Carbon Sequestration Capacity of Trees at Cal State East Bay Concord Campus' Galindo Creek Field Station, Fall 2019

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The Galindo Creek Field Station is a 53.9 acre biological research station at the Cal State East Bay Concord Campus. The primary ecosystem types at Galindo Creek are riparian and oak woodland, with some exotic species found in both. The site is bisected by an asphalt road of which Galindo Creek runs through the eastern half of the site, flowing from south to north. The western half of the site is currently used for cattle grazing. The site is bordered by suburban housing developments on the south and east, a city recreational area to the north, and open oak woodland space to the west. Located in Concord, CA, USA, the field station climate is Mediterranean, which was taken into consideration during the allometric calculations shown below.

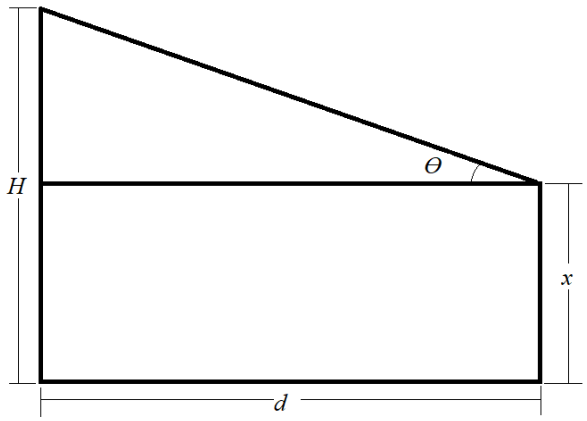
The initial inventory data was collected by trained volunteers, the field station coordinator and student assistant during October and November of 2019. The data necessary for aboveground biomass (AGB) calculations, according to Dahlin et al., includes the tree species, DBH, and height (2015, pg. 107).

To calculate aboveground biomass and obtain carbon capacity of the trees, every tree with a diameter over 2" within the Galindo Creek Field Station boundaries was measured. Each tree was tagged with a unique numbered aluminum tag (see Appendix A) which also prevented duplication. Tags were then photographed to establish the tree's geolocation (See Appendix B)

The diameter at breast height (DBH) and height of each tree were measured as follows: DBH was measured using aluminum tapes from Spencer Products Co. to the tenth of an inch and height was calculated using CST/Berger clinometers, or Kager Inc. tangent height gauges, and Kesson fiberglass tape measurers. This raw data was put into allometric equations from previous studies of aboveground biomass.

DBH tapes were used to measure trunk diameter by wrapping the tape around the trunk of each tree at approximately 52" from the ground. In the event of multiple trunks at 52", each trunk was measured. The largest trunk diameter was added to half the sum of the remaining trunks' diameters. In the event of multiple trunked trees that were inaccessible at 52", due to dense foliage or steep slopes, a measurement was taken at a portion of trunk within reach and at approximately the same diameter at 52".

Height was calculated trigonometrically. First, an observer established a position in which to use a clinometer or tangent height scale to view the top of the tree canopy, measuring the angle of observation (Θ). A second team member measured the distance (d) from the observer to the base of the tree using a fiberglass tape. Finally, the distance from the ground to the observer's eye (x) was measured to account for the difference between height the height of observation and base height (see diagram). Height (H) was calculated using the equation $H = d \times \tan(\theta) + x$.



Allometric equations were obtained from the literature (see references). Equations were specific to either tree species or genus. Jenkins et al demonstrate parameters for calculation of AGB by hardwood vs. softwood, then species (2003, pg. 2). According to Dahlin et al, there are some allometric equations that require diameter of basal area (DBA) rather than DBH. In this case, the DBH was multiplied by 1.1 (Dahlin, 2015, appendix A, pg. 2). The following equations were used to calculate aboveground biomass for most species present. Some (noted) species had no available formula; therefore an average calculation was used for the final biomass calculation (Birdsey).

Species	Equation	Reference
Valley Oak (*Quercus lobata*)	AGB = $(.0000334750 \times (\text{DBH}^{2.33631}) \times (H^{0.74872})) \times 705$	Dahlin, appendix A, pg. 2
Fremont Cottonwood (*Populus fremontii*)	AGB = $exp((-2.2094 + 2.3867) \times ln(\text{DBH}))$	Jenkins, pg. 2
Red Willow (*Salix laevigata*)	AGB = $(exp\ (3.303 + 2.762 \times ln(\text{DBH} \times 1.1)))/1000$	Jenkins, pg. 2
Olive (*Olea europea*)	AGB = $exp(-0.7152 + 1.7029 \times ln(\text{DBH}))$	Dahlin, appendix A, pg. 2
California Pepper (*Shinus molle*)	*Unable to locate species formula*	Birdsey, pg. 51

California Buckeye (*Aesculus californica*)	AGB = *exp(-2.48 + 2.4835 × ln(*DBH*))*	Jenkins, pg. 2
Black Walnut (*Juglans nigra*)	AGB = *exp(-2.48 + 2.4835 × ln(DBH))*	Jenkins, pg. 2
Fan Palm (*Washingtonia filifera*)	*Unable to locate species formula*	Birdsey, pg. 51
Common Fig (*Ficus carica*)	*Unable to locate species formula*	Birdsey, pg. 51
Black Locust (*Robinia pesudoacacia*)	AGB = *exp(-2.48 + 2.4835 x ln(*DBH*))*	Jenkins, pg. 2
Blue Elderberry (*Sambucus nigra*)	*Unable to locate species formula*	Birdsey, pg. 51

After biomass was calculated, carbon storage could be extrapolated. In a U.S. Forest Service report, Birdsey asserted that the average percent carbon of biomass for softwoods is 52.1 and 49.1 for hardwoods. This factor was used to convert each tree's AGB into its carbon content. Assuming the molar mass of CO_2 is 44 g/µ, the CO_2e was also calculated and compared to the national average CO_2 emissions per capita of 16.5 metric tons (World Bank 2014).

Analysis

The calculations show that the total AGB of the site's tree population is 715,976 kg and its carbon capacity is therefore 143.17 metric tons (525.0 metric tons CO_2e). We validated this calculation using the USDA Forest Service iTree canopy tool, which estimated, based on the area of the tree canopy, that the site stores 553 metric tons CO_2e. Considering the national average CO_2 emissions per capita referenced above, the trees within Galindo Creek Field Station offset the approximate emissions of 32 people for one year.

References

Birdsey, R. A. (1992). Carbon storage and accumulation in United States forest ecosystems. Gen. Tech. Rep. WO-59. Washington DC: US Department of Agriculture, Forest Service, Washington Office. 51p., 59.

Dahlin, K. M., Asner, G. P., & Field, C. B. (2015). Environmental filtering and land-use history drive patterns in biomass accumulation in a Mediterranean-type landscape. *Ecological Applications*, 104-118.

Jenkins, J. C., Chojnacky, D. C., Heath, L. S., & Birdsey, R. A. (2004). Comprehensive Database of Diameter-based Biomass Regressions for North American Tree Species. Newtown Square: USDA Forest Service.

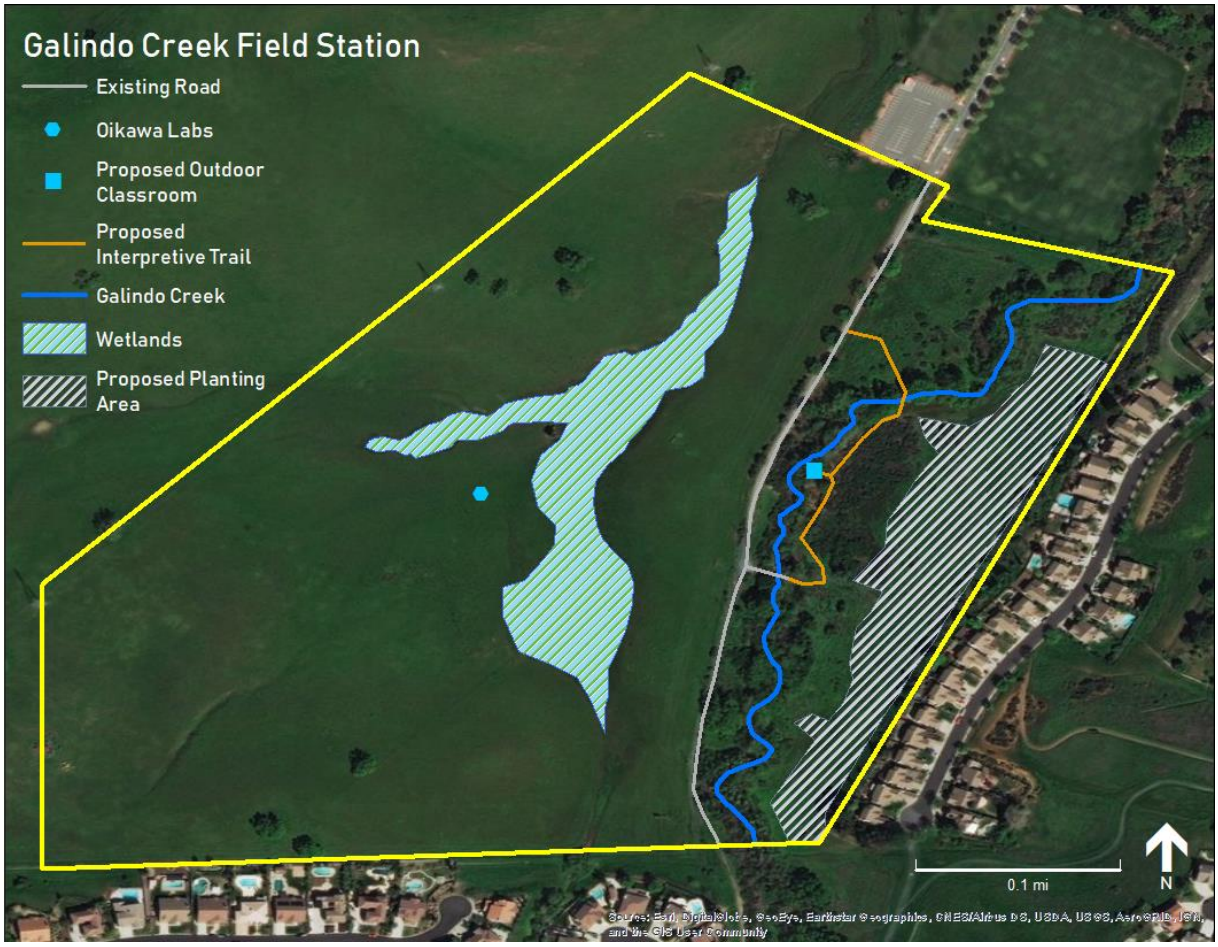
APPENDIX A

Species	Count
Black Locust *(Robinia pesudoacacia)*	1
Black Walnut (*Juglans nigra)*	21
Blue Elderberry (*Sambucus nigra)*	1
California Buckeye (*Aesculus californica)*	10
California Pepper (S*hinus molle)*	3
Fremont Cottonwood (*Populus fremontii)*	20
Fan Palm *(Washingtonia filifera)*	7
Olive (*Olea europea)*	44
Red Willow (*Salix laevigata)*	34
Valley Oak (*Quercus lobata)*	157

APPENDIX B

Maps of Galindo Creek Field Station

The map below depicts the boundaries of the field station including an inset of the field location within the University property.



Credit: Dylan Vaughn-Jansen

The map below conveys the information collected from the first complete tree inventory taken at the field station during the month of October of 2019.

Credit: Dylan Vaughn-Jansen