March through late April, a time difference which varied the growth cycle of each field, and thereby, the type of satellite detection at the different recording dates. Twenty-two fields were planted in winter wheat, seeded from October 1 through November 8, 1984 and harvested throughout the spring and summer of 1985. Each of these fields contained a summer 1984 potato crop. Due to winter wheat kill, resulting from a cold spell during the 1984/85 winter, small sections of ten fields had to replanted in late March. Eleven fields were in barley, five in spring barley which were planted in early March and six in winter barley which were planted in the first half of October, 1984. Alfalfa, the most common crop, accounted for thirty fields, eleven of which were planted from late July through August, 1985. Most of these eleven fields were previously planted in winter wheat; consequently, these fields went through more than one crop use during the 1985 summer. The other fields were planted prior to 1985 with the earliest field being planted in 1980. Farmers do not have to replant alfalfa every year since the roots stay alive during the cold season. Also, they like to use alfalfa to build up fields previously planted in other crops, such as wheat and corn, which consume large amounts of nitrogen. Oats were grown in two fields and corn, not grown in 1985, was planted in six fields in 1984. Due to the growth cycle of these different crops and the planting and harvest dates of the fields a complex land cover pattern existed on this farm which had to be considered in analyzing the classified images. The cropland patterns associated with this farm are typical of many of the large potato farms in the Columbia Basin served by Cropix.

GROUND TRUTH AND SATELLITE DATA

Excellent ground truth information existed for this farm, and four 1985 Landsat MSS data sets, which included the farm area, were available for the summer growing season from May to August. The ground truth information consisted of 1984 and 1985 field maps identifying the crop planted in each field and records showing for each field the planting, emergence and harvest dates, acreage, and amounts and types of fertilizers used. Having this information, which corresponded in time with the MSS data sets, assisted greatly in checking classification accuracy and identifying problem conditions. The four data sets, covering the dates of May 21, June 22, July 8, and August 25, 1985, were rather evenly spread across the growing season. The data sets were 512 elements by 512 scan lines in size and free of any clouds. The low humidity conditions related to the semiarid environment allowed the dynamic data ranges of the spectral channels, especially the infrared channels, to be quite large relative to the maximum potential data range of 127. With large dynamic data ranges, data separation is greater which could create better

classification conditions. In addition, a twelve channel data set was established by merging together channels 2-4 of the four individual data sets and from this new data set a principal components data set was developed.

ANALYSIS AND FINDINGS

Rather than classify an entire 512 x 512 data set, the study centered on a rectangular area that covered the farm and adjacent land, an area of 224 elements by 125 scan lines in size. SEARCH, a computer algorithm developed by NASA, was used to scan the portion of the data sets corresponding to the study area and to develop spectral classes based on the statistical nature of the spectral data.[2] For the four monthly data sets the following number of spectral classes were generated: May (65 classes), June (55 classes), July (63 classes), and August (54 classes). The twelve channel data set permitted a great number of various channel combinations to be tested, too many to be handled within the scope of this paper. However, one combination consisting of four infrared channels, one from each of the four months, was tested using SEARCH and produced 29 spectral classes. The four channels selected had the four greatest dynamic ranges within the data set. The principal components data set also consisted of twelve channels, but the first six channels accounted for 98.406 percent of the variance within the data set. These six channels used in conjunction with SEARCH created 23 spectral classes. In developing these spectral classes the same SEARCH parameters were employed with each data set eliminating a great amount of potential bias in testing the different data sets. Each set of spectral classes along with its respective data set was processed using the maximum likelihood technique to produce a statistically classified image. An analyst checked each spectral class displayed on the classified image to determine the best land cover condition to be associated with each class. This checking was done in conjunction with the provided farm records.

The statistically classified images produced from the four individual monthly data sets identified clearly those crops reaching maturity at the point in time that the satellite scanned the area. The May image clearly detected the winter wheat and barley fields. Winter wheat and winter barley would have been at a strong "green" stage in growth at this point in time and easy to separate from the dry, natural vegetation. These two crops could not be easily separated at this time period and no separation existed between spring and winter barley. The spring barley fields were already two and one-half months into their growth cycle and reaching maturity. Selected alfalfa fields appeared to be reaching maturity but most fields showed indications of the alfalfa being cut. The potato fields were not identifiable.

The June classified image showed definitely the potato fields but they were difficult to isolate from certain alfalfa fields. According to the 1984 and 1985 field maps most of these alfalfa fields contained winter wheat in 1984 which would have been planted in fall 1983 and harvested in late July or early August of 1984. In early August 1985, these fields were planted in alfalfa. However, what is not known is what these fields contained from late summer 1984 to mid-summer 1985. The winter wheat and barley fields were at a mature stage at this time and nearly ready for harvesting, especially barley, which made it difficult to separate these fields for general vegetation.

The Russet potato fields were well defined in the July classified image but could not be completely separated from certain alfalfa fields. The Norgold fields were not well defined and appeared to be beyond the peak of their growth period. Many of the other fields gave the appearance of being fallow. In the August classified image, three Norgold fields and four Russet fields had been harvested and could not be separated from the other non-active fields. Again certain alfalfa and Russet fields were spectrally similar and could not be divided. Some type of preparatory work was being done on five wheat fields getting them ready for fall planting.

With the combination classified image, potato fields were well separated from other fields except for sections of certain alfalfa fields. However, Russet and Norgold fields could not be separated from each other. The final classified image, based on the principal components data set, possessed results similar to the combination classified image. Except for one field which was identified as having alfalfa, the classification accuracy of potato fields was in the 92-95 percent range. The problem alfalfa field was planted on August 18, 1984 and cut several times during the 1985 growning season. The type of seed used on this field was different from the type used on the other alfalfa fields and the cut yield for this field was low, especially on its first cutting. Also, this field was cut four times in 1985, three of which occurred a few days immediately after three of the satellite images were taken. Consequently, this field could have been at a high level of greeness. The principal components classified image separated those potato fields harvested before the end of August in comparison to those harvested in September and October. Also, the edges of the fields were poorly defined, being intermixed with other land cover.

CONCLUSION AND FUTURE WORK

Although both the combination classified image and the principal components classified image contain certain problems with respect to classification accuracy, they provide much better results in identifying potato fields than any of the four individual monthly images. Additional work is needed on the individual monthly images in order to improve their their classification accuracy. Cropix needs not only good, accurate results at the end of the growing season but also at the beginning and throughout the season. Changing some of the parameter values on SEARCH might create better results. The next stage in this study is to produce an ancillary data layer and incorporate it into the respective data sets. This data layer will contain the geographic location and spatial dimensions for each field and will identify each field as a separate entity with its planting, emergence, fertilizing, and harvest records. Using this new data layer the various classified data sets will be examined through the process known as "postclassification class sorting."[3] This process has been successfully used to improve classification accuracy under more complex land cover conditions and should be an effective means to address the problem of detecting potato fields.[4]

1.George R. Waddington, Jr. and Frank G. Lamb, "The Commercial Use of Satellite Data to Monitor the Poato Crop in the Columbia Basin," Technical Papers: 1990 ACSM-ASPRS Annual Convention, Denver, CO., Vol. 4 pp. 379-388.

2.NASA Earth Resources Laboratory, ELAS: A GeoBased Information System (NASA/NSTL:Earth Resources Laboratory, 1980), Appendix B-3.

3.Charles F. Hutchinson, "Techniques for Combining Landsat and Ancillary Data for Digital Classification Improvement," Photogrammetric Engineering and Remote Sensing, 1982, Vol. XLIII, No. 1, pp. 123-130.

4.Paul R. Baumann and James B. Greenberg, "Postclassification Class Sorting in Creating a General Land Cover Inventory," Technical Papers: 1990 ACSM-ASPRS Annual Convention, Denver, CO., Vol. 4, pp. 53-59.