TREE CANOPY ASSESSMENT
CHELAN, WASHINGTON

SCOPE OF WORK

Chelan, a city of approximately eight square miles, is surrounded by agricultural areas and the popular vacation area of Lake Chelan. It has a population of roughly 4,000 residents. The city and its unincorporated areas are experiencing urban growth as a result of its popularity. With this growth comes new development which is often associated with a loss of trees and other types of vegetation. This study aimed to provide the City with a benchmark of it's tree canopy and other land cover types in order to track changes and monitor its urban forest health and growth. This urban forest resource is a critical element of the region's green infrastructure, contributing to environmental quality, public health, water supply, local economies, and aesthetics.

SUMMARY OF FINDINGS

This study measured the 2017 tree canopy coverage in the urban growth area (UGA) of the City of Chelan. Appropriate aerial images and LiDAR data were available from federal and state sources to complete the analysis. The study found that in 2017, including both incorporated and unincorporated areas, the UGA had a tree canopy coverage of 8% or a total of 510 acres of canopy. 853 acres or 13% of all land area in Chelan were considered areas where trees could be planted.

DATA SOURCES

Two different data sources were used as the primary inputs to the remote sensing process of mapping Chelan's tree canopy. Four-band, multispectral, 1-meter, aerial imagery from the National Agriculture Imagery Program (NAIP) was acquired from the U.S. Department of Agriculture. This imagery was the latest available imagery at the time that met all project needs for the area. Images were collected in July 2017. The four bands represent different wavelengths of the electromagnetic spectrum including the red, green, blue, and the near-infrared. The first three bands represent natural color or what is naturally visible to the human eye. The near-infrared band is not visible to the human eye, but specialized sensors on the camera can detect levels of radiation in this wavelength. The near-infrared band is crucial when mapping urban tree canopy as healthy vegetation reflects large amounts of near-infrared light compared to other land cover types such as water and impervious surfaces.

Figure 1. | NAIP aerial imagery from July 2017 (top) and LiDAR normalized digital surface model from 2015 (bottom).

The second source used was a LiDAR dataset collected by the Washington Department of Natural Resources in 2015. LiDAR provides extremely detailed information on the height of objects on the Earth's surface using reflectance of light from a laser. Two different subsets of the raw point cloud were used to prepare the data for the needs of this project: the first returns and last returns. The first returns represent the top of objects when looking from overhead and often represent building rooftops, tree canopy, or ground if the landscape is bare. The last returns typically represent bare ground unless an object is present that the laser cannot penetrate such as a building. A normalized digital surface model (nDSM) was created by subtracting the last returns from the first returns representing the relative height of objects including trees.

METHODOLOGY

An object-based image analysis (OBIA) software program called Feature Analyst was used to classify land cover features through an iterative approach, where the spectral signatures across the four aerial image bands (blue, green, red, and near-infrared), LiDAR height, as well as textures and pattern relationships were considered. This process resulted in one land cover class representing tree canopy cover. After the initial automated classification, manual classification was performed to improve and check for quality control by GIS technicians at roughly 1':1,500" scale in ArcGIS.

RESULTS

This assessment covered 6,512 acres using the urban growth area (UGA) as the main area of interest, including both incorporated and unincorporated areas of Chelan. Tree canopy and other types of land were measured in this assessment. Land cover results of this study indicated that in 2017, the UGA for Chelan contained 8% urban tree canopy (or 510 of the City's 6,512 total acres); 14% non-canopy vegetation (913 acres); 58% soil/dry vegetation (3,770 acres); 18% impervious (1,190 acres); and 2% water (128 acres). Urban tree canopy (UTC) and possible planting area (PPA) results are based on land area which is equal to the total area minus water area (6,512 - 128 = 6,383 acres). UTC cover was 8% (510 acres), 13% (853 acres) was suitable for future tree plantings, and 79% (5,020 acres) was unsuitable due to its current land use or other restraint. Results within the UGA boundary and land use classes are discussed below.

Within the incorporated UGA there was approximately 7.7% UTC (329 acres) while unincorporated UGA areas had

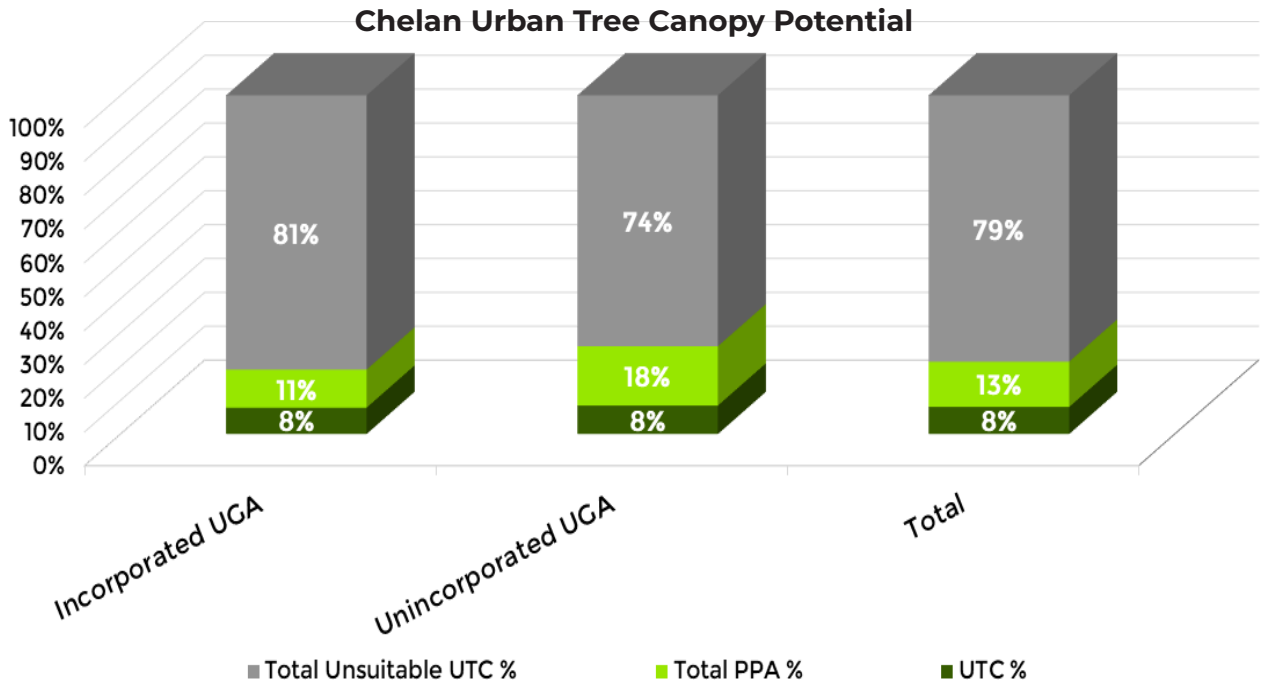


Figure 2. | Urban tree canopy, possible planting area, and area unsuitable for UTC in the City of Chelan, WA.

8.4% UTC (182 acres). PPA in incorporated areas was 11% (474 acres) while unincorporated areas had 18% PPA (379 acres).

Examining the results within Chelan's land use classes showed that the highest percentages of canopy cover were found in Tourist Mixed Use and Downtown Single Family areas, each with 23% UTC. The lowest UTC was in Waterfront Commercial with 4%. The largest portion of Chelan's UTC was found in the Single-Family Residential land use which contained 31% of all UTC; however, canopy coverage in these areas was only 9%. The largest opportunity for future tree canopy expansion was found in the Special Use District with 35% PPA (248 acres). However, a large portion of the PPA in this area is located in vineyards and may not actually be suitable for planting. The next highest PPA was found in Public Lands and Facilities with 26% PPA. Single Family Residential areas had 12% PPA, but contained over a quarter of all PPA in the City. The land use class with the lowest PPA was Waterfront Commercial with 4%.

Table 1. | Urban Tree Canopy assessment results by land use. UTC and PPA results include acres, percent of area covered by UTC or PPA (%), and distribution of the UGA's total UTC or PPA within each land use type.

Land Use	Land Area		Urban Tree Canopy			Possible Planting Area		
	Acres	*Dist.*	*Acres*	*%*	*Dist.*	*Acres*	*%*	*Dist.*
Airport (A)	123	2%	19	16%	4%	15	12%	2%
Highway Service Commercial (C-HS)	44	1%	6	13%	1%	7	17%	1%
Waterfront Commercial (C-W)	13	0%	1	4%	0%	1	4%	0%
Downtown Mixed Residential (DMR)	167	3%	35	21%	8%	24	15%	3%
Downtown Mixed Use (DMU)	30	1%	3	10%	1%	2	6%	0%
Downtown Public (DP)	12	0%	2	14%	0%	1	11%	0%
Downtown Single Family (DSF)	11	0%	3	23%	1%	2	20%	0%
Public Lands and Facilities (PLF)	336	6%	41	12%	9%	86	26%	11%
Single Family Residential (R-L)	1,625	31%	138	9%	31%	198	12%	26%
Multifamily Residential (R-M)	285	5%	30	11%	7%	38	13%	5%
Special Use District (SUD)	700	13%	92	13%	21%	248	35%	33%
Tourist Accommodation (T-A)	1,184	23%	44	4%	10%	97	8%	13%
Tourist Mixed Use (TMU)	7	0%	2	23%	0%	1	13%	0%
Warehouse and Industrial (W-I)	650	13%	30	5%	7%	38	6%	5%
Totals	**5,186**	**100%**	**446**	**9%**	**100%**	**758**	**15%**	**100%**

ACCURACY

An accuracy assessment was completed using 200 sample points that were randomly distributed across the urban growth area. Each sample point was then referenced using the July 2017 NAIP aerial photo and assigned one of five generalized land cover classes by a technician. An automated script was then used to assign values from the classification raster to each point. The classification supervisor provides unbiased feedback to quality control technicians regarding the types of corrections required. Misclassified and corresponding canopy cover were inspected for necessary corrections. Accuracy was re-evaluated until an acceptable overall accuracy of 92% was achieved.

Overall accuracy serves two main purposes: First, accuracy assessments provide information to technicians producing the classification about where processes need to be improved and where they are effective. Secondly, measures of accuracy provide information about how to use the classification and how well land cover classes are expected to estimate actual land cover on the ground. Based on the accurate classification of 199 out of 200 points and with a 95% confidence interval, there was a relatively small 1% margin of error equating to 8% canopy cover +/- 1% or a possible range of 9% to 7%. A general lack in biodiversity due to the local dry climate can help in classification accuracy.

Table 2. | Error matrix for land cover classifications in Chelan, WA (2017).

		Reference Data					
		Tree Canopy	Vegetation	Impervious	Soil / Dry Veg.	Water	Total Reference Pixels
Classification Data	Tree Canopy	12	0	0	0	0	12
	Vegetation	0	27	0	1	0	28
	Impervious	0	0	37	0	0	37
	Soil / Dry Veg.	0	0	0	121	0	121
	Water	0	0	0	0	2	2
	Total	12	27	37	122	2	200

Overall Accuracy = 100%

Producer's Accuracy	
Tree Canopy	100%
Veg. / Open Space	100%
Impervious	100%
Bare Ground / Soil	99%
Water	NA

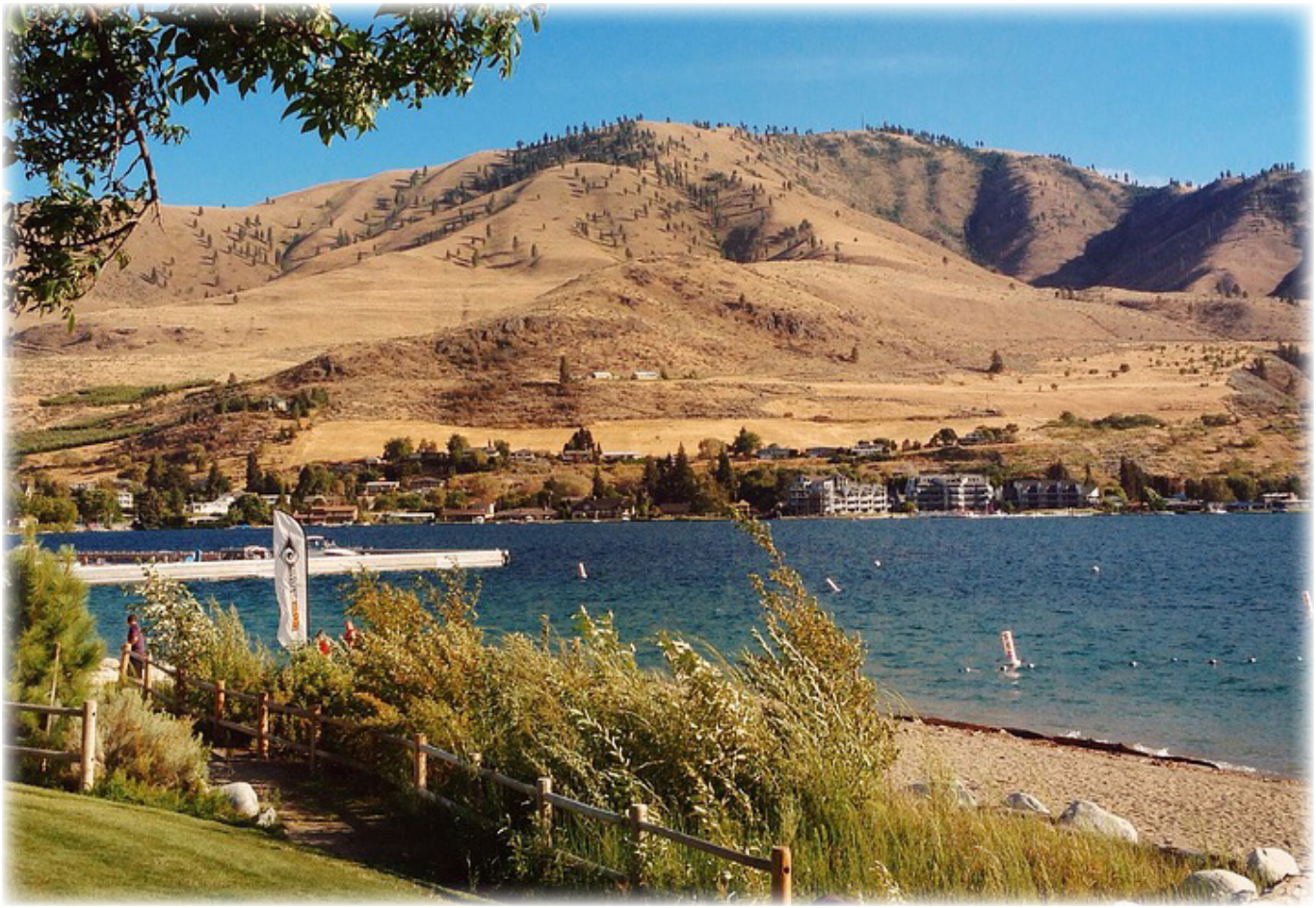
User's Accuracy	
Tree Canopy	100%
Veg. / Open Space	96%
Impervious	100%
Bare Ground / Soil	100%
Water	NA

RECOMMENDATIONS

To preserve, protect, and maintain Chelan's tree canopy, the City should continue to have a tree canopy assessment performed on a regular interval. As the City changes, they will be able to use these data to ensure that their urban forest policies and management practices prioritize its maintenance, health, and growth. The City's urban forest provides Chelan with a wealth of environmental, social, and even economic benefits which relate back to greater community interest in citywide initiatives and priorities. These results can be used to identify where existing tree canopy cover should be preserved, where there are opportunities to expand the City's canopy cover, and which areas would receive the greatest benefits from the investment of valuable time and resources into Chelan's urban forest.

The City of Chelan and its various stakeholders can utilize the results of the UTC and PPA analyses to identify the best locations to focus future tree planting and canopy expansion efforts. While the City has canopy coverage spread throughout its entire area, breaking up the results by a few different geographic boundaries demonstrated that this canopy is not evenly distributed. These results can be used as a guide to determine which areas would receive the greatest benefits from the investment of valuable time and resources into Chelan's urban forest.

This study found the land use type Public Lands and Facilities contained 26% PPA, while Single Family Residential areas contained 26% of all PPA in Chelan. Public lands are key areas for the City to concentrate tree canopy expansion efforts as they may be owned or managed by the City. These areas often contain public parks and open spaces where tree canopy will directly benefit both visitors and residents. The City should use these results to identify specific areas within publicly owned land on which to focus its resources towards new tree plantings and maintenance of existing trees. In addition, the City and its partners should develop education and outreach programs towards homeowners to inform citizens of the environmental, social, and financial benefits that trees can provide. Engaging private property owners on the need for increased canopy on private lands, particularly in conjunction with tree giveaways, tree planting programs, and other incentives are ways to further promote growth of Chelan's urban forest.



ACKNOWLEDGEMENTS

Funds for this project were provided by the USDA Forest Service Urban and Community Forestry Program, administered through the State of Washington Department of Natural Resources Urban and Community Forestry Program. The USDA is an equal opportunity provider and employer. Other project support came from the City of Chelan, Cascadia Conservation District, WSU Chelan County Extension, and the Chelan Ridge Firewise Community.