Drought and its effect on vegetation, comparison of Landsat NDVI for Drought and non-drought years related to Land use Land cover classifications.

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Abstract:

The purpose of this study is to analyze the effects of drought on various land use and land cover types. Imagery was selected for both drought and non-drought conditions based on precipitation data. The Normalized Difference Vegetation Index (NDVI) was then calculated for both images in order to detect the amount of change within the study area. The NDVI images were then analyzed for change for selected USGS land use/cover classification to determine which classification was the most susceptible to drought in terms of reduced NDVI values.

Introduction:

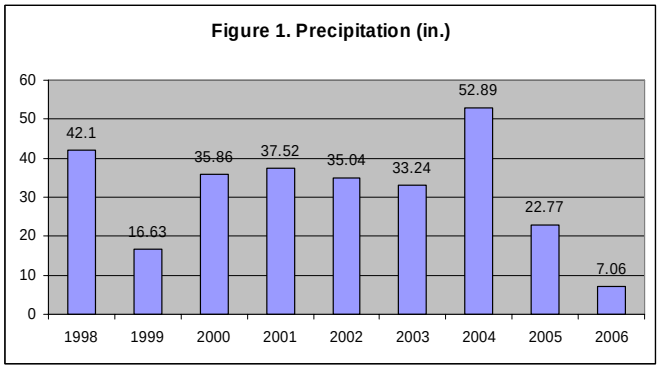
Many studies have been done on the effects of drought and its relation to the Normalized Difference Vegetation Index (NDVI). It has been well documented that there is a direct correlation between the NDVI and the amount of stress vegetation is experiencing. The purpose of this project will be to determine drought effects on NDVI in the San Antonio region and also the effects on selected land use land cover types within the region to determine which type is most susceptible to drought conditions.

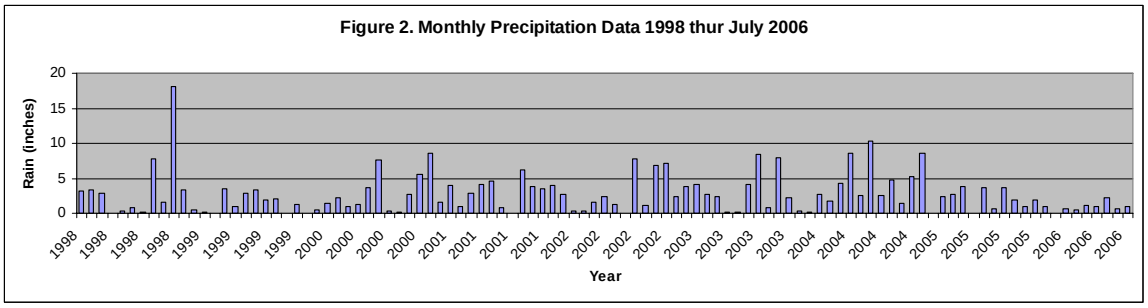
Texas is currently under severe drought conditions and has been for the previous year. Precipitation data suggests that rainfall is several inches below normal. In order to determine the effects of drought and make a statistical comparison to non-drought years it is necessary to identify drought periods. Rain gauge data was used to determine dry periods and Landsat imagery will be used to derive NDVI using ENVI software.

Data:

Precipitation data was downloaded and compiled from the NOAA internet site in order to determine years of drought vs. non-drought conditions using the yearly average of precipitation. Normal rainfall for San Antonio is approximately 30-inches per year

[http://www.srh.noaa.gov/ewx/html/cli/satcli.htm]. The data analyzed (1998 to present) revealed two dry periods. These include the current drought condition and a dry period that took place in 1999. **Figure 1** presents the yearly precipitation data for 1998 thru July 2006. **Figure 2** presents a time series rainfall by month from January 1998 thru July 2006.





From **Figures 1** and **2** it is easily observed that there are two years suitable to analyze imagery for drought conditions. These are 1999 and 2006. For this study 1999 will be used to analyze drought conditions as 1999 had precipitation levels 14-inches below normal. The year 2002 will be used for non-drought conditions. It should be noted that even though the rainfall appeared normal for the 2002 image, much of the central Texas area was still under drought conditions.

Imagery Data:

Data was downloaded from the Texas View Remote Sensing Consortium webpage. In order to select images to show differences in drought vs. non-drought conditions the 1999 image be used for drought. The 2002 year was used for the non-drought condition. The downloaded imagery was in the National Land Archive Processing System Data Format (NDF) format. Specifically, the header file (H1) and band 3 and 4 (I3 and I4) were used for processing. The 2002 image was acquired 11/13/02 at 16:51. The 1999 image was acquired 10/20/1999 at 16:56. These images were also selected due to their closeness in seasonal timeframe.

Land use and land cover data LU/LC collected by the USGS NMD is useful for environmental assessment of land use patterns with respect to water quality analysis, growth management, and other types of environmental impact assessment. The Landuse Landcover shapefile was downloaded from the TNRIS website. It was used to refine the study area and also for comparison of effects of drought on different Land use land cover classifications in terms of drought effects on vegetation (NDVI).

Methods:

Study Area:

For this project a study was selected in the San Antonio region. Figure 3 illustrates the geographic extent of the study area. The specific area was refined by using a Land Use Land Cover shapefiles in order to simplify classification. Four LULC tiles were selected form the LULC shapefile which comprised an area of approximately 2,400

square miles and also 21 different land classification types. The types represented and the areas for each type in the study area are provided in **Table 1**. **Figure 4** provides the geographic extent for each LULC class in the study area.

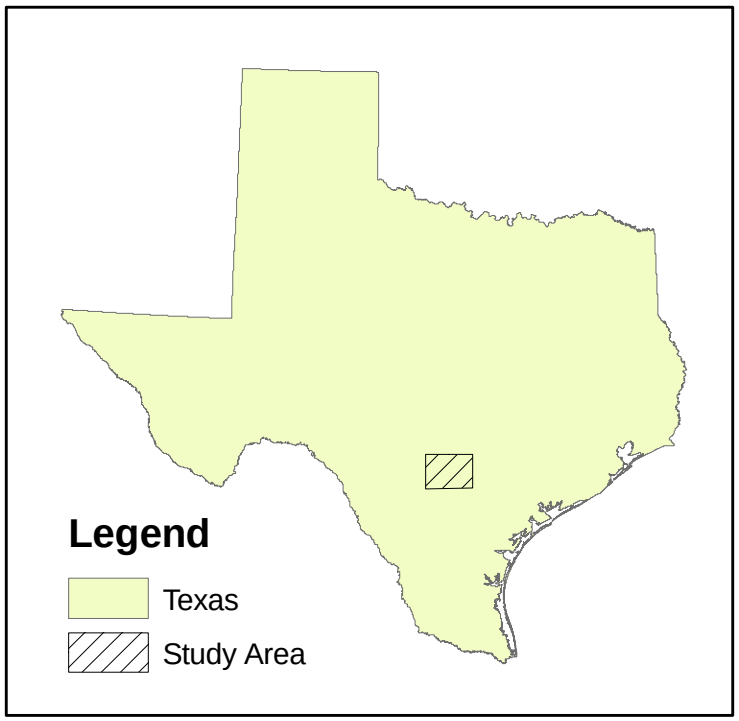


Figure 3. Study area.

TABLE 1. Land use Landover (LULC) types and areas within study area.

LULC CODE	Description	Used For Study	Square Miles
42	Evergreen forest land	X	214.867
11	Residential	X	161.181
14	Transportation, communication, utilities		19.283
75	Strip mines, quarries, gravel pits		12.488
21	Cropland and pasture	X	1325.998
32	Shrub and brush rangeland	X	206.609
24	Other agricultural land		8.023
41	Deciduous forest land	X	230.461
17	Other urban or built-up land		30.281
76	Transitional areas		30.254
13	Industrial		4.284
12	Commercial and services		42.945
53	Reservoirs		14.844
33	Mixed rangeland		42.971
16	Mixed urban or built-up land		6.833
43	Mixed forest land	X	66.318
23	Confined feeding operations		0.782
31	Herbaceous rangeland		1.196
62	Non-forested wetland		0.106
22	Orchards, groves, vineyards, nurseries, and ornamental horticultural		2.606
52	Lakes		0.093

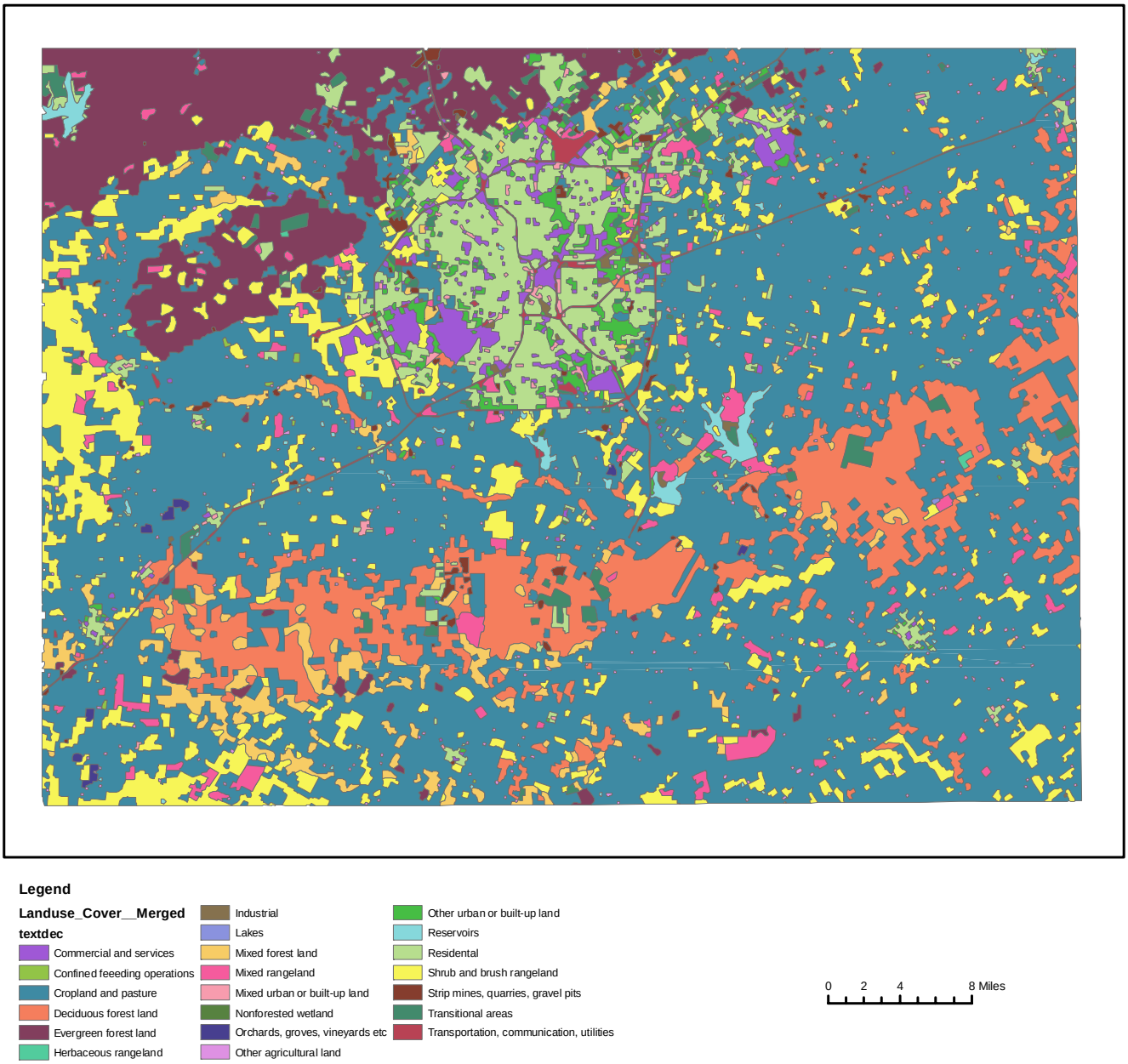


Figure 4. Landuse Landcover Classification within study area.

Image Preprocessing:

Image preprocessing included clipping the original images to the study area. This was accomplished by creating a shapefile in ArcView from the Landuse Landcover shapefile, which was imported into ENVI and used to clip the original images. The Dark Object Subtract method was used to adjust images to remove all atmospheric interference.

Change Detection:

In order to determine the effects of drought condition the Normalized Difference Vegetation Index (NDVI) was used. The NDVI is the ratio between the maximum absorption of radiation in the red (R) spectral band (0.66 μm) versus the maximum reflection of radiation in the near infrared (NIR) spectral band (~0.83 μm). For Landsat image (TM or ETM+ image), they are band 3 and band 4, respectively. NDVI images were created for both the 1999 and 2002 using the ENVI built in NDVI tool.
For this study change is defined as a change in the mean of the NDVI pixel values for the study area between the two images (1999 and 2002). Change was evaluated for 1) overall change in NDVI pixel vales for the entire study and 2) selected LULC classification areas. The individual change detection for each LULC class was preformed in order to determine which class was most affected by the drought conditions during 1999.

In order to find the change for selected land classes it was necessary to first merge all polygons of the same classification in the LULC shapefile into one polygon for each

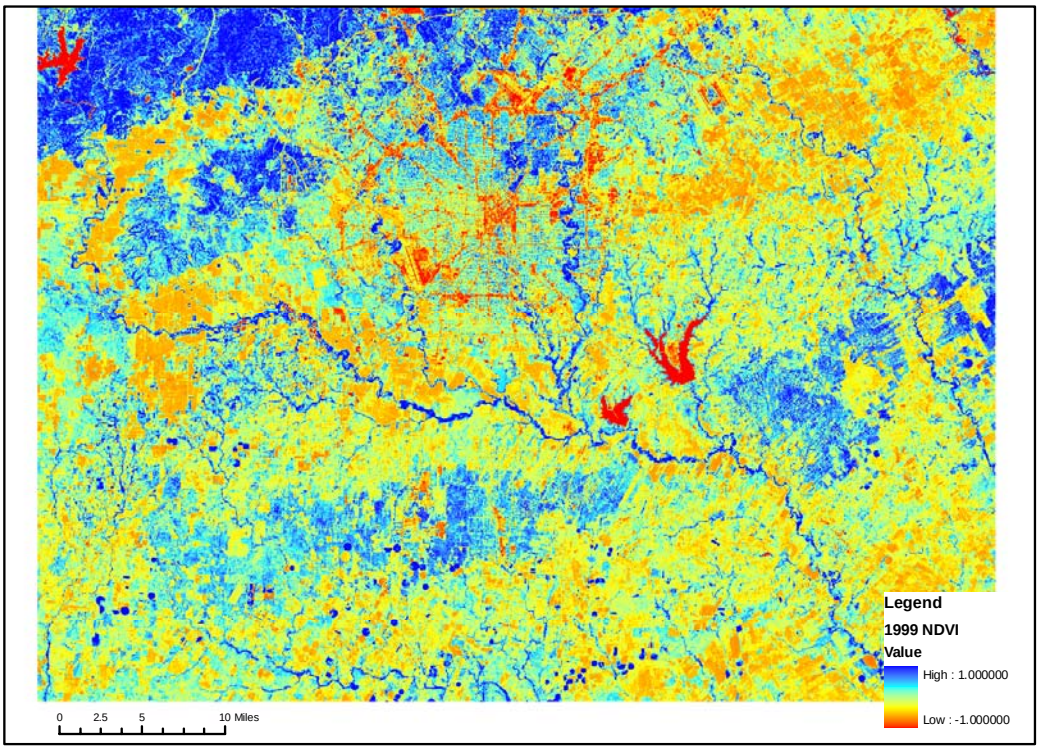
class. After merging polygons selected LULCs were exported to individual shapefiles and then imported into the ENVI software to use as Regions of Interest (ROI). This allowed for computation of NDVI statistics for each ROI/LULC classification for the NDVI images. The selected LULC classification types used to detect change are also provided in **Table 1.** This process was performed for both the 1999 and 2002 images (drought and non-drought conditions), and the results were compared to determine the droughts effects upon selected LULC types.

Results:

The NDVI images for 1999 and 2002 demonstrated a noticeable change in the overall NDVI values. **Figure 5** presents the NDVIs for both years. There are more pronounced and concentrated low NDVI areas for the 2002 image (red); however the 1999 has a larger area that is affected by the drought and is represented by the orange areas. The means for images changed from 0.195 in 1999 to 0.361 in 2002. **Figure 6** provides the histograms for both NDVI images.

The same trend observed in the overall image was also observed for the selected LULC classified areas. The crop and pasture land classification had the highest percent change between the two NDVI images; mean NDVI value change form 0.147 to 0.346 resulting in a 40 percent change due to drought effects. **Table 2** presents descriptive statistics and percent changes for the selected land classifications evaluated. Deciduous forests and Evergreen forest land classification (LULC 41 and 42) experienced the least effects from the drought as the two classes changed 10 and 11 percent respectively.

A



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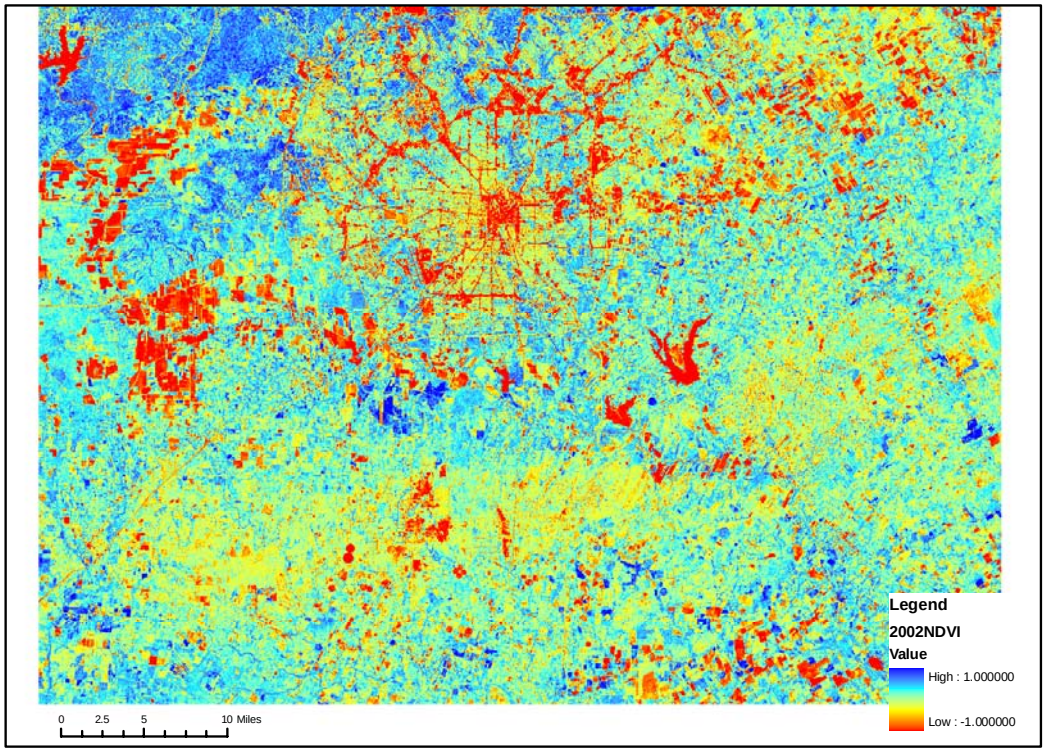

Figure 5. Normalized Difference Vegetation Index (NDVI) for A) 1999 and B) 2002.

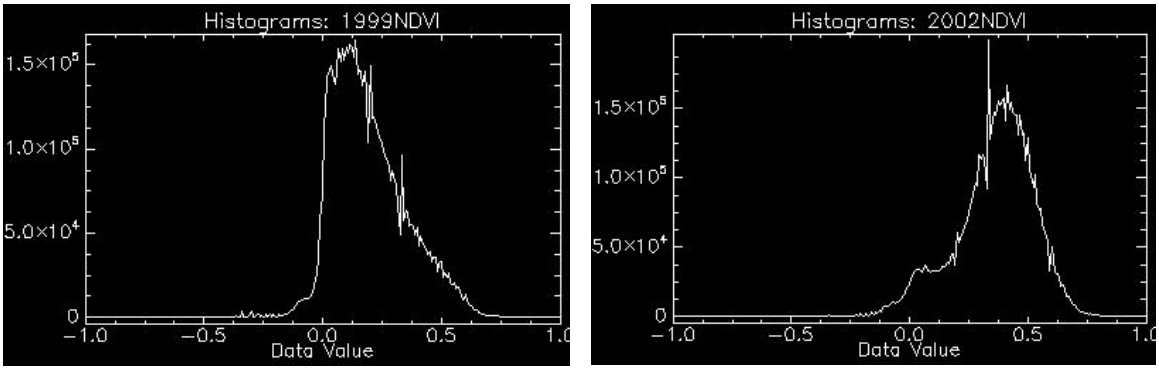

Figure 6. NDVI histograms for 1999 and 2002.

Table 2. Descriptive statistics for NDVI values for selected Land use land cover classifications.

		1999 NDVI Values				**2002 NDVI Values**				% Change
Code	**Land Classification**	**Min**	**Max**	**Mean**	**Stdev**	**Min**	**Max**	**Mean**	**Stdev**	
11	Residential	-0.767	0.758	0.233	0.153	-0.730	0.832	0.349	0.165	19.81
21	Cropland and Pasture	-0.735	0.827	0.147	0.125	-0.714	0.882	0.346	0.165	40.30
32	Shrub and brush rangeland	-0.652	0.796	0.224	0.119	-0.529	0.873	0.427	0.127	31.13
41	Deciduous Forest Land	-0.797	0.848	0.290	0.137	-0.605	0.845	0.355	0.118	10.08
42	Evergreen Forest Land	-0.895	0.770	0.375	0.163	-0.736	0.871	0.467	0.165	10.95
43	Mixed forest Land	-0.760	0.795	0.269	0.141	-0.636	0.803	0.388	0.134	18.16

The residential and mixed forest land experienced a 19.8 and 18 percent change respectively. Shrub and rangeland showed a 31 percent change in NDVI values. Figure 7 presents the histograms for the selected LULC classifications within the study area.

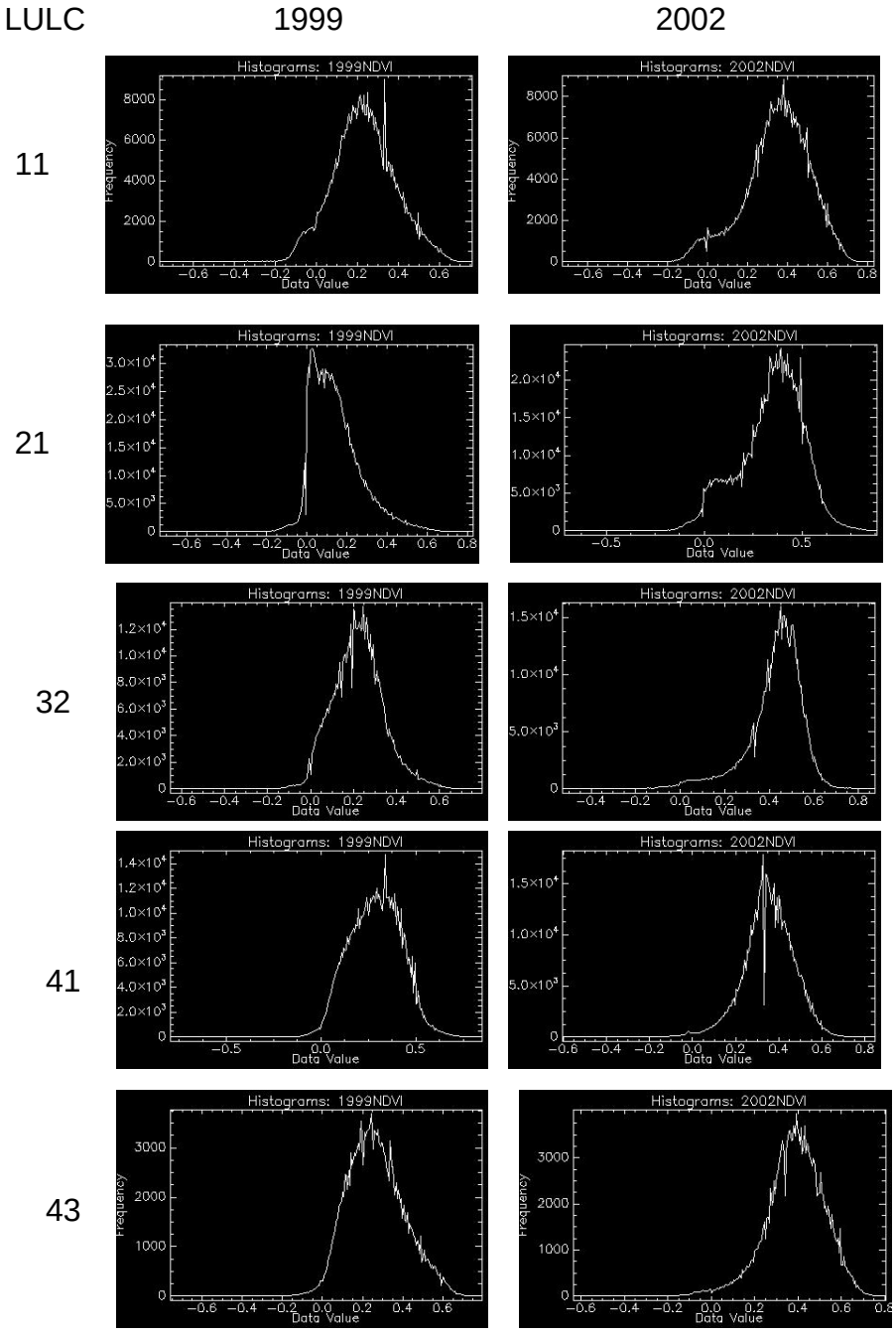

Figure 7. NDVI Histograms for selected LULC classifications for 1999 and 2002. **11**. Residential, **21.** Cropland and Pasture, **32.** Shrub and brush rangeland, **41.** Deciduous Forest Land, and **43.** Mixed forest Land.

Conclusions:

Overall there was a decrease in the NDVI values for drought conditions as expected. Of the specific land classifications that were evaluated the non-native vegetation types appeared to be more negatively effected by drought. Croplands and pastures were the most effected land classification; however there are several factors that occur in this class including irrigation and harvest that could have skewed the results.

The NDVI method used to evaluate the vegetation health could have been flawed. Further research needs to be conducted to determine the exact procedures the built in NDVI tool in the ENVI software. Additonally, the LULC shapefile used to create the ROIs for this study are generalized and may be, in some areas, out of date. The land use land cover classification could be further refined using the ENVI software to create more precise classifications which could be used to identify land cover types that provide a more accurate measure of the effects of drought. However, this technique would be subject to operator discretion and could provide different results between studies based on the operators classifications.

This technique could be applied to any number of thematic map types including soil types, elevation, eco-regions etc. It provides a simple tool to evaluate the effects of the classification type on the NDVI. However, caution should be observed as there are many factors that contribute to the NDVI, most importantly, drought.

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