Shoreline Management Plan Revision and Master Plan Supplement

Environmental Impact Statement

Vegetation Change Analysis

Eufaula Lake, Oklahoma

Prepared for:

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Contents

Figures:

Acronyms

ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
ERDAS IMAGINE	A software product of ERDAS, Inc.
ETM+	Enhanced Thematic Mapper Plus
FIR	Far-infrared energy spectrum
GLOVIS	Global Visualization Viewer
IR	Middle infrared energy spectrum
ISODATA	An algorithm for classify multispectral data
Landsat	Land + Satellite
m	meter
MP	Master Plan
NASA	National Aeronautics and Space Administration
NDVI	Normalized Difference Vegetation Indices
NEPA	National Environmental Policy Act
NIR	Near infrared energy spectrum
ODWC	Oklahoma Department of Wildlife Conservation
RBG	Red-blue-green energy spectrum (visible light)
SMP	Shoreline Management Plan
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VNIR	Visible and Near Infrared energy spectrum

Section 1

Introduction

The purpose of the vegetation change analysis is to evaluate changes in vegetation and land cover at Eufaula lake since the late 1990s. U.S. Army Corps of Engineers (USACE) actions on government-owned lands, such as approval of shoreline use permits for the construction of private docks or vegetation modification may affect vegetation near the shoreline. In addition, the Eufaula Lake Shoreline Management Plan (SMP) shoreline allocations and Master Plan (MP) land use classifications may influence land use on private lands adjacent to USACE-owned lands along the lakeshore. Over time, these direct and indirect effects of shoreline allocations may affect the natural vegetation and habitats around the lake. The vegetation change analysis is intended to evaluate whether and how the vegetation around the lakeshore may have changed over the past decade since the last revision of the SMP.

Past revisions of the SMP have changed the amount and locations of areas allocated as Limited Development. The 1998 SMP revision allocated 271 miles of shoreline as Limited Development. Residential development on adjacent private lands has steadily increased over the past decade. In addition to formal approval to mow or thin vegetation or construct improved access paths on the USACE-owned lands along the lakeshore, adjacent residential development may also result in an increase in informal trails or access paths to the water. This increased activity and informal trail development may also affect vegetative cover.

Alteration of the vegetation could affect habitat values and increase erosion and sedimentation in the lake. Prior SMP revisions increased the amount of shoreline allocated as Limited Development, but potential effects of this allocation have not been previously evaluated. This analysis evaluated whether there have been significant changes in the vegetation around the lake and whether there are observable differences between areas with different shoreline allocations or varying levels of development on adjacent private lands. This analysis may also help inform the decisions about how much shoreline to allocate to each SMP designation and MP land use classification under the current proposed revision of the SMP and MP.

It may be reasonably expected that residential development would be more likely to occur adjacent to shorelines allocated as Limited Development because of the opportunity to construct private floating facilities and a greater degree of access the lakeshore. Vegetation management policies that allow mowing or thinning of vegetation on government lands along Limited Development shorelines with a shoreline use permit may also result in changes in shoreline vegetation and habitat quality. Using historical and current imagery, cumulative changes in vegetation and land cover around the lakeshore were assessed to evaluate potential cumulative impacts of USACE management practices.

Section 2
Methodology

This section provides an overview of the regulatory framework, data sources, and general methodology used in the analysis. A description of the data processing procedures is found in Section 3.0.

Vegetation cover types on USACE-owned lands around Eufaula Lake and on adjacent private lands within 0.5 mile of the government land boundary were characterized using 1999, 2006, and 2011 multispectral satellite imagery. Specific vegetation classes were established based on the spectral signatures of the imagery throughout the study area.

2.1 Regulatory Framework

The National Environmental Policy Act (NEPA) requires an evaluation of potential impacts of a proposed action including direct, indirect, and cumulative impacts. Direct effects are those that may occur directly as a result of the action. For example, the decision to designate a particular section of shoreline as Limited Development would have the direct effect of allowing vegetative modification permits to be issued for mowing or thinning. This designation also allows for private dock construction, which may have direct effects on the environment.

Indirect impacts are those that are removed in time or location from the proposed action. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use (40 CFR 1508.8). For example, a decision to designate a particular section of shoreline on Eufaula Lake as Limited Development could result in increased residential development on adjacent private lands. This increased residential development could result in indirect or secondary impacts to water quality of the lake due to increased runoff and erosion from areas on private land that are cleared for development.

A cumulative impact is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40CFR 1508.7). For example, vegetation management practices along the shoreline may affect habitats or water quality by increasing erosion to the lake. A single vegetation management permit may not result in an adverse effect on habitats or water quality, but many such actions considered together or over a period of time may result in adverse impacts.

2.2 Data Sources

Satellite imagery was used to evaluate vegetation changes. Historic aerial photography was not used for the reason that within the appropriate time period aerial photography is available in black-and-white (gray-scale) only and at a low resolution. This gray-scale photography does not provide any spectral information about vegetation condition and there is no visible distinction between light colored grasses and other features such as bare dirt or pavement. Roof tops, bare earth, roadways, and grasslands are often visually indistinguishable from one another on much of this photography. Interpretations must be made manually and interpreter bias may significantly affect the results. In addition, the size of the area to be classified (almost 350,000 acres) limits the feasibility of a manual classification methodology.

Multispectral satellite sensors have the ability to detect the energy being reflected in the near infrared (NIR), middle infrared (IR), and far infrared (FIR) along with the visual 'red-green-blue' (RGB) spectrum (the energy that is picked up with the human eye). For these reasons, the use of medium to high resolution multispectral satellite image data is the industry standard for regional mapping of vegetative change and land use change studies (Ychun Xie, *et al.* 2008).

Sensors that detect NIR, IR, and FIR energy are considered advantageous over most aerial image datasets that only utilize the visual spectrum or images that are gray scale. Modern techniques in remote sensing include the use of spectral signatures to delineate classes of data (Ychun Xie, *et al.* 2008). This is more accurate compared to techniques that require the user to determine what they perceive using only the visual spectrum where the user's eyes are the main tool for determining classes. Mapping entirely by visual analysis requires some degree of guess work and introduces individual bias compared to the more objective technique of using spectral signatures from multispectral data captured by the satellite receivers.

Land and vegetative features are associated with different types of radiation (reflectance) and specific types of vegetation reflect light energy (radiate) at different rates. These spectral signatures are the measurable data that can be related to classes of data such as vegetation type or land use. Detection of near infrared energy is essential for vegetation mapping because most of the energy reflected by vegetation exists in the near infrared energy spectrum. Thus to gather information about vegetative biomass, it is necessary to use imagery from the NIR band width. Satellites that separate the NIR band from the rest of the electromagnetic data are therefore most beneficial for mapping the existence of vegetation. For example, using the NIR, Green, and Red reflectance values, it is possible to determine ratios of GREEN INDEX from vegetative features and also separate out non-green vegetation, that is, vegetation that is experiencing low rates of photosynthesis, such as fallow fields (Ychun Xie et al. 2008).

The use of satellites that specifically compartmentalize the NIR reflectance values into a separate band allows the user to quantitatively assign registered reflectance values to classes of vegetation. Moreover image data that retains information in the IR and FIR bands are beneficial for delineating water bodies and other features that are not vegetation including anthropomorphic features such as roads and buildings.

There are two satellites that store reflectance values into bands that correspond with the NIR, IR, FIR, and RGB wavelengths. These two satellites are the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), launched in 2000, and Landsat 7 Enhanced Thematic Mapper Plus (ETM+) Launched in 1999, which contains 7 bands; NIR, IR, R, G, B, thermal IR, and the black and white panchromatic band. The analysis of this imagery was augmented with available historic and recent aerial photography.

When analyzing vegetation types, spectral resolution is generally more important than spatial resolution. Spectral resolution refers to the type of energy being acquired from the sensors. Typically it is rare to have both high spatial resolution and high spectral resolution. However, with the ASTER and Landsat 7 satellites it is possible to get adequate spatial resolution for regional vegetation studies. A 15 meter (m) resolution is recommended for regional studies of land-use change because vegetation classes and land-cover types do not generally exist homogeneously in areas smaller than 15 meter X 15 meter. This resolution is sufficient to distinguish roads and individual houses.

The spatial resolution of the image only needs to be as high as the class that has the smallest fragment (i.e. the smallest area that a type of land-cover can exist in as a homogenous class). Vegetation classes, non-vegetation, and anthropomorphic features rarely exist in areas smaller than 15 meter X 15 meter. At a regional scale, it is not useful to attempt to classify individual trees or shrubs. Fifteen square meter areas would be classified as grassland or forest depending on the reflectance values of the area. Anthropogenic features would be appropriately classified as bare ground or urban/built classes.

In addition to the satellite imagery, data such as aerial photographs that may have a higher spatial resolution (albeit a lower spectral resolution) were incorporated into the analysis to account for smaller fragmented areas of classes. These aerial photographs, such as may be available through Google, do not have the spectral resolution necessary to distinguish vegetation classes, but they can help refine the spatial analysis. Automated computer mapping techniques and user-defined methods were used to incorporate the aerial data with the satellite data.

2.3 Analysis Methods

Three satellite images were selected that spanned the past decade and included images from 1999, 2006, and 2011. The reasons for selecting these particular years and images is described in detail in Section 3.0. Images were selected that provided the most complete coverage of the area without data gaps or cloud cover. Images were also selected based on the time of year, with images taken during the growing season preferred over fall or winter images that would not provide spectral information about vegetation.

Vegetation types and land use classes were mapped for the USACE-owned lands and adjacent private lands along the shoreline of Eufaula Lake. Specific vegetation classes were established based on the spectral signatures throughout the study area for the three images. The classification of the satellite imagery was automated and verified with ancillary data such as from available aerial photos for selected areas. The combination of reflectance values from the satellite imagery coupled with aerial photography is a very powerful tool to establish vegetation classes and for analyzing changes in vegetation or vegetation condition on a regional scale.

Seven vegetation and land cover classes were distinguishable from the imagery. The spectral data defines the vegetation classes as similar spectral ranges are grouped into similar subsets. The process for classifying the images is described in Section 3.0. The vegetation and land cover classes identified included:

- Bare Land/Fallow Land
- Residential/Built
- Emergent Wetlands
- Bottom Land Forest (included forested wetlands)
- Mowed Grass
- Pasture/Grazing (includes natural grasslands that are not maintained)
- Forest (upland or dry forests)

For each year, the number of acres within each of seven vegetation/land cover classes was calculated. In addition, a small amount of cloud cover was present in the eastern corner of the lake in the 2011 image. This area of cloud cover was identified as a separate "land cover" class and was included in the totals.

The use of auxiliary image data, such as aerial photographs, was incorporated with the multispectral data to enhance the scale of data being classified. This was done both by using automated techniques (pan sharpening) and by using the aerial images for reference to add additional information into the classification process. This process enhanced the classification of spectral signatures, established vegetation classes, and allowed these classes to be mapped and digitized for designated lands along the shoreline of Eufaula Lake.

The land area analyzed included the USACE-owned lands around the lake shore and the private lands within 0.5 miles of the government land boundary. The greatest amount of vegetation change is predicted to be due to human activity along the shoreline areas. Dock and access path construction as well as mowing, tree thinning and limbing, and informal lake access from adjacent private lands is expected to result in the greatest amount of observable change in vegetation/land cover classes. These types of human activities are generally linked to residential developments adjacent to the USACE-owned lake shore. Docks may only be constructed by property owners with direct access to the lake, such as from an abutting property or a community access point. Community access points would be primarily used by property owners in the development that is immediately adjacent to the USACE-owned lands. Therefore, an area within 0.5 miles of the USACE boundary would include these residential areas or potential residential areas where the greatest amount of public access and activity that would be related to the lake shore would be expected.

Comparisons were made between the relative distributions of vegetation/land cover classes between USACE-owned lands and adjacent private lands. The results are compared for the entire study area, for areas associated with different shoreline allocations, and for areas associated with recent residential development and with residential developments of differing densities.

Changes in vegetation/land cover classes over time were correlated with shoreline designations that may allow vegetation management and with adjacent development on private lands. This analysis provides a basis to evaluate direct, indirect, and cumulative impacts of shoreline management activities over time as well as to evaluate how each alternative may affect natural resources and land uses adjacent to the government lands along the lakeshore.

Section 3

Data Collection and Processing

3.1 Data

The image data consisted of multispectral datasets from the years 1999, 2006, and 2011. All data was ordered and downloaded from the U.S. Geological Survey (USGS) Global Visualization Viewer (GLOVIS) data distribution service. The multispectral data used for the classification of each year consisted of visual and near infrared reflectance values in each image dataset. Vegetation has a peak reflectance in the near infrared electromagnetic spectrum and thus this spectrum is essential for creating classifications of vegetation. The green, red, and NIR (VNIR) region of the electromagnetic spectrum provide the most valuable information on radiance and absorption rates of vegetation.

The best multispectral image data available for this project were the National Aeronautics and Space Administration (NASA) Landsat and Terra ASTER satellite images. Selected images must be taken during the growing season in order to capture the vegetation cover, cover the entire Eufaula Lake region, and be as cloud-free as possible. Given that images of eastern Oklahoma are not captured with every pass of the satellite, these selection criteria greatly restricted the number of potential images available. Several sets of ASTER data of eastern Oklahoma were eliminated because they did not extend far enough south to capture the bulk of Eufaula Lake.

It was determined that 15 meter resolution, or better, was necessary for providing an analysis of land-cover change within the study area. Therefore the year 1999 (leaf on) was chosen as the earliest date for the temporal data because that was the first year NASA's Landsat 7 Enhanced Thematic Mapper Plus (ETM+) satellite imagery was available. This imagery includes a 15 meter panchromatic band which allows rescaling of the 30 meter Landsat multispectral data to 15 meters. The image captured July 25, 1999, provided the best coverage with minimal cloud coverage during the leaf-on growing season. The image consists of 7 bands of multispectral data including visual, near infrared, infrared, and thermal infrared bands.

Terra ASTER imagery is typically preferred over Landsat data as it consists of 15-meter resolution for all bands, however the only year in which ASTER data was available during the leaf-on growing season over the Eufaula Lake area was 2006. Therefore, that year was chosen as the second temporal dataset and it provided the best data available with minimal cloud coverage existing between 1999 and 2011. That image consisted of two image tiles (for full coverage of the study area) captured on May 26, 2006. The multispectral bands for this data include visual and near infrared bands (band 2, 3 and 4). This data set did not include other bands in the NIR and far infrared spectrum.

A leaf-on season image from 2011 was chosen as the third temporal dataset as it represented the most recent leaf-on growing season. No ASTER data was flown in 2011 over the study area and the only available data was Landsat 5 and Landsat 7 ETM+ data.

Due to a malfunction in the Landsat 7 ETM+ satellite in May 2003, images after that date contain striping errors in some parts of some images (consisting of up to 25 percent data gaps in images). This data can be repaired with other Landsat data by "filling in the gaps" if the image data from other dates overlap with the striping errors (http://landsat.usgs.gov/using_Landsat_7_data.php). Image data captured by the Landsat-5 satellite (an older predecessor to the Landsat 7 satellite) provided complete images with no errors at the same resolution. Therefore, Landsat-5 image data was acquired from May 15, 2011. To rescale the data to 15 meter resolution a "gap filled" (processed) 15 meter scaled grayscale image was created from two Landsat 7 ETM+ band-8 images. One band-8 image was captured on May 15, 2011, and another band-8 captured from the same growing season were both used to rescale the 30 meter Landsat 5 visual and NIR bands.

3.2 Data Resolution and Limitations

Given the study area size (approximately 800 miles of shoreline), 15-meter resolution data was determined to be the most reasonable option available. Medium resolution imagery with 2- to 30-meter resolution is best used for regional scale studies and is advantageous for regions that cover large areas (county or state) (Yichun Xie, *et al.* 2008). However, this data should not be used for analyses at the parcel level or to discern land-use changes that may occur at a scale smaller than 15 square meters. High resolution data consisting of 0.5-meter to 5-meter resolution is best used for local or small community scale study areas (Yichun Xie, *et al.* 2008).

3.3 Data Pre-processing

The 1999 image was processed and rescaled to 15-meter resolution with band 8 (panchromatic band) using the Pan Sharpening tool in ERDAS IMAGINE. Panchromatic bands are grayscale images that retain information in the VNIR spectrum that allows for rescaling multispectral data to 15-meter resolution. The 15-meter resolution band 8 image from the same dataset was used to rescale the image's VNIR data to 15-meter also (http://landsat.usgs.gov/panchromatic_image_sharpening.php). After the rescaling, additional radiometric enhancement was completed to provide the reflectance values and to minimize errors due to atmospheric conditions or satellite errors caused by angle-of-sun radiance.

The study area was then clipped out for classification processing. The study area included all of the USACE-owned lands around Eufaula Lake and the adjacent private lands within one half mile of the government lands boundary.

The 2006 ASTER data consists of two image tiles, which were merged into a mosaic and then the study area was clipped out. The ASTER data acquired included Level 1-B processing (USGS processing) which provides reflectance values (radiometric enhancement) thus no radiometric corrections were necessary. The data consists of 15 meter pixels; and therefore, no rescalingwas necessary.

The 2011 Landsat 5 image, which had a 30-meter resolution, was rescaled to 15-meter resolution using a processed panchromatic band from two Landsat 7 panchromatic bands captured from May and July. The band-8 on the Landsat 7 satellite provided a 15-meter panchromatic band that allowed for rescaling of data taken near or on the same date of the lower resolution data. Striping errors affect approximately 25 percent of the image. This data was filled in using an image filling technique recommended by the USGS and NASA (http://landsat.usgs.gov/using_Landsat_7_data.php). The gap filling was accomplished in ERDAS IMAGINE Model Maker tool by creating a model where values of zero (no data) are filled with a value above zero. Clouds covered a small portion of the 2011 image and were classified as clouds in the classification processing. These clouds were given "no data" values in the change detection so that classes were not affected by clouds in the statistics.

3.4 Image Processing

Unsupervised (ISODATA) classification was performed on each of the images. ISODATA Unsupervised classification is most beneficial for studies with minimal or no training sites (areas observed in the field) or in situ data to identify classes before processing. In an unsupervised classification, the computer program uses a statistical algorithm to clump spectral signatures into classes that can then be defined by the user and recoded into vegetation or land cover classes. Forty unsupervised classes using the Green, Red, and NIR bands were created for each image. The classes were then collapsed to eight defined land-cover types. However due to spectral overlap of different classes having the same spectral signatures, a second unsupervised classification was performed using 60 classes for each temporal dataset to help identify similar classes. This provided more variability in class breaks and was beneficial for distinguishing between some classes such as mowed grass and pasture lands.

Normalized Difference Vegetation Indices (NDVI) were created in ERDAS IMAGINE for each dataset. NDVI are used to create an index of vegetation, and the resulting image can be used to determine the "greenness" of features. The index was created by the following expression: NDVI equals (NIR minus Visual) divided by (NIR plus Visual). The result is an image with measurable values of "greenness". This is useful for identifying areas of vegetation and helps determine the types of vegetation present. Pixels with values above zero contain chlorophyll activity; and thus are considered vegetation. This was helpful in distinguishing bare land from pasture/grassland areas. However, the amount of "greenness" coming from grasslands, mowed areas, and wetlands was similar to the "greenness" of forested areas. Therefore, the NDVI was not sufficient for classifying forests from other vegetation with high rates of photosynthesis and forest cover was delineated via other user defined techniques.

There was considerable overlap of spectral signatures for non-similar classes. For example, pixels within wetlands had similar spectral signatures as mowed-grass in non-wetlands areas. Bare earth along the shore of the lake had similar spectral signatures as urban areas due to high reflectance of the dry compacted soil. Some areas of healthy grass in the south part of the study area had reflectance values that were very similar to those of forest along the shoreline in other parts of the study area. These areas were differentiated by creating subsets of regional ecological zones to create masks that were then classified and copied onto the classified image so that the classes become unique to each part of the study area. This process allowed the classification to correctly identify values as bare earth in one region and not incorrectly classified the area as urban, for example. This proved to be the most accurate method for delineating classes with similar spectral signatures in the multispectral data.

A matrix change detection in ERDAS IMAGINE was performed from 1999 to 2006 and from 2006 to 2011. The matrix accounts for change (or no change) for any given pixel between the two temporal datasets. Cloud coverage and shadowing caused by clouds were given no data in the change matrix tool in ERDAS IMAGINE.

Section 4
Results

This section presents the analyses of how the vegetation varies across the three image years that span the past decade. The results are compared for the entire study area, for areas associated with different shoreline allocations, and for areas associated with recent residential development and with residential developments of differing densities.

4.1 Study Area General Characteristics

Each image year contains a slightly different number of total acres for a variety of reasons, but the differences between total acres in each year is less than one percent. Most of this difference is due to slight differences in lake elevation that exposes variable amounts of land surface. The acres of lake surface in each image are 102,650.27 (1999), 102,290.21 (2006), and 102,497.65 (2011). Therefore, the lake level was slightly higher in 1999 as compared to the other two years. However, the largest difference in lake area acres occurs between the 1999 and 2006 images and is only 360 acres or 0.4 percent.

Over the entire Eufaula Lake study area, which encompasses almost 350,000 acres, the largest difference between years (2006 to 2011) is 0.3 percent and represents an acceptable degree of accuracy between images. In the discussion below, however, the data for each vegetation class are presented as the percent of acres within an image year. This allows the comparisons between years to be more direct as the percentages normalize the differences. Tables showing the raw data in acres for each comparison are in Appendix A.

4.2 Vegetation/Land Cover Classification Results

As described in Section 3, several vegetation classes presented very similar reflectance values and environmental conditions at the time of each image may confound the classification process. For example, recent rainfall or the use of irrigation may make mowed grass and pasture grass difficult to distinguish. In addition, different activities on different classes of land may result in similar vegetation patterns. For example, haying conducted by ODWC for upland game bird habitat management may look like agricultural management of pastureland or mowed grass associated with residential development.

In addition, while the images were selected from earlier in the growing season rather than late summer, the reflectance values of pasture land and bare earth were often difficult to distinguish. In particular, the 2006 and 2011 images appear to have had a high degree of overlap between pasture land and fallow lands that were classified with bare earth. Therefore, the bare earth/fallow land category in those years is somewhat exaggerated.

The amount of bare earth visible in each image would also be expected to vary significantly by lake level. However, as discussed above, the maximum difference between images in the lake surface is only 360 acres, while the maximum difference in the amount of “bare earth/fallow land” is over 3,850 acres. This indicates that the lake level, and the potential for lower lake levels to expose more bare earth, is not a significant factor in the observed results.

The reflectance values for residential/urban development only include the actual buildings and impervious surfaces. Therefore, in the rural landscape surrounding Eufaula Lake, these components would only ever be a small percentage of the total area. While “bare earth” would be expected to precede residential development, once an area is built, the cleared areas surrounding buildings would be classified as bare earth, mowed grass, or even pasture land/grassland cover types. This makes it more difficult to assess the potential habitat impacts that may be related to conversion of one type of grassland to another with residential development. Therefore, the loss of forest cover may be a more accurate metric for assessing the impact to habitats from development.

The amount of wetlands appears to have increased significantly over the time span. This is another vegetation class that would be significantly affected by how wet the environment was at the time of the image. Less wet conditions might result in areas being classified as forest or grassland rather than wetland. In addition, there are sediment deposition zones where the major rivers and creeks enter the lake. These areas would present as bare earth or as wetlands depending on the spring floods and whether emergent vegetation had a chance to establish itself since the last deposition event. The observed increases in wetland areas over the study area are probably a result of some of these sediment deposition zones becoming vegetated.

4.3 Vegetative Change Over the Entire Study Area

Between 1999 and 2011, the residential/built category changed the most during the second half of the decade, regardless of whether it occurred on government lands or on private lands. **Table 4-1** summarizes the analysis results for each of the three years of analysis for private and government land.

The bare land category changed the most during the first half of the past decade, with the biggest changes seen on private lands. Often bare land is a precursor to residential development; however, in the Eufaula Lake area, bare land may also be a result of oil and gas exploration in areas that are not otherwise converting to residential development.

Forest land declined across all categories over the three years, but it declined at nearly twice the rate on private lands compared to government lands. On private lands, the amount in the pasture/grazing vegetation category stayed about the same across the decade, but mowed grass increased.

Table 4-1. Vegetative Change over Time for Entire Study Area

Vegetation Cover Type	USACE-owned Land (percent of total)			Adjacent Private Land[2] (percent of total)		
	1999	2006	2011	1999	2006	2011
Bare Land/Fallow Land	6.4	11.4	12.6	4.0	19.2	17.9
Residential/Built	0.7	0.5	1.4	0.4	0.7	1.5
Emergent Wetlands	0.6	1.2	3.4	0.3	0.7	1.3
Bottom Land Forest	27.1	26.1	23.4	12.5	11.0	10.7
Mowed Grass	0.06	0.8	2.1	0.3	1.5	2.0
Pasture/Grazing	10.2	7.9	9.9	33.5	25.8	30.2
Forest	55.0	52.2	47.0	49.1	41.2	36.4
Cloud Cover[1]	0.0	0.0	0.1	0.0	0.0	0.1

1- Cloud cover was only present in a small portion of the 2011 imagery.

2- Includes private lands within 0.5 miles of the government land boundary

4.4 Vegetative Change By Adjacent Shoreline Allocation

In compliance with USACE shoreline management regulation (Engineer Regulation (ER) 1130-2-406) and 36 CFR 327.30, Eufaula Lake's shorelines have been classified into four allocation categories. "Limited Development" shoreline allocations are areas where private activities such as vegetation modification, and/or the mooring or construction of privately owned floating facilities may be permitted. "Public Recreation" shorelines are areas where developed public recreational sites, federal, state, or similar public uses, and commercial concessionaire facilities are permitted. No private shoreline use facilities and/or activities, such as docks are permitted within or near designated or developed public recreation areas.

"Protected" shoreline areas are designated primarily to protect or restore aesthetic, fish and wildlife, cultural, or other environmental values. Shorelines may also be designated in this category for physical protection reasons, such as heavy siltation, rapid dewatering, erosion or exposure to high wind, wave, or current action. Land access and boating are permitted along these shorelines, provided aesthetic, environmental, and natural resource values are not damaged or destroyed, but private floating recreation facilities may not be moored or constructed in these areas. "Prohibited" shoreline allocations prohibit public access for security reasons, the protection of ecosystems, or for the physical safety of the recreation visitor. Mooring of private floating facilities and the modification of land forms and vegetation are not permitted in Prohibited shoreline areas.

It could be expected that private lands adjacent to shorelines allocated as Limited Development would be more attractive for residential development because of the opportunity for lakeshore landowners to install private docks. Private lands adjacent to other shoreline designations would be expected to be less attractive for residential development. It would be reasonable to assume that USACE lands adjacent to Limited Development shorelines would experience the greatest amount of vegetative change over time due to the demands for lake access and vegetation modification permits that would be generated by adjacent residential development. If residential development is the most significant agent of vegetation change in the study area, then differences between areas attractive for residential development and areas less attractive for residential development should be observable.

Construction of private docks and vegetation modification such as mowing may be allowed on lake shores adjacent to Limited Development shorelines with a shoreline use permit. However, these activities are not allowed adjacent to shorelines allocated as Protected although general lake access is allowed. Therefore, the analysis differentiated and compared the observed vegetative change over time on lands adjacent to each of these shoreline allocations.

The results, summarized in **Table 4-2** show that overall, vegetative changes on lands adjacent to Limited Development shoreline are similar in magnitude and direction to those observed across the entire study area, which may indicate that development adjacent to Limited Development shorelines is not a significant driver of the observed change. The primary exception is with respect to grasslands on USACE-owned lands. Adjacent to Limited Development shorelines, grasslands declined by 34 percent compared to only 3 percent over the entire study area.

On government lands adjacent to Limited Development shorelines between 1999 and 2011, forest cover decreased about 10 percent and grassland cover decreased about 34 percent. When the analysis focuses on areas that have actually experienced adjacent residential development over the last decade, forest cover on government lands declined about 10 percent, but grasslands declined almost 50 percent (see

Section 4.4). Grasslands on government lands appear to be converted to mowed grass and bare earth at a much higher rate than forest cover is converted.

On private lands adjacent to Limited Development shorelines between 1999 and 2011, forest cover decreased over 24 percent and grassland cover decreased by only 8 percent.

The bare land category changed the most during the first half of the past decade, with the biggest changes seen on private lands. Adjacent shoreline zoning does not appear to be a significant factor in the changes in this category. Often bare land is a precursor to residential development, so it would be expected that changes in the bare land/fallow land category would precede changes in the residential/built category. However, in the Eufaula Lake area, bare land may also be a result of oil and gas exploration in areas that are not otherwise converting to residential development.

Between 1999 and 2011, the residential/built category changed the most during the second half of the decade, regardless of whether it occurs on government lands or on private lands, with the greatest degree of change observed on lands adjacent to Limited Development shorelines.

Table 4-2. Vegetative Change Associated with Limited Development Shorelines

Vegetation Cover Type	USACE Land Adjacent to Limited Development Shorelines (percent of total)			Private Land Adjacent[2] to Limited Development Shorelines (percent of total)		
	1999	2006	2011	1999	2006	2011
Bare Land/Fallow Land	7.7	13.3	16.4	4.2	18.8	17.6
Residential/Built	1.2	1.1	2.7	0.6	1.1	2.3
Emergent Wetlands	0.7	0.4	2.9	0.01	0.1	0.2
Bottom Land Forest	14.4	13.9	9.8	2.2	2.0	1.9
Mowed Grass	0.1	0.3	1.7	0.5	1.1	2.1
Pasture/Grazing	10.2	6.6	6.8	34.0	26.6	31.4
Forest	65.7	64.4	59.7	58.5	50.3	44.4
Cloud Cover[1]	0	0	0.03	0	0	0.1

1- Cloud cover was only present in a small portion of the 2011 imagery.

2- Includes private lands within 0.5 miles of the government land boundary

Table 4-3 shows the magnitude of vegetative change appears to be slightly greater on private lands adjacent to Protected shorelines as compared to private lands adjacent to Limited Development shorelines (forest cover declined 27 percent compared to 24 percent and grasslands declined 11 percent compared to 8 percent, respectively). This may indicate that land uses other than the expected residential development adjacent to Limited Development shorelines are significant contributors to vegetative change on private lands.

Table 4-3. Vegetative Change on Private Lands from 1999 to 2011

Vegetation Cover Type	Private Land Adjacent to Limited Development Shorelines (percent)			Private Land Not Adjacent[2] to Limited Development Shoreline (percent)		
	1999	2006	2011	1999	2006	2011
Bare Land/Fallow Land	4.2	18.8	17.6	3.9	19.3	18.0
Residential/Built	0.6	1.1	2.3	0.3	0.5	1.1
Emergent Wetlands	0.01	0.1	0.2	0.4	0.9	1.7
Bottom Land Forest	2.2	2.0	1.9	16.6	14.6	14.3
Mowed Grass	0.5	1.1	2.1	0.2	1.7	1.9
Pasture/Grazing	34.0	26.6	31.4	33.3	25.4	29.7
Forest	58.5	50.3	44.4	45.3	37.5	33.1
Cloud Cover[1]	0	0	0.1	0	0	0.1

1- Cloud cover was only present in a small portion of the 2011 imagery.

2- Includes private lands within 0.5 miles of the government land boundary

Unencumbered government land is land that is not leased or licensed to another management entity such as the Oklahoma Department of Wildlife Conservation (ODWC). Unencumbered lands are open for public access, but along shorelines allocated as Protected, private docks and improved trails are not permitted, and vegetation modification other than minimal clearing for firebreaks is not allowed.

Overall, the vegetative change on unencumbered government lands and the adjacent private lands along shorelines where private docks are not allowed is similar to the change observed for the entire study area, with the exception of grasslands (**Table 4-4**). Grasslands on government lands adjacent to unencumbered Protected shorelines increased by 16 percent compared to a 3 percent decline over the entire study area.

Table 4-4. Vegetative Change Associated with Unencumbered Government Lands Adjacent to Protected Shorelines

Vegetation Cover Type	Unencumbered USACE Land Adjacent to Protected shoreline (percent)			Private Land Not Adjacent[2] to Limited Development Shoreline (percent)		
	1999	2006	2011	1999	2006	2011
Bare Land/Fallow Land	5.5	11.5	11.8	3.9	19.3	18.0
Residential/Built	0.8	0.5	1.4	0.3	0.5	1.1
Emergent Wetlands	0.3	0.3	0.9	0.4	0.9	1.7
Bottom Land Forest	16.1	15.6	14.7	16.6	14.6	14.3
Mowed Grass	0.04	0.2	0.5	0.2	1.7	1.9
Pasture/Grazing	11.5	9.1	13.4	33.3	25.4	29.7
Forest	65.7	62.9	57.2	45.3	37.5	33.1
Cloud Cover[1]	0	0	0.1	0	0	0.1

1- Cloud cover was only present in a small portion of the 2011 imagery.

2- Includes private lands within 0.5 miles of the government land boundary

Encumbered USACE lands are those that are leased or licensed to other management entities such as the Oklahoma Department of Wildlife Conservation for wildlife management purposes, to the State of Oklahoma for state parks, or which are dedicated to recreational uses. These lands are presumed to change little over time as their management emphasizes natural resource values and developed recreation areas have changed little over the past decade. At Eufaula Lake there are very large areas (approximately 29,700 acres or about 45 percent of the government lands surrounding the lake) that are managed for habitat and where minimal amounts of vegetation modification are allowed. The private lands adjacent to encumbered lands may be even less attractive for residential development due to additional restrictions on use imposed by the licensed management entity.

Although the type of uses and vegetation modifications that may be allowed along encumbered and unencumbered Protected shorelines may be similar, the results do not show similar patterns of vegetative change (**Table 4-5**). Vegetative change on encumbered government lands is more similar to the results for government lands over the entire study area than to unencumbered government lands adjacent to Protected shorelines. On encumbered government lands forest lands declined by 17 percent compared to 14 percent over the entire study area and 13 percent on unencumbered Protected shorelines. Grasslands declined five percent on encumbered lands and three percent on the whole study area, compared to a 16 percent increase on unencumbered Protected shorelines.

Table 4-5. Encumbered USACE Lands Compared to Unencumbered USACE Lands Adjacent to Shorelines Allocated to Protected and Public Recreation

Vegetation Cover Type	Encumbered USACE Land Adjacent to Protected and Public Recreation Shoreline (percent)			Unencumbered USACE Land Adjacent to Protected shoreline (percent)		
	1999	2006	2011	1999	2006	2011
Bare Land/Fallow Land	5.9	9.9	11.0	5.5	11.5	11.8
Residential/Built	0.5	0.4	1.0	0.8	0.5	1.4
Emergent Wetlands	0.6	1.6	4.2	0.3	0.3	0.9
Bottom Land Forest	31.7	30.7	27.7	16.1	15.6	14.7
Mowed Grass	0.1	1.0	2.6	0.04	0.2	0.5
Pasture/Grazing	8.8	7.1	8.4	11.5	9.1	13.4
Forest	43.5	41.2	36.1	65.7	62.9	57.2
Cloud Cover[1]	0	0	0.1	0	0	0.1

1- Cloud cover was only present in a small portion of the 2011 imagery.

2- Includes private lands within 0.5 miles of the government land boundary

Changes on encumbered lands adjacent to Protected shorelines may be most related to natural processes such as oak blight rather than due to human-related vegetative modification. Such natural processes would be expected to be observed across all areas, but differentiating natural effects from human caused effects may not be possible. It is also possible that a greater degree of human activity or vegetative management may be beneficial in reducing adverse effects of some types of natural processes. The results indicate that forest cover declined 14 percent over the entire study area but only by 10 percent along shorelines allocated to Limited Development.

4.5 Vegetative Change Associated with Recent Residential Developments

Fourteen subdivision areas that have been developed over the last decade were selected and the vegetation classes for each image year were measured on both the private lands and the USACE-owned lake front at each selected development area (**Table 4-6**). These areas, shown on **Figure 4-1**, would have been undeveloped in 1999 and all have some level of development in the 2011 imagery. The data for each individual subdivision is presented in Appendix A.

This sample of subdivision areas evaluates changes in vegetation/land cover classes in areas where residential development pressure has been high. Within the selected areas, there was a much higher percentage of area in pasture/grazing in 1999 than on adjacent private lands than on USACE-owned lands. USACE-owned lands had a higher percentage of forest cover than was found on the adjacent private lands.

Based on this sample of residential developments that have been constructed over the past decade, it appears that the biggest impact on vegetation on government lands has been to grasslands. The "pasture/grazing" vegetation class includes any type of non-irrigated, non-mowed grassland. On government lands adjacent to residential development, these areas are more likely to be grasslands rather than active pastures. Grasslands on government lands adjacent to residential developments were converted to bare earth or mowed grass at a much higher rate than for similar grassland vegetation classes on adjacent private lands. Grasslands declined by almost 50 percent on the government lands within the selected areas compared to a 25 percent decline on adjacent private lands.

Conversely, USACE-managed shorelines appear to be much more protective of forest cover than adjacent private ownership where residential developments are constructed. Forest cover on USACE-owned lands decreased less than 10 percent within these sample areas where development pressure has been high, while on private lands, forest cover decreased by almost 40 percent. It should be recognized that some effects on vegetative cover may take longer than 10 years to become apparent. For example, bare earth may convert back to grassland or forest cover may continue to decline with more time.

Table 4-6. Vegetative Change Associated with Recent Residential Development

Vegetation Cover Type	USACE-owned Land (percent)			Adjacent Private Land [1] (percent)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	7.7	13.8	17.4	5.6	23.4	30.1
Residential/Built	0.7	0.7	1.6	1.1	2.0	3.9
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.03	0.03	0.03	0.02	0.02	0.02
Mowed Grass	0.03	0.2	1.3	1.0	2.2	4.7
Pasture/Grazing	10.9	6.4	5.6	28.0	23.0	21.0
Forest	80.7	78.8	74.0	64.4	49.4	40.2

1- Includes private lands within the selected areas as shown in Figure 4-1.

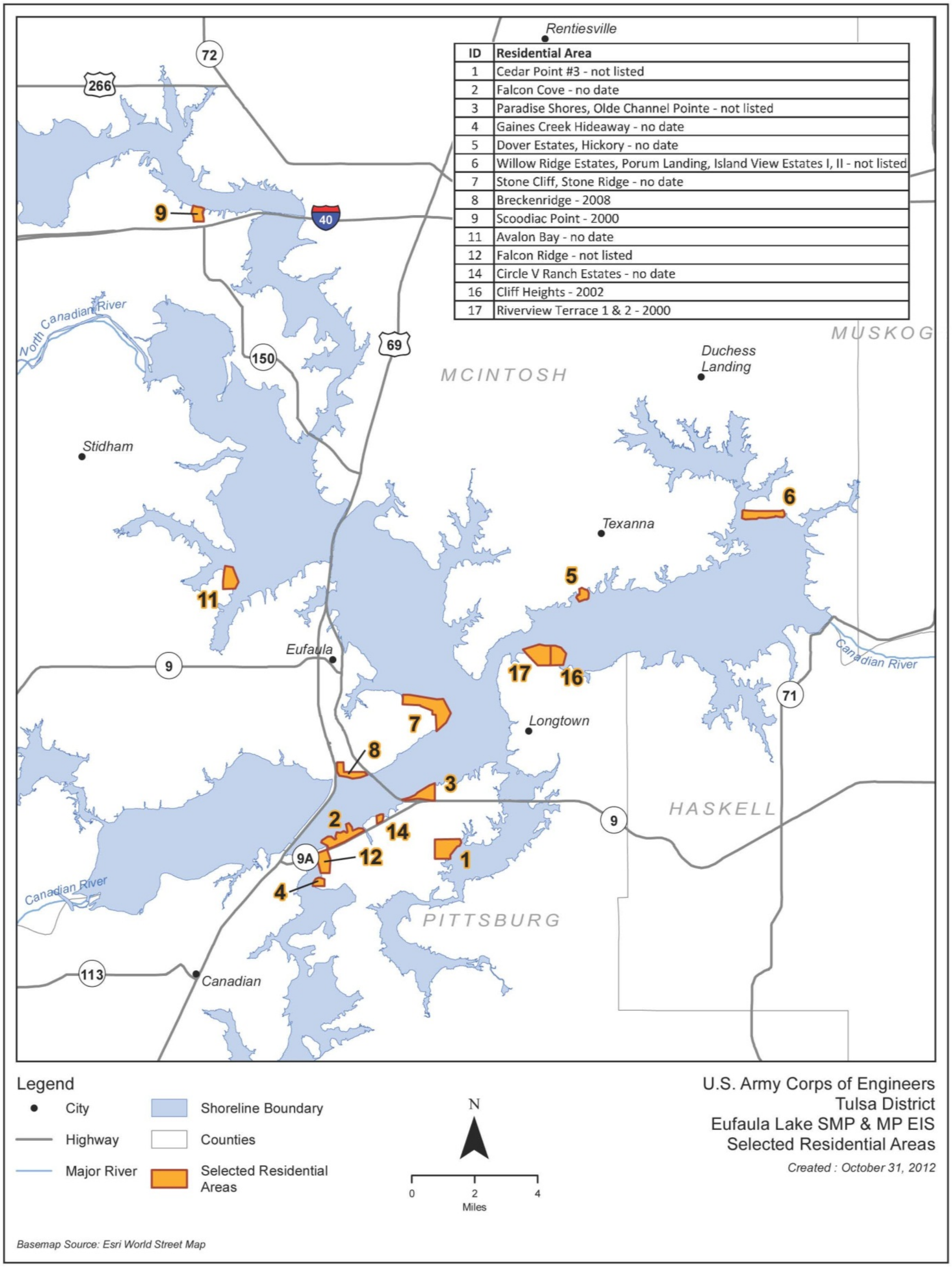

Figure 4-1. Selected Residential Areas Developed between 1999 and 2011

4.6 Vegetative Change by Density of Adjacent Residential Development

In order to evaluate the effect of adjacent residential density on vegetative change, five representative areas around the lake were selected where residential developments of medium and high densities were located in close proximity to each other and to areas of low or no residential development on the lake shore. The locations were also selected for similarity in apparent dock suitability and approximate size. All of the high and medium density developments included existing docks. Some of the low density developments also have constructed docks, albeit in lower numbers than their more dense neighbors.

The five areas selected included residential developments near Belle Starr, Bixby Creek, I-40, Longtown, and Porum Landing. The low, medium, and high density areas selected in each area are shown in **Figure 4-2** through **Figure 4-6**. The age of the development was not controlled in this comparison as information on the age of residential developments is incomplete in county records. More dense residential areas may take longer to build out to their final higher densities and thus some observed changes in vegetation may be the result of a combination of the increased levels of use and a longer time over which impacts have occurred. Alternatively, many areas around the lake may have developed at low densities initially and would still be present at their original low densities due to an initial pattern of large lots. Therefore, the low density areas sampled may be equally as old as the high density areas. County records are not sufficiently detailed to determine the age of the residential areas sampled.

The trends in vegetative change over time are similar regardless of residential density, but the magnitude of the change is greater with increasing residential density (**Tables 4-7**, **4-8**, and **4-9**). For example, forest cover on USACE-owned lands adjacent to residential development declined under all scenarios, but it only declined by approximately 12 percent adjacent to low density developments while forest cover declined almost 23 percent when adjacent to high density developments. While these numbers are higher than reported in the previous sections, this analysis did not consider the age of the development and there may be continued loss of forest cover over time that was not detected in the analysis of recent developments.

Similar to the results for all lands, grasslands experienced the greatest amount of change, declining up to 77 percent on government lands adjacent to high density development when compared across the decade. Private ownership appeared to be much less protective of forest cover compared to USACE-owned lands, but did not result in as much change in grasslands. This trend is similar to that observed in previous comparisons.

The data for each of the five areas that are compiled into the following tables are presented in Appendix A.

Table 4-7. Vegetative Change Associated with Low Density Development

Vegetation Cover Type	USACE-owned Land (percent)			Adjacent Private Land[2] (percent)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	4.3	10.2	12.5	2.1	13.2	14.2
Residential/Built	0.2	0.3	0.7	0.3	0.6	1.2
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.02	0.02	0.02
Mowed Grass	0.07	0.07	0.7	0.2	0.3	1.1
Pasture/Grazing	10.9	6.8	8.3	23.3	21.0	23.7
Forest	84.5	82.5	74.0	74.0	64.9	53.6
Cloud Cover[1]	N/A	NA	3.8	N/A	N/A	6.3

1- Cloud cover was only present in a small portion of the 2011 imagery.
2- Includes private lands within the selected areas.

Table 4-8. Vegetative Change Associated with Medium Density Development

Vegetation Cover Type	USACE-owned Land (percent)			Adjacent Private Land[2] (percent)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	6.3	17.2	18.0	7.0	27.3	33.7
Residential/Built	0.4	0.8	1.4	1.0	4.3	7.3
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.1	0.2	4.1	1.9	4.9	7.5
Pasture/Grazing	13.1	3.6	2.6	46.6	33.5	28.5
Forest	80.2	78.2	74.0	43.4	30.1	22.9
Cloud Cover[1]	N/A	N/A	0.0	N/A	N/A	0.0

1- Cloud cover was only present in a small portion of the 2011 imagery.
2- Includes private lands within the selected areas.

Table 4-9. Vegetative Change Associated with High Density Development

Vegetation Cover Type	USACE-owned Land (percent)			Adjacent Private Land[2] (percent)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	8.8	22.8	22.9	12.8	37.6	44.6
Residential/Built	3.7	4.5	7.9	5.3	10.7	14.2
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.02	0.02	0.02
Mowed Grass	0.7	2.5	13.5	3.0	7.0	12.1
Pasture/Grazing	22.4	10.1	5.2	55.5	28.0	17.0
Forest	64.4	60.1	49.8	23.3	16.8	12.0
Cloud Cover[1]	N/A	N/A	0.6	N/A	N/A	0.002

1- Cloud cover was only present in a small portion of the 2011 imagery.
2- Includes private lands within the selected areas.

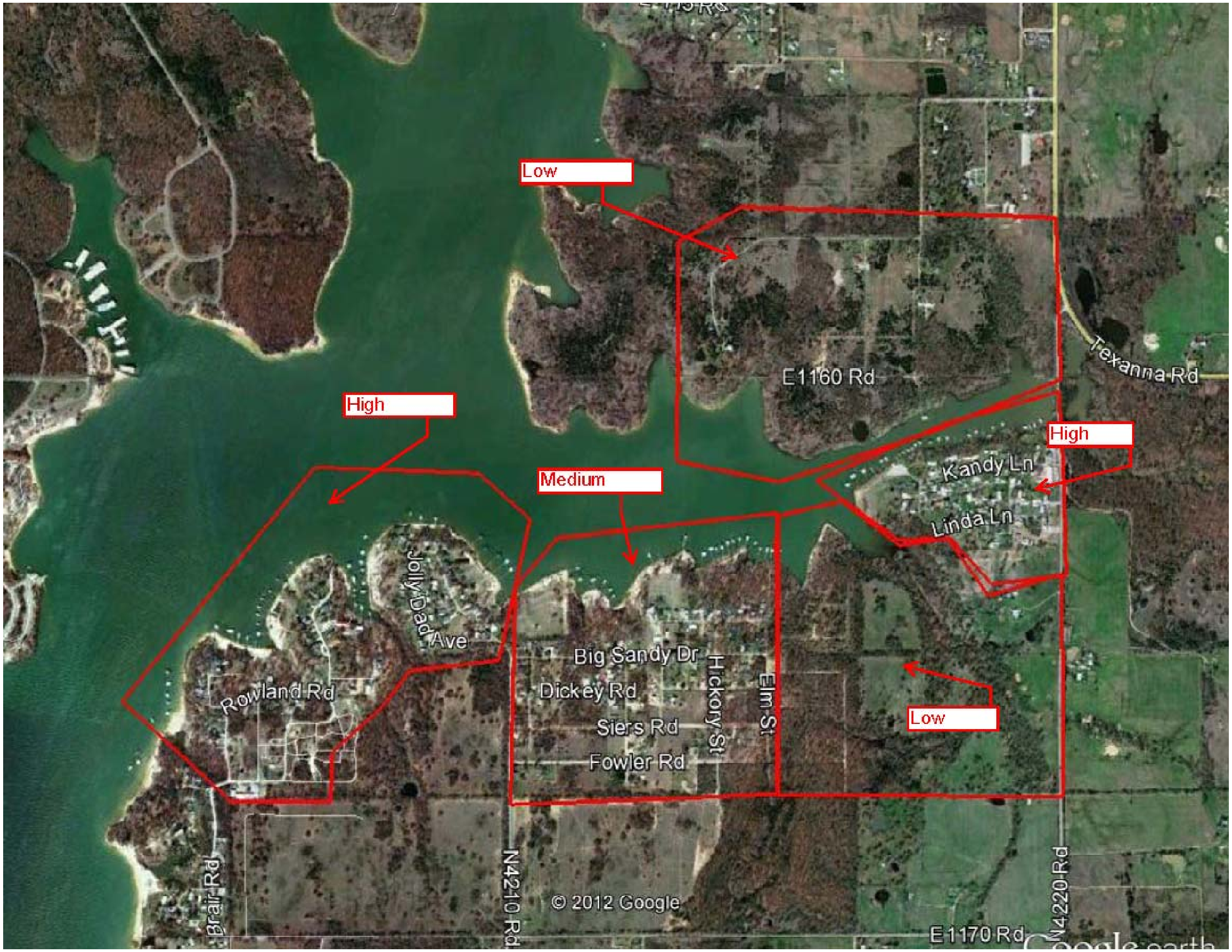

Figure 4-2. Belle Starr Area Residential Developments

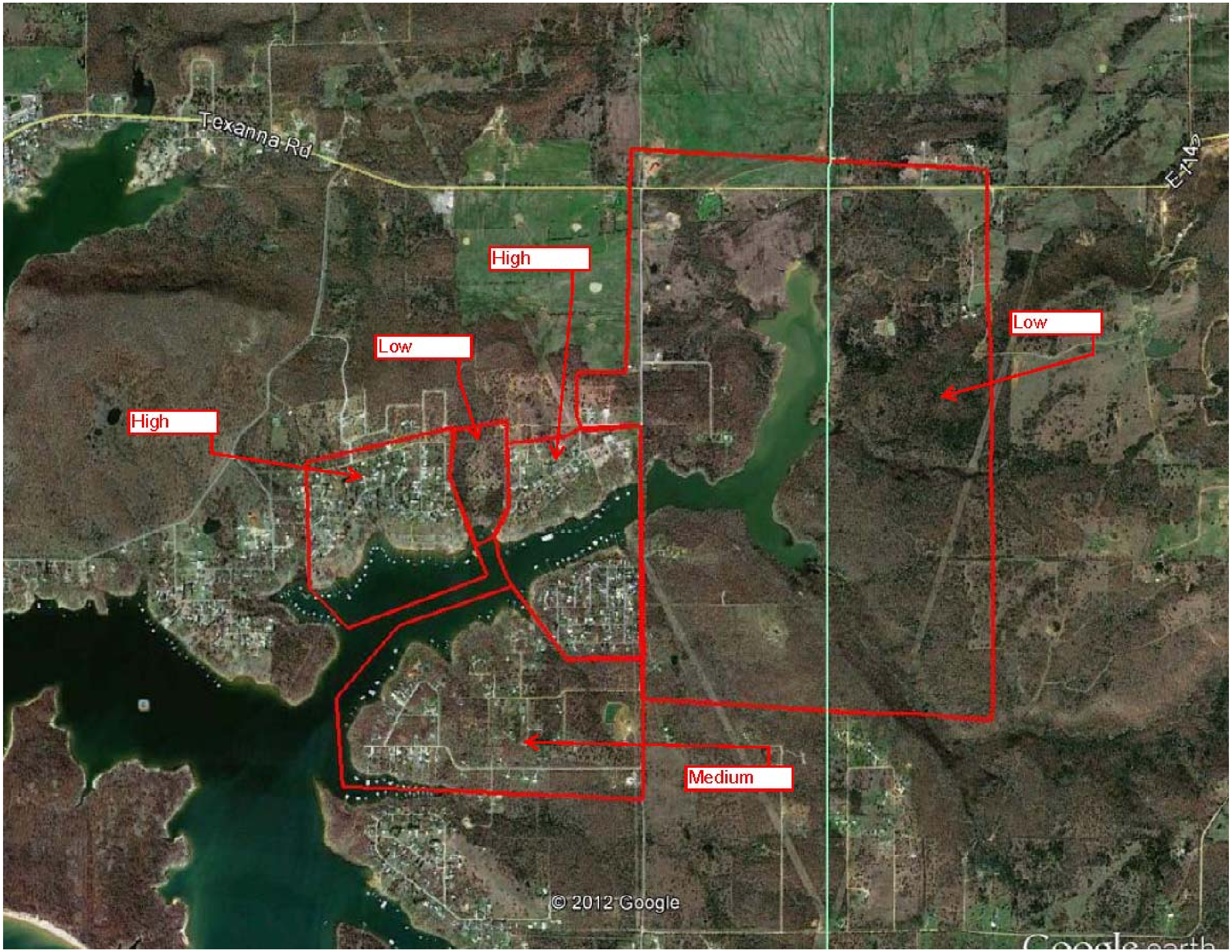

Figure 4-3. Bixby Creek Area Residential Developments

Figure 4-4. Interstate 40 Crossing Area Subdivisions

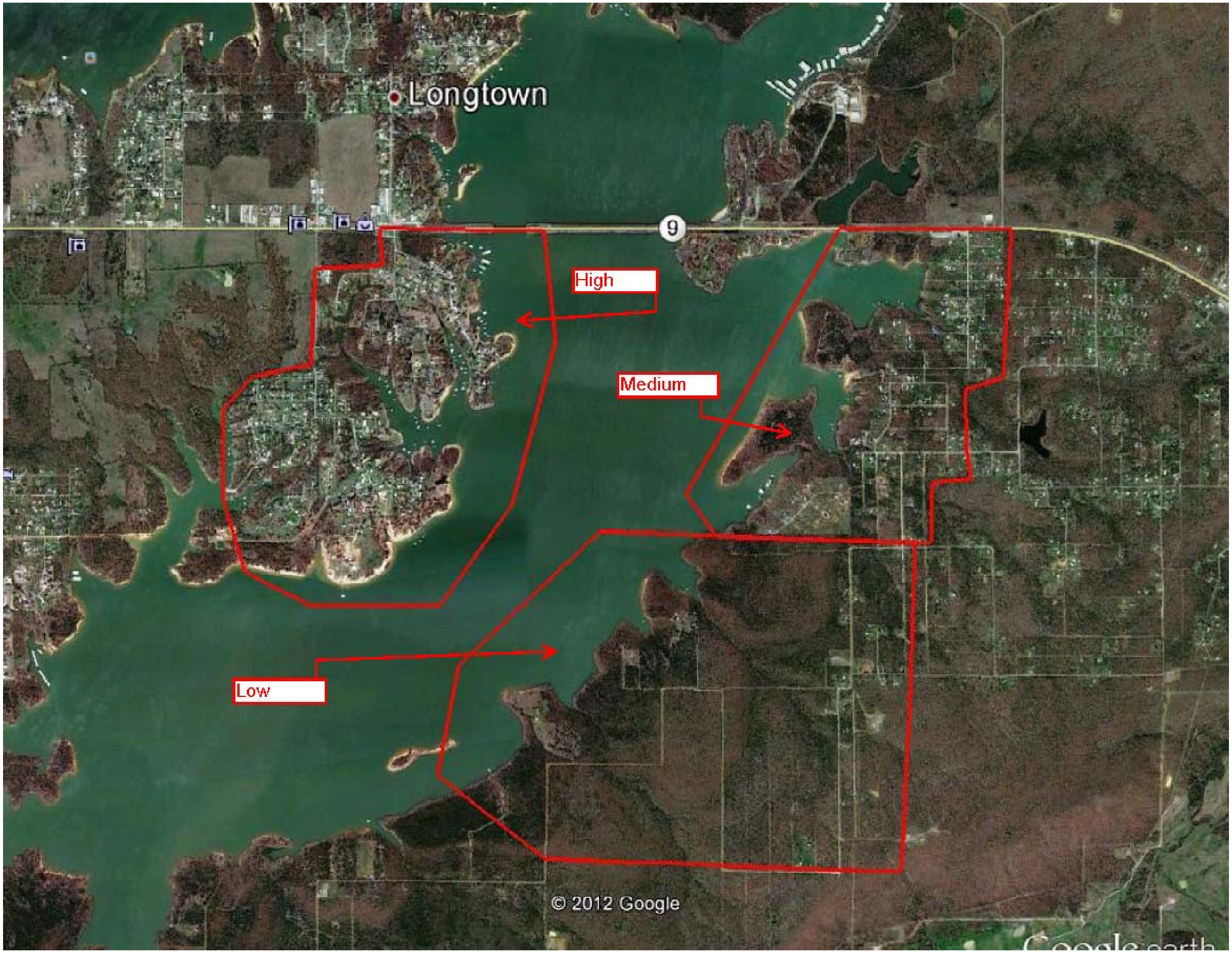

Figure 4-5. Longtown Area Subdivisions

Figure 4-6. Porum Landing Area Subdivisions

Section 5

Conclusions and Evaluation of Alternatives

The analysis compared the observed vegetative change by a several different land areas that may have different management regimes and variable development pressures. Forest land declined across all categories, but it declined at nearly twice the rate on private lands over government lands. On private lands, the amount in pasture/grazing vegetation categories stayed about the same across the decade; but mowed grass increased without respect to adjacent shoreline zoning. On government lands adjacent to Limited Development shorelines, mowed grass increased while pasture grass declined. **Table 5-1** summarizes the percent change observed between 1999 and 2011 for each vegetation cover type and compares the percent change between the entire study area and only those areas adjacent to Limited Development allocated shorelines.

Table 5-1. Percent Change in Vegetation Cover Types from 1999 to 2011

	Entire Study Area (percent change)		Adjacent to Limited Development Shoreline Only (percent change)	
Vegetation Cover Type	**USACE – owned Land**	**Adjacent Private Land[2]**	**USACE – owned Land**	**Adjacent Private Land[2] O**
Bare Land/Fallow Land	96	348	113	319
Residential/Built	100	275	125	283
Emergent Wetlands	467	333	314	1900
Bottom Land Forest	-14	-14	-32	-14
Mowed Grass	3400	567	1600	320
Pasture/Grazing	-3	-10	-34	-8
Forest	-14	-26	-9	-24

1- Cloud cover was only present in a small portion of the 2011 imagery.

2- Includes private lands within 0.5 miles of the government land boundary

Table 5-2 summarizes the percent change observed between 1999 and 2011 for each vegetation cover type and compares the percent change associated with the three residential development intensity levels. While higher density developments are associated with greater loss of forest cover on government lands, even low levels of residential development appear to result in significant conversion of grasslands.

Table 5-2. Percent Change in Vegetation Cover Types Associated with Residential Development from 1999 to 2011

Vegetation Cover Type	USACE-Owned Land[1] (percent change)			Adjacent Private Land[2] (percent change)		
	Low Density	Medium Density	High Density	Low Density	Medium Density	High Density
Bare Land/Fallow Land	190	186	160	576	381	248
Residential/Built	250	250	114	300	630	168
Emergent Wetlands	0	0	0	0	0	0
Bottom Land Forest	0	0	0	0	0	0
Mowed Grass	900	4000	1829	450	295	303
Pasture/Grazing	-240	-80	-77	2	-39	-69
Forest	-12	-8	-23	-28	-47	-48

1- Includes USACE-owned lands between the lakeshore and private lands developed at the respective densities.

2- Includes private lands adjacent to the government land boundary and developed at the respective densities.

5.1 No Action Alternative

Based on the analysis of impacts to vegetation over the past decade, it would be expected that similar trends would extend into the future. As adjacent private lands develop, forest and grassland vegetation is affected through vegetation clearing, permitted mowing, and formal and informal lake access. On government lands adjacent to Limited Development shorelines between 1999 and 2011, forest cover decreased about 10 percent and grassland cover decreased about 34 percent. When the analysis focuses on areas that have actually experienced adjacent residential development over the last decade, forest cover on government lands still only declined about 10 percent but grasslands declined almost 50 percent. Grasslands on government lands appear to be converted to mowed grass and bare earth at a much higher rate than forest cover. Under the existing condition, there are 1,673 existing private boat docks. Using the minimum spacing of 50 feet between docks and an average dock width of 31.8 feet, there are approximately 26 miles of shoreline currently developed. If the observed declines in vegetative cover are assumed to be applied uniformly to the entire area currently developed, this would affect about 3 percent of the total shoreline at Eufaula Lake.

On government lands adjacent to shorelines allocated to Limited Development (Low Density Recreation land classification), forests currently cover about 60 percent of the area and grasslands cover about 7 percent. Based on the observed trend, forest cover would be expected to decline to about 54 percent and grasslands to about 4.6 percent under the No Action Alternative. While these grasslands may include some remnant prairie habitats, they are more likely already modified through the introduction of non-native species and past grazing or other vegetation modification.

When more than 10 percent of the forest cover of a watershed is cleared, it can have impacts on stormwater runoff patterns which affect aquatic systems within the watershed (Booth, *et al.* 2002). However, the watershed surrounding Eufaula Lake is already impacted beyond this 10 percent threshold through clearing for agriculture and residential development, and oil and gas exploration. In addition, the lake is a reservoir that is already a highly modified aquatic environment. While it is expected that forest cover on the government lands immediately adjacent to the shorelines allocated as Limited Development (approximately 33 percent of the total shoreline) would continue to decline by about 10 percent as adjacent private lands develop, this additional decline would only affect another 109 miles or 13 percent of the shoreline at full build out under the No Action Alternative. A 10 percent decline in forest cover along 13 percent of the lake shore would not likely be a significant impact on habitat; however, there could be potential impacts to other resources such as water or visual quality from this predicted loss of vegetative cover.

Based on the analysis of impacts to vegetation on adjacent private lands over the past decade, it would be expected that similar trends would also extend into the future. Private lands adjacent to shorelines allocated as Limited Development would likely continue to develop because of the amenities provided by lake access and the opportunity to construct private docks. There would be about 109 miles or 13 percent of the lakeshore still available for private dock construction and therefore prone to adjacent private residential development.

As adjacent private lands develop, forest and grassland vegetation is affected through vegetation clearing, permitted mowing, and both formal and informal lake access. On private lands adjacent to Limited Development shorelines between 1999 and 2011, forest cover decreased over 24 percent and grassland cover decreased by only 8 percent. When the analysis focuses on areas that have actually experienced adjacent residential development over the last decade, forest cover on private lands declined by almost 38 percent but grasslands declined by only 25 percent.

On private lands within 0.5 mile of shorelines allocated to Limited Development (Low Density Recreation land classification), forests currently cover about 46 percent of the area and grasslands cover about 31 percent. Based on the observed trend, forest cover would be expected to decline to about 35 percent and grasslands to about 29 percent under the No Action Alternative. This additional decline would only affect another 109 miles or approximately 13 percent of the shoreline at full build out under the No Action Alternative. The potential impact to habitats would not likely be significant; however, there could be potential impacts to other resources such as water or visual quality from this predicted loss of vegetative cover.

5.2 Alternative 1

Of all the alternatives, Alternative 1 has the least potential to result in significant impacts. Under Alternative 1, no additional private boat dock construction would be allowed, greatly reducing the attractiveness of the lake for new lakeside residential development. This would likely greatly reduce the potential for residential development adjacent to government lands and thus would reduce the potential impacts to vegetation cover associated with such developments.

5.3 Alternative 2

While it would be expected that forest cover on the government lands immediately adjacent to the shorelines allocated as Limited Development (approximately 23 percent of the total shoreline under Alternative 2) would continue to decline as adjacent private lands develop, this additional decline would only affect another 66 miles or 8 percent of the shoreline at full build out under Alternative 2. With the implementation of the extended vegetation management buffer policy proposed under Alternative 2, the observed declines in forest cover would likely be less than the current observed rate of 10 percent. The vegetation management buffers would also likely be more protective of grasslands, resulting in a rate of decline less than the observed 34 percent. Therefore, potential impacts to habitats would not likely be significant.

Under Alternative 2, there would be about 66 miles or about 8 percent of the lakeshore still available for private dock construction and therefore prone to adjacent private residential development. Observed declines in vegetative cover on adjacent private lands would likely continue under Alternative 2 and would not be affected by the vegetation management buffers. It is also possible that with the reduced amount of shoreline available for private boat docks, adjacent residential developments could be designed to accommodate higher densities than has been typical in the region in the past.

While lot size is dependent on the amount of land needed to meet Oklahoma Department of Environmental Quality regulations for septic systems, development density would likely be regulated primarily by the limitations on the number of docks that could be constructed. Therefore, it is likely that the rates of vegetation conversion on private lands associated with high density developments would be more typical. The declines in forest and grassland cover can reach 23 percent and 77 percent, respectively, on private lands developed in high density residential. However, this potential for higher residential densities would be limited to the remaining 8 percent of the shoreline that would be available for private dock construction, and impacts may be partially offset by the 5 percent of the shoreline that would receive additional protection under Alternative 2; therefore, potential impacts would not likely be significant.

5.4 Alternative 3

It would be expected that forest cover on the government lands immediately adjacent to the shorelines allocated as Limited Development (approximately 46 percent of the total shoreline under Alternative 3) would continue to decline as adjacent private lands develop, and this additional decline would affect another 158 miles or almost 20 percent of the shoreline at full build out under Alternative 3. It is also likely that with the implementation of the baseline vegetation management buffer policy that the observed declines in forest cover would be less than the current observed rate of 10 percent. The vegetation management buffers would also likely be more protective of grasslands, resulting in a rate of decline less than the observed 34 percent. A less than 10 percent reduction in forest cover over 20 percent of the shoreline would result in a less than 2 percent reduction in forest cover around the lakeshore as a whole. Therefore, potential direct impacts to habitats on government lands would not likely be significant.

Under Alternative 3, there would be about 158 miles or about 20 percent of the lakeshore still available for private dock construction and therefore prone to adjacent private residential development. Observed declines in vegetative cover on adjacent private lands would likely continue under Alternative 3 and would not be affected by the vegetation management buffers. Since there would be more shoreline available for private dock construction than under the No Action Alternative, it is likely that development densities would be similar to the existing condition. Therefore, it is likely that the rates of vegetation conversion on private lands associated with residential developments would reflect the average rates described under the No Action Alternative. Under Alternative 3, over 10 percent of the forest cover on private lands within 0.5 miles of the government lands allocated as Limited Development could be lost under full build out. Therefore, potential indirect impacts would likely be significant.

5.5 Alternative 4

It would be expected that forest cover on the government lands immediately adjacent to the shorelines allocated as Limited Development (approximately 60 percent of the total shoreline under Alternative 4) would continue to decline as adjacent private lands develop, and this additional decline would affect another 214 miles or almost 26 percent of the shoreline at full build out under Alternative 4. It is also likely that with the implementation of the baseline vegetation management buffer policy that the observed declines in forest cover would be less than the current observed rate of 10 percent. The vegetation management buffers would also likely be more protective of grasslands, resulting in a rate of decline less than the observed 34 percent. A less than 10 percent reduction in forest cover over 26 percent of the shoreline would result in a less than 3 percent reduction in forest cover around the lakeshore as a whole. Therefore, potential direct impacts to habitats on government lands would not likely be significant; however, there could be potential impacts to other resources such as water or visual quality from this predicted loss of vegetative cover and localized impacts could be significant.

Under Alternative 4, there would be about 214 miles or about 26 percent of the lakeshore still available for private dock construction and therefore prone to adjacent private residential development. The observed declines in vegetative cover on adjacent private lands would likely continue under Alternative 4 and would not be affected by the vegetation management buffers. Since there would be more shoreline available for private dock construction than under the No Action Alternative, it is likely that the pattern of residential development and typical densities would be similar to the existing condition. Therefore, it is likely that the rates of vegetation conversion on private lands associated with residential developments would reflect the average rates described under the No Action Alternative. Under Alternative 4, over 14 percent of the forest cover on private lands within 0.5 miles of the government lands allocated as Limited Development could be lost under full build out; therefore, potential indirect impacts would likely be significant.

Section 6

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Appendix A
Data Tables

This appendix presents the raw data tables of vegetation classes by acres for each of the analyses performed. Each image year contains a slightly different number of total acres for a variety of reasons, but the differences between total acres in each year is less than one percent. For example, slight differences in lake elevation would expose variable amounts of land surface. The acres of lake surface in each image are 102,650.27 (1999), 102,290.21 (2006), and 102,497.65 (2011). The largest difference in lake area acres occurs between the 1999 and 2006 images and is only 360 acres or 0.4 percent.

The land area analyzed included the USACE-owned lands around the lake shore and the private lands within one half mile of the government land boundary. The total acres within this area varies slightly due to variations in the water surface area in each year and the other variables within the images. The largest difference in land area also occurs between the 1999 and 2006 images and is only 409 acres or 0.6 percent. In 1999, the water surface area is slightly larger than in 2006 indicating that the water level was slightly higher than in 2006. Therefore, there is more land exposed in 2006 than in 1999. When the difference of 360 acres of water surface is accounted for, the difference in land area in the analysis area is less than 50 acres or 0.08 percent. Over an area the size of the Eufaula study area, which encompasses more than 164,013 acres, this is an acceptable degree of accuracy between images.

Entire Study Area

Table A-1. Vegetative Change 1999 to 2011 for Entire Study Area

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land[2] (acres)		
	1999	2006	2011	1999	2006	2011
Bare Land/Fallow Land	3,927.88	7,007.77	7,779.43	7,246.01	34,905.75	32,447.12
Residential/Built	437.39	317.91	874.12	726.18	1,189.76	2,647.61
Emergent Wetlands	363.73	726.17	2,097.91	552.54	1,246.52	2,323.47
Bottom Land Forest	16,587.32	16,104.61	14,378.60	22,675.31	20,016.48	19,402.39
Mowed Grass	41.37	465.31	1,296.23	471.97	2,814.68	3,589.73
Pasture/Grazing	6,258.25	4,856.16	6,097.29	60,998.44	46,955.55	54,756.82
Forest	33,698.37	32,245.47	28,914.16	89,302.52	75,102.84	65,940.11
Cloud Cover[1]	0.0	0.0	60.10	0.0	0.0	130.33

1- Cloud cover was only present in a small portion of the 2011 imagery.

2- Includes private lands within 0.5 miles of the government land boundary

By Adjacent Shoreline Allocation

The following tables present the amount of land in each vegetation class by adjacent shoreline allocation. The study area was divided up into the areas adjacent to Limited Development versus Protected shorelines. In addition, government lands that are encumbered by a lease or a license to another management entity were also evaluated separately. Encumbered lands represent more than 45 percent of the government lands around the shoreline.

Table A-2. Vegetative Change Associated with Limited Development Shorelines

Vegetation Cover Type	USACE Land Adjacent to Limited Development Shorelines (acres)			Private Land Adjacent[2] to Limited Development Shorelines (acres)		
	1999	2006	2011	1999	2006	2011
Bare Land/Fallow Land	712	1,223	1,7493	2,200	9,861	9,236
Residential/Built	108	100	247	326	604	1,228
Emergent Wetlands	68	36	260	3	49	80
Bottom Land Forest	1328	1,278	897	1,146	1,027	1,010
Mowed Grass	9	26	158	271	588	1,123
Pasture/Grazing	939	603	618	17,890	13,965	16,485
Forest	6,068	5,902	5,443	30,758	26,459	23,280
Cloud Cover[1]	0	0	3	0	0	29

1- Cloud cover was only present in a small portion of the 2011 imagery.

2- Includes private lands within 0.5 miles of the government land boundary

Unencumbered government land is land that is not leased or licensed to another management entity such as the Oklahoma Department of Wildlife Conservation. Unencumbered lands are open for public access, but along shorelines allocated as Protected, private docks and improved trails are not permitted, and vegetation modification other than minimal clearing for firebreaks is not allowed.

Table A-3. Vegetation Change Associated with Unencumbered Government Lands Adjacent to Protected Shorelines

Vegetation Cover Type	Unencumbered USACE Land Adjacent to Protected shoreline (acres)			Private Land Not Adjacent[2] to Limited Development Shoreline (acres)		
	1999	2006	2011	1999	2006	2011
Bare Land/Fallow Land	848	1,774	1,819	5,144	25,293	23,455
Urban/Built up	119	72	223	410	599	1,454
Emergent Wetlands	40	47	133	552	1,197	2,266
Bottom Land Forest	2,461	2,391	2,282	21,867	19,313	18,696
Mowed Grass	6	31	77	204	2,241	2,512
Pasture/Grazing	1,766	1,394	2,071	43,433	33,211	38,587
Forest	10,055	9,662	8,855	59,881	49,900	43,791
Cloud Cover [1]	0	0	18	0	0	106

1- Cloud cover was only present in a small portion of the 2011 imagery.

2- Includes private lands within 0.5 miles of the government land boundary

Encumbered USACE lands are those that are leased or licensed to other management entities such as ODWC for wildlife management purposes, to the State of Oklahoma for state parks, or which are dedicated to recreational uses. These lands are presumed to change little over time as their management emphasizes natural resource values and developed recreation areas have changed little over the past decade.

Table A-4. Vegetation Change on Encumbered Government Lands Adjacent to Shorelines Allocated to Protected and Public Recreation

Vegetation Cover Type	Encumbered USACE Land Adjacent to Protected and Public Recreation Shoreline (acres)		
	1999	2006	2011
Bare Land/Fallow Land	2,368	4,011	4,467
Urban/Built up	210	146	404
Emergent Wetlands	256	643	1,705
Bottom Land Forest	12,798	12,436	11,200
Mowed Grass	26	408	1,061
Pasture/Grazing	3,553	2,859	3,408
Forest	17,575	16,681	14,616
Cloud Cover [1]	0	0	39

1- Cloud cover was only present in a small portion of the 2011 imagery.

Selected Residential Areas Developed Since 1999

Fourteen subdivision areas that have been developed over the last decade were selected and the vegetation classes for each image year were measured on the private lands and the USACE-owned lake front at each selected area. Table A-5 presents the data for all 14 subdivisions aggregated and the following tables present the data for each individual subdivision area selected. A map of the selected subdivision areas is presented in Section 4.4.

Table A-5. Vegetative Change Associated with 14 Selected Recent Residential Developments

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land (acres)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	28.8	51.7	64.5	52.8	220.5	284.1
Residential/Built	2.7	2.71	6.1	10.13	19.3	37.1
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.1	0.1	0.1	0.2	0.2	0.2
Mowed Grass	0.11	0.7	4.8	9.2	20.7	44.2
Pasture/Grazing	40.8	24.1	20.6	263.8	216.0	197.9
Forest	303.2	295.1	273.6	607.2	465.6	379.1

Table A-6. Avalon Bay

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land (acres)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	1.7	4.7	5.4	3.0	11.3	12.5
Residential/Built	0.8	0.3	1.2	0.6	0.2	1.0
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.1	0.1	0.1	0.2	0.2	0.2
Mowed Grass	0.0	0.0	0.0	0.0	0.0	0.2
Pasture/Grazing	6.2	4.4	4.3	21.4	16.6	20.0
Forest	24.3	23.7	22.1	28.5	25.3	19.7

Table A-7. Breckenridge

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land (acres)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	1.0	1.3	2.4	0.6	2.9	15.9
Residential/Built	0.1	0.0	0.1	0.03	0.0	0.1
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.0	0.0	0.0	0.1
Pasture/Grazing	0.6	0.7	0.4	3.0	9.7	14.9
Forest	19.0	18.7	17.8	50.5	41.4	23.2

Table A-8. Cedar Point #3

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land (acres)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	1.6	3.9	5.3	20.6	49.1	45.5
Residential/Built	0.0	0.0	0.1	3.2	1.9	7.5
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.1	0.2	0.6	0.9	3.8	8.1
Pasture/Grazing	3.6	1.9	1.7	59.4	35.9	31.3
Forest	33.7	33.2	31.3	21.4	14.7	13.1

Table A-9. Circle V Ranch Estates

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land (acres)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	2.1	3.3	3.8	0.4	3.2	3.9
Residential/Built	0.0	0.1	0.2	0.0	0.0	0.2
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.3	0.0	0.3	0.6
Pasture/Grazing	2.0	1.3	1.1	3.6	1.9	1.7
Forest	5.5	5.1	4.0	2.7	1.4	0.3

Table A-10. Cliff Heights

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land (acres)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	0.0	0.3	0.5	0.0	3.5	2.8
Residential/Built	0.0	0.0	0.0	0.0	0.0	0.1
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.0	0.1	0.0	0.1
Pasture/Grazing	0.4	0.1	0.1	8.2	7.1	10.9
Forest	21.2	21.2	20.8	63.7	61.3	58.1

Table A-11. Dover Estates, Hickory

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land (acres)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	0.2	0.6	1.2	0.5	6.4	10.2
Residential/Built	0.0	0.1	0.2	1.0	1.6	1.9
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.0	0.0	0.0	0.1
Pasture/Grazing	0.6	0.2	0.4	3.6	5.0	5.7
Forest	8.3	8.2	7.1	19.0	10.8	5.9

Table A-12. Falcon Cove

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land (acres)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	6.5	9.0	10.3	3.1	18.3	30.1
Residential/Built	0.0	0.0	0.2	0.0	0.3	1.5
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.1	0.6	0.2	2.5	3.5
Pasture/Grazing	3.2	3.2	1.6	21.5	19.7	7.3
Forest	58.6	57.4	53.6	24.1	8.1	6.5

Table A-13. Falcon Ridge

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land (acres)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	6.6	6.8	8.9	1.4	28.5	39.6
Residential/Built	0.1	0.01	0.2	0.4	1.2	2.3
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.0	0.0	0.0	0.0
Pasture/Grazing	4.6	2.8	3.4	8.8	15.3	4.0
Forest	20.5	18.3	15.4	44.9	10.3	9.3

Table A-14. Gaines Creek Hideaway

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land (acres)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	0.3	0.9	1.2	0.4	4.9	6.4
Residential/Built	0.0	0.0	0.0	0.0	0.0	0.1
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.0	0.0	0.0	0.1
Pasture/Grazing	0.3	0.1	0.0	8.4	9.0	8.3
Forest	6.9	6.7	6.6	14.3	9.2	8.2

Table A-15. Paradise Shores, Olde Channel Pointe

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land (acres)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	2.3	4.4	5.2	7.4	30.2	31.0
Residential/Built	0.0	0.0	0.3	0.0	2.1	6.4
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.2	0.0	0.9	1.5
Pasture/Grazing	2.3	1.3	1.5	33.6	15.6	11.3
Forest	21.8	21.0	19.5	15.2	7.3	6.0

Table A-16. Riverview Terrace 1, Riverview Terrace 2

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land (acres)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	0.4	1.5	1.5	4.0	16.7	14.8
Residential/Built	0.0	0.002	0.002	0.0	0.4	1.7
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.0	0.0	0.0	0.0
Pasture/Grazing	1.1	0.2	0.3	26.4	21.5	26.5
Forest	17.3	17.1	17.0	108.9	100.6	96.3

Table A-17. Scoodiac Point

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land (acres)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	0.0	0.2	0.5	0.1	5.7	7.2
Residential/Built	0.1	0.1	0.4	0.2	0.9	2.0
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.2	0.1	0.5	1.1
Pasture/Grazing	0.2	0.0	0.1	7.7	10.0	12.9
Forest	13.4	13.4	12.4	36.6	27.6	21.4

Table A-18. Stone Cliff, Stone Ridge

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land (acres)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	0.9	3.4	3.8	0.6	17.6	37.4
Residential/Built	0.0	0.0	0.1	0.0	0.9	1.1
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.1	2.8	6.2	9.8	26.5
Pasture/Grazing	2.3	0.0	0.6	18.9	23.7	22.1
Forest	27.4	27.1	23.1	170.4	144.0	109.0

Table A-19. Willow, Porum Landing, Island View Estates 1, Island View Estates II

Vegetation Cover Type	USACE-owned Land (acres)			Adjacent Private Land (acres)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	5.2	11.4	14.5	10.7	22.2	26.8
Residential/Built	1.6	2.1	3.1	4.7	9.8	11.2
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.01	0.3	0.1	1.7	2.9	2.3
Pasture/Grazing	13.4	7.9	5.1	39.3	25.0	21.0
Forest	25.3	24.0	22.9	7.0	3.6	2.1

By Density of Adjacent Residential Development

Five areas around the lake were selected where there was residential development of varying density in close proximity. The five areas are shown on Figures 4-2 through 4-6 in Section 4.5. The following tables present the detailed information for each area first by percent area and then by acres. Because each area is a different size, the acres are not directly comparable.

Belle Starr Area

Percent Area Tables

Table A-20. Low Density – Belle Starr						
	USACE-owned Land (Percent)			Adjacent Private Land (Percent)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	2.8	6.6	8.8	4.7	24.4	18.0
Urban/Built up	0.0	0.0	0.1	0.1	0.06	0.8
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	1.8	0.0	0.0	0.06
Pasture/Grazing	12.9	11.9	13.9	38.1	23.5	33.1
Forest	84.3	81.5	75.5	57.1	52.0	48.1
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-21. Medium Density – Belle Starr						
	USACE-owned Land (Percent)			Adjacent Private Land (Percent)		
Vegetation Cover Type	1999	2006	1999	1999	2006	2011
Bare Earth/Fallow land	6.1	28.4	11.7	17.5	47.1	44.8
Urban/Built up	0.9	1.9	2.8	1.0	1.1	5.6
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.5	0.0	24.8	2.1	6.5	13.6
Pasture/Grazing	22.8	0.5	0.6	43.4	17.5	14.9
Forest	69.7	69.3	60.1	35.9	27.8	21.0
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-22. High Density – Belle Starr						
	USACE-owned Land (Percent)			Adjacent Private Land (Percent)		
Vegetation Cover Type	1999	2006	1999	1999	2006	2011
Bare Earth/Fallow land	14.4	23.5	21.7	13.6	44.8	48.8
Urban/Built up	4.4	5.3	7.9	2.5	4.7	8.8
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	3.0	31.6	0.9	8.0	17.1
Pasture/Grazing	19.1	11.0	3.7	59.9	22.9	14.0
Forest	62.2	57.2	35.1	23.0	19.6	11.3
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Area by Acres Tables

Table A-23. Low Density – Belle Starr						
	USACE-owned Land (Acres)			Adjacent Private Land (Acres)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	3.2	7.57	10.04	8.0	41.79	30.74
Urban/Built up	0.0	0.0	0.12	0.22	0.11	1.39
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	2.0	0.0	0.0	0.11
Pasture/Grazing	14.95	13.71	15.84	65.26	40.24	56.65
Forest	97.5	93.92	86.22	97.7	89.10	82.32
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-24. Medium Density – Belle Starr						
	USACE-owned Land (Acres)			Adjacent Private Land (Acres)		
Vegetation Cover Type	1999	2006	1999	1999	2006	2011
Bare Earth/Fallow land	1.44	6.72	2.78	16.87	45.4	43.2
Urban/Built up	0.22	0.44	0.66	1.0	1.06	5.39
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.11	0.0	5.89	2.05	6.27	13.15
Pasture/Grazing	5.39	0.11	0.15	41.85	16.81	14.33
Forest	16.5	16.38	14.28	34.56	26.79	20.27
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-25. High Density – Belle Starr						
	USACE-owned Land (Acres)			Adjacent Private Land (Acres)		
Vegetation Cover Type	1999	2006	1999	1999	2006	2011
Bare Earth/Fallow land	5.39	9.15	8.11	14.53	47.82	52.13
Urban/Built up	1.63	2.05	2.93	2.65	5.01	9.36
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	1.17	11.78	1.0	8.49	18.23
Pasture/Grazing	7.14	4.28	1.39	63.93	24.43	14.99
Forest	23.26	22.28	13.08	24.58	20.88	12.02
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Bixby Creek Area

Percent Area Tables

Table A-26. Low Density – Bixby Creek						
	USACE-owned Land (Percent)			Adjacent Private Land (Percent)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	5.3	13.3	15.1	2.4	16.5	18.6
Urban/Built up	0.3	0.5	0.8	0.4	1.0	1.4
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.1	0.1	0.2	0.03	0.3	0.05
Pasture/Grazing	12.1	5.8	8.3	23.7	22.0	26.3
Forest	82.1	80.2	68.4	73.4	60.2	38.3
Clouds (2011 Data Only)	N/A	N/A	7.2	N/A	N/A	15.3

Table A-27. Medium Density – Bixby Creek						
	USACE-owned Land (Percent)			Adjacent Private Land (Percent)		
Vegetation Cover Type	1999	2006	1999	1999	2006	2011
Bare Earth/Fallow land	11.1	24.2	29.1	5.0	14.5	31.7
Urban/Built up	0.3	0.5	1.0	1.8	9.7	12.5
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.2	0.6	0.6	3.9	4.4	2.5
Pasture/Grazing	18.1	7.2	5.1	36.8	37.3	26.8
Forest	70.2	67.5	64.2	52.5	34.1	26.6
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-28. High Density – Bixby Creek						
	USACE-owned Land (Percent)			Adjacent Private Land (Percent)		
Vegetation Cover Type	1999	2006	1999	1999	2006	2011
Bare Earth/Fallow land	16.2	33.1	46.0	19.2	26.9	38.1
Urban/Built up	5.7	8.2	10.0	17.8	35.4	38.4
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	1.3	3.6	3.3	7.4	4.6	6.1
Pasture/Grazing	32.7	17.9	7.3	45.8	27.4	14.2
Forest	44.0	32.3	30.2	9.8	5.8	3.2
Clouds (2011 Data Only)	N/A	N/A	3.2	N/A	N/A	0.01

Area by Acres Tables

Table A-29. Low Density – Bixby Creek						
	USACE-owned Land (Acres)			Adjacent Private Land (Acres)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	12.48	30.83	34.75	14.45	98.37	111.17
Urban/Built up	0.81	1.1	1.89	2.63	6.12	8.07
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.26	0.31	0.36	0.18	1.61	0.3
Pasture/Grazing	28.23	13.47	19.14	141.84	131.4	157.13
Forest	192.1	185.52	157.51	438.65	358.81	229.06
Clouds (2011 Data Only)	N/A	N/A	16.64	N/A	N/A	91.6

Table A-30. Medium Density – Bixby Creek						
	USACE-owned Land (Acres)			Adjacent Private Land (Acres)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	3.13	6.8	8.23	7.84	22.58	49.34
Urban/Built up	0.09	0.14	0.29	2.81	15.2	19.44
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.07	0.17	0.17	6.09	6.82	3.88
Pasture/Grazing	5.09	2.02	1.45	57.49	58.16	41.75
Forest	19.74	19.0	18.17	82.01	53.16	41.46
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-31. High Density – Bixby Creek						
	USACE-owned Land (Acres)			Adjacent Private Land (Acres)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	7.28	14.79	20.55	24.84	32.91	49.24
Urban/Built up	2.56	3.65	4.49	22.98	43.28	49.68
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.59	1.59	1.46	9.52	5.6	7.94
Pasture/Grazing	14.68	8.0	3.26	59.26	33.46	18.38
Forest	19.76	16.66	13.52	12.65	7.07	4.08
Clouds (2011 Data Only)	N/A	N/A	1.44	N/A	N/A	0.01

I-40 Crossing Area

Percent Area Tables

Table A-32. Low Density – I-40						
Vegetation Cover Type	USACE-owned Land (Percent)			Adjacent Private Land (Percent)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	1.0	1.9	5.1	0.7	15.6	3.2
Urban/Built up	0.0	1.8	3.3	1.1	0.7	3.7
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.2	0.2	0.2
Mowed Grass	0.0	0.0	6.5	2.0	1.6	9.6
Pasture/Grazing	1.9	0.3	2.4	47.2	39.7	44.2
Forest	97.2	96.0	82.7	48.8	42.2	39.1
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-33. Medium Density – I-40						
Vegetation Cover Type	USACE-owned Land (Percent)			Adjacent Private Land (Percent)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	3.1	6.7	9.6	2.4	21.6	10.9
Urban/Built up	0.0	4.6	5.4	2.2	8.4	14.7
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	1.0	9.4	3.4	15.5	26.5
Pasture/Grazing	7.5	2.0	1.5	65.0	37.2	35.6
Forest	89.4	85.7	74.1	27.0	17.3	12.3
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-34. High Density – I-40						
Vegetation Cover Type	USACE-owned Land (Percent)			Adjacent Private Land (Percent)		
	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	9.5	17.2	9.3	3.1	25.0	14.7
Urban/Built up	0.3	9.0	17.4	2.8	9.5	21.0
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	2.7	2.2	26.1	5.2	14.9	24.4
Pasture/Grazing	23.0	11.3	3.8	49.2	14.8	7.4
Forest	64.5	60.3	43.4	39.6	35.8	32.4
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Area by Acres Tables

Table A-35. Low Density – I-40						
	USACE-owned Land (Acres)			Adjacent Private Land (Acres)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	0.11	0.22	0.58	1.11	24.67	4.99
Urban/Built up	0.0	0.20	0.37	1.7	1.08	5.88
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.33	0.33	0.33
Mowed Grass	0.0	0.0	0.73	3.16	2.56	15.21
Pasture/Grazing	0.21	0.03	0.27	74.75	62.79	70.02
Forest	11.03	10.89	9.32	77.28	66.86	61.87
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-36. Medium Density – I-40						
	USACE-owned Land (Acres)			Adjacent Private Land (Acres)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	0.45	0.99	1.39	2.75	24.98	12.61
Urban/Built up	0.0	0.68	0.78	2.56	9.75	17.07
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.14	1.37	4.0	17.89	30.73
Pasture/Grazing	1.09	0.29	0.22	75.68	43.07	41.15
Forest	12.95	12.6	10.75	31.38	20.04	14.19
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-37. High Density – I-40						
	USACE-owned Land (Acres)			Adjacent Private Land (Acres)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	2.19	4.08	2.13	1.9	15.16	8.87
Urban/Built up	0.06	2.14	3.97	1.72	5.75	12.7
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.62	0.53	5.98	3.17	9.03	14.75
Pasture/Grazing	5.31	2.67	0.87	29.77	8.96	4.47
Forest	14.89	14.3	9.92	23.92	21.71	19.56
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Longtown Area

Percent Area Tables

Table A-38. Low Density – Longtown						
	USACE-owned Land (Percent)			Adjacent Private Land (Percent)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	4.6	9.4	12.7	1.3	5.7	11.8
Urban/Built up	0.0	0.1	0.2	0.04	0.2	0.3
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.09	0.0	0.09	0.01	0.0	0.02
Pasture/Grazing	8.5	5.0	2.4	11.8	14.1	11.6
Forest	86.9	85.5	84.7	86.8	80.0	76.3
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-39. Medium Density - Longtown						
	USACE-owned Land (Percent)			Adjacent Private Land (Percent)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	4.7	13.2	15.4	6.2	31.2	39.8
Urban/Built up	0.3	0.2	0.8	0.1	0.7	2.0
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.0	0.0	0.0	0.03
Pasture/Grazing	10.0	3.5	2.5	46.3	34.4	31.6
Forest	85.0	83.1	81.3	47.4	33.7	26.6
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-40. High Density - Longtown						
	USACE-owned Land (Percent)			Adjacent Private Land (Percent)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	3.9	18.9	16.3	10.0	40.0	49.4
Urban/Built up	3.5	2.1	5.6	1.1	2.6	3.2
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.04	0.04	0.04
Mowed Grass	0.3	2.0	8.6	1.5	6.7	11.7
Pasture/Grazing	18.8	6.6	5.3	58.9	32.7	22.4
Forest	73.5	70.4	64.2	28.3	18.0	13.2
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Area by Acres Tables

Table A-41. Low Density – Longtown						
	USACE-owned Land (Acres)			Adjacent Private Land (Acres)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	2.56	5.23	7.07	6.5	27.63	56.79
Urban/Built up	0.0	0.06	0.11	0.17	0.94	1.38
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.05	0.0	0.05	0.06	0.0	0.12
Pasture/Grazing	4.7	2.79	1.31	56.98	68.08	56.22
Forest	49.3	47.58	47.18	420.07	387.11	368.78
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-42. Medium Density - Longtown						
	USACE-owned Land (Acres)			Adjacent Private Land (Acres)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	5.21	14.62	17.0	13.91	69.81	89.09
Urban/Built up	0.33	0.22	0.89	0.22	1.5	4.39
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.0	0.0	0.0	0.06
Pasture/Grazing	11.02	3.87	2.78	103.56	76.9	70.57
Forest	93.96	92.03	89.97	105.96	75.43	59.52
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-43. High Density - Longtown						
	USACE-owned Land (Acres)			Adjacent Private Land (Acres)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	4.69	22.42	19.39	26.01	103.8	125.41
Urban/Built up	4.21	2.55	6.71	2.96	6.68	8.21
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.11	0.11	0.11
Mowed Grass	0.31	2.37	10.17	3.97	17.3	29.84
Pasture/Grazing	22.37	7.89	6.28	152.69	84.86	56.93
Forest	87.38	83.66	76.34	73.43	46.65	33.61
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Porum Landing

Percent Area Tables

Table A-44. Low Density – Porum Landing						
	USACE-owned Land (Percent)			Adjacent Private Land (Percent)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	2.2	5.3	9.6	0.3	1.8	6.5
Urban/Built up	0.6	0.4	1.7	0.1	0.1	0.3
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.0	0.0	0.0	0.1
Pasture/Grazing	2.7	1.3	0.2	5.9	9.2	14.0
Forest	94.5	93.1	88.5	93.7	88.9	79.0
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-45. Medium Density Porum Landing						
	USACE-owned Land (Percent)			Adjacent Private Land (Percent)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	25.4	46.0	67.1	7.3	24.1	44.4
Urban/Built up	0.0	0.0	0.0	0.2	0.2	1.1
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.0	0.0	0.0	0.5
Pasture/Grazing	23.5	4.0	1.4	41.4	39.8	30.6
Forest	51.1	50.0	31.4	51.0	35.9	23.5
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-46. High Density – Porum Landing						
	USACE-owned Land (Percent)			Adjacent Private Land (Percent)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	17.2	60.1	69.3	24.8	52.7	74.9
Urban/Built up	0.0	0.3	0.3	3.4	3.9	9.1
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.0	0.0	0.0	0.0
Pasture/Grazing	47.0	6.9	0.0	64.4	33.8	13.3
Forest	35.7	32.7	30.4	7.4	4.6	2.6
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Area by Acres Tables

Table A-47. Low Density – Porum Landing						
	USACE-owned Land (Acres)			Adjacent Private Land (Acres)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	0.67	1.64	2.97	0.17	0.98	3.52
Urban/Built up	0.2	0.11	0.53	0.08	0.06	0.14
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.0	0.0	0.0	0.06
Pasture/Grazing	0.84	0.39	0.05	3.17	4.94	7.56
Forest	29.14	28.74	27.35	50.47	47.97	42.55
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-48. Medium Density Porum Landing						
	USACE-owned Land (Acres)			Adjacent Private Land (Acres)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	1.21	2.19	3.31	3.41	11.25	20.77
Urban/Built up	0.0	0.0	0.0	0.11	0.11	0.5
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.0	0.0	0.0	0.22
Pasture/Grazing	1.12	0.19	0.07	19.28	18.61	14.32
Forest	2.43	2.38	1.55	23.74	16.79	11.0
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0

Table A-49. High Density – Porum Landing						
	USACE-owned Land (Acres)			Adjacent Private Land (Acres)		
Vegetation Cover Type	1999	2006	2011	1999	2006	2011
Bare Earth/Fallow land	0.55	1.91	2.23	8.02	18.68	24.29
Urban/Built up	0.0	0.01	0.01	1.10	1.25	2.96
Emergent Wetlands	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land Forest	0.0	0.0	0.0	0.0	0.0	0.0
Mowed Grass	0.0	0.0	0.0	0.0	0.0	0.0
Pasture/Grazing	1.5	0.22	0.0	20.88	10.93	4.23
Forest	1.14	1.04	0.98	2.4	1.5	0.85
Clouds (2011 Data Only)	N/A	N/A	0.0	N/A	N/A	0.0