Title

Aboveground spatial variation of arthropod biomass and diversity along gradients of plant biomass and net primary productivity in Central Texas Hill Country forests.

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Abstract

The production of forests -both their standing crops of biomass and growth rates of such biomass- is universally underestimated, as research favors measuring plant production while neglecting consumer production. Consumer (including herbivore) production is a non-negligible component of primary production because averaged over time, consumer production in a closed ecosystem only results from energy drawn from plant production.

Determining the covariation of consumer production with plant production is crucial to understand forest energy (=carbon) storage and flows. A strong positive relationship between consumer and plant production while controlling for environmental variability is expected. Consumer production may co-vary with plant production so closely that simple invertebrate sampling can be used to accurately estimate plant production in forests.

Finding higher net productivity values of forests by including net consumer productivity will (at least marginally) increase estimates of rates of forest carbon sequestration. Even though the absolute quantity of energy held in consumer bodies in a given instant is very small compared to such energy held in plants, and consumer respiration rates are high, the higher metabolic demand and biomass turnover of consumers suggest they draw huge amounts of plant energy. This

heretofore only cursorily measured enegetic draw is foremost in structuring the forest ecosystem and the evolutionary ecology of its inhabitants. Ultimately, all human life depends upon the ecosystem production, especially from forests (Melillo et al. 1993), and accurate quantification of forest production will inform our decisions to exploit or protect forests.

Introduction

Definitions:

Biomass: the energy content of organisms per unit area.

Productivity: biomass per unit time.

Production: for convenience, this paper uses production *only* when referring to *both* biomass and biomass per unit time, using producti*vity* to distinguish the latter alone.

Net primary productivity (NPP): plant (and other producer) productivity not respired.

Globally, production estimates of forests are systematically underestimated because production measurement is biased towards wood while huge losses to consumers such as animals are neglected (Roy et al. 2001, Clark et al. 2001). Accurately measured animal production data can be used to estimate these losses to consumers (Petrusewicz 1967). If exacting quantification methods are used, and environmental variability is controlled, a forest's animal production may show consistently predictable covariance along plant production gradients, allowing estimation of animal production as a function of plant production.

Forest NPP encompasses new growth, litterfall, leachates, volatiles, mortality, and losses to herbivory (Clark et al. 2001, Fahey and Knapp 2007). However, studies of forest NPP mostly measure new wood and litterfall, ignoring herbivory or other consumer losses (Roy et al. 2001, Clark et al. 2001). When herbivory *is* measured, most studies consider only leaf-chewing herbivore guilds because methods of measuring and simulating leaf area loss are well established (Clark et al. 2001, Basset et al.

2003, Lowman and Rinker 2004, Zvereva et al. 2010). Studies measuring production of non-herbivore consumers such as detritovores are yet more rare (Clark et al. 2001).

Studies measuring herbivore production largely consider folivores (leaf-eaters) because methods of measuring and simulating leaf area loss are well established (Clark et al. 2001, Lowman and Rinker 2004). Leaf-chewers may typically eat 10-30% of a tree's leaf production but the amount eaten by sap-feeders or other herbivore feeding guilds is more uncertain (Lowman and Rinker 2004, Zvereva et al 2010). A recent review suggests sap-feeders may use more carbon and nutrients than leaf-chewers and alone reduce woody plant growth by 29% (Zvereva et al 2010). Dixon (1971) found aphid-excluded lime trees had 200% greater wood production than aphid-infested ones. Karban (1982) found significantly higher wood production in trees physically excluded from cicadas. Crawley (1985) demonstrated insecticidal reduction of herbivory on oaks increased acorn production.

Clearly herbivores are an important, but often neglected, component of forest production. The energetic role of non-herbivore consumers in forest production is virtually entirely ignored by the literature. In addition to applying standard NPP measurements, this study applies novel consumer production measurements, thereby increasing estimates of forest production.

In most general terms, this study asks the following question: how does consumer production co-vary with primary production in forest ecosystems? More specifically, this study asks: in central TX forests, controlling for variability in the abiotic environment, from scales spanning the individual tree to its resident grove to its local topographic forest type, how do scientifically estimated quantities of aboveground plant biomass and productivity co-vary with aboveground arthropod biomass and productivity?

Hypotheses: The greater the biomass and productivity of plants at all scales (tree, grove, and forest type), canopy arthropods will exhibit higher than expected 1) alpha and beta diversity, both a) taxonomically and b) by feeding guild / trophic level; 2) total and average per feeding guild biomass; and 3) recolonization rates of herbivores relative to higher trophic levels – a possible proxy for

productivity. The alternative / null hypothesis is that if trends 1-3 are exhibited by canopy arthropods are independent of plant production. In other words, I expect to find a strong positive correlation between consumer (canopy arthropod) production and plant (aboveground oak tree and local aboveground plant community) production.

Materials and Methods

STUDY AREA: This study was conducted at Wild Basin Wilderness Preserve (WB), a 227-acre protected area that is part of the Balcones Canyonlands Preserve system. These preserves follow the eponymous Balcones Fault and Escarpment, which delineate the southeastern border of the Edward's plateau. This plateau covers most of central Texas, spreading northwest from the Austin, which is on or by the Balcones Escarpment, until interrupted by the Llano uplift. Other uplifted formations delineate the Edwards plateau further west. The limestone bedrock of the Edward's plateau was formed in the Cretaceous by shallow sea deposits, then uplifted in the Miocene while the Gulf Coast region to the east subsided. Erosion of the plateau formed the karst topography characterizing the area today: rolling rocky hills with abundant creeks, springs, and caves. These karst formations are especially extensive near Austin, San Marcos and other areas bordering and on the Balcones escarpment intersected by river systems, such as the Colorado river running through Austin.

Ecosystems of the plateau, called the Texas Hill Country, encompass juniper-oak woodland savannas, subtropical riparian forests, and scrubby grasslands. Vegetative cover is determined largely by topography and disturbance history. Savannah and grasslands are found on drier hilltops or recently burned or cleared areas, while more productive forests with closed canopies and tall trees are restricted to old-growth bottomlands near streams, rivers, and springs. Grasslands are dominated by little-bluestem grass, prickly-pear cacti, yucca, and mesquite, and intergrade with woodland dominated by Ashe's juniper (*Juniperus ashei*), live oaks (*Quercus virginiana var. fusiformis*), spanish oaks (*Q. texana*), and bastard oaks (*Q. sinuata*). Natural grass/shrublands of this region were historically

maintained by fire, with grass/shrublands forming early seral stages. However, massive decimation of the region by development and ranching have reduced protected savanna and forest to about 2% of their pre-settlement area. WB is one of these refuges, yet even here the scars of deforestation and cattle ranching can be seen on parts of the property (figure 8). Fire suppression at WB has resulted in the majority of the property being forested. Variation in forest type follows topography, with all forests most dominated by Ashe's juniper (*Juniperus ashei*), hilltop forests co-dominated by escarpment live oak (*Quercus virginiana var. fusiformis*) and bastard oak (*Quercus sinuata*), hillside forests co-dominated by escarpment live oak and Texas oak (*Quercus texana*), lower slope/creek forests co-dominated by escarpment live oak, cedar elm (*Ulmus crassifolia*) Texas oak (*Quercus texana*), and forest directly beside creeks dominated by black willow, black walnut, eastern cottonwood, and American sycamore. This study was confined to the hilltop (hill) and lower/slope (creek / bottomlands) forests between either 880-900 or 720-740 ft altitude, respectively, because these forests were both relatively flat and mesic, (compared to the steep hillsides and hydric riparian forests) with distinct, yet similar flora (Figure 1, inset.)

METHODS: To measure the biomass of forest transects and live oak groves, aboveground correlates of plant biomass were measured. In the same areas, aboveground arthropod community structure was assessed by capturing the canopy arthropods with fogging and analyzing these samples in the lab.

Transects were randomly chosen from a possible 100 m transects drawn on a map along topographic isoclines matched to the surrounding topography of the live oak groves used for this study (figure 1). The groves were randomly chosen from the set of all groves of oaks on the property, which were discovered and geotagged in an exhaustive survey. The chosen transects ran adjacent to or across the groves studied (figure 2).

Live oak trees were chosen as they are a dominant tree in the local and regional ecosystems, have canopy morphology amenable to collection by fogging, and have arthropod fauna somewhat

representative of other locally dominant trees, harboring fewer specialists than the three other most dominant tree species in the area (M. Quinn, unpublished data).

Live oak groves for the study (figures 2 and 3) were chosen by exhaustively surveying the entire property for all live oaks greater than 1 ft diameter at breast height (table 1), recording the characteristics of the tree and its surroundings, then selecting two best characteristic-matched groves (i.e. slope less than 15 degrees, litter and humus layer greater than 6 in. deep, part of closed-canopy forest, at least 3 m. from trails / roads, and at least 200 ft from any open standing or flowing water sources as per insecticide regulations) in both the upland and lowland topographic areas, for a total of four groves with three live oak trees in each.

Aboveground plant biomass was estimated along the two 100 m point-quarter transects and for each live oak in the four groves. Along each of these transects, ten points at least 5 m apart were randomly selected and at each point species richness and biomass were calculated for trees, shrubs, dead wood, and ground cover. Trees were defined as having at least one stem diameter at 30 cm above ground level equal to or exceeding 4 cm. Shrubs were defined as having at least one stem diameter at 30 cm above ground less than 4 cm, and greater than or equal to 1 cm. Dead wood was defined as woody matter touching the ground with a diameter at its midpoint greater than 2 cm. For each point-quarter (40 per transect), the distance to the nearest tree, that circumference of all stems of that tree at both 30 cm and 130 cm above ground level, the height of the tree, the distance to the nearest shrub, the diameter of all stems of that shrub at 20 cm, the height of the shrub, the distance to nearest piece of dead wood, the diameter at the midpoint of the dead wood, and the length of the dead wood were recorded. Additionally, ground cover was estimated in each point-quarter, and expressed as visual estimate of percentage cover of woody plant seedlings, grass, and dicot herbs extending out in a 3 m. radius.

To estimate NPP, four 8 sq. ft. litterfall collection funnels were placed at random locations along each transect (8 total) in late July. The litterfall was collected in late December 2012, and the

funnels left in place. The litterfall from these funnels was again collected in mid-April 2013, and then in late July 2013. Litterfall samples were (will be) sorted into components: bark, twigs, wood (stems greater than 1 cm diameter, leaves, animal tissues, and unidentifiable/other. Each component was dried and (will be) weighed.

In each grove, aboveground live oak tree biomass was estimated by measuring circumferences of all stems of each tree at 30 cm and 130 cm and height. To estimate grove NPP, one 8 sq. ft. litterfall collection funnel was placed under the canopy of each tree near its trunk in all groves (12 total) in late July. The litterfall was collected in late December 2012, leaving the funnels left in place, then re-collected in both mid-April and late July 2013.

Aboveground arthropod biomass, diversity, and trophic structure were estimated by the near-comprehensive collection of arthropods with insecticidal thermal fogging of live oak grove canopies and along adjacent transects, and analysis of samples. The smallest sample units were collection funnels of known ground surface coverage, yeilding the above metrics (e.g. arthropod biomass) per unit ground area. The woody plant species above the funnels were identified, and the percent coverage of each plant species above each funnel was visually estimated, allowing the rough determination of which arthropods came from which plants.

Using standardized methods (Adis et al. 1998, Terry Erwin pers. comm. 2012), trees were fogged with a contact insecticide (1.0% pyrethrin in a mix of highly refined white oil and diesel) delivered from a portable fogger (Golden Eagle Thermal Fogger, Dyna-Fog, USA) on medium fog thickness setting "6," held by the author in the understory of the grove or transect, directing fog upwards to evenly cover the entire canopy of the grove, taking about 5-10 minutes depending on stopping times to maneuver through understory brush (equivalent to 5 mins of continuous fogging), beginning sometime between 0400-0500 hrs when no breeze was detectable. Collection funnels captured dying insects fallen from pyrethrin-induced spasms for at least 2 hrs after fogging, sufficient time to capture all affected insects (Adis et al. 1998). Funnels were made of smooth clear painter's

plastic sheeting or white ripstop nylon, allowing the thorough finding and sweeping of even the tiniest insects with a fine paintbrush down into the point of the funnel, which terminated into a jar containing 70% isopropyl alcohol.

For each fogging of the groves, four collection funnels with a 50 sq. ft collection surface area and 20 collection funnels with a 8 sq. ft collection surface area (totaling 360 sq. ft. of under-canopy coverage) were placed directly under the canopy and above the understory of each tree in the grove, covering about 50-90% of the canopy of all the live oaks in the grove (figures 5 and 6). The occasional juniper bough unavoidably overlapped areas (< 5%) of live oak canopy that were fogged. Funnels were secured in place to lines over limbs in the canopy the day prior to fogging (figure 4) and were activated (the bottom closed, sometimes with containers attached) and carefully (avoiding disturbing branches) pulled up to position in the two hours before fogging. Individual funnels did not overlap trees, and the tree each funnel covered was recorded on the collected samples so that the tree each arthropod fell from is known.

At three of the four groves (not grove 02 due to time constraints), recolonized arthropods were collected by following the above fogging protocol identically five to six days later, with each collection funnel in almost the exact same location.

On sequential days from 27 April – 1 March 2013, four different 30 m transects were fogged with methods identical to the above, except only ripstop nylon funnels (either white or green) were used and per each transect, four large (2.72 m^2), and eight small (0.72 m^2) funnels were used (total 16.7 m^2). Two transects were in hilltop sites (elevation 880-900 ft) and the other two at bottomlands sites (elevation 720-740 ft) These transect locations are shown in figure 3.

All fogging dates and locations are shown in tables 2 and 6. Fogging locations shown in figures 2 and 3.

Arthopod samples were transported by the author for analysis in his adviser's laboratory at the University of California at Berkeley. Once analyzed, samples will be returned to Texas and deposited

at the University of Texas Insect Collection, housed in the Lake Austin Centre at Brackenridge Field Laboratory, 3001 Lake Austin Blvd., Austin TX 78703.

The author attempted to sample at least four more transects this summer 2013, but after locating these sites, and setting up funnels at the first site, it was discovered the fogger was not in working condition. Despite extensive maintenance and troubleshooting, the author was unable to get his fogging machine to function correctly. In the process of troubleshooting, small amounts of pyrethrin fog (much less than applied when collecting) were released in the open air above the widest part of the gravel parking lot, and was directed according to winds so that all fog dissipated in the open atmosphere, never reaching any plant or building.

Results

Vegetation point-quarter transects suggest that compared to the hill forest, the absolute biomass of the creek forest is lower for trees, higher for shrubs, and lower for dead wood (table 3.I). Hill and creek forests had similar woody plant species richness, with a few species clearly preferring one or the other forest type (table 3).

Apportioning of biomass among woody plants was similar in the two forest types across shared tree taxa (table 3.I.a), although yaupon holly and Lindheimer's silktassel shrubs were more important in the creek forests (table 3: I.b and c; II.b and c). Dead oak wood was more important near the creek, while dead Ashe's juniper wood was most important on the hill (table 3.II.c). The hill had more groundcover, mostly because it had more grass than near the creek, but the creek had slightly more seedlings and dicot herbs (table 3.d). Productivity comparisons cannot be made until litterfall is collected in late December 2012 and transects are re-measured in summer 2013.

At the individual tree and grove scales, in general, escarpment live oaks had higher biomass in the creek forests compared to the hill forests (table 4). Productivity comparisons cannot be made until litterfall is collected in late December 2012 and trees are re-measured in summer 2013.

Of the 11 trees fogged (and 9 trees re-fogged), only the arthropods collected from the initial fog from the first grove (3 trees) have been sorted, identified, and their biomass quantified. Results from this fogging are summarized in table 5.

Samples from transects fogged in April have not yet been analyzed. Nor have litterfall samples.

Discussion / Conclusions

The general predicted result at all scales - that animal production directly increases with plant production - will provide more accurate, increased estimates of plant production by including losses to animals. Furthermore, if a close animal-plant production relationship holds within and between trophic guilds, it may be possible to use invertebrate sampling to estimate plant production, even at the resolution of storage compartments such as dead wood, conifer leaves, and litterfall. This invertebrate sampling may give cheaper, quicker, but more accurate estimates of both plant and consumer production in forests. Revealing the nature of producer - consumer production relationships is crucial to understanding basic ecosystem energetics; laws that govern global carbon cycling and storage.

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Tables and Figures

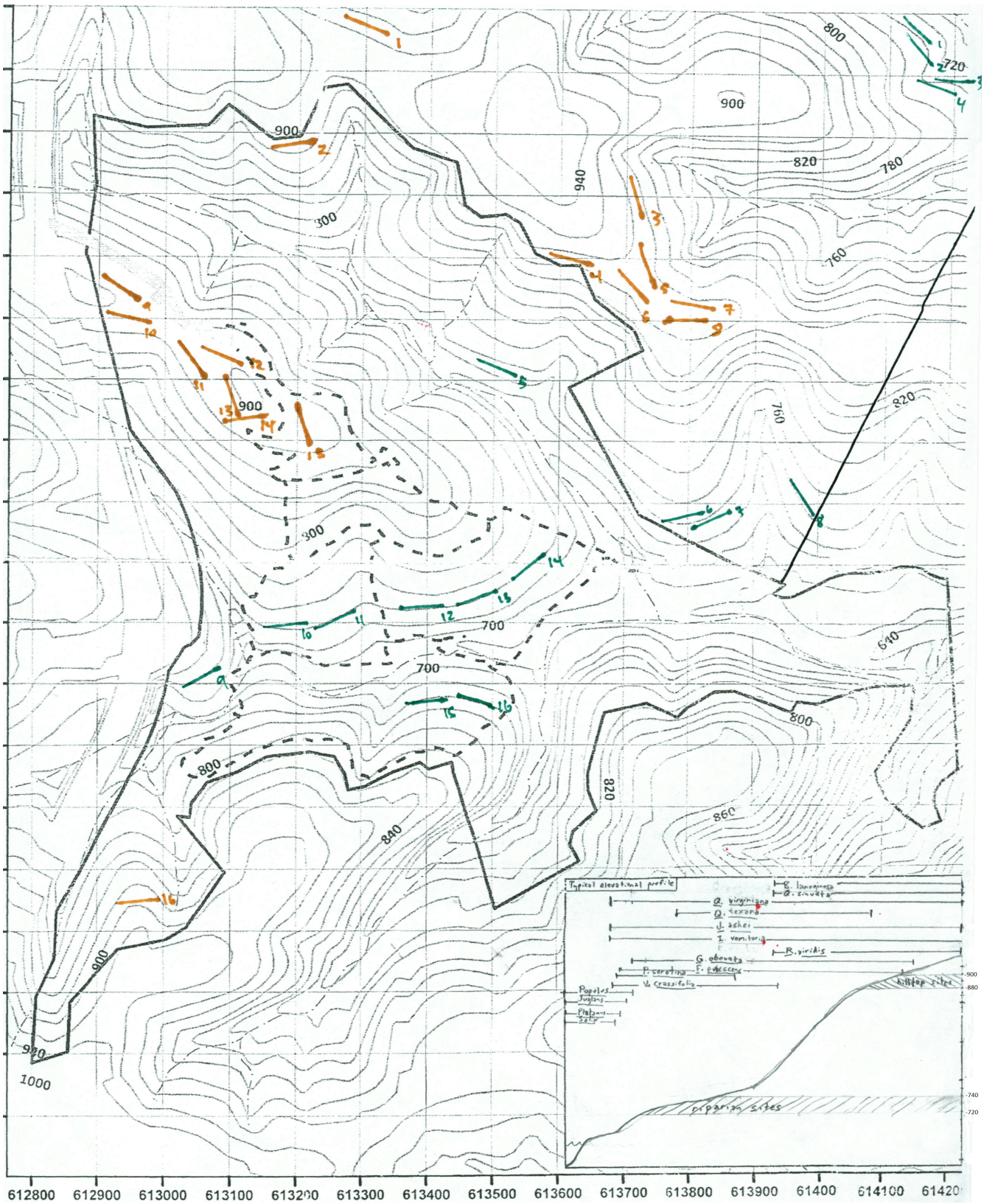

Figure 1. Locations of all potential hill (brown) and creek (green) 100 m transects. Inset: typical topographic profile showing areas of dominance of common trees and shrubs.

	GPS coordinates			GPS coordinates			GPS coordinates	
Tree ID	Latitude	Longitude	Tree ID	Latitude	Longitude	Tree ID	Latitude	Longitude
A	30.3094	97.8252	O	30.3115	97.8249	CA	30.3124	97.8259
B	30.3071	97.8243	P	30.3115	97.8249	DA	30.3124	97.8259
C	30.3075	97.8243	Q	30.3115	97.8249	EA	30.3124	97.8258
D	30.3079	97.8239	R	30.3110	97.8257	MA	30.3076	97.8176
E	30.3070	97.8243	S	30.3110	97.8257	QA	30.3082	97.8177
F	30.3123	97.8256	T	30.3110	97.8257	RA	30.3083	97.8176
G	30.3123	97.8256	U	30.3110	97.8257	SA	30.3080	97.8181
H	30.3123	97.8256	V	30.3105	97.8250	TA	30.3071	97.8199
I	30.3123	97.8256	W	30.3105	97.8250	UA	30.3097	97.8188
J	30.3123	97.8256	X	30.3105	97.8250	VA	30.3097	97.8188
K	30.3121	97.8252	Y	30.3105	97.8250	WA	30.3096	97.8195
L	30.3118	97.8245	Z	30.3102	97.8244	XA	30.3035	97.8210
M	30.3110	97.8246	AA	30.3116	97.8222	YA	30.3027	97.8211
N	30.3110	97.8246	BA	30.3123	97.8260	ZA	30.3110	97.8216

	GPS coordinates			GPS coordinates		fogged trees	GPS coordinates	
Tree ID	Latitude	Longitude	Tree ID	Latitude	Longitude	Tree ID	Latitude	Longitude
XA(2)	30.3074	97.8167	OC	30.3063	97.8241	YA	30.3107	97.8249
XB	30.3076	97.8169	OD	30.3057	97.8241	YB	30.3107	97.8249
XC	30.3076	97.8169	OE	30.3052	97.8240	YC	30.3107	97.8250
XD	30.3077	97.8170	OF	30.3052	97.8243	Y2A	30.3112	97.8259
XE	30.3077	97.8171	OG	30.3053	97.8243	Y2B	30.3112	97.8257
XF	30.3067	97.8179	OH	30.3053	97.8244	Y2C	30.3112	97.8256
XG	30.3070	97.8177	Y3A	30.3112	97.8259	OA(OF)	30.3052	97.8243
XH	30.3069	97.8177	Y3B	30.3112	97.8257	OB(OG)	30.3053	97.8243
XI	30.3054	97.8216	Y3C	30.3112	97.8256	OC(OH)	30.3053	97.8244
XM	30.3025	97.8192	HwA	30.3056	97.8247			
XL	30.3066	97.8175	HwB	30.3056	97.8247			
XK	30.3066	97.8175	HwC	30.3053	97.8247			
OA	30.3093	97.8252						
OB	30.3072	97.8245						

Table 1. GPS coordinates of all live oak trees >1 ft diameter at breast height found by the author. Note ten trees (FA-PA) were flagged but gps coordinates not taken. Also note in small but live oak-dense pockets in the southwesternmost sector of the property, a number of live oaks were not flagged or their gps coordinates taken. GPS coordinates of the O2 plot are not included.

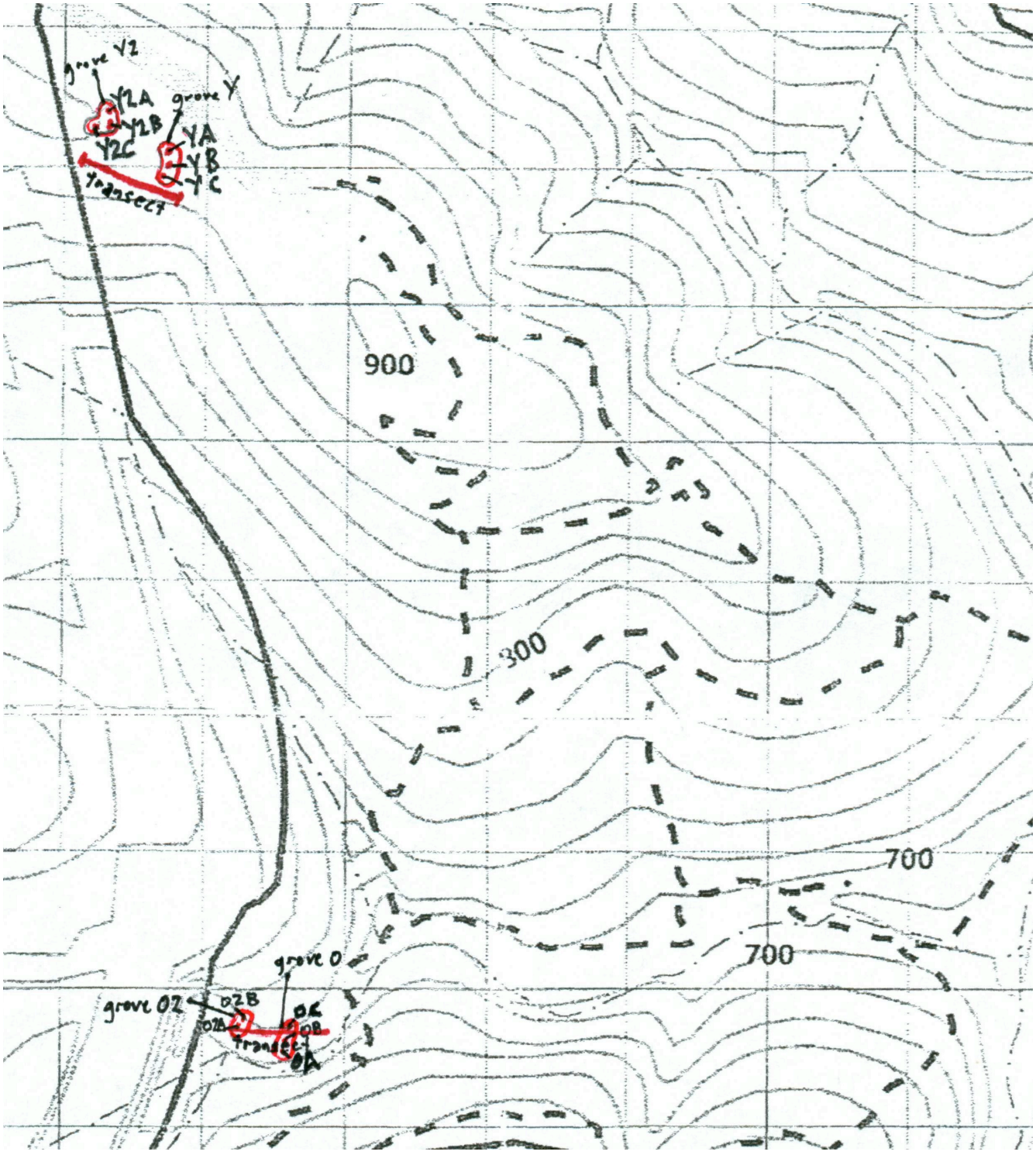

Figure 2. Locations of chosen transects and live oak groves fogged in 2012.

Date of fogging	Grove fogged	1st or 2nd fogging of grove
25.VI.2012	Y	1st

31.VI.2012	Y	2nd
03.VII.2012	Y2	1st
09.VII.2012	Y2	2nd
15.VII.2012	O	1st
20.VII.2012	O	2nd
06.VIII.2012	O2	1st
(no 2nd fog performed)	O2	2nd

Table 2. Fogging dates and locations in 2012.

I. Absolute

	Density		Area		Volume	
a) Tree	**Hill #/ha**	**Creek #/ha**	**Hill m2/ha**	**Creek m2/ha**	**Hill m3/ha**	**Creek m3/ha**
J. ashei	1777.97	758	358	218.85	19074.32	18104.9
Q. virginiana	229.42	51	216	32.01	8653.52	2422.85
Q. texana	0	51	0	21.83	0	1871.19
Q. sinuata	57.35	0	9.43	0	462.09	0
R. viridis	172.06	0	13	0	229.7	0
B. lanuginosa	57.35	0	3.63	0	116.42	0
I. vomitoria	0	126	0	2.56	0	119.1
P. serotina	0	25	0	1.08	0	48.6
total	2294.15	1011	600.06	276.33	28536.05	22566.63
b) Shrub						
J. ashei	480.08	259	0.254	0.11	5.72	2.99
Q. virginiana	34.29	0	0.003	0	0.03	0
Q. texana	0	43	0	0.01	0	0.05
R. viridis	34.29	0	0.021	0	0.36	0
B. lanuginosa	17.15	0	0.003	0	0.03	0
I. vomitoria	68.58	1037	0.006	0.44	0.06	12.81
G. ovata	34.29	173	0.013	0.12	0.28	4.5
F. pubescens	17.15	43	0.001	0	0.01	0.05
U. crassifolia	0	130	0	0.11	0	3.22
P. serotina	0	43	0	0.06	0	2.9
total	685.83	1728	0.3	0.85	6.5	26.53
c) Dead wood						
J. ashei	10162	1448	11.55	2.87	105.44	22.53
Q. virginiana	1311.2	2051	1.8	2.2	7.95	27.88
Q. texana	0	1327	0	1.54	0	35.94
Q. sinuata	655.61	0	1.14	0	23.5	0
R. viridis	655.61	0	0.82	0	8.22	0
I. vomitoria	327.8	0	0.35	0	6.52	0
total	13112.22	4826	15.66	6.61	151.62	86.34

II. Relative Importance

a) Tree	Hill (area)	Creek (are	Hill (vol)	Creek (vol)
J. ashei	190.56	210.39	200.28	211.4
Q. virginiana	56.02	28.97	56.12	28.13
Q. texana	0	25.56	0	25.97
Q. sinuata	15.53	0	9.7	0
R. viridis	25.82	0	24.91	0
B. lanuginosa	12.08	0	8.45	0
I. vomitoria	0	25.93	0	25.53
P. serotina	0	9.14	0	8.97
total	300.01	299.99	299.46	300
b) Shrub				
J. ashei	204.47	41.94	208.08	40.56
Q. virginiana	16.1	0	15.4	0
Q. texana	0	7.94	0	7.46
R. viridis	22.06	0	20.56	0
B. lanuginosa	8.38	0	7.96	0
I. vomitoria	21.89	154.38	20.98	151.15
G. ovata	19.16	38.78	19.31	41.25
F. pubescens	7.95	7.74	7.71	7.44
U. crassifolia	0	34.39	0	33.93
P. serotina	0	14.84	0	18.2
total	300.01	300.01	300	299.99
c) Dead wood				
J. ashei	210.04	113.38	205.86	96.09
Q. virginiana	39.12	110.8	32.89	109.79
Q. texana	0	75.82	0	94.12
Q. sinuata	18.18	0	26.38	0
R. viridis	22.03	0	22.19	0
I. vomitoria	10.63	0	12.68	0
total	300	300	300	300

D) GROUNDCOVER	HILL	CREEK
Type	Mean % cover	Mean % cover
(all groundcover)	36.5	21.7
Grass	23.6	8.78
Seedlings	7.03	10.2
Dicot herbs	5.88	2.73

Table 3. Summarized point-quarter transect absolute (I) and relative (II) results for trees (a), shrubs (b), dead wood (c), and ground cover (d). Units: Absolute density in individuals/ha, relative density as percent, total and mean area in sq. cm., relative cover and frequency as percent, and importance (no units) can range from 0-300. Note also the tree tables show values calculated for both circumference at 30 cm and 130 cm above the ground, the shrub tables show values calculated for diameter at 30 cm, and the dead wood tables show values calculated for diameter at the center of the piece of wood. Volume was calculated by area times tree / shrub height or dead wood length.

Oak Biomass data

plot	oak	c30 area	c130 area	volume
Y	A	0.8	0.47	46.6
	B	1.26	0.61	69.79
	C	0.37	0.24	22.12
Y2	A	0.39	0.35	30.71
	B	0.35	0.26	25.35
	C	0.38	0.32	26.29
O	A	0.49	0.34	31.37
	B	3.48	1.75	225.78
	C	0.68	0.33	35.66
O2	A	0.37	0.37	29.59
	B	1.83	1.84	147.03

Table 4. Location and size of live oaks fogged showing basal area (m^2) at 30 cm and 130 cm and average of this area times tree height for estimated tree volume (m^3).

A)

Order	# individuals	Families	Species
Acari	6	1	4
Araneae	129	3	20
Blatteria	4	1	2
Coleoptera	18	7	12
Collembola	25	3	6
Diptera	45	4	12
Hemiptera	279	8	23
Hymenoptera	234	11	21
Isopoda	6	1	1
Isoptera	374	1	1
Lepidoptera	6	4	4
Neuroptera	15	3	3
Opiliones	1	1	1
Orthoptera	3	1	2
Psocoptera	735	1	3
Thysanoptera	6	1	2
Thysanura	394	1	1
Totals	2280	52	118

B)

Tree	Coverage	# individu	#/sq.ft.	Vol. (mL)	mL./sq.ft.
A	106	1064	10.04	10.6	0.1
B	198	967	4.88	4.4	0.02
C	56	931	16.63	0.9	0.02

Table 5. Summarized results of arthropods collected by first fogging of one hill live oak grove listing (A) minimum taxonomic diversity for orders, families, and (morpho-)species, and (B) biomass data, showing area covered by collection funnels per tree, total number and volume (estimated as the product of each specimen's length, width, and height) of arthropods collected per tree, and such number and volume divided by area covered by collection funnels.

Date fogged	Location	Transect number
27.IV.2013	Hilltop	13
29.IV.2013	Hilltop	14
29.IV.2013 and 30.IV 2013	Bottomlands	15
01.V.2013	Bottomlands	16

Table 6. Fogging dates and locations in 2013.

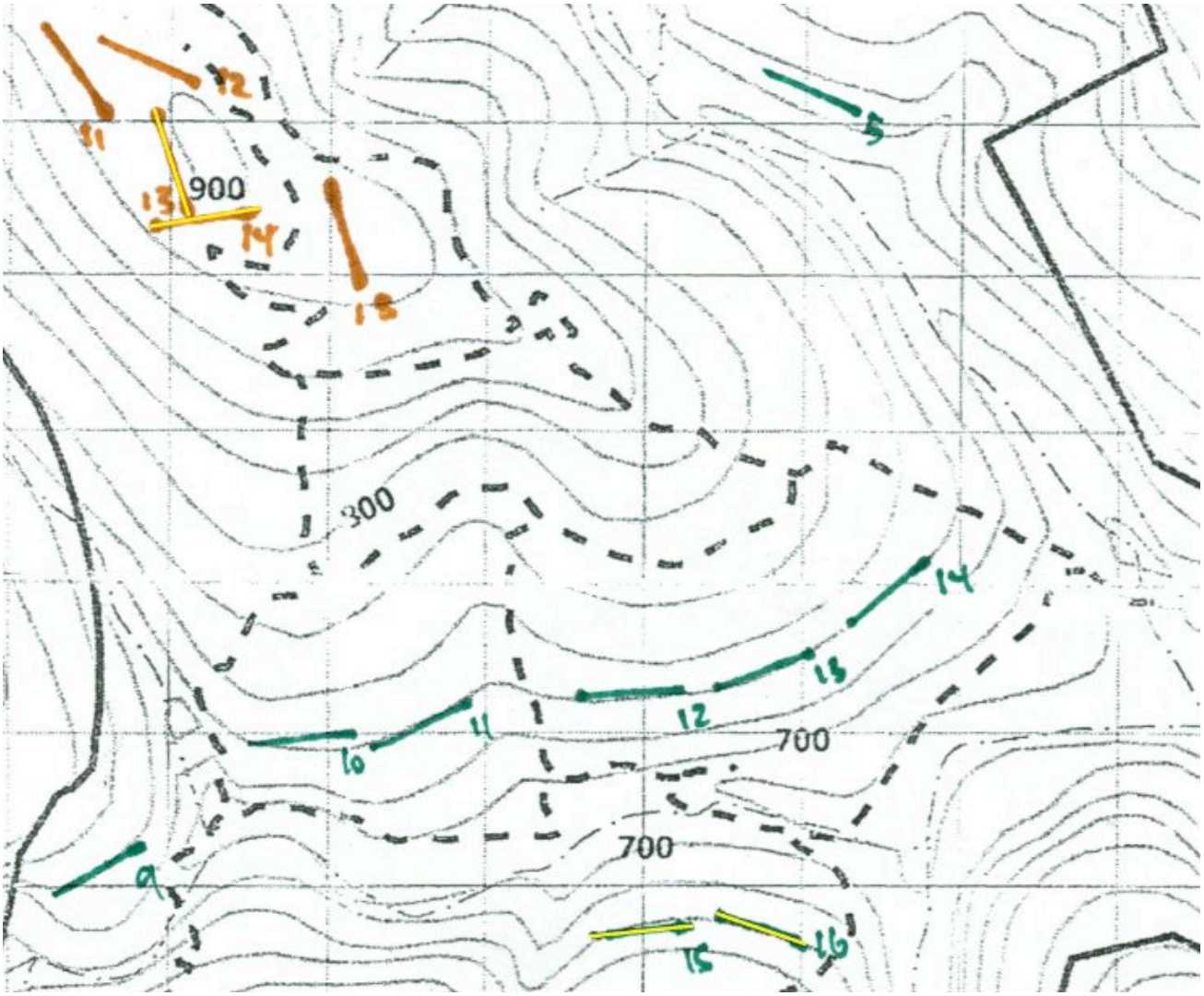

Figure 3. Transect locations (highlighted) fogged in 2013.