TECHNICAL REPORT

USF Preserve Area

GIS6306: Environmental Applications of GIS

Assessment of Forested Land of USF Preserve Area using GIS and Remote Sensing

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2023

INTRODUCTION

Background of the Project

Forested land offers a variety of advantages, including carbon sequestration, water regulation, soil stabilization, and wildlife habitat which plays an indicator of ecosystem service in urban area (Dobbs et al., 2011;Wu et al., 2008). Unfortunately, it is in danger due to wildfires, land use changes, deforestation, urbanisation, and other disturbances (Barrette et al., 2017). With the expansion of city area, vegetation cover had been decreasing in urban area resulting adverse impacts of climate change (Hirokawa, 2011). Two significant sources of remote sensing data are Landsat and Lidar data, which are used to evaluate forested land through identifying the change in Normalized Difference Vegetation Index (NDVI) and Green Chlorophyll Index (GCI) over the time. NDVI and GCI offer comprehending information which is essential for comprehending the health of the forest (Wu et al., 2012) and for identifying the changes in the composition and density of the forest throughout time (Martinez & Labib, 2023;Landry et al., 2008). Lidar data offers extremely precise 3D information on canopy height, canopy cover, and density of the forest's trees as well as other aspects i.e., biomass, carbon storage (Alonzo et al., 2016;Qin et al., 2021). Urban area generates huge amount of carbon every day (Davies et al., 2011) and the quantity of carbon storage varies with the presence of vegetation for which the estimation of the biomass and carbon storage of the forest depends heavily on this information(Gulcin & Konijnendijk Van Den Bosch, 2021). Landsat data offers spectral information on the composition and health of forests, including the presence of vegetation, moisture levels, and disturbances like wildfires and insect outbreaks (Ren et al., 2015). A more thorough evaluation of forested area is possible when lidar and Landsat data are combined, allowing for a more complex understanding of the factors that contribute to forest degradation and regeneration (Qin et al., 2021b).

Scope of the Project

The project's findings will be valuable to forest managers, policymakers, and conservationists who require accurate and current information on forested land to make wise decisions about managing and conserving forests. The study will also provide insights into the causes of forest degradation and regeneration and help establish a baseline for tracking changes in forested land cover over time. By combining lidar and Landsat data, it will be possible to examine forested land more thoroughly and gain a more detailed understanding of the factors that contribute to forest degradation and restoration.

Study Area

USF preserve area has been served as multiple purpose i.e., research, entertainment, conservation to USF faculty, students (Fox et al., 2013). The area comprised of roughly 6.33 sq.km which ranges from Golf course to Riverfront Park. The area has great composition of LULC (figure 1) where stream and lake swamps (Bottomland) occupies the most. This area is like a home of diverse trees and animals. As concerns over the deterioration of forested land, the project was carried out in USF Preserve area to assess the status of forested land in 5 years from 2017 to 2022.

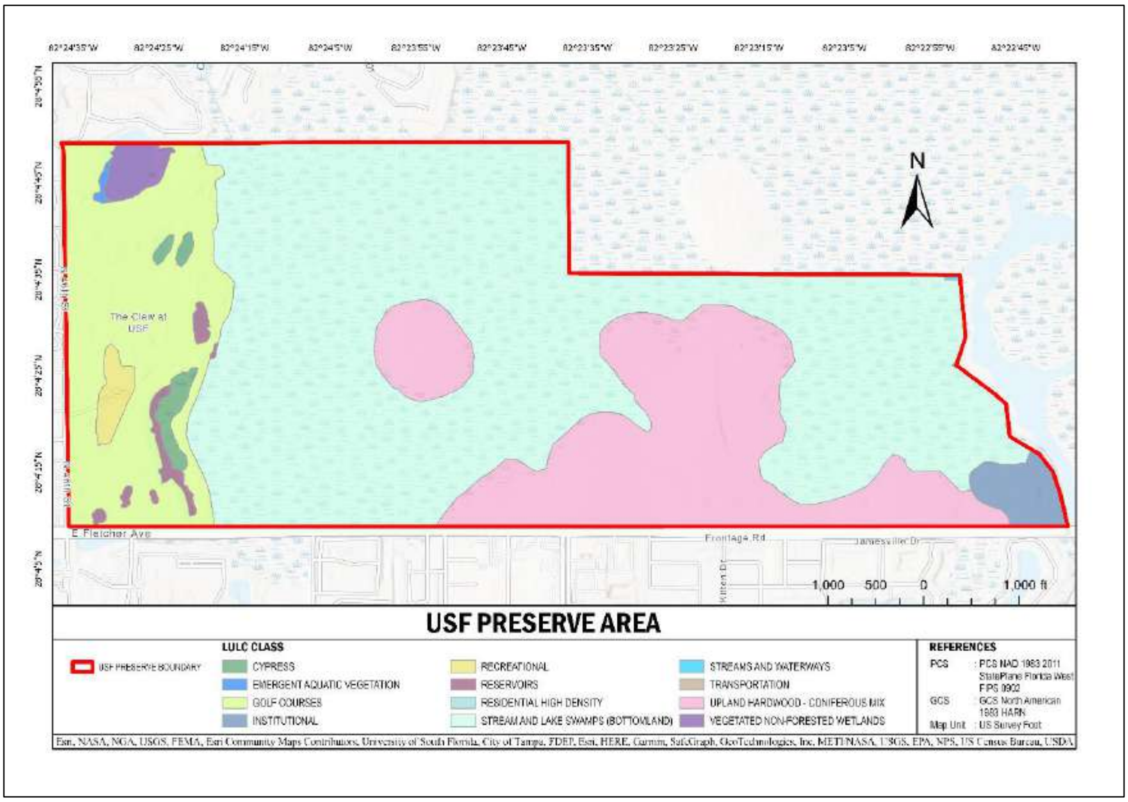

Figure 1 Study Area: USF Preserve Area

METHODS

Two types of data were used in this project i.e., LiDAR and Landsat Data. Landsat Data was obtained from USGS Earth explorer for 2017 and 2022. LiDAR dataset containing 12 files of point features within USF Preserve area.

Table 1 Data Source

Parameters	Data Source	Bands	Data Acquisition Date
NDVI & GCI	Landsat 8	2, 3, 4, 5	2017/04/07
	Landsat 8	2, 3, 4, 5	2022/05/30
Topographic	LiDAR	N/A	Present and up to date

Landsat Data: For NDVI and GCI change assessment, Landsat 8 images was used for year 2017 and year 2022. 4 bands (Near-infrared (NIR), Red, Green, and blue bands) of each landsat image were combined using "composite bands" tool in arcgis pro to visualize true color and false color image for making ease the process of identification of different features and healthy vegetation where natural color was created Band 3, Band 2, Band 1 in order and false color was created Band 4, Band 3, Band 2 in order.

Then, NDVI was calculated to understand the status of vegetation for each landsat image using the following formula:

$$NDVI = (Band\ 5 - Band\ 4) / (Band\ 5 + Band\ 4)$$

After calculating NDVI, each landsat image was extracted using the study area and then calculated the NDVI for each LULC class within study area using "Zonal Statistics as Table".

Similar to NDVI calculation, GCI was calculated to measure plants' health for each landsat image using the following formula:

GCI = Band 5 / (Band 3 - 1)

After calculating GCI, each landsat image was extracted using the study area and then calculated the GCI for each LULC class within study area using "Zonal Statistics as Table".

To find out the overall change in NDVI and GCI in 5 years, the following formula was used:

*Percentage of Change in NDVI or GCI = 100 * ((NDVI or GCI of 2022 - NDVI or GCI of 2017) / (NDVI or GCI of 2017))*

The summary table from NDVI and GCI calculation would help to make comparison the change over the time from 2017 to 2022.

LiDAR Data: LiDAR Dataset was comprised of 12 LAS files which needed to be converted into single raster.

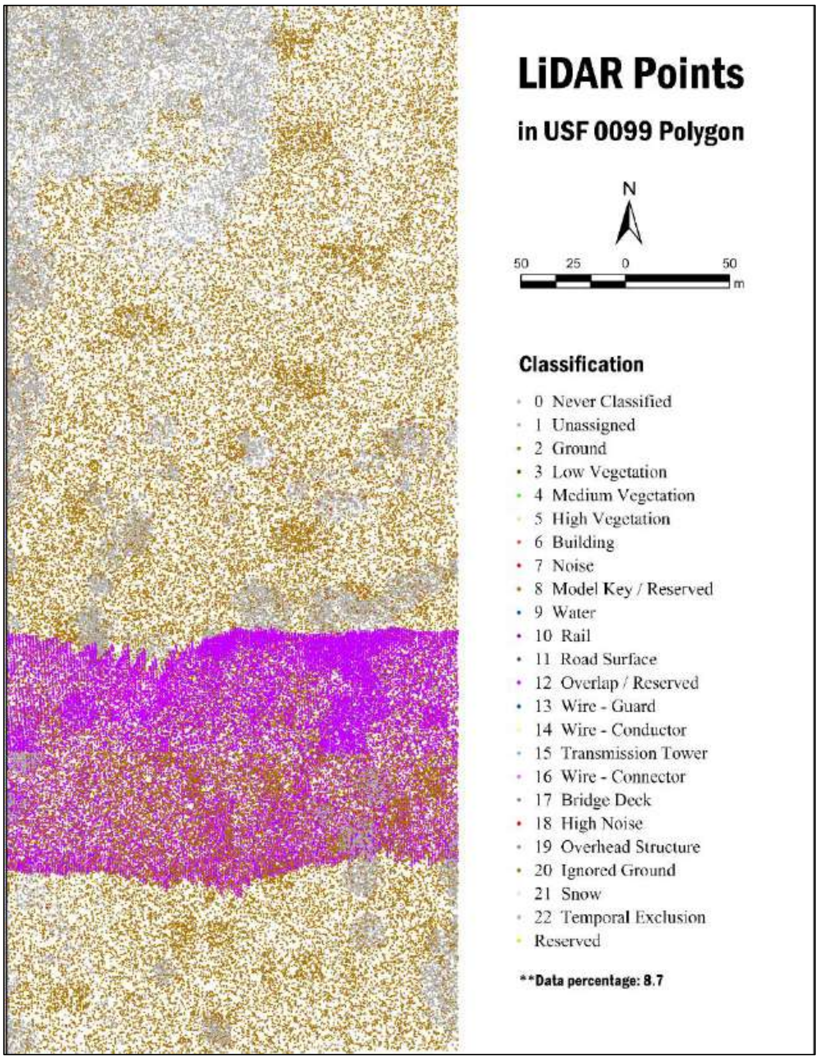

Figure 2 Data view of LiDAR Data. Different points classify different LULC class.

For that, LAS dataset was created using “Create LAS Dataset”. LAS Dataset could be displayed as 2d and 3d to distinguish the features in a better. It would help to understand the height of the object from the ground (figure 3).

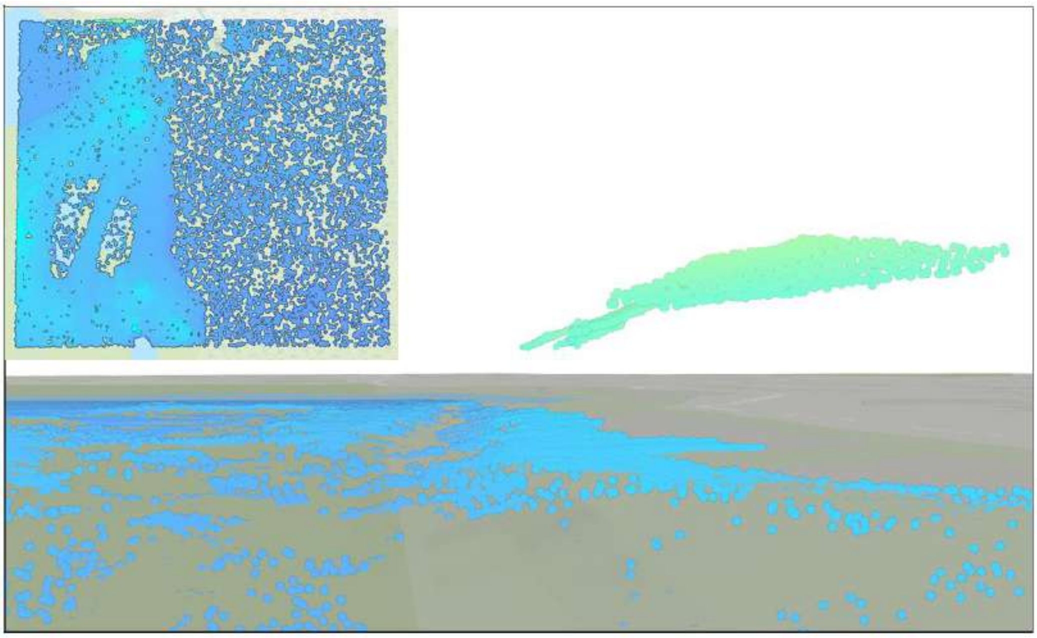

Figure 3 2d and 3d Presentation of LiDAR Dataset. Blue points represent ground points and Light Green points represent building features.

For creating Digital Elevation model, only ground points were extracted using “LAS filters”. Following that, Digital Elevation Model was created using “LAS Dataset to Raster” tool with following parameters:

Interpolation Type: Triangulation
Interpolation Method: Natural Neighbor
Sampling Value: 2

Following DEM, Digital Surface Model (DSM) was created using “LAS Dataset to Raster” tool with following parameters after filtering all points except “Noise” and “Overlap/Reserved”:

Interpolation Type: Binning
Cell Assignment: Maximum
Sampling Value: 2

Digital Height Model (DHM) was used for identifying heights of specific objects. It was calculated using “Raster Calculator” with following formula:

$$DHM = DSM - DEM$$

Index contours was calculated using “Surface” tool to visualize the height and steepness of slope from the LiDAR Dataset using with contour interval “**2**” where the optimum results was found. The contour interval more than or less 2 came out with less contours.

Hillshade was created for both DSM and DEM for better visualisation in 3D using “Hillshade” tool with following parametes:

Azimuth: 315
Altitude: 45
Z factor: 1

RESULTS

Summary Table

In 5 years (2017-2022), there was found massive change in NDVI where the value ranges from -1332.52 to 4449.84 which dictated that there was huge decline of vegetation in some LULC classes (figure 4(A)). There were found few areas with significant positive change deriving the increase of vegetation due to low or no human disturbance or reforestation.

Similar to NDVI, there was found noticeable change in GCI where the value ranges from -25.3102 to 119.537 (figure 4(B)). It was evident that with the decline of vegetation, the health status of vegetation also had been deteriorated over the time. There were found few areas with significant positive change deriving the maintenance of healthy ecosystem in terms of health status of plants on these places.

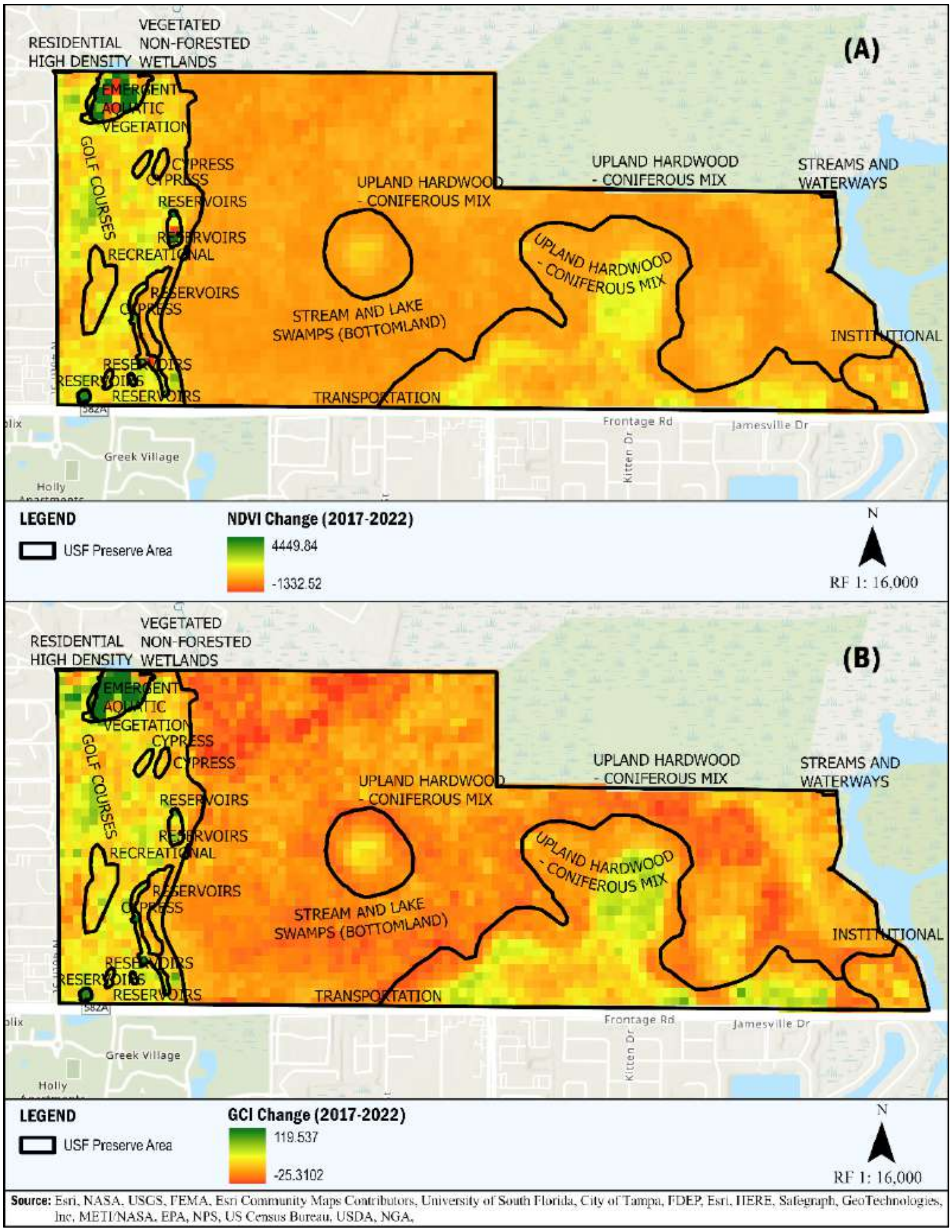

Figure 4 Change in NDVI and GCI. NDVI change in USF Preserve Area from 2017 to 2022 (A), GCI change in USF Preserve Area from 2017 to 2022 (B)

It was found that vegetated non-forested wetlands went through massive deforestation and reforestation process over the time, following reservoirs (table-2). Due to human disturbance or other factors, the health status of trees was found poor in Institutional areas over the time ranging from -15.47 to 2.78 next to Stream And Lake Swamps (Bottomland) area ranging from -25.31 to 3.71. The higher NDVI value in Golf courses and Reservoirs areas indicated satisfactory vegetation growth over the time with well maintenance of health with higher GCI value.

Table 2 Change in NDVI and GCI from 2017 to 2022 in USF Preserve Area

LULC Class	NDVI minimum	NDVI maximum	GCI minimum	GCI maximum
Institutional	-26.62	22.25	-15.47	2.78
Recreational	-21.21	17.09	-13.22	13.25
Upland Hardwood - Coniferous Mix	-30.09	20.40	-18.43	19.56
Reservoirs	-53.32	509.91	-8.42	27.04
Cypress	-27.09	3.05	-11.02	7.11
Vegetated Non-Forested Wetlands	-1332.52	4449.84	-13.86	119.54
Emergent Aquatic Vegetation	2.82	9.86	5.25	18.10
Golf Courses	-28.44	74.02	-15.16	29.35
Stream And Lake Swamps (Bottomland)	-29.32	-3.13	-25.31	3.71

Composite Images and Vegetation Indices

True color composition of year 2017 and 2022 identified the vegetation very clearly where the vegetation was represented distinctly with dense vegetation (figure 5(C)) in year 2017 image in comparison to year 2022 image with less or moderate vegetation (figure 5(A)) with healthy vegetation in Stream and Lake Swamps (Bottomland) as it was identified as dark red in false color composition (figure 5(D)) in comparison to year 2022 image (figure 5(B)).

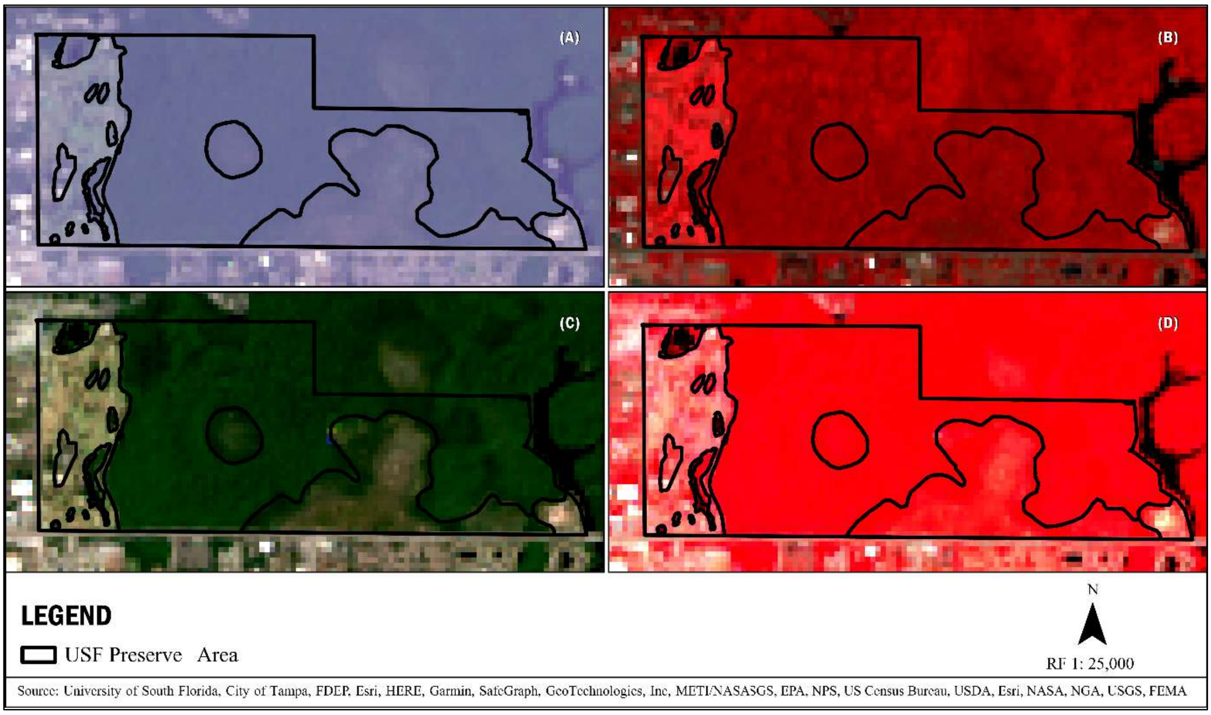

Figure 5 True-color and False-color Composition. True-color composition of USF Preserve Area in 2022 (A), False-color composition of USF Preserve Area in 2022 (B), True-color composition of USF Preserve Area in 2017 (C), False-color composition of USF Preserve Area in 2022 (D)

There was found slight change in NDVI over the time as in 2017 NDVI value ranges from 0.558892 to -0.0307004 and in 2022 NDVI value ranges from 0.467752 to -0.0301443 indicating vegetation loss. The value of NDVI for both years (figure 6) indicated the following findings:

- NDVI values close to and less than zero (0) indicated low vegetation cover or non-vegetated surfaces such as water or bare soil in Institutional, Emergent Aquatic Vegetation, Gold Courses and Reservoirs area.
- NDVI values between 0 and 0.3 indicated sparsely vegetated or stressed areas in Upland Hardwood-Coniferous Mix and Golf Courses area.
- NDVI values between 0.3 and 0.6 indicate moderate vegetation cover, such as shrubs or grassland in Upland Hardwood-Coniferous Mix, Cypress area and Stream and Lake Swamps (Bottomland).

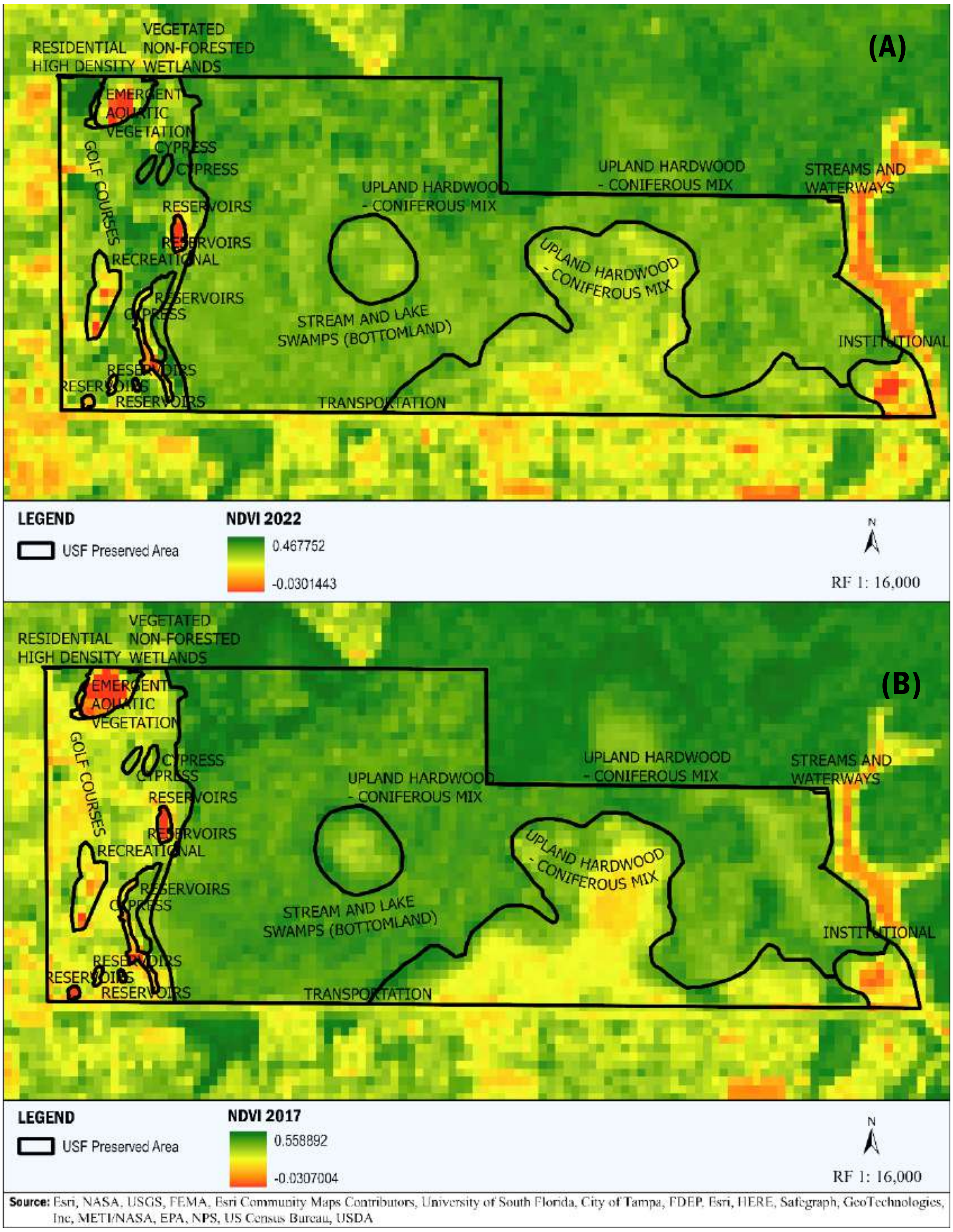

Figure 6 NDVI of USF Preserve Area. NDVI of 2022 (A), NDVI of 2017 (B)

There was found slight change in GCI over the time as in 2017 GCI value ranges from 2.89822 to 0.831525 and in 2022 GCI value ranges from 2.49246 to 0.926263 indicating the deterioration of vegetation's health. The value of GCI for both years (figure 7) indicated the following findings:

- GCI with lower value indicated unhealthy and low-quality vegetation with less chlorophyll due to water scarcity, deficiency in nutrients, disease infestations or environmental pollutants in Institutional, Emergent Aquatic Vegetation, Gold Courses and Reservoirs area.
- GCI with higher value indicate moderate vegetation cover, such as shrubs or grassland in Upland Hardwood-Coniferous Mix, Cypress area and Stream and Lake Swamps (Bottomland).

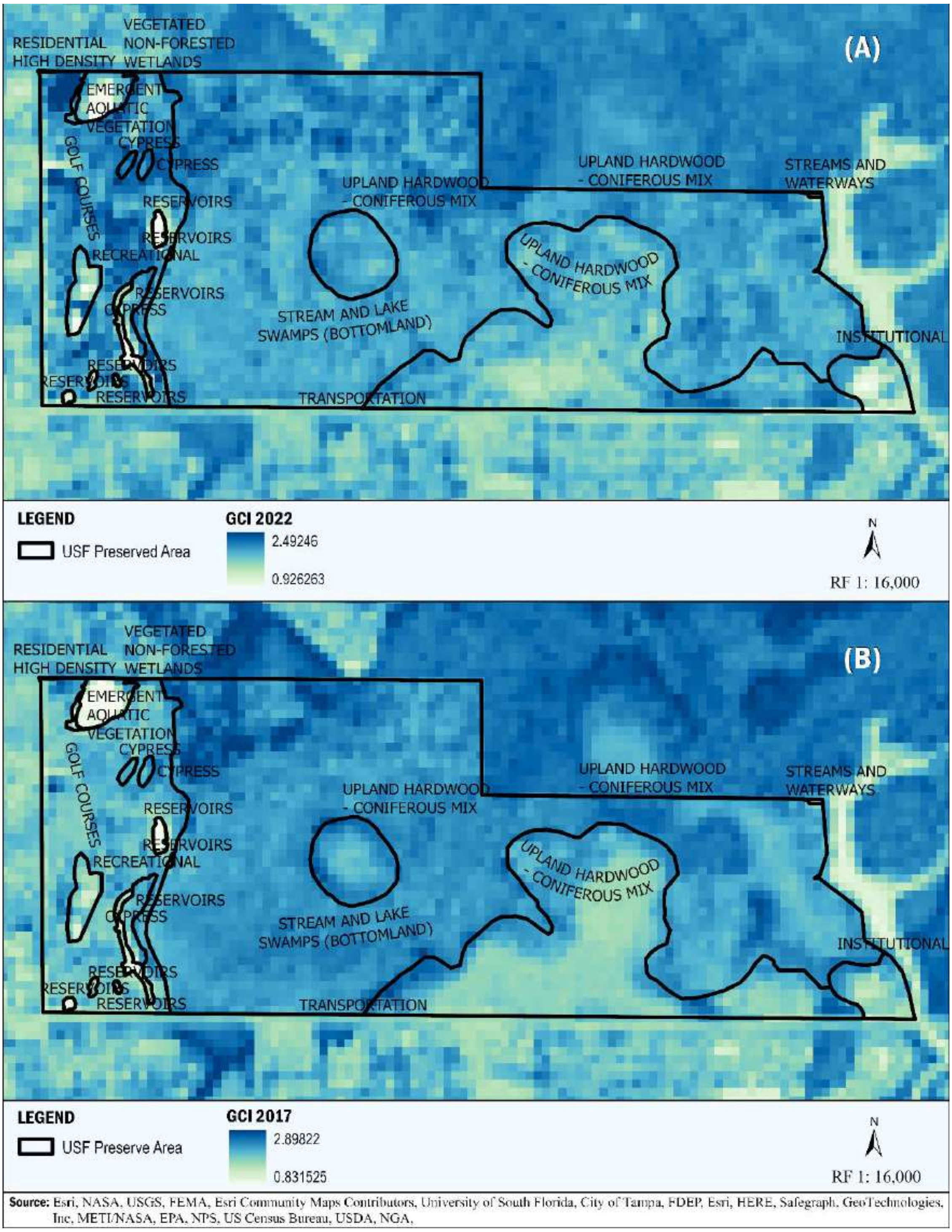

Figure 7 GCI of USF Preserve Area. GCI of 2022 (A), GCI of 2017 (B)

LiDAR Images

The topographic profile of the study area was interpreted through DEM, DSM and DHM. From figure 8(A) and figure 9, it was evident that most of the land within study area was found less fluctuations in terrain especially in Stream and Lake Swamps (Bottomland), few portions of the area was found with moderate height and high elevation (Upland Hardwood-Coniferous Mix, Golf Course, Cypress). From figure 8(B) and (figure 9)., it was evident that different in terrain was found in Upland Hardwood-Coniferous Mix next to institutional LULC class due to uprise elevation of buildings and trees in these locations. DHM identified the height of the features within the study area. figure 8(C) dictated that there are a few high-rise objects in golf course due to pretty gentle slope. A large number of objects was identified in Stream and Lake Swamps (Bottomland) and Upland Hardwood-Coniferous Mix with significant height due to height of trees. The highest value (592.649) indicating that these trees grow more than 300 feet tall in reference to "Tree Mapper".

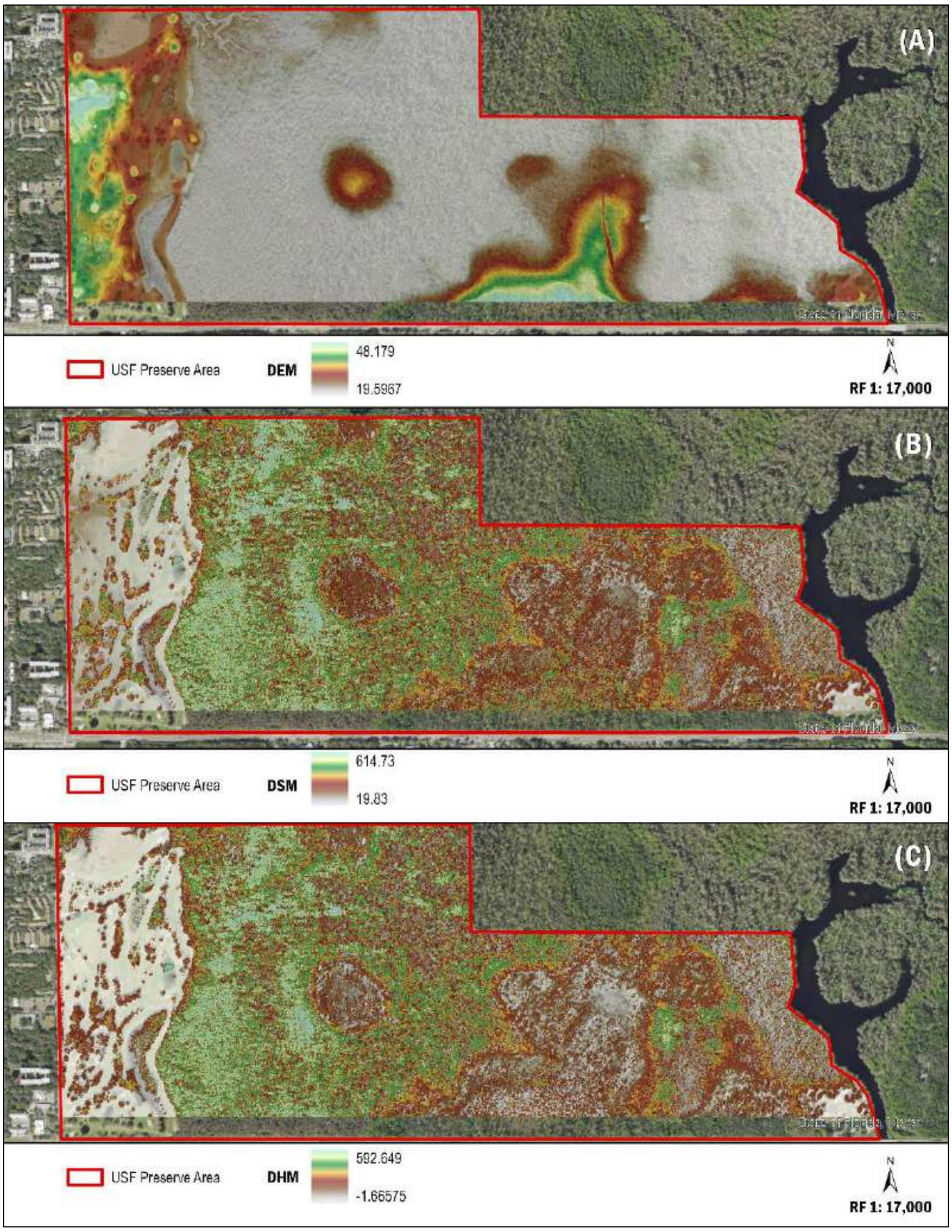

Figure 8 Topographic Profile of USF Preserve Area. DEM of USF Preserve Area (A), DSM of USF Preserve Area (B), DHM of Preserve Area (C).

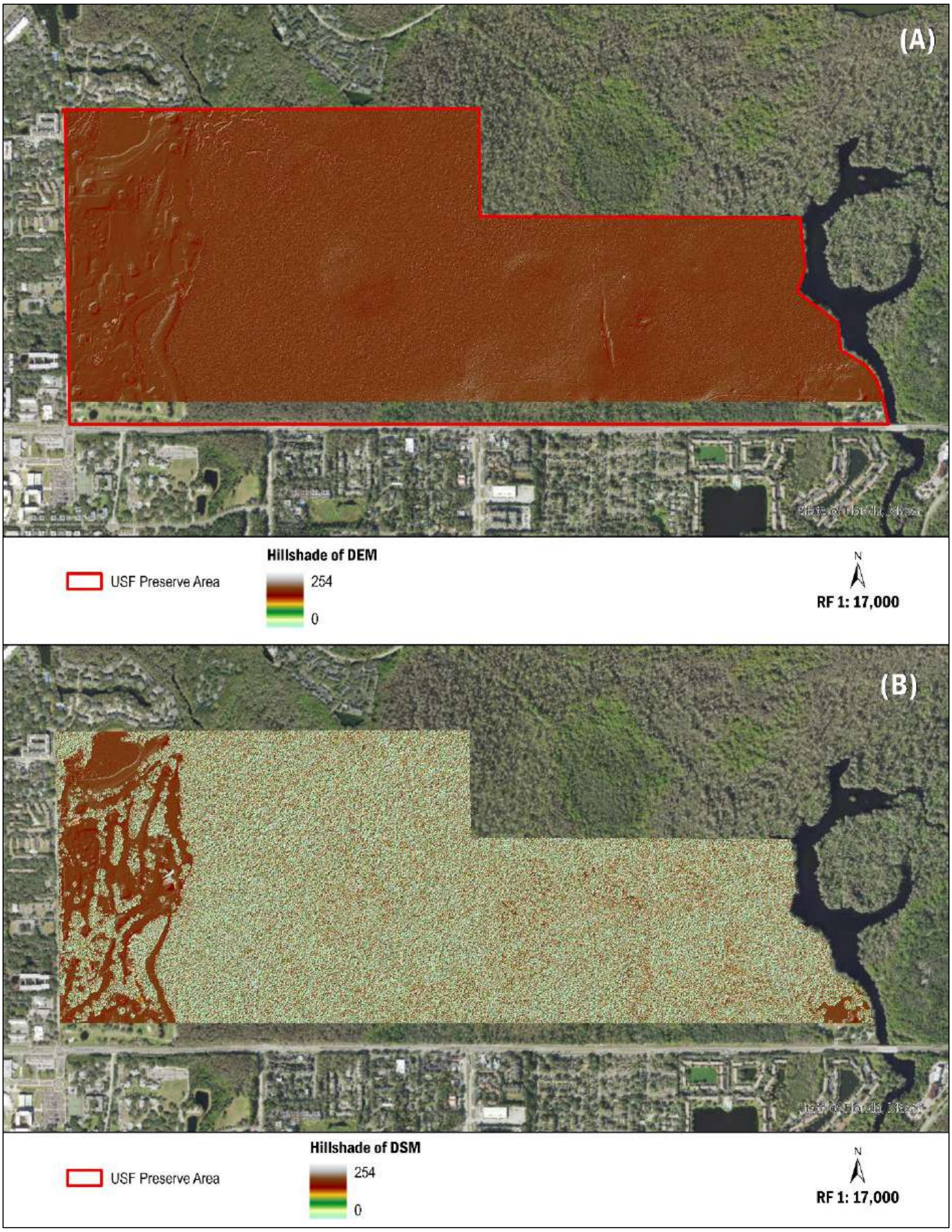

Figure 9 Hillshade of DEM and DSM. Hillshade of DEM (A), Hillshade of DEM (B)

In Stream and Lake Swamps (Bottomland), contours were found very close indicating steeper slope in comparison to other areas. On the other hand, gentle slope was found in golf course where contours were found farther apart (figure 9)

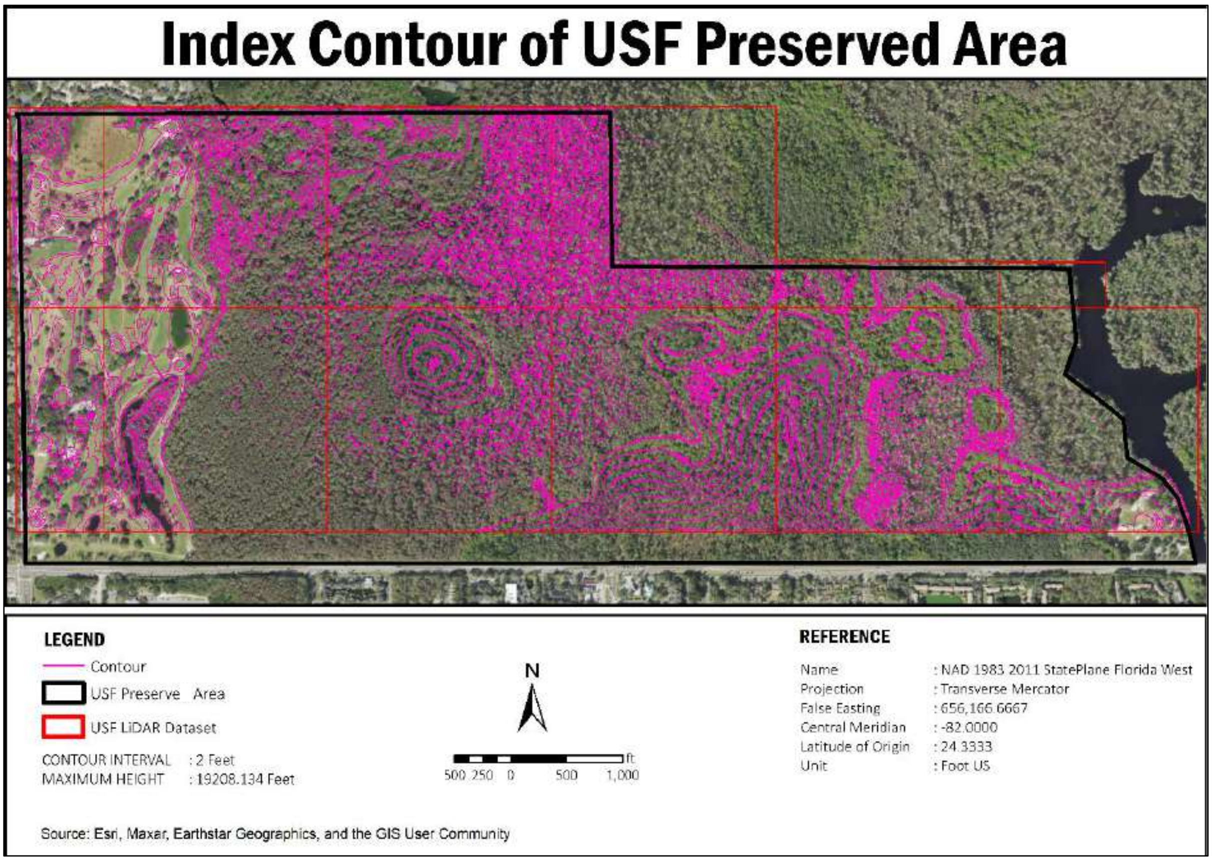

Figure 10 Index Contour of USF Preserve Area

CONCLUSION AND RECOMMENDATIONS

Through the analysis of topographic profile of USF preserve area, it was evident that the area was pretty flat with gentle slope. Some places within the study area went through vegetation loss and some places had pretty satisfactory vegetation growth with maintenance of healthy vegetation over the study time period from 2017 to 2022. Vegetation loss in some locations concurred the deterioration of health condition of plants due to human disturbance, mismanagement or disease infestation, all in all indicated for better management plan for maintenance of forested land.

GIS and Remote sensing are now one of the most cutting-edge technologies which could be integrated in forest management plan as it could serve following purposes:

- The concerned authority could perform mapping forest over through identification of deforestation, forest degradation using remote sensing data which would make ease to formulate policies .
- The concerned authority could create database of forest resources with tree species, age, density using GIS data which would help to determine high conservation value of invasive species if they would find any in future (Singh et al., 2022).
- The concerned authority could monitor forest health and spatio-temporal changes in forest condition using remote sensing data which would help to decide the degree of intervention for ameliorating the consequences (Nowak et al., 2002).
- The concerned authority could obtain the information on forest structure, biomass, canopy cover which would help them to identify the needs of reforestation or restoration.

REFERENCES

Alonzo, M., McFadden, J. P., Nowak, D. J., & Roberts, D. A. (2016). Mapping urban forest structure and function using hyperspectral imagery and lidar data. *Urban Forestry and Urban Greening*, *17*, 135–147. https://doi.org/10.1016/j.ufug.2016.04.003

Barrette, M., Bélanger, L., De Grandpré, L., & Royo, A. A. (2017). Demographic disequilibrium caused by canopy gap expansion and recruitment failure triggers forest cover loss. *Forest Ecology and Management*, *401*, 117–124. https://doi.org/10.1016/j.foreco.2017.07.012

Davies, Z. G., Edmondson, J. L., Heinemeyer, A., Leake, J. R., & Gaston, K. J. (2011). Mapping an urban ecosystem service: Quantifying above-ground carbon storage at a city-wide scale. *Journal of Applied Ecology*, *48*(5), 1125–1134. https://doi.org/10.1111/j.1365-2664.2011.02021.x

Dobbs, C., Escobedo, F. J., & Zipperer, W. C. (2011). A framework for developing urban forest ecosystem services and goods indicators. *Landscape and Urban Planning*, *99*(3–4), 196–206. https://doi.org/10.1016/j.landurbplan.2010.11.004

Fox, G. A., Lewis, D., Mccoy, E. D., & Mushinsky, H. (2013). *USF FOREST PRESERVE WHITE PAPER **.

Gülçin, D., & Konijnendijk Van Den Bosch, C. C. (2021). Assessment of above-ground carbon storage by urban trees using lidar data: The case of a university campus. *Forests*, *12*(1), 1–20. https://doi.org/10.3390/f12010062

Hirokawa, K. H. (2011). Sustainability and the Urban Forest: An Ecosystem Services Perspective. *Natural Resources*, *233*. http://www.maweb.org/documents/document.356.aspx.pdf.

Landry, S. M., Andreu, M. G., Friedman, M. H., & Northrop, R. J. (2008). City of Tampa Urban Ecological Analysis 2006-2007. In *Final Report to the City of Tampa*.

Martinez, A. de la I., & Labib, S. M. (2023). Demystifying normalized difference vegetation index (NDVI) for greenness exposure assessments and policy interventions in urban greening. *Environmental Research*, *220*. https://doi.org/10.1016/j.envres.2022.115155

Nowak, D. J., Stevens, J. C., Sisinni, S. M., & Luley, C. J. (2002). EFFECTS OF URBAN TREE MANAGEMENT AND SPECIES SELECTION ON ATMOSPHERIC CARBON. *Journal of Arboriculture*, *28*(3).

Qin, H., Zhou, W., Yao, Y., & Wang, W. (2021a). Estimating aboveground carbon stock at the scale of individual trees in subtropical forests using uav lidar and hyperspectral data. *Remote Sensing*, *13*(24). https://doi.org/10.3390/rs13244969

Qin, H., Zhou, W., Yao, Y., & Wang, W. (2021b). Estimating aboveground carbon stock at the scale of individual trees in subtropical forests using uav lidar and hyperspectral data. *Remote Sensing*, *13*(24). https://doi.org/10.3390/rs13244969

Ren, Z., Zheng, H., He, X., Zhang, D., Yu, X., & Shen, G. (2015). Spatial estimation of urban forest structures with Landsat TM data and field measurements. *Urban Forestry and Urban Greening*, *14*(2), 336–344. https://doi.org/10.1016/j.ufug.2015.03.008

Singh, A., Mishra, A., Pant, H., & Singh, J. (2022). *GIS Applications in Forest Management*. https://www.researchgate.net/publication/363262810

Wu, C., Niu, Z., & Gao, S. (2012). The potential of the satellite derived green chlorophyll index for estimating midday light use efficiency in maize, coniferous forest and grassland. *Ecological Indicators*, *14*(1), 66–73. https://doi.org/10.1016/j.ecolind.2011.08.018

Wu, C., Xiao, Q., & McPherson, E. G. (2008). A method for locating potential tree-planting sites in urban areas: A case study of Los Angeles, USA. *Urban Forestry and Urban Greening*, *7*(2), 65–76. https://doi.org/10.1016/j.ufug.2008.01.002